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Stability and Performance Analysis for Grain Sorghum Hybrids and ther Parental Lines

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ABSTRACT

This investigation aimed to study the stability and performance of 30 sorghum genotypes across 8 environments. Twenty grain sorghum crosses and five introduced cytoplasmic male sterile lines (CMS-lines), four restorer lines (R-lines) and hybrid H-305 as the check were evaluated at eight environments i.e.; two years (2016 and 2017), two locations (Shandaweel Agric. Res. Station, Sohag Governorate and Arab El-Awamer Agric. Res. Station, Assiut Governorate) and two planting distances 20 (D_1) and 15 (D_2) cm between hills.The combined analysis of variance of 30 genotypes over eight environments appear highly significant differences among genotypes and environments for all studied traits.Moreover, the genotypes × environments interaction variance was also highly significant for all the studied traits, evidence that genotypes responded differently to environmental factors. Most crosses were earlier and heavier in 1000 grains weight, taller and higher in grain yield per plant than best parents over eight environments. In addition, decreasing planting distances from 20 cm to 15 cm decline in plant height,1000 grains weight and grain yield/plant. While, decreasing planting distances from 20 cm to 15 cm led to increasing in days to 50% flowering. The joint regression analysis showed highly significant differences between genotypes and between environments, as well as significant genotype x environment interactions, 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 studied traits, except plant height. The stability parameters (b_i and s^2d) for grain yield per plantshowed that the genotypes varied in their (b_i) values as well as S^2d.It could be noticed that the regression coefficient (b_i) for genotypes (A SH-21×R SH-76), (A SH-16×R SH-76), (A SH-10×R SH-10), (A SH-16×R SH-10), (A SH-10×R SH-37), (A SH-14×R SH-37), (A SH-21× ICSR-92003), (A SH-28×ICSR-92003) and (R-SH-10) were insignificant from unity and the deviation from regression (S^2di) were insignificant from zero indicating that these genotypes considered to be stable for grain yield per plant. Seven genotypes had significant higher grain yield per plant than the grand mean (A SH-21×R SH-76), (A SH-10×R SH-10), (A SH-16×R SH-10), (A SH-10×R SH-37), (A SH-14×R SH-37), (A SH-21× ICSR-92003) and (A SH-28×ICSR-92003).

Keywords: Grain Sorghum, planting distances Regression stability analysis

INTRODUCTION

New hybrids to released must show high performance for yield over a wide range of environment conditions. In other words, the superior hybrids have to highly stable and possess a great yield potential. The instability of genotype X productivity under different environments is due to high genotype environmental interactions (GE-Interaction). This phenomenon attracts the attention of several works and breeds hence, numerous investigations were conducted to elucidate it. The most common definition of stability in crop plants is the repeatability or consistency of performance in different environments.

To pave the way for a greater understanding of this phenomenon , several parameters and methods were postulated to define and estimate stability. The variance of genotype across environments was used by Roemer (1917), this variance considers all deviations from the genotype mean and is known as environmental variance. Wricke (1962) developed this statistic of stability, which squared and summed GE-interaction effects across all environments and termed it as equivalence (Wi). Sdehukla (1972) discussed this parameter and developed an unbiased estimate of this variance .

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 depend largely on the environment. This variation is further complicated by the fact that all genotypes do not interact similarly to change in the environment. Mean yield across environments is adequate indicator of genotypic performance only in the absence of genotype by environment (GE) interaction. GE is differential genotypic response to the environment. Most often GE complicates breeding, testing and selection of superior genotypes. It is importantfor plant breeders to identify specific genotypes adapted or stable over environments. thereby achieving quick genetic gain through screening of genotypes for greater adaptation and stability over environments prior to release 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 composition are major factors that could greatly influence farm production and management in the future. Climatic changes expected to occur play a major role in directing the plant breeders. Stability of yield, defined as the ability of a genotype to avoid substantial fluctuations in yield over a range of environments is 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 (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 interested primarily 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 evaluating genotypes across different environments.

Analysis stability of green sorghum genotypes over14 different production environments at Middle and Upper Egypt, Eweis (1998) reported that genotype × environment interactions were always highly significant that suggested estimating yield stability in selection programs. Studying a number of crosses in 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. While, Mostafa (2001) reported that genotypes and genotypes × year's 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 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) 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 locations and 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. Aml *et al*. (2015) found that G X E interactions showed significant linear functions with the environments for all studied traits, except for panicle length.

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 hybrids tested under eight environments .

MATERIALS AND METHODS

A- Developing the crosses:

Twenty grain sorghum crosses developed at Shandaweel Agric. Res. Station, Sohag, Egypt, in 2015 summer season. These crosses were developed from five introduced cytoplasmic male sterile lines (CMS- lines) and four restorer lines (R- lines) using line x tester mating design as described by Kempthorne (1957). The origin and some agronomic characters of the five male sterile lines (CMS- lines) and the four restorer lines (R- lines) are presented in Table (1).

The heads of both parents (R- lines and CMS- lines) were bagged at flowering time (pre-an thesis). The pollen were collected from each of the four restorer lines and the stigmas of the five male sterile lines (CMS-lines) were pollinated with the collected pollen to produce the twenty crosses.

B- Evaluation the crosses and their parental lines:

Twenty grain sorghum crosses and five introduced cytoplasmic male sterile lines (CMS-lines), four restorer lines (R-lines) and hybrid H-305 as the check were evaluated in eight environments i.e.; two years (2016 and 2017), two locations (ShandaweelAgric. Res. Station, Sohag Governorate and Arab El-Awamer Agric. Res. Station, Assiut Governorate), and two planting distances 20 (D_1) and 15 (D_2) cm between hills. The genotypes in both location were sown on 22nd and 24th of June 2016, respectively, and 21st and 23rd of June 2017, respectively.

The experimental layout was a split-plot design with three replications. The main plot was assigned to the distances between hills and the sub-plot was allotted to thirty genotypes. This was the same for both years and locations. Each sub-plot was sown in one row 4.0 m long and 60 cm apart. Planting were done in hills spaced 15 and 20 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 kernel weight (g) and Grain yield / plant (g).

Table 1. Origin and some agronomic traits of B-lines and R-lines used.

No	Lines	Origin	Days to 50% flowering	Plant height cm
		B-lines		
1	B Sh -21	Egypt	70	130
2	B Sh -10	Egypt	73	135
3	B Sh -14	Egypt	70	130
4	B Sh -16	Egypt	72	145
5	B Sh -28	Egypt	76	120
		Restorer (R) lines		
1	R Sh -76	Egypt	72	150
2	R Sh -10	Egypt	73	160
3	R sh -37	Egypt	72	150
4	ICSR- 92003	India	70	165

Statistical Analysis

Each trial was subjected to the standard analysis of variance and the combined analysis of variance over eight environments was performed according to Gomez and Gomez (1984). Least significant differences (LSD) were used for comparing means. 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 as stable one; these criteria are follows:

1-Regression coefficient significantly different from zero ($b \neq 0$) and 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.

RESULTS AND DISCUSSION

The combined analysis of variance of 30 genotypes over eight environments (Table 2) appear highly significant differencesamong genotypes and environments for all studied traits. Moreover, the genotypes × environments interaction variance was also highly significant for all the studied traits, evidence that genotypes responded differently to environments factors. These results are in harmony with those reported by El-menshawi (2005), Mahmoud *et al* (2007), Mahdy *et al* (2011), Mahmoud *et al* (2012) , Mahmoud *et al* (2013) and Aml *et al* (2015) . They found significant variance for genotypes, environments and the genotypes × environments interaction for most studied traits.

Table 2. Combined mean squares of 30 genotypes over eight environments for the studied traits during 2016 and 2017 seasons.

Source of variation	df	Mean squares			
		Day to 50% flowering	Plant height	1000 grain weight.	Grain yield/plant
Environments (Env)	7	599.23**	13740.23**	3279.78**	7883.73**
Rep(Env)	16	10.82	38.77	5.83	31.91
Genotype (G)	29	245.15**	11907.10**	87.85**	5943.51**
Env × G	203	10.92**	99.83**	11.73 **	42.03**
error	464	4.55	17.25	2.22	4.56

***, ** Significant at 0.05 and 0.01 probability levels, respectively.**

The combined analysis of variance of 20 F_1's and 9 parents across environments for the studied traits indicated that years and locations effects were significant for all the studied traits (Table 3), reflecting the differences in climatic and edaphic factors prevailing at the two locations. Mean squares indicated that the effect of locations was more important than that of years for all traits. Planting distances show significant differences for all traits as it would be expected variation between the two planting distances 20 (D_1) and 15 (D_2) cm between hills.Highly significantdifferences among genotypes and their partitions; parents, crosses, females and males for all the studied traits, which showed the presence of genetic variability in this material. Male x female interaction also showed highlysignificant differences for all traits, indicating specificcombing ability. Moreover, the relative of mean squares due to parents vs crosses was high and significant (p>O.01) for all studied traits, emphasizing great heterotic effects for these traits. These results are in agreement with these reported byMahmoud (1997), Amir (1999), Ali (2000) and Hovny *et al.* (2005). Besides, genotypes x year interaction effects were highly significant for all the studied traitsexcept for 1000 grain weight. Genotype x location, genotype x planting distances interaction and genotype x planting distances × years effects werehigh and significant (p>O.01)for all traits, indicating that these traits differed between locations, planting distances and years among genotypes. Moreover, genotypes x years x locations x planting distances interaction was highly significant for plant height and grain yield, this indicates that it is vital to evaluate genotypes for such traits under different environments.Environmental conditions at Shandaweel were good for sorghum production in both seasons under two planting distances compared to Arab El-Awamer (as a stress soil), as observed in Tables3,4,5 and 6.

Table 3. Significant of mean squares of 20 F_1's and 9 parents across environments for the studied traits during 2016 and 2017 seasons.

S.O.V	d.f	Mean squares			
		Days to 50% flowering	Plant Height(cm)	1000 grain weight (g)	Grain yield/Plant (g)
Year (Y)	1	98.13*	237.62**	273.565*	454.817**
Location (L)	1	2731.25**	46957.434**	13197.48**	44230.475**
Y × L	1	12.60	896.355**	71.70**	406.995*
Error (a)	8	11.58	46.61	6.19	36.733
Distance (D)	1	1112.77**	43257.90**	8672.29**	8560.686**
Y × D	1	54.45*	1408.56**	0.26	40.16
L × D	1	0.10	101.62	538.44**	506.24**
Y × L × D	1	0.01	148.09	47.096	0.800
Error (b)	8	10.01	35.45	5.40	25.17
Genotypes (G)	28	252.85**	12232.57**	90.300**	6082.74**
Crosses (C)	19	131.41**	2221.30**	84.01**	1083.47**
Females (F)	4	155.83**	923.43**	108.48**	213.46**
Males (M)	3	250.37**	1872.52**	168.13**	2621.08**
F × M	12	93.53**	2741.13**	54.83**	989.08**
Parents (P)	8	105.85**	7367.00**	77.22**	1377.40**
P vs. C	1	3736.25**	241371.20**	314.40**	138711.55**
Y × G	28	19.89**	155.98**	2.48	25.10**
L × G	28	13.53**	88.45**	25.56**	66.16**
Y × L × G	28	4.42	106.53**	3.12**	28.36**
D × G	28	15.71**	190.02**	35.836**	59.84**
Y × D × G	28	15.09**	90.54**	6.808**	22.96**
L × D× G	28	3.81	35.50**	1.68	58.17**
Y × L × D × G	28	5.83	39.180**	3.15	37.48**
Error (b)	448	4.66	17.38	2.21	4.63

***, ** Significant at 0.05 and 0.01 probability levels, respectively.**

Mean Performance of genotypes

1- Days to 50% flowering.

The mean performance of days to 50% floweringof thirty grain sorghum genotypes in two years at two locations and two planting distances are presented Table 4.

Most the genotypes (crosses and parents) were earlier at Shandaweel compared to Arab El-Awamer location in the two years under two planting distances, also, most the genotypes (crosses and parents) were varied in flowering from year to year and from plant distance to another. Over all environments, days to 50% flowering for the female lines ranged from 72.83(BSH-21) to 79.61 (B SH 28) with an average 75.32 days. While, for the R-lines it ranged from 73.5 (ICSR – 92003) to 75.69 (R- SH -10) with an average 74.99 days. Moreover, for the crosses it ranged from 66.34 (A SH-28×R SH-76) to 75.28 (A SH-16× ICSR-92003) with an average 70.16 days. Generally, 13 out of 20 crosses Over all environments were earlier significantly compared to the check hybrid H-305. The results clearly showed that decrease planting distance increase mean number of days to 50% flowering of genotypes (crosses and parents) in two years at two locations. The hybrids were earlier than the parents confirming the significant contrast of parents vs. crosses. Similar results were obtained by El-Bakry *et al* (2000), Hovny (2000), Hovny *et al* (2000) and Hovny *et al* (2001), Abd El-Halim (2003) and Mohamed (2014). They concluded that most of the F_1 crosses were earlier than their parents.

2- Plant height (cm.)

Plant height of the 20 F_1 crosses, their parents and the check hybrid H-305, over eight environments are presented in Table (5). Most the genotypes (crosses and parents) were taller at Shandaweel compared to Arab El-Awamer location in the two years under two planting distances, also most of the genotypes (crosses and parents) were varied in plant height from year to year and from planting distance to another. Over all environments, plant height for the female lines ranged from 99.96 (B SH-28) to 123.42 (B SH-16) with an average 114.83cm. Whereas, for the restorer-lines it ranged from 137.18 (R SH-76) to 155.61 (ICSR - 92003) with an average 144.14 cm. Also, for the crosses it ranged from 152.71 (A SH-14×R SH-10) to 183.25 (A SH-16× ICSR-92003) with an average 168.11cm. Generally, 8 out of 20 crosses over all environments were taller significantly compared to the check hybrid H-305. The results indicated that decrease planting distance decrease mean plant height of genotypes(crosses and parents) in two years at two locations. The hybrids were taller than the parents approving significant contrast of parents vs. crosses. These results are in harmony with those obtained by Borgonovi (1985), Hovny *et al*. (2001), Abd El- Halim (2003), Abd EL-Mottaleb (2004) and Mohamed (2014).They reported that most of the crosses were taller than their parents.

Table 4. Means of days to 50% flowering of thirty grain sorghum genotypes in two years at two locations and two planting distances during 2016 and 2017 seasons.

No.	Genotypes	Shandaweel				Arab El- Awamer				Average
		2016		2017		2016		2017		
		D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2	
1	A SH-21×R SH-76	64.00	69.00	68.04	70.50	69.00	71.41	71.00	72.19	69.39
2	A SH-10×R SH-76	64.00	68.27	66.55	71.04	69.00	73.10	72.56	74.23	69.84
3	A SH-14×R SH-76	63.33	64.50	63.00	70.73	66.56	70.83	69.46	70.56	67.37
4	A SH-16×R SH-76	67.48	68.22	67.78	69.70	70.90	71.00	68.66	70.46	69.28
5	A SH-28×R SH-76	64.21	65.00	62.46	63.50	67.52	69.33	68.23	70.50	66.34
6	A SH-21×R SH-10	64.56	66.57	66.25	67.40	69.48	70.50	68.00	69.00	67.72
7	A SH-10×R SH-10	66.44	67.73	67.08	68.70	70.52	74.00	71.00	71.56	69.63
8	A SH-14×R SH-10	66.04	70.23	68.01	69.12	71.00	72.65	72.21	73.91	70.40
9	A SH-16×R SH-10	69.04	72.33	71.58	72.00	74.00	74.92	74.23	74.53	72.83
10	A SH-28×R SH-10	69.73	70.23	67.19	68.00	73.00	73.23	72.01	72.60	70.75
11	A SH-21×R SH-37	64.52	70.52	68.71	69.55	66.60	73.09	70.33	72.67	69.50
12	A SH-10×R SH-37	66.52	67.67	66.64	68.45	69.25	72.76	71.00	72.00	69.29
13	A SH-14×R SH-37	65.63	69.00	66.96	68.40	68.27	72.83	70.00	71.50	69.07
14	A SH-16×R SH-37	65.82	66.23	65.03	69.50	71.91	74.23	73.00	74.00	69.97
15	A SH-28×R SH-37	66.04	75.87	68.04	70.00	68.66	85.60	70.00	72.23	72.05
16	A SH-21× ICSR-92003	64.70	68.47	65.53	66.45	67.67	72.60	66.45	67.00	67.36
17	A SH-10× ICSR-92003	68.52	69.23	67.90	68.34	70.76	71.85	70.50	71.60	69.84
18	A SH-14× ICSR-92003	69.04	73.17	72.39	74.00	72.37	73.60	72.17	76.00	72.84
19	A SH-16× ICSR-92003	66.19	75.00	74.71	77.47	69.00	82.12	77.56	80.24	75.28
20	A SH-28×ICSR-92003	63.33	73.23	71.64	72.45	78.19	79.40	78.56	79.40	74.53
Mean of all crosses		65.96	69.52	67.78	69.77	70.18	73.95	71.35	72.81	70.16
21	B SH-21	69.08	72.11	71.50	72.23	73.08	74.56	74.50	75.56	72.83
22	B SH-10	72.56	73.80	73.41	75.50	79.00	80.00	79.00	80.50	76.72
23	B SH-14	68.96	74.37	70.74	72.60	73.00	75.00	74.55	77.33	73.32
24	B SH-16	72.72	74.37	71.12	72.50	77.00	73.67	75.00	76.60	74.12
25	B SH 28	74.27	75.33	78.00	82.00	78.26	79.00	82.33	87.67	79.61
Mean of all female		71.52	73.99	72.95	74.97	76.07	76.45	77.08	79.53	75.32
26	R- SH- 76	71.33	73.56	72.31	74.20	75.33	80.00	77.00	78.90	75.33
27	R- SH -10	72.67	74.00	72.71	75.00	75.33	79.83	76.33	79.60	75.69
28	R- SH -37	72.19	73.90	72.44	75.17	75.77	76.50	75.33	82.23	75.44
29	ICSR – 92003	69.46	70.90	70.62	71.50	75.48	77.00	75.00	78.00	73.50
Mean of all males		71.41	73.09	72.02	73.97	75.48	78.33	75.92	79.68	74.99
H-305		68.53	71.23	70.19	72.20	73.33	75.67	73.00	78.60	72.84
LSD 0.05		4.35	4.33	3.80	5.23	1.73	1.80	1.93	1.94	3.41

Table 5. Means of plant height (cm) of thirty grain sorghum genotypes in two years at two locations and two planting distances during 2016 and 2017 seasons.

No.	Genotypes	Shandaweel				Arab El- Awamer				Average
		2016		2017		2016		2017		
		D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2	
1	A SH-21×R SH-76	202.67	178.67	190.00	170.00	173.67	163.33	174.33	158.33	176.38
2	A SH-10×R SH-76	188.00	180.00	180.00	165.00	170.33	162.33	170.00	156.33	171.50
3	A SH-14×R SH-76	192.00	181.67	201.67	186.67	171.67	163.67	169.67	154.67	177.71
4	A SH-16×R SH-76	183.00	176.33	205.00	180.67	165.00	160.67	166.67	157.00	174.29
5	A SH-28×R SH-76	169.33	160.00	169.33	153.00	146.33	136.67	156.00	137.00	153.46
6	A SH-21×R SH-10	175.67	165.00	174.33	160.67	154.00	142.67	162.33	142.00	159.58
7	A SH-10×R SH-10	165.67	159.00	173.33	159.33	154.67	149.00	161.33	141.00	157.92
8	A SH-14×R SH-10	162.67	153.33	170.00	154.00	146.00	142.33	154.00	139.33	152.71
9	A SH-16×R SH-10	171.67	163.67	177.00	162.33	154.00	140.00	160.00	151.00	159.96
10	A SH-28×R SH-10	187.33	174.33	215.00	166.33	174.00	158.00	208.33	165.33	181.08
11	A SH-21×R SH-37	182.33	168.33	184.00	170.00	167.67	158.67	171.33	160.33	170.33
12	A SH-10×R SH-37	191.67	179.33	191.00	174.00	178.00	160.00	175.00	162.00	176.38
13	A SH-14×R SH-37	167.00	156.67	172.00	157.00	151.33	145.33	156.00	144.00	156.17
14	A SH-16×R SH-37	180.00	167.33	180.00	170.00	162.00	151.67	166.67	145.33	165.38
15	A SH-28×R SH-37	194.33	184.00	195.00	177.67	174.33	165.33	175.00	159.33	178.13
16	A SH-21× ICSR-92003	193.00	174.00	190.00	173.00	167.67	160.67	172.33	160.33	173.88
17	A SH-10× ICSR-92003	171.00	158.00	171.67	153.33	159.00	145.33	160.00	147.00	158.17
18	A SH-14× ICSR-92003	180.33	172.00	183.00	172.00	166.00	152.00	166.67	153.67	168.21
19	A SH-16× ICSR-92003	199.00	188.33	198.00	184.33	179.33	172.33	179.00	165.67	183.25
20	A SH-28×ICSR-92003	185.00	172.67	180.00	164.00	164.33	151.00	170.00	155.00	167.75
Mean of all crosses		182.08	170.63	185.02	167.67	163.97	154.05	168.73	152.73	168.11
21	B SH-21	131.00	115.75	129.33	116.33	114.67	97.67	124.00	109.33	117.26
22	B SH-10	137.33	117.74	138.00	118.00	119.00	97.00	126.67	111.00	120.59
23	B SH-14	129.83	118.67	134.00	108.33	108.67	86.67	116.00	101.33	112.94
24	B SH-16	140.33	119.33	163.67	113.67	121.33	101.33	121.00	106.67	123.42
25	B SH 28	123.00	106.33	119.67	75.33	106.00	86.00	115.00	68.33	99.96
Mean of all female		132.30	115.57	136.93	106.33	113.93	93.73	120.53	99.33	114.83
26	R- SH- 76	151.67	137.15	163.67	132.15	132.33	112.33	143.00	125.15	137.18
27	R- SH -10	158.33	142.00	166.33	139.00	144.67	124.67	153.00	132.00	145.00
28	R- SH -37	162.67	146.04	150.00	132.00	137.67	117.67	139.00	125.00	138.76
29	ICSR – 92003	176.33	166.33	164.50	152.67	150.87	130.87	157.67	145.67	155.61
Mean of all males		162.25	147.88	161.13	138.96	141.38	121.38	148.17	131.96	144.14
H-305		189.33	171.67	177.00	161.67	166.53	146.53	165.33	154.67	166.59
LSD 0.05		6.87	6.97	7.04	7.81	6.09	6.30	6.15	5.69	6.65

3- 1000 grain weight (g)

The mean performance of 1000 grain weight of thirty grain sorghum genotypes in two years at two locations and two planting distances in Table (6). Most the genotypes (crosses and parents) had higher in 1000-grain weight at Shandaweel compared than Arab El-Awamer location in the two years under two planting distances , also, most the genotypes (crosses and parents) were varied in 1000-grain weight from year to year and from planting distance to another.1000-grainweight over all environments for the female lines varied from 20.38 (B SH-21) to 23.7(B SH 28) with an average 21.90 gm.While, for the male lines varied from21.24 (R-SH -37) to 26.33 (ICSR– 92003) with an average 23.08 gm.Also, for the crosses it ranged from 19.46 (A SH-28×R SH-76) to 27.61(A SH-16× ICSR-92003) with an average 23.87 gm. Generally, 1 out of 20 crosses over all environments had significant 1000-grain weight compared to the check hybrid H-305.The results clearly showed that that decrease planting distance decrease mean 1000 grain weight of genotypes (crosses and parents) in two years at two locations. Most, the crosses had lower 1000 grain weight compared to the parents, reflecting presence the heterosis. Mohamed (2007) and Mohamed (2014)revealed that hybrids had lower 1000 grain weight compared to the parents.

4- Grain yield per plant (g).

Grain yield per plant of the 20 F_1 crosses, their parents and the check hybrid H-305, over eight environments are presented in Table (7).Most the genotypes (crosses and parents) had high grain yield / plant at Shandaweel compared than Arab El-Awamer location in the two years under two planting distances,also, most the genotypes (crosses and parents) were varied in grain yield / plant from year to year and from planting distance to another. Over all environments, grain yield per plant for the female lines ranged from 33.79 (B SH-10) to 43.81 (B SH-28) with an average 39.26 gm. Whereas, for the R-lines it ranged from 47.08 (R- SH- 37) to 57.88 (R- SH -10) with an average 51.24 gm. Also, for the crosses it ranged from 59.66 (A SH-16×R SH-76) to 82.20 (A SH-16×R SH-10) with an average 75.10gm.Generally 8out of 20 crosses over all environments produced significantly higher grain yield / plant compared to the check hybrid H-305. The results indicated that decrease planting distance decrease mean grain yield per plant of genotypes (crosses and parents) in two years at two locations.Most of the crosses had high grain yield / plant compared to its parents, reflecting presence the heterosis. Similar results were obtained by Badhe and Patil (1997), Hovny (2000), Abd El-Halim (2003) and Abd EL-Mottaleb (2004). They reported that most of hybrids yielded more than the yield of higher parent.

Table 6. Means of 1000 grains weight (g) of thirty grain sorghum genotypes in two years at two locations and two planting distances during 2016 and 2017 seasons.

No.	Genotypes	Shandaweel				Arab El- Awamer				Average
		2016		2017		2016		2017		
		D1	D2	D1	D2	D1	D2	D1	D2	
1	A SH-21×R SH-76	29.33	21.97	28.13	20.50	20.00	16.73	22.11	16.03	21.85
2	A SH-10×R SH-76	30.23	24.53	29.23	21.60	21.20	17.73	23.18	17.81	23.19
3	A SH-14×R SH-76	29.56	24.15	29.56	21.57	20.73	17.58	21.12	15.44	22.46
4	A SH-16×R SH-76	32.45	25.38	30.95	24.48	21.73	18.73	21.55	15.96	23.90
5	A SH-28×R SH-76	34.15	18.57	31.15	15.59	19.60	9.70	19.12	7.78	19.46
6	A SH-21×R SH-10	33.23	26.25	33.23	24.80	22.60	19.90	22.23	17.44	24.96
7	A SH-10×R SH-10	34.23	25.20	30.23	24.01	23.62	20.94	23.23	17.85	24.91
8	A SH-14×R SH-10	35.23	19.24	33.82	17.67	24.73	10.23	23.90	8.92	21.72
9	A SH-16×R SH-10	31.06	25.97	31.56	21.56	22.40	19.52	22.23	17.59	23.99
10	A SH-28×R SH-10	32.99	26.54	31.99	23.07	23.73	20.73	21.79	16.86	24.71
11	A SH-21×R SH-37	30.77	26.27	30.77	23.00	22.95	20.24	22.23	18.20	24.30
12	A SH-10×R SH-37	33.44	25.62	30.44	25.13	24.01	19.63	25.23	20.88	25.55
13	A SH-14×R SH-37	31.56	25.57	31.06	23.50	22.73	19.70	23.45	19.40	24.62
14	A SH-16×R SH-37	36.56	26.71	31.56	26.11	24.73	20.73	23.50	19.22	26.14
15	A SH-28×R SH-37	30.44	21.80	26.44	19.50	19.52	16.91	20.84	14.93	21.30
16	A SH-21× ICSR-92003	31.52	23.71	28.52	23.23	21.20	18.17	21.16	16.21	22.97
17	A SH-10× ICSR-92003	30.88	24.08	30.88	21.55	23.10	19.49	23.12	17.16	23.78
18	A SH-14× ICSR-92003	36.30	25.59	31.63	26.18	22.98	20.14	21.32	17.30	25.18
19	A SH-16× ICSR-92003	35.64	28.03	34.24	27.07	26.73	23.73	24.84	20.59	27.61
20	A SH-28×ICSR-92003	31.44	27.14	31.44	24.00	22.81	20.38	22.98	18.84	24.88
Mean of all crosses		32.55	24.62	30.84	22.71	22.55	18.55	22.46	16.72	23.87
21	B SH-21	32.44	21.54	28.93	20.60	17.83	11.39	17.89	12.42	20.38
22	B SH-10	33.23	23.56	32.23	22.23	18.83	12.18	16.89	11.15	21.29
23	B SH-14	34.22	22.07	29.22	21.54	18.98	12.74	19.84	13.74	21.54
24	B SH-16	36.44	22.77	31.44	23.50	18.68	13.17	19.71	14.82	22.57
25	B SH 28	37.44	24.71	32.64	24.74	21.55	14.27	20.38	13.86	23.70
Mean of all female		34.75	22.93	30.89	22.52	19.17	12.75	18.94	13.20	21.90
26	R- SH- 76	34.74	20.73	29.84	22.27	20.43	13.17	18.83	12.83	21.61
27	R- SH -10	37.77	21.93	31.77	22.98	20.80	15.02	20.54	14.26	23.13
28	R- SH -37	34.17	21.33	28.37	21.50	18.89	12.11	19.71	13.87	21.24
29	ICSR – 92003	37.56	26.11	36.56	24.83	24.67	17.01	25.03	18.90	26.33
Mean of all males		36.06	22.53	31.64	22.89	21.20	14.33	21.03	14.96	23.08
H-305		30.23	26.53	26.93	27.00	23.00	20.00	22.67	18.33	24.34
LSD 0.05		2.85	2.23	2.54	2.16	2.70	2.05	2.37	2.04	2.38

Table 7. Means of grain yield/plant (g) of thirty grain sorghum genotypes in two years at two locations and two planting distances during 2016 and 2017 seasons.

No.	Genotypes	Shandaweel				Arab El- Awamer				Average
		2016		2017		2016		2017		
		D1	D2	D1	D2	D1	D2	D1	D2	
1	A SH-21×R SH-76	85.00	82.58	86.57	83.50	73.87	62.66	75.00	63.88	76.63
2	A SH-10×R SH-76	91.00	86.56	84.80	84.80	71.34	64.23	77.33	60.96	77.63
3	A SH-14×R SH-76	74.00	70.93	77.00	67.80	59.67	40.56	61.00	37.05	61.00
4	A SH-16×R SH-76	68.00	66.56	72.00	62.80	55.32	46.56	56.00	50.05	59.66
5	A SH-28×R SH-76	88.00	84.66	91.23	81.80	71.03	42.67	75.00	64.75	74.89
6	A SH-21×R SH-10	85.00	83.40	81.56	81.56	62.24	59.56	72.00	66.75	74.01
7	A SH-10×R SH-10	76.33	73.38	74.63	71.11	59.52	55.23	65.00	54.67	66.23
8	A SH-14×R SH-10	83.50	73.35	85.23	78.11	67.58	60.56	72.00	62.00	72.79
9	A SH-16×R SH-10	92.00	88.23	94.26	87.10	75.15	67.45	81.58	71.83	82.20
10	A SH-28×R SH-10	75.33	70.89	78.23	68.00	58.92	48.56	61.00	70.00	66.37
11	A SH-21×R SH-37	83.67	83.60	85.70	83.63	69.78	67.45	75.30	67.06	77.02
12	A SH-10×R SH-37	87.00	81.07	90.23	80.55	69.92	63.45	73.00	66.75	76.50
13	A SH-14×R SH-37	92.47	84.50	93.23	83.99	76.02	68.56	76.67	69.75	80.65
14	A SH-16×R SH-37	92.33	86.64	88.17	87.55	71.69	71.87	80.00	71.88	81.27
15	A SH-28×R SH-37	91.83	84.26	93.23	86.00	59.50	70.26	79.83	67.75	79.08
16	A SH-21× ICSR-92003	91.74	87.90	88.23	85.64	74.69	71.56	79.83	72.08	81.46
17	A SH-10× ICSR-92003	85.37	83.23	83.23	79.56	71.74	62.56	75.66	59.00	75.04
18	A SH-14× ICSR-92003	91.55	80.56	92.23	85.50	78.08	68.56	79.55	67.05	80.38
19	A SH-16× ICSR-92003	92.47	88.23	91.23	87.95	72.72	63.45	82.22	63.75	80.25
20	A SH-28×ICSR-92003	86.65	82.50	90.48	84.66	74.50	68.23	75.77	68.75	78.94
Mean of all crosses		85.66	81.15	86.07	80.58	68.66	61.20	73.69	63.79	75.10
21	B SH-21	51.67	46.52	53.23	45.00	33.86	27.23	31.00	27.75	39.53
22	B SH-10	42.00	41.23	43.00	43.00	29.24	22.56	25.56	23.71	33.79
23	B SH-14	45.33	44.23	49.00	41.89	31.58	23.50	33.23	22.00	36.35
24	B SH-16	55.33	48.56	54.00	45.08	39.91	29.23	40.56	30.06	42.84
25	B SH 28	52.67	46.45	52.00	50.26	43.24	30.45	43.67	31.75	43.81
Mean of all female		49.40	45.40	50.25	45.05	35.57	26.59	34.80	27.05	39.26
26	R- SH- 76	66.67	53.49	64.00	57.25	51.75	26.13	54.23	37.75	51.41
27	R- SH -10	63.72	62.90	67.00	61.95	54.92	46.12	57.66	48.75	57.88
28	R- SH -37	52.89	42.40	61.00	43.41	43.37	42.56	45.23	45.75	47.08
29	ICSR – 92003	60.67	53.41	54.00	53.32	43.82	36.23	47.23	40.05	48.59
Mean of all males		60.99	53.05	61.50	53.98	48.46	37.76	51.09	43.08	51.24
H-305		83.00	78.23	86.22	75.06	71.86	63.56	74.23	68.00	75.02
LSD 0.05		3.81	2.18	2.51	5.50	2.47	2.92	3.36	3.42	3.42

Estimated stability parameters

The stability performance thirty genotypes were studied over eight environments i.e.; two years, two locations and two planting distancesfor, days to 50% flowering, plant height, 1000-grain weight and grain yield/plant. The analysis of variance given in Table (8) revealed the presence of genetic variability on the material under study for all traits for genotypes and environment indicated that these genotypes differed considerably across different environments. In addition, the genotypes x environment interaction were a linear function, which were highly significant for all the studied traits except plant height. For that reason, the regression coefficient (bi) and deviation from regression (S^2d) pooled across the eight environments were calculated for each genotypes. The significant of days to 50% flowering and 1000 grain weight indicate that genotypes were genetically different in their response to different environments when tested against pooled deviation. Furthermore,the highly significant of pooled deviation for plant height and grain yield/ plant indicated that non linear component of genotypes x environment interaction was operating. These finding are in harmony with those obtained by Ewis (1998), Ali (2000), Mostafa (2001), Ali (2006), Mahmoud *et al* (2007), Mahdy *et al* (2011), Mahmoud *et al* (2013)and EL-Kady (2015).Based on the stability analysis results, it is possible to identify the best genotypes to be grown under the different environments. Eberhart and Russel (1966) proposed that ideal genotypes is the one which has the highest yield over a broad range of environments, b=1 and S^2d= 0.

Table 8. Analysis of variance of 30 genotypes under eight environments for studied traits.

S.O.V	d.f	Mean squares			
		Days to 50% flowering	Plant Height (cm)	1000- grain weight(g)	Grain yield /plant(g)
Genotypes (G)	29	81.68**	3969.03**	29.28**	1981.17**
Env. + (G x E)	210	10.17**	184.83**	40.22**	101.14**
Env. (liner)	1	1396.94**	32060.53**	7652.89**	18395.38**
G x Env. (Liner)	29	5.83**	39.12	16.57**	30.58**
Pooled deviation	180	3.18	31.22**	1.74	10.87**
Pooled error	464	4.55	17.25	2.22	4.56

***, ** significantly different from unity for (bi) and from zero for(S2d) at 0.05 and 0.01 probability levels, respectively.**

1-**Days to 50% flowering**

For days to 50% flowering, stability parameters indicate that the genotypes varied in their (bi) values as well as S2d (Table 9). It could be noticed that the regression coefficient (bi) for genotypes No. 4, 15, 19, 20 and 24 were significant from unity and the deviation from regression (S2d) were significant from zero for genotypes No. 3, 15, 16, 19, 20, 25 and 28, indicating that these genotypes could be considered unstable for days to 50% flowering. The other genotypes. were stable (bi not significant from unity and the deviation from regression (S2d) were insignificant from zero).

Table 9. Stability parameters of days to 50% flowering and plant height (cm) evaluated under eight environmental conditions.

No.	Genotypes	Days to 50% flowering			Plant height (cm)		
		Mean	Bi	S^2d	Mean	Bi	S^2d
1	A SH-21×R SH-76	69.39	0.92	-0.20	176.38	1.08	24.24**
2	A SH-10×R SH-76	69.84	1.31	-0.30	171.50	0.77	18.94**
3	A SH-14×R SH-76	67.37	1.13	2.33*	177.71	1.13	50.62**
4	A SH-16×R SH-76	69.28	0.45*	-0.73	174.29	1.09	65.99**
5	A SH-28×R SH-76	66.34	1.01	0.74	153.46	1.02	1.16
6	A SH-21×R SH-10	67.72	0.68	-0.76	159.58	1.01	1.56
7	A SH-10×R SH-10	69.63	0.94	-0.66	157.92	0.75	7.87*
8	A SH-14×R SH-10	70.40	0.98	-1.03	152.71	0.80	3.65
9	A SH-16×R SH-10	72.83	0.72	-1.00	159.96	0.90	8.70*
10	A SH-28×R SH-10	70.75	0.66	1.35	181.08	1.31	191.12**
11	A SH-21×R SH-37	69.50	0.94	1.45	170.33	0.72	-2.55
12	A SH-10×R SH-37	69.29	0.90	-1.11	176.38	0.92	0.40
13	A SH-14×R SH-37	69.07	0.87	-1.07	156.17	0.77	-1.01
14	A SH-16×R SH-37	69.97	1.38	0.97	165.38	0.95	9.91*
15	A SH-28×R SH-37	72.05	1.57*	24.49**	178.13	0.99	6.27
16	A SH-21× ICSR-92003	67.36	0.63	2.20*	173.88	0.95	3.46
17	A SH-10× ICSR-92003	69.84	0.53	-0.96	158.17	0.77	-1.60
18	A SH-14× ICSR-92003	72.84	0.59	0.32	168.21	0.88	3.75
19	A SH-16× ICSR-92003	75.28	1.66*	11.04**	183.25	0.90	9.97*
20	A SH-28×ICSR-92003	74.53	1.98**	4.15**	167.75	0.92	0.45
21	B SH-21	72.83	0.78	-1.19	117.26	0.83	11.19**
22	B SH-10	76.72	1.18	0.01	120.59	1.04	15.18**
23	B SH-14	73.32	0.93	-0.29	112.94	1.20	9.66*
24	B SH-16	74.12	0.47*	1.60	123.42	1.50**	61.02**
25	B SH 28	79.61	1.21	8.81**	99.96	1.39*	152.21**
26	R- SH- 76	75.33	1.18	-1.15	137.18	1.23	15.65**
27	R- SH -10	75.69	1.04	-0.92	145.00	1.06	14.24**
28	R- SH -37	75.44	1.03	1.83*	138.76	1.08	23.29**
29	ICSR - 92003	73.50	1.19	-0.16	155.61	1.02	38.30**
30	H-305	72.78	1.15	-0.08	166.59	1.00	20.62**
Mean		71.75			155.98		

***, ** significantly different from unity for (bi) and from zero for(S2d) at 0.05 and 0.01 probability levels, respectively.**

2- Plant height (cm.)

Regarding plant height,the stability parameters indicate that the genotypes varied in their (bi) values as well as S^2d (table 9). It could be noticed that the regression coefficient (bi) for genotypes No. 5, 6, 8, 11, 12, 13, 16, 17, 18 and 21 were insignificant from unity and the deviation from regression (S^2di) were insignificant from zeroindicating that these genotypes considered to be stable for this traits. The other genotypes were unstable (bi were significant from unity and / or the deviation from regression (S^2d) were significant from zero).

3- 1000 grain weight (g).

Regarding1000 grain weight, stability parameters indicate that the genotypes varied in their (bi) values as well as S^2d (Table 10). It could be noticed that the regression coefficient (bi) for genotypes No. 4, 6, 7, and 14 were insignificant from unity and the deviation from regression (S2di) were insignificant from zero indicating that these genotypes considered to be stable for this traits. The other genotypes were unstable (bi were significant from unity and / or the deviation from regression (S^2d) were significant from zero).

Table 10. Stability parameters of days to 1000 grains weight (g) and grain yield / plant (g) evaluated under eight environmental conditions.

No.	Genotypes	1000 grain weight (g)			Grain yield/plant (g)		
		Mean	Bi	S^2d	Mean	Bi	S^2d
1	A SH-21×R SH-76	21.85	0.78**	-0.03	76.63	0.99	1.63
2	A SH-10×R SH-76	23.19	0.76**	0.12	77.63	1.14	9.33**
3	A SH-14×R SH-76	22.46	0.83*	0.01	61.00	1.53**	18.33**
4	A SH-16×R SH-76	23.90	0.93	0.08	59.66	0.95	1.31
5	A SH-28×R SH-76	19.46	1.50**	3.42**	74.89	1.58**	33.42**
6	A SH-21×R SH-10	24.96	0.94	0.32	74.01	1.02	13.26**
7	A SH-10×R SH-10	24.91	0.84	0.03	66.23	0.93	1.06
8	A SH-14×R SH-10	21.72	1.50**	13.22**	72.79	0.96	3.12**
9	A SH-16×R SH-10	23.99	0.83*	0.91*	82.20	1.05	-0.44
10	A SH-28×R SH-10	24.71	0.90	0.90*	66.37	0.82	38.89**
11	A SH-21×R SH-37	24.30	0.75**	0.25	77.02	0.83	2.75*
12	A SH-10×R SH-37	25.55	0.74**	-0.05	76.50	1.02	1.07
13	A SH-14×R SH-37	24.62	0.76**	-0.36	80.65	1.00	1.49
14	A SH-16×R SH-37	26.14	0.93	0.13	81.27	0.87	6.00**
15	A SH-28×R SH-37	21.30	0.82*	0.19	79.08	1.13	38.47**
16	A SH-21× ICSR-92003	22.97	0.83*	-0.42	81.46	0.83	1.69
17	A SH-10× ICSR-92003	23.78	0.80*	0.45	75.04	1.02	7.24**
18	A SH-14× ICSR-92003	25.18	1.01	1.22*	80.38	0.96	6.37**
19	A SH-16× ICSR-92003	27.61	0.83*	0.07	80.25	1.26	4.64**
20	A SH-28×ICSR-92003	24.88	0.77*	0.30	78.94	0.88	0.73
21	B SH-21	20.38	1.21*	0.01	39.53	1.11	7.73**
22	B SH-10	21.29	1.35**	1.29*	33.79	0.93	11.04**
23	B SH-14	21.54	1.19*	0.25	36.35	1.08	2.16*
24	B SH-16	22.57	1.30**	1.55**	42.84	1.04	2.07*
25	B SH 28	23.70	1.35**	0.32	43.81	0.88	4.83**
26	R- SH- 76	21.61	1.24**	0.62	51.41	1.34*	26.54**
27	R- SH -10	23.13	1.31**	0.90*	57.88	0.79	0.22
28	R- SH -37	21.24	1.18*	1.06*	47.08	0.43**	29.52**
29	ICSR - 92003	26.33	1.20*	0.90*	48.59	0.85	3.04**
30	H-305	24.34	0.61**	2.39**	75.02	0.77	3.06**
	Mean	23.45			65.94		

***, ** significantly different from unity for (bi) and from zero for(S2d) at 0.05 and 0.01 probability levels, respectively.**

4- Grain yield/plant (g).

With respect to grain yield/plant stability parameters indicate that the genotypes varied in their (bi) values as well as S^2d (Table 10). It could be noticed that the regression coefficient (bi) for genotypes (A SH-21×R SH-76), (A SH-16×R SH-76), (A SH-10×R SH-10), (A SH-16×R SH-10), (A SH-10×R SH-37), (A SH-14×R SH-37), (A SH-21× ICSR-92003), (A SH-28×ICSR-92003) and (R-SH-10) were insignificant from unity and the deviation from regression (S2di) were insignificant from zero indicating that these genotypes considered to be stable for grain yield per plant. Seven genotypes had significant higher grain yield per plant than the grand mean (A SH-21×R SH-76), (A SH-10×R SH-10), (A SH-16×R SH-10), (A SH-10×R SH-37), (A SH-14×R SH-37), (A SH-21× ICSR-92003) and (A SH-28×ICSR-92003). These results are in harmony with those reported by Mostafa (2001), Mahmoud *et al (*2007), Mahdy *et al* (2011), Mahmoud *et al* (2012) and Mahmoud *et al* (2013).

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تقييم سلوك وتحليل الثبات الوراثي لبعض الهجن وابائها في محصول ا لذرة الرفيعة للحبوب

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أجريت هذه التجربة في ثمانية بيئات مختلفة لتقييم سلوك ودراسة الثبات الوراثي لعدد عشرين هجينا وآبائهم التسعة بالإضافة الي هجين ٣٠٥ للمقارنة وذلك خلال موسمي الصيف ٢٠١٦ و ٢٠١٧ في موقعين (محطة البحوث الزراعية بشندويل – سوهاج و محطة بحوث عرب العوامر - أسيوط) بإستخدام مسافتين للزراعة ٢٠ و ١٥ سم . أظهر تحليل التباين المشترك لثلاثين تركيب وراثي عبر ثمانية بيئات إختلافات عالية المعنوية للتراكيب الوراثية والبيئات لجميع الصفات المدروسة. وعلاوة على ذلك،كان التفاعل بين التراكيب الوراثية والبيئات عالي المعنوية لجميع الصفات المدروسة،مما يدل على إختلاف إستجابة التراكيب الوراثية لمختلف البيئات. كانت معظم الهجن مبكرة مقارنة بالآباء و قد كانت معظم الهجن أعلى من الآباء فى وزن الألف حبة كذلك كانت معظم الهجن أطول و أعلى فى محصول الحبوب لكل نبات مقارنة بأحسن الأبوين و ذلك خلال ثمانية بيئات. أظهرت النتائج وجود اختلافات عالية المعنوية بين التراكيب الوراثية وبين البيئات وذلك بالنسبة لجميع الصفات محل الدراسة .كما كان تباين التفاعل بين التراكيب الوراثية والبيئات عالى المعنوية لجميع الصفات المدروسة . علاوة على هذا فقد أوضحت النتائج أن التراكيب الوراثية قد أظهرت تباين فى سلوكها من سنة لأخرى ومن موقع لموقع آخر لجميع الصفات المدروسة. أظهر تحليل الإنحدار المشترك للتباين للصفات التى تمت دراستها وجود إختلافات عالية المعنوية بين التراكيب الوراثية وبين البيئات والتفاعل بين التراكيب الوراثية والبيئات لكل الصفات المدروسة وهذا يشير إلى أن التركيب الوراثي يختلف إختلافا كبيرا عبر البيئات المختلفة .وعلاوة على ذلك،فإن التفاعل بين التراكيب الوراثية والبيئات) دالة خطية (كان عالى المعنوية لجميع الصفات المدروسة فيما عدا صفة طول النباتأظهر تقيم الثبات b_i و S^2d بالنسبة لصفة محصول الحبوب للنبات أن التراكيب الوراثية تختلف فى قيمتها من حيث b_i وكذلك تختلف فى قيمتها من حيث S^2d. ويمكن ملاحظة أن معامل الإنحدار b_i للتراكيب الوراثية *(A SH-21×R SH-76)* و *(A SH-16×R SH-76)* و *(A SH-10×R SH-10)* و *(A SH-16×R SH-10)* و *(A SH-10×R SH-37)* و *(A SH-14×R SH-37)* و *(A SH-21× ICSR-92003)* و *(A SH-28×ICSR-92003)* و *(R-SH-10)* كان أقل من الواحد الصحيح كما كانت قيمة الإنحراف عن الإنحدار S^2d غير معنوية عن الصفر وهذا يشير إلى أن هذه التراكيب تعتبر ثابتة بالنسبة لصفة المحصول للبيئات المجهدة وقد أحرزت سبعة هجن محصول حبوبا أعلى معنويا من متوسط محصول الحبوب لهجين ٣٠٥ وبالتالي تعتبر هجن مبشرة.