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PERFORMANCE AND STABILITY EVALUATION OF SOME GRAIN SORGHUM HYBRIDS AND VARIETIES OVER YEARS

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ABSTRACT

Performance and stability evaluation of twelve grain sorghum varieties and hybrids representing different geographic origins and have a wide genetic diversity from ICRISAT, India was done at Shandaweel Agricultural Research Station over four growing seasons i.e. 1992, 1993, 1994 and 1995. The tested sorghum genotypes included CSH-1, CSH-11, Serado, ICSV-112, Framida, E 35-1, IRAT 204, Naga white, S 35, IS 2284, IS 3693 and Dorado. A Randomized Complete Block Design with four replications was used in each trial. Data were taken for days to 50 % flowering, plant height (cm), 1000-grain weight (gm) and grain yield (ard./fed.). Data were statistically analyzed and stability parameters were estimated.

Combined analysis over years showed significant mean squares due to years for days to 50 % flowering, plant height and grain yield and highly significant mean squares due to genotypes (varieties and hybrids) and genotypes x years interaction for days to 50 % flowering, plant height and grain yield. Mean grain yield (ard./fed.) when combined over years ranged among genotypes from 15.39 to 29.75 with an average of 21.53 ard./fed. The highest genotypes for grain yield over years were E 35-1, S 35, Dorado, ICSV-112 and CSH-11 in descending order.

The stability parameters of the 12 sorghum genotypes over four years revealed the presence of genetic variability among the materials. The varieties x environments interaction including environmental linear were highly significant, in addition, the linear component of variety x environment interaction were highly significant. The significance of pooled deviation for grain yield indicates that the genotypes differed considerably with respect to their stability. Data showed that the variety E 35-1 had a (b) value (1.75) and an average grain yield higher than the grand mean and it seemed to be the most desirable and stable genotype.

Key words: ***Grain sorghum, Stability, G x E interaction, Variety evaluation.***

INTRODUCTION

Evaluation of the genotype performance at different environments is important in plant breeding. The differential response of genotypes to different environments poses a major problem of relating phenotypic performance to genetic construction and makes it difficult to decide which genotype should be selected. The existence of interactions among genotypes and environmental factors has long been recognized and accounted for significant part of total variation; and thus it should be assessed and quantified. Rao (1970) tested six sorghum genotypes at 18 locations over a two years period in India and reported that genotype x location and genotype x location x year interactions were highly significant, while genotype x year interaction was non significant. Rao (1972) showed that there is more significant genotype x location than genotype x year interaction indicating that genetic superiority over a large number of locations even during a single year could enable earlier release of new hybrids or varieties resulting in saving of time and effort. Kambal and Mahmoud (1978) evaluated 16 varieties at three locations over three years. They found that variety x location was of greater significance than variety x year interactions. They also presented an evidence that the years of testing could be reduced by increasing the number of test locations. Desai *et al* (1983) found a significant genotype x environment interaction in sorghum hybrids evaluated at four locations; the high yielding ability of hybrids was primarily due to better management.

Heinrich *et al* (1983) evaluated stable and unstable hybrids for yield and yield components across diverse environments at Nebraska and Kansas. The results showed that all the hybrids had a comparable yield potential in good environments; also they found that the stable hybrids were higher yielding in poor environments. Saeed *et al* (1984) reported that genotypes showed larger interaction with locations within a year than with years irrespective of maturity. Also they found that minimizing differences in maturity among genotypes reduces G x E interaction. They suggested that testing at more locations should be done rather than testing in more years. Moreover, they reported that increasing number of replications per test more than two, environments in a year more than eight, and years of testing more than two, was not effective in increasing efficiency in genotype evaluation, especially for early and medium maturing genotypes. Patel *et al* (1985) showed that each of site, genotype and site x genotype interaction contribute significantly to the variance of grain yield. Ahmed (1993) reported that genotypes which were superior for all studied traits showed average stability. Muppidathi *et al* (1995), studied genotypic and phenotypic stability for panicle characters in grain sorghum and identified the superior genotypes in the favorable environments.

Eweis (1998) in a stability study across 14 different production environments at Middle and Upper Egypt found that genotypes x environment interactions were always highly significant that justified placing more emphasis on yield stability in the selection process. Ali (2000) reported that mean squares due to crosses x environments (linear) interaction were highly significant for panicle weight and grain yield/plant.

The main objectives of this study were (i) to evaluate mean performance of twelve grain sorghum genotypes representing different geographic origins and having wide genetic diversity across four years and (ii) to identify the grain yield stability of each genotype over years.

MATERIALS AND METHODS

Twelve grain sorghum varieties and hybrids of different geographic origins and having a wide genetic diversity obtained from ICRISAT, India were evaluated at Shandaweel Agricultural Research Station, ARC for four growing seasons i.e. 1992, 1993, 1994 and 1995. These genotypes included two hybrids CSH-1, CSH-11 and ten varieties; Seredo, ICSV-112, Framida, E35-1, IRAT 204, Naga white, S 35, IS 2284, IS 3693 and Dorado. A Randomized complete block design with four replications was used in each trial. Plot size was four rows, 5 meters long, 70 cm. apart. Planting was done in hills spaced 20 cm apart within row and seedlings were thinned to two plants per hill. Planting dates were July, 11th, 1992, June 20th, 1993, June 29th, 1994 and July 6th, 1995. Data were taken on the two central rows for days to 50 % flowering, plant height, 1000-grain weight and grain yield. Grain yield in kg/plot was converted to ard./fed. All the agronomic practices as recommended for grain sorghum were followed whenever needed. Each trial was subjected to the standard analysis of variance and the combined analysis of variance over years was performed according to Steel and Torrie (1980). The stability analysis for grain yield was carried out according to Eberhart and Russel (1966).

RESULTS AND DISCUSSION

Combined analysis of variance showed significant or highly significant mean squares due to years, genotypes and genotypes x years interactions for all studied traits except those due to years and genotypes x years interaction for 1000-grain weight trait, which were non significant (Table 1).

Mean performance:

Mean performance of days to 50 % flowering and plant height for the 12 genotypes is presented in Table (2). Days to 50 % flowering across years ranged from 55.8 (IRAT 204) to 85.7 (E 35-1). Days to flowering across genotypes also differed from 70.6 in 1992 to 83.2 in 1995.

The average performance of plant height (cm) for the 12 genotypes differed within each year and over years. Plant height across years ranged from 144 cm for IRAT 204 to 361 cm for IS 2284. Across genotypes, plants were the shortest in 1994 and the tallest in 1993 season. It is worthy to note

Table 1. Combined analysis of variance for evaluating 12 genotypes in four seasons for days to flowering plant height, 1000-grain weight and grain yield.

Source of variation	d.f	Mean Squares			
		Days to 50 % flowering	Plant height	1000-grain weight	Grain yield
Years (Y)	3	364.54**	5157.08*	0.46	2634.85**
$Error_{(a)}$	12	4.45	341.28	0.96	1.46
Genotypes (G)	11	1469.37**	57690.38**	496.37**	293.83**
G x Y	33	100.99**	1250.54**	0.48	70.24**
$Error_{(b)}$	132	1.49	223.28	0.57	3.56

*, ** indicate significant at 0.05 and 0.01 levels of probability, respectively.

Table 2. Mean number of days to 50 % flowering and plant height for 12 grain sorghum genotypes tested in four years.

No	Genotypes	Average days to 50 % flowering					Average plant height (cm)				
		Year 1	Year 2	Year 3	Year 4	Over all years	Year 1	Year 2	Year 3	Year 4	Over all years
1	CSH-1	63.5	59.5	63.0	73.0	64.8	169	158	130	144	150
2	CSH-11	62.5	63.0	65.0	75.8	66.6	203	204	185	203	198
3	Seredo	64.8	82.5	88.5	93.5	82.3	198	252	224	258	233
4	ICSV-112	76.8	61.8	65.0	73.5	69.2	233	177	174	190	193
5	Framida	74.5	75.5	85.8	87.0	80.7	269	250	243	225	247
6	E 35-1	76.5	81.8	89.0	95.5	85.7	251	264	231	248	248
7	IRAT 204	54.3	51.8	55.5	61.8	55.8	154	140	131	150	144
8	Naga white	75.5	77.8	87.3	94.8	83.8	236	240	199	199	218
9	S 35	68.3	68.5	74.3	77.5	72.1	255	254	230	248	247
10	IS 2284	75.5	81.8	86.3	85.5	82.3	349	401	360	335	361
11	IS 3693	85.0	83.0	72.8	97.5	84.6	204	221	180	245	213
12	Dorado	69.8	67.5	73.0	83.0	73.3	150	144	139	150	146
	Average	70.6	71.2	75.4	83.2	75.1	222	225	202	216	216
	$L.S.D_{0.05}$	1.93	1.79	2.21	0.69	1.69	15.48	16.11	29.01	22.34	20.71

that the shortest genotypes (IRAT 204 and CSH-1) were the earliest ones in flowering.

The mean performance of 1000-grain weight (gm) and grain yield (ard./fed.) is presented in Table (3). There were a lot of differences for 1000-grain weight among genotypes within each year and when data were combined over years. Mean 1000-grain weight over years ranged from 16.18 gm (IS 3693) to 32.69 gm (S 35). 1000-grain weight did not change significantly from year to year.

Table 3. Mean 1000-grain weight and grain yield ard./fed. for 12 grain sorghum genotypes tested in four years.

No	Genotypes	1000-grain weight (gm)					Grain yield (ard./fed.)				
		Year 1	Year 2	Year 3	Year 4	Over all years	Year 1	Year 2	Year 3	Year 4	Over all years
1	CSH-1	27.73	27.55	28.40	26.92	27.65	21.49	22.93	14.09	21.49	20.00
2	CSH-11	23.33	23.35	23.18	23.20	23.26	29.98	17.36	19.62	23.02	22.49
3	Seredo	20.98	20.75	20.53	21.20	20.86	34.50	14.61	11.56	27.35	22.00
4	ICSV-112	20.38	20.71	19.73	20.15	20.24	32.57	20.54	16.01	23.21	23.08
5	Framida	18.80	18.58	18.58	19.13	18.77	32.80	12.93	10.56	16.50	18.20
6	E 35-1	29.48	29.60	28.88	29.75	29.43	48.70	23.01	19.12	28.20	29.75
7	IRAT 204	18.75	18.13	19.15	19.40	18.86	21.13	17.02	10.01	18.05	16.55
8	Naga white	19.43	19.64	19.40	19.50	19.49	39.82	16.95	11.39	13.80	20.49
9	S 35	32.65	32.33	33.08	32.73	32.69	34.34	27.86	21.32	28.61	28.03
10	IS 2284	30.70	30.12	30.20	30.45	30.37	28.14	16.55	11.92	18.67	18.82
11	IS 3693	16.33	16.10	15.93	16.38	16.18	24.45	12.87	7.48	16.76	15.39
12	Dorado	29.08	28.48	28.81	28.73	28.77	31.55	25.57	15.07	22.10	23.57
	Average	23.97	23.78	23.82	23.96	23.88	31.62	19.02	14.01	21.48	21.53
	$L.S.D_{0.05}$	0.98	0.96	1.18	1.18	1.05	3.82	2.34	1.35	2.73	2.61

The average grain yield (ard./fed.) across genotypes differed significantly from year to another. It was noticed that grain yield of the third year was the lowest (14.01 ard./fed.), while that of the first year was the highest (31.62 ard./fed.). The range of grain yield (ard./fed.) when data were combined over years was from 15.39 ard./fed. (for IS 3693) to 29.75 ard./fed. (for E 35-1). The highest yielding genotypes were E 35-1 and S 35 (with no significant difference between them) followed by Dorado, ICSV-112 and CSH-11.

In general, we noticed that there were many differences among genotypes in all the studied traits because of geographic and genetic diversity among them.

Stability analysis: -

The analysis of variance for grain yield (ard./fed.) stability (Table 4) of the 12 genotypes over four years revealed the presence of genetic variability among genotypes. The mean squares due to linear component of environments, linear component of varieties x environment interaction and

Table 4. Analysis of variance for yield stability of twelve sorghum genotypes at four environments.

Source of variation	d.f	Mean squares
genotypes (G).	11	293.83**
Environments + (G x E)	36	283.96**
Environment (linear).	1	1974.12**
G x E (linear).	11	38.58**
Pooled deviation	24	6.55*
CSH-1	2	16.91*
CSH-2	2	8.53
Seredo	2	22.91**
ICSV-112	2	-20.55**
Framida	2	6.31
E 35-1	2	7.27
IRAT 204	2	6.08
Naga white	2	30.87**
S 35	2	-12.95*
IS 2284	2	-0.23
IS 3693	2	1.21
Dorado	2	12.25*
Pooled Error	132	3.56

*, ** indicate significant at 0.05 and 0.01 levels of probability, respectively.

pooled deviation were highly significant. The highly significance of pooled deviation for grain yield (ard./fed.) indicated that the sorghum genotypes differed considerably with respect to their stability.

The environmental index (Table 5) measured the differences between genotype mean yield and overall genotypes mean yield. Covered a wide range (from –6.14 to + 8.22 ard./fed.) displaying a good balanced environmental distribution. Therefor, the required assumption for stability is fulfilled, Russell and Prior (1975). Based on the stability analysis results, it is possible to identify the best stable variety to be grown under different environments. To determine yield stability of individual genotypes across environments, the regression coefficient (bi) of genotypes mean on environmental index and the deviation from regression (S^2d) were computed to obtain estimates of stability parameters which are shown in Table (5).

Table 5. Stability parameters for 12 sorghum genotypes across four environments.

Genotypes	$\bar{X}$	Deviation	b_i	S^2d
CSH-1	20.00	-1.53	0.29	16.02*
CSH-11	22.49	+0.96	0.67	7.64
Seredo	22.00	+0.47	1.36	22.02**
ICSV-112	23.08	+1.55	1.07	21.45**
Framida	18.20	-3.33	1.33	5.42
E 35-1	29.75	+8.22	1.75	6.39
IRAT 204	16.55	-4.98	0.57	5.20
Naga white	20.49	-1.04	1.66	29.98**
S 35	28.03	+6.50	0.70	-13.84*
IS 2284	18.82	-2.71	0.92	-1.12
IS 3693	15.39	-6.14	0.96	0.33
Dorado	23.57	+2.04	0.85	11.36*
General mean	21.53		1.0	5.66
$L.S.D_{0.05}$	2.61			

$\bar{X}$ = Genotype mean in ardab/feddan.
Deviation = genotype yield-grand mean yield.
(b_i) = Regression coefficient.
(S^2d) = deviation from regression.
*, ** indicate significant at 0.05 and 0.01 levels of probability, level respectively.

Eberhart and Russel (1966) proposed that an ideal genotype is the one which has the highest mean yield over a broad range of environments, b = 1, and $S^2d = 0$.

Data show that the variety E 35-1 had (b) value of (1.75) and had the highest average grain yield and this variety seems to be the most desirable and stable genotype. The varieties ICSV-112, Seredo, Framida, and Naga white performed consistently better in favorable environments because the regression coefficient (b_i) were more than one, while the varieties CSH-11, S 35, IS 2284, IS 3693 and Dorado performed better in less favorable environments (b_i is less than one).

Meanwhile, the highest S^2d value for the varieties CSH-1, Seredo, Naga white and Dorado indicated a significant instability for grain yield.

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تقييم الأداء والثبات لبعض هجن وأصناف الذرة الرفيعة فى عدة سنوات

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تم إجراء التقييم لعدد ١٢ هجين وصنف من الذرة الرفيعة قادمة من الايكريسات بالهند والتى تتبع مناطق جغرافية وبينها تباعد وراثى ، وقد تم التقييم فى محطة بحوث شندويل فى سنوات ١٩٩٢، ١٩٩٣، ١٩٩٤ و١٩٩٥ والأصناف هى CSH-1, CSH-11, Seredo, ISCV-112, Framida, IS 2284, IS 3693, S 35, Naga white, IRAT 204, E 35-1 ودورادو .

استخدم فى التجربة تصميم القطاعات الكاملة العشوائية فى أربعة مكررات وتم أخذ البيانات لعدد الأيام حتى ٥٠ % تزهير، ارتفاع النبات بالسم، ووزن الألف حبة ومحصول الحبوب (أردب/فدان) وقد تم تحليل البيانات لكل سنة على حدة وكذلك التحليل المجمع للبيانات.

أظهرت النتائج وجود اختلافات معنوية بين الأصناف فى كل سنة وكذلك للتحليل المتجمع على السنوات لكل الصفات كما أظهرت النتائج وجود اختلافات معنوية بين السنين للتزهير وارتفاع النبات والمحصول وكذلك يوجد معنوية للتفاعل بين السنوات والأصناف لكل من التزهير والأطول والمحصول. وقد تراوح محصول الأصناف كمتوسط للسنوات ما بين ١٥,٣٩ إلى ٢٩,٧٥ بمتوسط ٢١,٥٣ أردب/فدان. وقد أعطت الأصناف التالية أعلى محصول وهى E 35-1, S 35, Dorado, ICSV-112, CSH-11. أظهرت نتائج تحليل الثبات للأصناف والهجن على مستوى السنوات وجود تباين وراثى بين مواد الدراسة وقد كان التفاعل بين الأصناف والسنوات متضمنة العلاقة الخطية للسنوات معنويا جدا وكذلك العلاقة الخطية بين الأصناف والسنوات كانت معنوية جدا وقد أظهرت معنوية متوسط مربعات الانحراف عن خط الانحدار أن الأصناف والهجن تختلف فيما بينها فى درجة

النبات. وقد أظهرت النتائج أن الصنف E 35-1 لدية قيمة (b) أكبر من الوحدة (١,٧٥) وقيمة (S^2d) صغيرة لا تختلف معنويا عن الصفر وأعلى متوسط محصول عن المتوسط العام ويبدو أنه احسن الأصناف محصولا وثباتا.

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