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PERFORMANCE AND STABILITY OF SOME GRAIN SORGHUM GENOTYPES UNDER DIFFERENT ENVIRONMENTAL CONDITIONS

Y.M.Y. El kady, O.A.Y., Abd Elraheem and Heba M. Hafez

Sorghum Research Department, Field Crop Research Institute, ARC, Egypt

ABSTRACT

Evaluation of sorghum genotypes under different environments is essential for testing stability of performance and degree of adaptation which are important goals of breeding programs. Fifteen grain sorghum genotypes (Sorghum bicolor (L.) Moench) of diverse origins were evaluated during 2019 and 2020 growing seasons at three locations, namely Shandaweel, New valley and Toshki Agric. Res. Stations. The joint regression analysis showed highly significant differences among genotypes and among environments, as well as significant genotype x environment interaction, indicating differential responses of genotypes to changes in environment for the studied traits. The G × E interactions were linear functions to the environment which were significant for all the studied entries. The evaluation parameters used were mean performance, regression coefficient and the mean squares deviation from regression. Stability analysis showed that the most stable genotypes were No. 15 for days to 50% flowering, No. 2 for plant height, No. 2, 9 and 13 for protein content, No. 10 for 1000-grain weight and genotype No. 11 for grain yield/plant.

Key words*: **Sorghum bicolor, Regression coefficient, Deviation from regression.***

INTRODUCTION

Exploitation of genetic variability is the most important tool in plant breeding especially in sorghum breeding and this has to be inferred by phenotypic expression. The consequences of the phenotypic variation depends largely on the environments. This variation is further complicated by the fact that all genotypes do not interact similarly to changes in the environments. Mean yield across environments is adequate indicator of genotypic performance only in the absence of genotype by environment (G x E) interaction. G x E indicates differential genotypic response to the environment. Most often G x E complicates breeding, testing and selection of superior genotypes. It is important for plant breeders to identify specific genotypes adapted to specific environment or stable across environments. Thereby, achieving quick genetic gain is possible through screening of genotypes for greater adaptation and stability across environments is important prior to release as commercial cultivars (Ariyo 1989, Flores *et al* 1998; Showemimo *et al* 2000, Mustapha *et al* 2001 and Yan and Kang 2003).

Changes in climate and atmospheric composition are major factors that could greatly influence farm production and management in the future. Climatic changes expected to play a major role in directing the plant breeders. Stability of grain yield could be defined as the genotypes ability to avoid substantial fluctuations in yield across a range of environments. It̓s also considered as a breeding objective difficult to achieve. Mechanisms of yield stability fall into four general categories, genetic heterogeneity, yield component compensation, stress tolerance, and capacity to recover rapidly from stress (Heinrich *et al* 1983). Adaptability and stability for performance of cultivars across locations and years are of great importance for national policy in crop production, therefore a grain producer is interested primarily in growing a cultivar with high yielding ability and stability of performance at a proper location. Yield stability across different environments is an important consideration in crop breeding programs that target areas with variable climatic patterns (Feizias *et al* 2010). So, most plant breeding programs in agricultural research center resorts to evaluate genotypes across different environments.

Studying analysis of grain sorghum genotypes across fourteen different environments at Middle and Upper Egypt, Eweis (1998) mentioned that G × E interactions were highly significant that suggested estimating yield stability in selection programs. Studying a number of crosses in grain sorghum in different environments.

Ali (2000) reported that mean squares due to crosses × environments (linear) interactions were highly significant for panicle weight and grain yield. Meanwhile, Mostafa (2001) found that genotypes and genotypes × year's interactions were significant for all studied traits, while those due to years and genotypes x years interactions for 1000- kernel weight, were insignificant. A joint regression analysis of variance performed by Ali (2006) showed significant variances due to genotypes, environments, and the genotype × environment interactions for most of the studied traits in grain sorghum. Six genotypes were found to be more stable for number of days to flowering, five genotypes for plant height, two for grain yield/plant, and 7 genotypes for 1000- grain weight. Genotypes x environment interactions were found to be operating several traits studied by Mahmoud *et al* (2007). Stability parameters across all environments indicated that, all genotypes exhibited significant linear response to environmental conditions. Mahdy *et al* (2011) reported that, the interaction effects of genotype x location x planting date were highly significant for all studied traits, whereas the effect of genotype x year interaction was highly significant for days to blooming, plant height and grain yield. Genotype x year x planting date interaction effect was highly significant for plant height, 1000-grain weight, and grain yield. However, genotype x year x location x planting date interaction was effect highly significant for plant height and grain yield. Mahmoud *et al* (2012) found highly significant mean squares due to genotypes, environments, and genotype × environment interaction for several traits in grain sorghum. For grain yield per plant, the genotypes varied in their response to changes in the environment as indicated by the (b_i) values. Tag *et al (*2015) found that the joint regression analysis showed highly significant differences among genotypes and among environments, as well as significant. Genotype x environment interaction, indicating differential responses to changes in environment for the studied traits. The G × E interactions were linear functions to the environment which were significant for all the studied traits, except for panicle length. Al-Naggar *et al* (2018) found that the significance of genotype × environment interaction was found for all characters revealing that genotypes interacted significantly with environments. The presence of significant environment by genotype interaction showed the inconsistency of performance of grain sorghum parental lines across the test environments. Stable genotypes differed from trait to trait.

The main objective of the present investigation was to study the performance and stability parameters of yield and some of its components in grain sorghum genotypes across six environments (the combinations of 2 years × 3 locations).

MATERIALS AND METHODS

The experimental work of this study was conducted at Shandaweel, New Valley and Toshki Agric. Res. Stations under the two growing seasons 2019 and 2020.

Genetic materials

Fifteen grain sorghum genotypes obtained from ICRISAT, USA, Zimbabwe and Sorghum Res. Department, Field Crops Res. Institute, ARC, Egypt. Name and origin of these genotypes are presented in Table (1).

Experimental work

Six field experiments represented different environments (E1, E2, E3, E4, E5 and E6) were carried out. The six environments were E1

(Shandaweel, 2019), E2 (Shandaweel, 2020), E3 (New Valley, 2019), E4 (New Valley, 2020), E5 (Toshki, 2019) and E5 (Toshki, 2020). Each experiment al layout was arranged in a randomized complete blocks design (RCBD) with three replications. Each genotype was sown in one row 4.0 m long and 50 cm apart. Planting was done in hills spaced 15 cm apart within rows and seedling were thinned to two plants per hill. Data were recorded on days to 50% flowering, plant height (cm), 1000-grain weight (g), grain protein content (%) and grain yield/ plant (g).

Statistical analysis

To estimate the extent or magnitude of variation among these genotypes the data obtained was subjected to analysis of variance for each environment based on plot means followed by a combined analysis of the data across six environments after homogeneity of variance was detected, these were done according to methods described by Gomez and Gomez (1984).

Stability analysis of the 15 genotypes was carried out for each trait according to the method of Eberhart and Russell (1966). Three criteria would be realized to consider a genotype as stable one. These criteria are as follows:

1-Regression coefficient significantly different from zero ($b \neq 0$) and not significantly different from unity ($b = 1$).

2- Non- significant sum of squares due to the deviation from regression, *i.e.* $S^2_d = 0$.

3- High performance with a reasonable range of environmental variation.

Environmental index (Ij)

$Ij = [(\sum iYij/ g) - (\sum i\sum jYij/ge)]$ With $\sum Ij = 0$

Where, Ij = environment index

Yij = summation of all the genotypes for jth environment

g = number of genotypes

$\sum i\sum jYij$ = summation of all the genotypes overall the environments.

ge = number of genotypes × number of environments

Table 1. Name and origin of the fifteen grain sorghum genotypes used in this study.

No.	Name	Origin	No.	Name	Origin
1	Adv.1	Egypt	9	RSH-18	Egypt
2	Adv.2	Egypt	10	ICSR-89016	India
3	Adv.3	Egypt	11	ICSR-89025	India
4	Adv.4	Egypt	12	MR-812	Zimbabwe
5	Adv.5	Egypt	13	ZSV-14	Zimbabwe
6	Adv.6	Egypt	14	NM-36565	Zimbabwe
7	Adv.16	Egypt	15	Dorado	USA
8	Adv.45	Egypt			

RESULTS AND DISCUSSION

Analysis of variance

The pooled analysis of variance provides an estimate of genotype × environment interaction, which measures changes in the mean of different environments. The mean squares due to environments and genotypes were significant for all studied characters (Table 2). The mean squares due to genotype × environment interaction was significant for all studied traits. Thus, stability analysis was carried out for all traits.

Analysis of variance for stability (Table 2) revealed the presence of variability among the genotypes for all studied traits, indicating that genotypic differences were highly significant for these traits. Significance of genotype × environment interaction was observed for all traits revealing that genotypes interacted significantly with environments. Similar result was reported on sorghum Abebe *et al*. 1984 and Al-Naggar *et al*. 2006. As shown in Table (2), partitioning of genotype by environment into linear and non-linear portions for studied traits indicated that both were vital. Genotype by environment (linear) and pooled deviations were significant when tested against pooled mean squares, revealing that both linear and non-linear components accounted for genotype by genotype x environment variance. The large significant genotype by environment variance suggests that the component was most important in contributing to differences in performance of genotypes across the test environments. The relatively large proportion of environmental variance when compared with genotype as main effect suggests the large influence of environment on performance of genotypes. These findings were in agreements with those obtained by Ali (2000), Mostafa (2001), Mahmoud *et al* (2007), Mahdy *et al* (2011), El-Kady (2015), El- Sagheer *et al (*2018) and Al-Naggar *et al* (2018).

Table 2. **Stability analysis of variance for all studied traits of fifteen grain sorghum genotypes evaluated under six different environmental conditions**.

SOV	df	Days to 50% flowering	Plant height	Grain protein content	1000-grain weight	Grain yield/ plant
Environments (Env)	5	210.26**	5256.09**	55.50**	350.87**	1.848.15**
Genotype (G)	14	169.24**	2121.78**	5.18**	33.95**	1052.85**
Env × G	70	18.59**	134.32**	2.44**	5.37**	59.30**
Env.+(G X E)	75	10.45**	158.59**	1.99**	9.47**	59.52**
Env.(Liner)	1	350.44**	8760.16**	92.49**	584.78**	3080.25**
G x Env. (liner)	14	8.62	125.15**	1.22	3.49**	80.76**
Pooled deviation	60	5.22**	23.04**	0.66**	1.28**	4.22**
Pooled error	168	1.12	6.36	0.25	0.38	1.32

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

Mean performance of genotypes in each and across environments

Means performance for all studied traits of the 15 genotypes across six environments (E1 to E6) is presented in Tables (3-8).

For number of days to 50% flowering (Table 3), the earliest genotypes were shown by No. 10, 3, 1, and 1 at environment (E1). While the earliest genotypes at environment (E2) were No. 9, 3 and 15, No. 1,15 and 11 in environment (E3), No 11 and 14 in (E4), No. 14, 3 and 13 in environment (5), No. 3 and 15 in environment (E6). Based on combined data, the earliest genotypes were No. 3, 1 and 15 while the latest genotypes were No. 4, 2 and 5.

Table 3. Means of number of days to 50% flowering of the fifteen grain sorghum genotypes under six environments.

No.	Genotypes	Environments						Average
		Shandaweel 2019 (E1)	Shandaweel 2020 (E2)	New valley 2019 (E3)	New valley 2020 (E4)	Toshki 2019 (E5)	Toshki 2020 (E6)	
1	Adv.1	64.67	66.67	68	73	73.33	70.67	69.39
2	Adv.2	73.67	75.33	78	74	82.67	76	76.61
3	Adv.3	63	64.33	69.67	70	68	65	66.67
4	Adv.4	74.33	73	77.67	77	78.33	81	76.89
5	Adv.5	73.33	68.67	79.33	76	73.67	73.33	74.06
6	Adv.6	72.33	71.67	71.67	73	75	73	72.78
7	Adv. 16	73.67	71	76	77	78.67	82.33	76.45
8	Adv. 45	69.33	71.67	73.67	77.33	75	73.67	73.45
9	RSH-18	70.67	68.67	72.33	71	68.67	70.67	70.34
10	ICSR-89016	62.33	67	73.33	75.67	70.33	76	70.78
11	ICSR-89025	69.67	70.33	74	69.33	67.33	70.67	70.22
12	MR-812	67.67	71.67	69	68.67	76	73.33	71.06
13	ZSV-14	68.67	70.33	71.33	72.33	74.33	70.67	71.28
14	NM-36565	66.67	63.67	75.33	75	70.67	73.33	70.78
15	Dorado	65.33	65	68.67	72	70	68.33	68.22
Average		69.02	69.27	73.2	73.42	73.47	73.2	71.93
Environment index		-2.91	-2.66	1.27	1.49	1.54	1.27	
LSD 0.05		2.72	3.49	3.5	2.91	2.06	2.65	2.89

For plant height, (Table 4), results showed that the tallest genotype was No. 11, 13 and 11 in environment (E1). Also, the genotypes No. 4, 9, 13 and 11 were the tallest in environment (E2). Beside, genotypes No. 13, 9 and 7 were the tallest in environment (E3), No. 13, 9 and 12 in environment (E4), No. 7, 4 and 3 at environment (E5) and No. 7 and 4 in environment (E6). Furthermore, the results across all six environments showed that the tallest genotypes were ZSV-14, Adv.4, R SH- 18, and MR-812, while the shortest genotypes were Adv.6 and Adv.2.

Table 4. Means of plant height (cm) of the fifteen grain sorghum genotypes under six environments.

No.	Genotypes	Environments						Average
		Shandaweel 2019 (E1)	Shandaweel 2020 (E2)	New valley 2019 (E3)	New valley 2020 (E4)	Toshki 2019 (E5)	Toshki 2020 (E6)	
1	Adv.1	154.33	157.67	143.33	141.83	133.67	141.67	145.42
2	Adv.2	140	142.33	122.67	125	118.67	116.67	127.56
3	Adv.3	165.67	162.33	144.67	143.33	152.33	143.33	151.94
4	Adv.4	168	174.67	145	146.83	156.33	150	156.81
5	Adv.5	141	147.67	134.67	137	133	128.33	136.95
6	Adv.6	137.33	130.67	120	122.67	118.33	116.67	124.28
7	Adv.16	165	160	154.33	145.33	157.67	150.67	155.5
8	Adv.45	160	155	143	149.33	146.33	145	149.78
9	RSH-18	168	173	158.33	156	136.67	138	155
10	ICSR-89016	173	167	146	143.67	144	130	150.61
11	ICSR-89025	171.33	171	149	140	125.33	119.33	146
12	MR-812	177	169.67	150.67	151.67	138.67	138.33	154.34
13	ZSV-14	176	173	161.5	157	144.33	140.67	158.75
14	NM-36565	160.67	149	134.33	132.67	133.33	115	137.5
15	Dorado	135	145	138	142.33	128.67	129	136.33
Average		159.49	158.53	143.03	142.31	137.82	133.51	145.78
Environment index		13.71	12.75	0.72	-3.47	-7.96	-12.27	
LSD 0.05		6.16	8.08	6.07	7.9	6.87	7.28	7.06

For grain protein content means (Table 5), the highest genotypes were No. 14 followed by 6 and 3 in environment (E1), No. 11 followed by 9 in environment (E2), No. 8 followed by 7 and 1 in environment (E3), No. 9 followed by 14 in environment (E4), No. 15 followed by 8 in environment (E5), No 10 followed by 14 and 15 in environment (E6). The combined mean for grain protein content across all the six environments showed that the highest value was observed by ICSR-89025, NM-36565 and Dorado, while the lowest genotypes were Adv.4 and Adv.5.

Table 5. Means of grain protein content (%) of the fifteen grain sorghum genotypes under six environments.

No.	Genotypes	Environments						Average
		Shandaweel 2019 (E1)	Shandaweel 2020 (E2)	New valley 2019 (E3)	New valley 2020 (E4)	Toshki 2019 (E5)	Toshki 2020 (E6)	
1	Adv.1	10.96	10.27	9.50	8.25	7.87	7.23	9.01
2	Adv.2	9.53	10.00	7.88	8.03	7.46	7.65	8.43
3	Adv.3	11.13	8.96	9.27	7.83	7.90	7.58	8.78
4	Adv.4	10.30	8.64	6.14	6.16	7.10	6.34	7.45
5	Adv.5	10.23	8.91	6.53	7.25	7.67	6.21	7.80
6	Adv.6	11.51	10.45	7.38	7.80	7.48	7.66	8.71
7	Adv.16	8.71	10.26	9.52	6.80	8.56	7.22	8.51
8	Adv.45	8.22	10.19	9.89	8.36	9.11	8.13	8.98
9	RSH-18	10.33	11.26	7.19	9.92	6.75	7.14	8.77
10	ICSR-89016	9.89	7.99	7.83	9.50	8.10	8.52	8.64
11	ICSR-89025	11.53	11.51	9.47	9.13	7.05	8.11	9.47
12	MR-812	10.80	8.78	7.20	7.24	6.34	8.26	8.10
13	ZSV-14	10.70	9.61	7.52	8.95	7.45	8.35	8.76
14	NM-36565	10.55	10.62	7.96	9.57	8.30	8.50	9.25
15	Dorado	8.99	10.95	8.85	8.78	9.16	8.37	9.18
Average		10.23	9.89	8.17	8.24	7.75	7.68	8.66
Environment index		1.57	1.23	-0.49	-0.42	-0.91	-0.98	
LSD 0.05		1.28	1.85	1.17	1.36	1.46	0.99	1.35

For 1000-grain weight (Table 6), the heaviest grain was shown by genotype No. 6 followed by 3 in environment (E1), No. 13 followed by 3, 6 and 10 in environment (E2), N0. (12, 13) followed by 6 and 10 in environment (E3), No. 9 followed by 10 in environment (E4), No. 1 followed by 4 in environment (E5), No 10 followed by 12 and 8 in environment (E6). The combined mean of 1000-grain weight across all the six environments showed that the highest value was observed for ICSR-89016, Adv.6 and Adv.3. On the contrary, the lowest genotypes in this trait were Dorado and Adv. 16.

Table 6. Means of 1000-grain weight (g) of the fifteen grain sorghum genotypes under six environments.

No.	Genotypes	Environments						Average
		Shandaweel 2019 (E1)	Shandaweel 2020 (E2)	New valley 2019 (E3)	New valley 2020 (E4)	Toshki 2019 (E5)	Toshki 2020 (E6)	
1	Adv.1	28.73	29.07	24.47	24.70	24.03	20.20	25.20
2	Adv.2	27.27	27.73	22.53	24.27	23.10	23.10	24.67
3	Adv.3	30.30	30.63	22.57	24.80	23.10	23.50	25.82
4	Adv.4	25.53	25.50	21.73	22.37	23.37	24.17	23.78
5	Adv.5	27.57	27.90	22.33	22.40	23.33	23.30	24.47
6	Adv.6	30.80	30.47	25.27	23.00	23.03	22.73	25.88
7	Adv.16	26.13	25.77	22.43	20.90	22.33	19.93	22.92
8	Adv.45	28.33	27.93	23.20	24.83	22.33	24.33	25.16
9	RSH-18	25.50	26.90	24.37	25.53	19.27	21.77	23.89
10	ICSR-89016	29.73	30.03	25.20	25.07	22.60	24.83	26.24
11	ICSR-89025	29.60	28.67	23.37	21.40	18.70	20.90	23.77
12	MR-812	27.67	28.73	25.60	23.47	22.17	24.50	25.36
13	ZSV-14	29.93	30.85	25.60	23.50	20.33	22.33	25.42
14	NM-36565	27.00	26.77	22.80	23.40	23.30	20.40	23.95
15	Dorado	24.87	24.77	19.67	17.57	18.23	20.73	20.97
Average		27.93	28.11	23.41	23.01	21.94	22.45	24.48
Environment index		3.45	3.63	-1.07	-1.47	-2.54	-2.03	
LSD 0.05		1.22	1.00	1.70	1.76	1.76	2.30	1.65

For grain yield/plant (Table 7), the highest mean was recorded by genotype No. 3 followed by 13 and 7 in environment (E1), No. 13 followed by 10 and 9 in environment (E2), No. 8 followed by 6 in environment (E3), No. 6 followed by 8 in environment (E4), No. 6 followed by 8 in environment (E5), No 6 followed by 7 in environment showed that (E6). The combined mean of grain yield/plant across all the six environments the highest value was observed for Adv.6, Adv.45 and Adv.16. On the contrary, the lowest yielding genotypes were Dorado and Adv.5.

Table 7. Means of grain yield/plant (g) of the fifteen grain sorghum genotypes under six environments.

No.	Genotypes	Environments						Average
		Shandaweel 2019 (E1)	Shandaweel 2020 (E2)	New valley 2019 (E3)	New valley 2020 (E4)	Toshki 2019 (E5)	Toshki 2020 (E6)	
1	Adv.1	72.37	69.23	46.33	45.57	42.77	41.23	52.92
2	Adv.2	64.87	60.37	51.37	55.50	49.27	58.67	56.68
3	Adv.3	74.53	74.33	47.33	46.80	42.50	43.10	54.77
4	Adv.4	61.53	64.30	47.70	48.13	44.13	43.53	51.55
5	Adv.5	53.43	53.50	48.63	47.50	46.17	47.90	49.52
6	Adv.6	74.00	74.63	66.40	70.43	69.87	70.97	71.05
7	Adv.16	74.20	73.00	64.87	65.53	63.17	67.77	68.09
8	Adv.45	74.00	71.07	66.60	68.77	65.37	65.60	68.57
9	RSH-18	72.57	74.67	65.60	62.60	62.13	63.03	66.77
10	ICSR-89016	72.97	75.17	65.33	67.00	62.73	62.73	67.66
11	ICSR-89025	72.33	73.80	62.00	64.17	60.70	59.33	65.39
12	MR-812	62.77	61.90	53.90	56.53	53.50	49.13	56.29
13	ZSV-14	74.30	76.13	56.97	57.13	52.77	51.20	61.42
14	NM-36565	67.37	68.23	65.30	61.40	51.30	57.63	61.87
15	Dorado	51.33	52.24	46.23	48.43	45.83	46.07	48.60
Average		68.17	68.15	56.97	57.70	54.15	55.19	60.06
Environment index		8.11	8.09	-3.09	-2.36	-5.91	-4.87	
LSD 0.05		2.16	3.13	3.21	3.57	3.23	3.57	3.15

The estimates of environmental index (Tables 3-7), showed that differences among the environments were significant; Results showed that E1 (Shandaweel, 2019) and E2 (Shandaweel, 2020) were the best environments for all traits studied, while E6 (Toshki, 2020) and E5 (Toshki, 2019) were the latest in flowering, had the shortest plants, the poorest in 1000 grain weight and grain protein content. these difference in the environmental index showed that the performance of the genotypes varied from location to location and from year to year.

3- Estimated Stability Parameters

Stability parameters of the fifteen grain sorghum genotypes with respect to days to 50% flowering, plant height, grain protein content, 1000 grain weight and grain yield per plant are presented in Tables (8 -10). The stability parameters in these tables are: 1- Average of different characters, 2-

Regression coefficient (b_i) of the performance on environmental indices, 3- Regression deviation (S^2_d). According to the definition of Eberhart and Russell (1966), a stable preferred variety would have approximately: 1) b_i = 1 , 2) S^2_d = 0 (i,e. not significantly different than zero) and 3) a high mean performance. Besides Paroda and Hayes (1971) and Lin *el al* (1986) indicated that the squared deviation from regression as a measure of stability, while the regression was regarded as a measure of response of a particular variety to environmental indices.

For number of days to 50% flowering (Table 8), most of the genotypes had a significant deviation from linear regression implying unstability across the environments for days to flowering. Four genotypes, viz No. (6, 13, 9 and 15) displayed below average performance; for days to 50% flowering and average responsiveness (b_i<1), except genotype (15) which had average responsiveness (b_i>1), indicating that this genotype responded to the favorable environment and could produce early plants when provided with suitable environments.

Table 8. Stability parameters of days to 50% flowering and plant height (cm) of 15 grain sorghum genotypes across six environments.

No.	Genotypes	Days to 50% Flowering			Plant height(cm)		
		Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}
1	Adv.1	69.39	1.38	12.92**	145.42	0.75	54.90**
2	Adv.2	76.61	0.79	31.26**	127.56	1.00	10.39
3	Adv.3	66.67	1.10	11.65**	151.94	0.81	85.86**
4	Adv.4	76.89	1.13	8.59*	156.81	0.92	178.98**
5	Adv.5	74.06	1.05	27.02**	136.95	0.57*	25.25
6	Adv.6	72.78	0.29*	4.25	124.28	0.72	19.15
7	Adv.16	76.45	1.44	21.56**	155.73	0.46	90.19**
8	Adv.45	73.45	1.09	7.48*	149.78	0.54*	33.68
9	RSH-18	70.34	0.21	6.89	155.00	1.28	125.96**
10	ICSR-89016	70.78	2.19	23.80**	150.61	1.47*	35.10
11	ICSR-89025	70.22	0.04	17.94**	146.00	2.00**	78.58**
12	MR-812	71.06	0.54	33.50**	154.34	1.45*	32.74
13	ZSV-14	71.28	0.67	6.00	158.75	1.29	55.81*
14	NM-36565	70.78	1.97	16.33**	137.5	1.37	99.77**
15	Dorado	68.22	1.12	5.48	136.33	0.37	110.16**
Mean		71.93			145.78		

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

Regarding the stability parameters for plant height (Table 9) most of the genotypes had a significant deviation from linear regression implying that these genotypes were unstable across the environments. In the context, genotype No. (2) displayed the lowest performance for plant height with regression coefficient ($b_i \geq 1$) and nonsignificant deviation from regression, indicating that this genotype is stable across to different environments. While, the genotypes No. (5, 6 and 8) had displayed below average performance and nonsignificant deviation from regression, except the genotype No. (8) which displayed above average performance, indicating that this genotype is stable across different environments. Moreover, the genotype No. (10 and 12) showed high performance for plant height with regression coefficient $b_i \geq 1$ and nonsignificant deviation from regression, indicating that this genotype suitable is for favorable environmental conditions.

Table 9. Stability parameters of grain protein content and 1000-grain weight (g) of 15 grain sorghum genotypes evaluated across six environmental conditions.

No.	Genotypes	Protein ratio			1000-grain weight		
		Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}
1	Adv.1	9.01	1.2	1.30*	25.2	1.06	8.55**
2	Adv.2	8.43	0.93*	0.26	24.67	0.78	1.75
3	Adv.3	8.78	0.97	2.30*	25.82	1.28	3.28*
4	Adv.4	7.45	1.38	1.85*	23.78	0.43*	4.04**
5	Adv.5	7.8	1.25	1.46	24.47	0.87	2.89*
6	Adv.6	8.71	1.57*	0.56	25.88	1.34*	1.89
7	Adv.16	8.51	0.63	4.71**	22.92	0.84	3.84*
8	Adv.45	8.98	0.13	2.92**	25.16	0.84	2.37
9	RSH-18	8.77	1.5	3.99**	23.89	0.77	13.04**
10	ICSR-89016	8.64	0.29	2.36*	26.24	1.05	1.17
11	ICSR-89025	9.47	1.52	1.46	23.77	1.56*	2.87*
12	MR-812	8.1	1.18	2.80**	25.36	0.84	3.14*
13	ZSV-14	8.76	1.01	1.25	25.42	1.47	3.96**
14	NM-36565	9.25	0.95	0.95	23.95	0.82	4.52**
15	Dorado	9.18	0.49	1.96*	20.97	1.05	5.78**
Mean		8.66			24.48		

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

For grain protein content (Table 9), most of the genotypes had a significant regression deviation, implying that these genotypes were unstable across the environments. The genotype No. (2) gave value near average performance, (b_i< 1) and non-significant deviation from regression, so it is considered suitable for poor environments. Out of the five genotypes (No. 5, 6, 11, 13 and 14), one genotype No. 5 had less average performance with regression coefficient (b_i> 1.0) and non-significant deviation from regression, the genotype No. 14 had high performance for grain protein content with regression coefficient (b_i< 1) and non-significant deviation from regression, indicating that this genotype is stable and widely adapted. The other genotypes No. (6, 11 and 13) revealed suitability for favorable environmental conditions; they showed high performance for grain protein content with a regression coefficient (b_i> 1.0) and non-significant deviation from regression.

For 1000-grain weight (Table 9), most of the genotypes had a significant regression deviation implying that most of genotypes were unstable across the environments. The genotype No. (2) displayed near mean value of 1000-grain weight, regression coefficient value of less than unity and non-significant deviation from the regression line and so it is considered suitable for poor environments. The genotype No. (6) showed the highest mean of 1000-grain weight, regression coefficient (b_i>1) and non-significant deviation from regression, indicating that this genotype is suitable for favorable environmental conditions. The genotype No. (8) displayed the highest mean value of 1000-grain weight, regression coefficient (b_i<1) and non-significant deviation from the regression line and so it is considered suitable for poor environments. The genotype No. (10) displayed the highest mean grain weight, regression coefficient value near unit and non-significant deviation from regression, indicating that this genotype is stable, widely adapted to different environments.

For grain yield per plant (Table 10), the genotypes No. (1, 2, 6, 12 and 14) had a significant regression deviation implying that these genotypes were unstable across the environments. The other genotypes (No. 3, 4, 5, 7, 8, 9, 10, 11, 13 and 15), were considered suitable for poor environments with predictable performance as they exhibited high performance for grain yield along with below average responsiveness (b_i<1) and non-significant deviation from regression line. While the genotypes No. 15 (Dorado) and No. 5 (Adv.5) gave the lowest mean value for grain yield, regression coefficient (b_i<1) and non-significant deviation from the regression line and so it is considered suitable for poor environments. On the contrary, the genotype No. 4 (Adv.4) gave the low mean value for grain yield, regression coefficient (bi<1) and non-significant deviation from the regression line indicating that this genotype adapted to good environments. These results are in line with those reported by Mostafa (2001), Mahmoud *et al* (2007), Mahdy *et al*. (2011), Mahmoud *et al* (2012), Tag *et al* (2015), El- Kady (2016) and El- Sagheer *et al (*2018).

Table 10. Stability parameters of grain yield/plant (g) of 15 grain sorghum genotypes evaluated across six environmental conditions.

No.	Genotypes	Grain yield/plant (g)		
		Mean	b_i	S^2_{di}
1	Adv.1	52.92	2.17**	13.88**
2	Adv.2	56.68	0.73	45.04**
3	Adv.3	54.77	2.39**	6.79
4	Adv.4	51.55	1.40**	4.7
5	Adv.5	49.52	0.48**	1.44
6	Adv.6	71.05	0.37*	12.51*
7	Adv.16	68.09	0.66	9.43
8	Adv.45	68.57	0.50**	5.06
9	RSH-18	66.77	0.83	6.92
10	ICSR-89016	67.66	0.81	3.8
11	ICSR-89025	65.39	0.95	3.94
12	MR-812	56.29	0.76	14.57**
13	ZSV-14	61.42	1.70**	6.11
14	NM-36565	61.87	0.83	53.93**
15	Dorado	48.36	0.43**	1.71
Mean		60.06		

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

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السلوك والثبات الوراثي لبعض تراكيب الذرة الرفيعة للحبوب تحت الظروف البيئية المختلفة

يوسف محمد يوسف القاضي, عمر ابو الحسن يونس عبد الرحيم و هبة محمد حافظ

قسم بحوث الذرة الرفيعة –معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

تقييم التراكيب الوراثية للذرة الرفيعة تحت بيئات مختلفة يتم لاختبار الثبات في الاداء المظهري ويقيس مدي التاقلم وهذه من اهم اهداف برامج التربية. تم تقييم ١٥ تركيب وراثي من الذرة الرفيعة للحبوب مختلفة المصدر خلال موسمي ٢٠١٩ و ٢٠٢٠ (الموسم الصيفي) في ثلاث مواقع مختلفة وهي محطة البحوث الزراعية بشندويل , ومحطة بحوث الوادي الجديد، ومحطة بحوث توشكي . أظهرت النتائج وجود اختلافات عالية المعنوية بين التراكيب الوراثية و البيئات وذلك بالنسبة لجميع الصفات محل الدراسة. كما كان تباين التفاعل بين التراكيب الوراثية والبيئات عالى المعنوية لجميع الصفات المدروسة. وقد أوضحت النتائج ان التراكيب الوراثية أظهرت تباين في سلوكها من سنة لأخرى ومن موقع لموقع آخر لجميع الصفات. اظهر تحليل الانحدار المشترك للتباين للصفات التى تم دراستها وجود اختلافات عالية المعنوية بين التراكيب الوراثية وبين البيئات والتفاعل بين التراكيب الوراثية و البيئات لكل الصفات المدروسة وهذا يشير إلى أن التركيب الوراثي يختلف اختلافا كبيرا عبر البيئات المختلفة. وعلاوة على ذلك، فان التفاعل بين التراكيب الوراثية و البيئات (دالة خطية) كان عالى المعنوية لجميع الصفات المدروسة. كانت معاملات التقييم المستخدمة هى متوسط سلوك التراكيب الوراثية ومعامل الانحدار ومتوسط مربعات الانحراف عن خط الانحدار. أظهر تحليل الثبات أن التراكيب الوراثية الأكثر ثباتا هى رقم ١٥ بالنسبة لصفة عدد الايام حتى تزهير ٥٠% ورقم ٢ بالنسبة لصفة إرتفاع النبات ورقم ٢،٩ و ١٣ لصفة نسبة البروتين ورقم ١٠ لصفة وزن الألف حبة ورقم ١١ لصفة محصول الحبوب/النبات.

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