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GENOTYPE by ENVIRONMENT INTERACTION IN GRAIN SORGHUM GENOTYPES UNDER UPPER EGYPT CONDITIONS

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ABSTRACT

Evaluation of sorghum genotypes under different environments is essential for testing stability in performances and degree of adaptations of genotypes and considered an important goals of breeding programs. In this respect, 13 grain sorghum genotypes (*Sorghum bicolor* (*L.*) Moench) derived from diverse origins were evaluated for several traits during 2010/2011, 2011/2012 and 2012/2013 growing seasons at two locations, namely Shandaweel and Arab El-Awamer Agric. Res. Stations. Thus, the evaluation included six environments. The joint regression analysis showed highly significant differences among each of genotypes and environments as well as genotype x environment interactions .This results indicated differential responses due to changes in environment. The G × E interactions showed significant linear functions with the environments for all studied traits, except for panicle length. The stability parameter (b_i) for grain yield per plant was quite variable among the genotypes ICSR -89016 and ICSR-93002 which were insignificantly deviated from unity, indicating average stability. The parameters of ICSR-89016 and ICSR-93002 were insignificantly deviated from zero indicating greater stability over the range of environments for grain yield per plant.
Keywords*: Sorghum, Regression stability analysis*

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 largely depend on the environment. This variation is further complicated by the fact that all genotypes do not interact similarly with the changes in the environment. Mean yield across environments would be an adequate indicator of genotypic performance in the absence of genotype by environment (GE) interaction. Most often, GE complicates breeding, testing and selection of superior genotypes. There for, is important to identify those specific genotypes which are adapted or stable over a set of environments. thereby achieve quick genetic gain through screening of genotypes for greater adaptation and stability prior to release them as 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 conditions are among the major factors that would greatly influence farm production and management in the future.Therefore,climatic changes which are expected to occur would play a major role in directing the plant breeders. Stability of yield and the ability of a genotype to avoid substantial fluctuations in yield over a range of environments is a breeding objective which would be 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 (Heinirich *et al*. 1983). Adaptability and stability of performance of cultivars over locations and years are important for national policy in crop production. Therefore, a grain producer is primarily interested in growing a cultivar with high yield 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.

Analysis of stability of green sorghum genotypes was investigated over 14 different production environment at Middle and Upper Egypt. Eweis (1998) reported that genotype × environment interactions were always highly significant and suggested estimating yield stability in selection programs. Studying a number of crosses of grain sorghum in different environments, Ali (2000) found that mean squares due to crosses × environments (linear) interaction were highly significant for panicle weight and grain yield. Mean while, Mostafa (2001) reported that genotypes and genotypes × years interactions for all studied traits were significant, while those due to years and genotypes x years interaction for 1000- kernel weight, were non-significant. A joint regression analysis performed by Ali (2006) of variance showed significant variances due to genotypes, environments and the genotype × environment interaction for most of the studied traits of 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) with the being accounted for by the linear regression on the environmental means. 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 genotypes with planting dates were highly significant for all studied traits, whereas genotype x year interaction effect 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 effect was highly significant only for plant height and grain yield. Mahmoud *et al*. (2012) found highly significant differences among 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 (bi) values.

Therefore, The objective of the present investigation was to study the performances and stability parameters of yield and its components in some grain sorghum genotypes over six environments which were the combinations of three years × two locations .

MATERIALS AND METHODS

Thirteen grain sorghum genotypes (*Sorghum bicolor* (L.) Moench) from diverse origins which are presented in Table 1 were evaluated at Arab El-Awamer and Shandaweel Agric. Res. Stations over the three growing seasons of 2011, 2012 and 2013. The soil at all sites was analyzed in the results are presented in Table 2. The experimental layout was a randomized complete blocks design with three replications. Each genotype was sown in one row 4.0m in length and 50cm in width. Planting were done in hills spaced 15cm apart within rows. Later on, seedlings were thinned to two plants per hill. Data were recorded on days to 50 % flowering , Plant height (cm) , 1000 kernel weight (g), Panicle width (cm) ,Panicle length (cm) and Grain yield / plant (g). The joint regression analysis was performed for each trait according to the method of Eberhart and Russell (1966). Three criteria would be realized to consider a genotype is a stable one. These criteria are follows:

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

2-Non- significant sums of squares of the deviation of regression, i.e., $S^2_d = 0$.

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

Table 1. Origin of the thirteen grain sorghum genotypes.

No.	genotype	Origin	No.	genotype	Origin
1	R line-629	India	8	ZSV-14	Zimbabwe
2	SV-1	India	9	ICSV- 273	India
3	Dorado	USA	10	ICSR-89039	India
4	NM-36565	Zimbabwe	11	MR-812	Zimbabwe
5	ICSR- 89028	India	12	ICSR-93001	India
6	R line-924	India	13	ICSR-93002	India
7	ICSR-89016	India			

Table 2 . Some physical and chemical properties of the experimental sites.

Properties	Arab El Awamer			Shandaweel		
	2010/2011	2011/2012	2012/2013	2010/2011	2011/2012	2012/2013
Mechanical analysis:						
Sand (%)	85.40	87.20	87.30	55.91	30.64	42.33
Silt (%)	8.70	7.20	8.00	11.84	24.26	19.88
Clay (%)	5.90	5.60	5.7	32.25	45.10	40.33
Texture	Sandy			Clay		
Chemical analysis:						
EC (1:1 extract) (dsm^{-1})	8.21	8.43	8.33	0.39	0.84	0.66
pH (1:1 suspension)	0.59	0.77	0.65	7.60	7.90	6.99
Available						
Total nitrogen (%)	0.06	0.04	0.06	1.26	0.80	1.02
$NaHCO_3$-extractable P (ppm)	5.14	4.88	5.00	8.33	6.30	9.70
NaOAC-extractable K (ppm)	0.14	0.12	0.12	0.33	0.26	0.35
Total $CaCO_3$ % (ppm)	27.33	32.15	32.0	2.33	2.86	1.72
Organic matter (%)	0.82	0.76	0.85	1.89	1.32	1.66

RESULTS AND DISCUSSION

1 -Analysis of variance

Data for each trait was statically analyzed as usual .Test of homogeneity of the error mean squares across all environments was done according the method of Eberhart and Russell (1966).When the error mean squares were homogenous, therefore the combined analysis would followed up as presented in Table3.

Table3. Means square of combined analysis of variance for the studied traits.

Source of variation	df	Mean squares					
		Plant height	Grain yield	Panicle length	1000 kW	Panicle width	Date flowering
Environments(E)	5	3978.8**	3991.9**	25.26**	844.1**	4.269**	1600.9**
Rep.(E)	12	17.62	6.281	3.377	3.329	0.065	1.688
Genotypes(G)	12	26929.7**	5560.3**	78.08**	1830.6**	3.855**	148.3**
E x G	60	170.8**	205.2**	7.698**	84.37**	0.736**	12.24**
Error	144	8.256	2.593	1.620	2.755	0.066	3.859

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

The combined analyses of variance in Table 3 revealed the presence of highly significant differences among genotypes, environments and genotypes x environments interaction for all studied traits. In other words, the rank of any given genotype varied within each environment from one year to another. The proportional participations of environments, genotypes and genotypes by environments interactions varied from trait to trait.

2- Mean Performance Of Genotypes

A- Days To 50% Flowering

The means of number of days to 50% flowering of the 13 grain sorghum genotypes at two locations in 2011, 2012 and 2013 seasons are presented in Table 4. The results showed different performance of genotypes from year to year and from location to another. The mean of days to 50 % flowering across all environments ranged from 69.88 days for ICSR-93002 to 78.38 days for ZSV-14. The average of days to 50% flowering across all genotypes and environments was 75.38 days.

Table 4:- Means of days to 50% flowering of the thirteen grain sorghum genotypes at two locations from 2011 to 2013 seasons.

	Arab El-Awamer			Shandaweel			Average
	2010/2011	2011/2012	2012/2013	2010/2011	2011/2012	2012/2013	
Rline -629	81.7	82.3	82.7	71.0	71.3	70.3	76.38
SV-1	84.7	86.0	82.3	70.7	70.0	69.3	77.16
NM- 36565	83.7	81.0	83.0	70.3	71.0	71.7	76.78
ICSR-89028	84.7	82.0	81.7	70.3	70.7	69.7	76.51
R line-924	87.0	84.3	82.7	73.3	71.3	70.7	78.21
ICSR-89016	87.3	82.3	86.3	70.3	69.7	68.3	77.36
ZSV-14	87.7	85.3	82.0	72.0	72.3	71.0	78.38
ICSV-273	86.0	82.3	84.7	70.0	70.3	68.7	77
ICSR-89039	84.3	83.3	82.3	70.0	67.7	70.3	76.31
MR-812	74.3	75.0	75.0	69.7	68.7	66.3	71.5
ICSR-93001	76.7	77.7	73.3	67.7	67.0	67.7	71.68
ICSR-93002	72.7	74	73.7	67.3	65.3	66.3	69.88
Dorado	78.0	78.0	75.0	68.3	69.3	67.3	72.65
Average	82.21	81.038	80.36	70.06	69.58	69.04	75.38

B- Plant Height (CM)

Means of plant height of the 13 grain sorghum genotypes at each environment and all over the six environments are presented in Table 5. The means of plant height of all genotypes ranged from 139.49 cm at Arab El-Awamer in 2013 season to 159.57 cm at Shandaweel in 2012 season. Furthermore, the results showed that the average of plant height across all environments ranged from 113.75 cm for ICSR-89039 to 266.1 cm for SV-1.

Table 5:- Means of plant height of the thirteen grain sorghum genotypes at two locations from 2011 to 2013 seasons.

	Arab El-Awamer			Shandaweel			Average
	2010/2011	2011/2012	2012/2013	2010/2011	2011/2012	2012/2013	
Rline -629	168.1	168.0	164.6	172.3	171.4	170.2	169.1
SV-1	270.2	261.7	258.9	268.5	268.7	268.6	266.1
NM- 36565	135.7	135.0	129.1	154.7	154.6	155.2	144.05
ICSR-89028	125.0	123.8	124.8	137.0	136.8	137.2	130.76
R line-924	150.7	150.3	146.9	159.0	160.0	160.0	154.48
ICSR-89016	112.0	103.8	107.3	123.6	125.0	123.8	115.91
ZSV-14	133.5	132.0	131.6	170.2	171.3	169.5	151.35
ICSV-273	133.2	132.4	132.0	134.1	135.3	135.6	133.76
ICSR-89039	108.3	107.0	107.6	119.3	120.9	119.4	113.75
MR-812	135.6	135.7	133.3	159.1	158.6	160.7	147.16
ICSR-93001	146.0	142.5	143.4	160.3	162.0	161.2	152.56
ICSR-93002	144.5	142.9	140.7	167.5	165.9	165.7	154.53
Dorado	97.2	94.8	93.2	145.0	144.0	145.3	119.9
Average	143.07	140.76	139.49	159.27	159.57	159.41	150.26

C- Panicle Length (CM):-

Panicle length means of the 13 grain sorghum genotypes at each environment and across all environments are presented in Table 6. The average of panicle length across all environments ranged from 21 cm. for

ICSR- 93001 to 27.9 cm for Dorado (as a check) and 27.27 cm for SV-1. The mean of panicle length a cross all genotypes ranged from 22.6 cm at Arab El-Awamer in 2012 season to 24.7cm at Shandaweel in 2011 and 2013 seasons.

Table 6:- Means of panicle length (cm) of the thirteen grain sorghum genotypes at two locations from 2011-2013.

	Arab El-Awamer			Shandaweel			Average
	2010/2011	2011/2012	2012/2013	2010/2011	2011/2012	2012/2013	
Rline -629	22.17	21.20	23.13	25.87	24.97	25.43	23.79
SV-1	27.20	25.73	28.10	27.50	27.60	27.53	27.27
NM- 36565	21.83	19.97	21.90	25.67	25.10	24.63	23.18
ICSR-89028	23.80	23.40	25.17	23.47	21.57	22.07	23.25
R line-924	27.07	26.57	27.50	24.10	24.63	25.23	25.85
ICSR-89016	25.93	24.43	26.30	24.83	24.03	24.20	24.95
ZSV-14	21.33	20.90	23.37	23.70	23.97	24.53	22.96
ICSV-273	24.97	23.43	25.30	23.83	28.43	27.70	25.61
ICSR-89039	22.30	19.00	21.37	24.23	23.60	23.50	22.33
MR-812	22.33	22.07	22.33	27.47	27.23	26.97	24.73
ICSR-93001	22.30	20.27	22.63	20.23	20.50	20.07	21
ICSR-93002	21.27	20.50	20.90	23.00	21.63	22.90	21.7
Dorado	30.60	26.50	31.00	27.00	26.13	25.93	27.9
Average	24.1	22.6	24.53	24.7	24.6	24.7	24.2

D - Panicle Width (CM):

For Panicle width (cm) means of the 13 grain sorghum genotypes at each environment and across all environments are presented in Table 7. The average of panicle length across all environments ranged from 4.76 cm. for ICSR- 93001 to 6.3 cm for SV-1. The mean of panicle width a cross all genotypes ranged from 5.26 cm at Arab El-Awamer in 2012 season to 6 cm at Shandaweel in 2012 season.

Table 7: Means of panicle width (cm) for 13 grain sorghum genotypes at two locations from 2011-2013.

	Arab El-Awamer			Shandaweel			Average
	2010/2011	2011/2012	2012/2013	2010/2011	2011/2012	2012/2013	
Rline -629	5.86	5.46	5.66	5.40	5.60	5.53	5.58
SV-1	6.36	5.86	5.56	6.60	6.76	6.93	6.3
NM- 36565	5.36	5.33	5.53	5.23	5.30	5.00	5.3
ICSR-89028	6.40	6.66	6.06	6.03	6.36	5.93	6.24
R line-924	5.10	5.00	5.40	5.16	5.50	5.83	5.33
ICSR-89016	5.30	5.46	5.06	5.90	6.03	5.43	5.53
ZSV-14	5.56	5.20	6.16	5.66	5.86	5.40	5.64
ICSV-273	5.93	5.86	5.96	6.26	6.00	6.70	6.11
ICSR-89039	5.46	5.06	5.76	6.60	6.73	6.66	6.045
MR-812	4.60	4.73	4.83	6.83	7.03	6.93	5.82
ICSR-93001	4.26	4.20	4.20	5.26	5.20	5.46	4.76
ICSR-93002	4.4	4.6	4.5	6.4	6.5	6.6	5.5
Dorado	5.23	4.96	5.4	4.9	5.1	5.13	5.12
Average	5.37	5.26	5.4	5.9	6	5.96	5.63