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Estimation of Genetic Variability, Heritability and Genetic Advance for Yield and Yield Components for some Sorghum (*Sorghum bicolor* (L.) Moench) Genotypes under Irrigation in Sudan

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Abstract

The study was carried out to estimate the amount of genetic variability, heritability and genetic advance in ten-advanced sorghum genotypes at Sinnar Agricultural Research Ten sorghum lines .Station Farm, Sinnar, Sudan, during two seasons 2012/13 and 2013/14 provided by the Sorghum Breeding Program, the Agricultural Research Corporation were used in the study. The experiment was arranged in a Randomized Complete Block Design (RCBD) with four replicates. The measured traits were days to 50% flowering, plant height (cm), head exertion (cm), panicle length (cm), number of grains per head, 100 grain weight (g) and grain yield (kg/ha). Analysis of variance indicated highly significant differences ($P < 0.01$) for all characters among genotypes in each season and their combined, except for number of grains per head in the second season. On the average, number of days to 50% flowering ranged between (60 -80 days), plant height (97 -140 cm), head exertion (6 – 12 cm), panicle length (18 -25 cm), number of grains per head (1466 – 2242 grain), 100 grain weight (3 - 4 g) and grain yield (1283 -1882 kg/ha). The values of broad sense heritability of agronomic characters observed ranged from high to moderate, while with grain yield were low. High heritability was observed for plant height (89.0%) followed by days to 50% flowering (71.8%), 100- grains weight (66.6%), and panicle length (64.3%), respectively. Moderate heritability estimate was obtained for number of grains / head (41%), followed by head exertion (37.3%). Heritability estimate was low for grain yield (26.4%) of combined data. In generally, phenotypic coefficients of variation (PCV) were higher than genotypic coefficients of variation (GCV) in all traits for both seasons and also for combined analysis. The GCV and PCV were high for plant height and head exertion (25.5, 27.0% and 21.9, 35.9 %) respectively. The lowest GCV and PCV were obtained for days to 50% flowering and panicle length (9.3, 10.9 and 11.5, 14.3%) respectively of combined data. High genetic advance was observed for grain yield, (107.4, 230.7 and 192.6), at both

seasons and combined, respectively. Genetic advance estimates were low for tested 100-grain weight (0.24, 0.45 and 0.32), at both seasons and combined analysis respectively.
Keywords: Genotypes, genetic variability, genetic advance, heritability, sorghum.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench, 2n=2x= 20, Poaceae) is one of the main staple food crops for the world (El Naim *et al.*, 2012). It is an important food crop in Africa, South Asia Central America Sorghum is the fifth major .and Australia cereal crop in the world after maize (*Zea mays* L.), wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), and barley (*Hordeum vulgare* L.). In Africa, sorghum comes second after maize in terms of production (FAO, 2011). According to FAO (2011) estimates, the average world production of sorghum amounted to 66 million metric tons per year.

The role of sorghum in the life of the Sudanese people call for not is dwelled upon unduly. Suffice it to know that the name for sorghum in Sudan, "*Esh*", means life. Bacon (1948) pointed sorghum as the nutritional backbone of the country. However, rural exodus and increased urbanization resulted in a shift towards more consumption of wheat rendering the statement by Bacon probably not as true today as it was then. In Sudan, sorghum is grown in an area ranged between 4.3 and 7.1 million ha with an average of 5.2 million ha (Elzein and Elamin, 2006). The national average grain yield reported is about 600 kg\ha which is very low compared to the world average of 1288 kg/ha (Elzein, 2008). Despite the crop's importance and the long experience in its cultivation, sorghum yield is very low (0.4 t/ha, FAO, 2006) compared to its potential. The low productivity can be attributed mainly to the use of traditional low-yielding varieties, limited or no use of fertilizers, poor management practices and prevalence of *striga* infestation (Ibrahim *et al*., 1995).

Progress in plant breeding depends on the extent of genetic variability present in a population. Therefore, the first step in any plant breeding program is the study of genetic variability, which cannot easily be measured. The phenotypic variability in a given environment can be measured easily, but it reflects non genetic as well as genetic influence on the phenotypic expression. The present study aims to estimate the amount of genetic variability, heritability and genetic advance in ten advanced sorghum genotypes.

Materials and Methods

The experiment was carried out during two consecutive seasons (2012/13 and 2013/14) at Sinnar Research Station Experimental Farm, Sudan (13° 36′N and 33° 32′E). The soil type of the experimental site is a heavy clay, belongs to the central clay plain of Sudan. The genetic material used in this study consisted of ten sorghum genotypes provided by the Sorghum Breeding Program of the Agricultural Research Corporation (ARC), Sudan. The genotypes tested included; (Edo26-18-45, Edo26-18-60, Edo13-10-12, Bashayir, Edo34-1-1, Edo26-18-64, Edo34-94-3, Edo4-1-15, plus Butana and Arfa Gadamak-8 were as checks. The experiment was arranged in a Randomized Complete Block Design (RCBD) with four replicates. Sowing dates were July 18, 2012 (first season) and 2nd July 2013 (second season). Each genotype was sown in four rows of five-meter length with spacing of 80 cm between rows and 20 cm within rows. After three weeks from sowing, plants were thinned to three seedlings per hill**.** Nitrogen fertilizer in the form of urea at the rate of 80 kg/ fed was applied, one week after thinning. Weeds were controlled by hand when needed. Irrigation was supplemented at 14 days' interval when necessary. Days to 50% flowering, plant height (cm), head exertion (cm), panicle length (cm), number of grains per head, 100 grain weight (g) and grain yield (kg/ha) were the main traits measured in the study. In all experiment, assessments were made in the central rows of each plot discarding one row or more at each side and all data were then based on 4.00 m of rows length except for days to 50% flowering, which were estimated on the entire row. Harvesting and threshing was performed by hand.

Analysis of variance was used for each season separately and the results of the two seasons were combined using the statistical package (SAS) to test -significant differences among genotypes for the phenotypic and genotypic variances and their coefficients, heritability in broad sense and genetic advance. For all traits mean separation was attained according to Duncan Multiple Range Test (DMRT).

Estimation of genetic parameters

Phenotypic and genotypic coefficients of variation, heritability in broad sense and genetic advance of mean were computed as mentioned below:

Genotypic and phenotypic variances were computed using the following formulas:

$$\sigma^2 G = \frac{MSg\_MSe}{r}$$

$$\sigma^2 e = MSe$$

$$\sigma^2 P = \sigma^2 G + \sigma^2 e$$

$$= \frac{MSg\_MSe}{r} + MSe$$

Where

$\sigma^2 g$ = genotypic variance

$\sigma^2 P$ = phenotypic variance

$\sigma^2 e$ = environmental variance

MS_g = mean squares of genotype

MS_e = error mean squares

r = number of replications

Heritability (h^2_B)

The heritability (broad sense) values were estimated by the formula suggested by Johnson *et al*. (1955).

$$^2{}_B = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where:

$\sigma^2 g$=Genotypic variance

$\sigma^2 p$ = Phenotypic variance

The heritability percentage was categorized as low, moderate, and high as suggested by Robinson *et al*. (1949) as follows:

0-30%: low.
31-60: Moderate.
61% and above: High

Genotypic and phenotypic coefficients of variation

The genotypic and phenotypic coefficients of variation were computed according to Burton and Devane (1953).

Genotypic coefficient of variation (GCV)

$$= \frac{\sqrt{\sigma^2 g}}{\overline{X}} \times 100$$

Phenotypic coefficient of variation

$$(PCV) = \frac{\sqrt{\sigma^2 p}}{\overline{X}} \times 100$$

Where

$\sigma^2 g$ = genotypic variance

$\sigma^2 p$ = phenotypic variance and,

$\overline{X}$ = general mean of trait

The PCV and GCV values are ranked as low, medium and high (Sivasubramanian and Menon, 1973) and are mentioned below:

0 - 10% - Low
10 - 20% - Moderate
>20% - High

Genetic advance (GA)

Genetic advance for each trait was calculated using the formula suggested by (Allard, 1960):

$$GA = \frac{\sigma^2 G}{\sigma^2 P} \times K\sigma p$$

Where:

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$= Phenotypic variance

K = selection differential which has the value of 2.06 at 5% selection intensity.

σp = Phenotypic standard deviation

Results and Discussion

Analysis of variance indicated highly significant differences ($P < 0.01$) for all agronomic characters among genotypes in each season and combined except for the number of grains per head in the second season (2013/2014) which showed no significant differences (Table 1). These findings indicated the presence of a wide range of genetic variability in the tested genotypes. Similar results were obtained by Karnataka, (2010).

During both seasons and their combined over two season, there were highly significant differences among the tested genotypes in their days to 50% flowering, indicating wide genetic variability. Days to 50% flowering during the first season (2012/2013), ranged from 64-80 days, the earliest variety was Arfa Gadamak-8, while Edo34-1-1, Edo34-94-3 and Edo4-1-15 were the latest entries. Days to 50% flowering during the second season (2013/2014), ranged from (57-79) days, with variety Arfa Gadamak-8 being the earliest, while Edo34-94-3 and Edo 34-1-1 were the latest genotypes. In combined over two season, the number of days to flowering ranged from 60 -80, Arfa Gadamak-8 was the earliest genotype; Edo34-1- and Edo34-94-3 were the latest ones. The lines means were (74, 70 and 72) at both seasons and combined respectively, (Table 1).

During both seasons and when combined over the two season, there were highly significant differences among the tested genotypes in their plant height this indicated that there is a wide genetic variability. Plant height during the first season ranged from (85 - 119 cm), the genotype Edo34-1-1 was the tallest genotype, while Edo26-18-60 the shortest one. Plant height during the second season was a wide range (107.4 – 177.1 cm), Edo34-1-1 the tallest genotype, while Edo26-18-64 the shortest. In combined, plant height ranged from (96.6 – 148.1), Edo34-1-1 the tallest genotype, and the shortest was Edo 26 -18-60. The lines means were (103, 151. and 131.) at both seasons and combined respectively. Most of the entries showed a reasonable plant height compared to the check. With many entries having a plant height shorter than check at both seasons and combined, (Table 1). Plant height is an important character because it describes the proportion of photosynthate allocation between the stem and grain. For grain sorghum purpose, very tall plants are not desirable because it will reduce the photosynthate allocation to grain production. In addition, medium and short height sorghum is generally associated with lodging resistance.

During both seasons and their combined over the two seasons, there were highly significant differences among tested genotypes in their head exertion, this might indicate that there is a wide genetic variability. Head exertion during the first season had a wide ranged from 6.0 to 14.0 cm, the variety Arfa Gadamak-8 showed the tallest head exertion, while Edo-13-10-12 had shortest one. Head exertion during the second season was a wide variability, ranged from 4.4 to 10.6 cm, the variety Arfa Gadamak-8 showed the tallest head exertion, while Edo 26-18-64 had shortest one. In combined, head exertion ranged from 5.6 to 12.3 cm, all lines having a head exertion shorter than the checks at both seasons and combined. The entries means were (8.8, 6.4 and 7.5) at both seasons and combined analysis respectively, (Table 1)**.**

During both seasons and when combined analysis, there were highly significant differences ($P < 0.01$) among the tested genotypes in their panicle length, this might indicate that there is a wide genetic variability. Panicle length during the first season, ranged from (17.2 to 25.1 cm), and from (18.9 to 25.8 cm) during the second season. In combined over two seasons, panicle length of entries ranged from (18.0 to 25.3 cm). The genotypes means were (21.4, 22.7 and 22.1) at both seasons and combined respectively. All of the entries having a panicle length tallest than of the check, Arfa Gadamak-8 at both seasons and combined (Table 1). Panicle length is one of important components because it is a place for branches containing grains.

During the first seasons number of grains per head of sorghum genotype ranged from 1172 to 2274, Edo34-94-3, had the highest number of grains per head (2274), followed by Edo13-10-12 (1939), while the check Arfa Gadamak -8 (1172), had the lowest number of grains per head. Number of grains per head during the second season ranged from (1545 to 2208), Edo34-94-3 showed the highest number of grains per head of (2208), while Bashayir, had the lowest number (1545) of grains per head, and from 1466 to 2242 Edo34-94-3, was the highest number of grains per head 2242, followed

Edo34-1-1 (1955) while the check Arfa Gadamak -8 had the lowest number (1466) of grains per head in combined over two seasons. The entries means were (1652, 1800 and 1739) at both seasons and combined respectively. All of the entries showed a number of grains per head more than of the check Arfa Gadamak -8 at the first seasons and combined in (Table 1)**.**

During both seasons and their combined, there were highly significant differences (P < 0.01) among tested genotypes for 100- grain weight, indicating possible genetic variability; 100- grain weight during the first season, ranged from 2.7 to 3.6 g, Arfa Gadamak-8 showed the highest 100- grain weight (3.6 g), while Edo -13-10 -12 recorded the lowest 100 grain weight (2.7 g). During the second season, 100- grain weight ranged from 3.5 to 4.4 g, Edo26-18-60 gave the highest 100- grain weight (4.4 g), while Edo 4-1-15 recorded the lowest weight (3.5 g). In the combined data 100- grain weight of the entries ranged from 3.2 to 3.9g, Arfa Gadamak-8 gave the highest 100- grain weight (3.9g), while Edo34-94-3 gave the lowest (3.2g) weight. The entries means were (3.0, 4.0 and 3.7) at both seasons and combined respectively, (Table 1)**.**

Table 1: Mean performance and rank of ten sorghum genotypes evaluated for yield and yield component at two seasons (2012/13, 2013/14) and their combined analysis

Means within the same column followed by the same letter (s) are not significantly different at the probability level of 0.05, and 0.01 (*, **) = significant at the 0.05 and 0.01 probability levels respectively. N.S = no significant at the probability level of 0.05.

Table1: cont.

Entry	Number of grains per head			100-seed weight (g)			Seed yield (Kg/ha)		
	(2012/2013)	(2013/2014)	Combined	(2012/2013)	(2013/2014)	Combined	(2012/2013)	(2013/2014)	Combined
Ed o26-18-45	1706^{ABC}	1551^{A}	1629^{AB}	**3 .2**^{B}	**4 .1**^{B}	3.6^{AB}	**11 02.0**^{BC}	**16 66.7**^{BC}	1384.^{BC}
Ed o26-18-60	1506^{BC}	1741^{A}	1625^{AB}	**3 .1**^{BC}	**4 .4**^{A}	3.8^{A}	**11 64.3**^{ABC}	**15 11.6**^{C}	1337.8^{C}
Bu tana	1540^{BC}	1550^{A}	1546^{AB}	**3 .0**^{BCD}	**4 .2**^{AB}	3.6^{AB}	**15 00.0**^{AB}	**14 47.2**^{C}	1473.6^{BC}
Ed o13-10-12	1939^{AB}	1195^{A}	1568^{AB}	**2 .7**^{D}	**3 .9**^{BC}	3.3^{AB}	**11 80.0**^{ABC}	**15 92.7**^{BC}	1386.2^{BC}
Ba shayir,	1484^{BC}	1545^{A}	1515^{B}	**3 .0**^{BCD}	**4 .1**^{B}	3.6^{AB}	**13 51.8**^{ABC}	**16 71.9**^{BC}	1511.7^{AB}
Ed o34-1-1	1862^{ABC}	2047^{A}	1955^{AB}	**3 .0**^{BCD}	**3 .7**^{C}	3.3^{AB}	**15 62.5**^{A}	**22 01.6**^{AB}	1882.0^{A}
Ed o26-18-64	1810^{ABC}	1850^{A}	1831^{AB}	**3 .1**^{B}	**4 .3**^{AB}	3.7^{AB}	**12 11.0**^{ABC}	**13 55.5**^{C}	1283.2^{D}
Ed o34-94-3,	2274^{A}	2208^{A}	2242^{A}	**2 .8**^{CD}	**3 .7**^{C}	3.2^{B}	**14 06.5**^{ABC}	**24 61.0**^{A}	1933.6^{A}

Entry									
Ed o4-1-15	1228^{BC}	2199^{A}	1715^{AB}	3 .0^{BC}	3 .5^{CD}	3.3^{AB}	10 00.0^{C}	17 27.2^{BC}	1363.6 C
Ar fa Gadamak-8	1172^{C}	1758^{A}	1466^{B}	3 .6^{A}	3 .6^{CD}	3.9^{A}	11 09.0^{BC}	16 26.9^{BC}	1368.1 CD
Me an	1652	1800	1739.1	3 .0	4.0	3.7	12 58.8	1683.8	1493.9
SE±	109.2	166.9	147.2	0 .05	0 .05	0.1	66. 1	10 1.2	95.3
Sig. level	*	N.S	*	* *	* *	**	*	*	**
(C.V. %)	26.4	32.3	30.7	6 .7	5	6.0	21. 0	24 .0	23.7

Entry	Days 50% flowering			Plant height (cm)			Head exertion (cm)				Panicle length (cm)		
	(2012/2013)	(2013/2014)	Combined	(2012/2013)	(2013/2014)	Combined	(2012/2013)	(2013/2014)	Combined		(2012/2013)	(2013/2014)	Combined
do26-18-45	5^{B}	9^{BC}	72^{CDE}	08.0^{BC}	40.5^{E}	124.0^{CD}	BCD	.6DE	6.7 CDE	2	1.4^{BCD}	2.8^{BCD}	22.0 BCD
do26-18-60	2^{BC}	7^{BCD}	70 DEFG	5.0^{E}	08.0^{G}	96.6 DE	.3 CD	.6 CDE	8.0 ABC	2	3.4^{AB}	25.8^{A}	24.5 A
utana	2 ^{BC}	5^{CDE}	69^{EF} G	11.0 ^{AB}	74.7^{B}	142.7 ^{B}	1 ^{B}	.3 ^{AB}	10.0 B	2	0.5^{CD}	1.3^{CD}	20.9 C^{D}
do13-10-12	1^{C}	0^{ED}	66 ^{FG}	01.0 ^{CD}	27.2^{F}	114.2^{D}	D	.6DE	6.0 CE	1	9.4^{DE}	1.9^{CD}	20.6 DE
ashayir,	1^{C}	7^{BCD}	70^{EF} G	14.0^{AB}	66.6^{BC}	139.9^{BC}	0 ^{BC}	.0 ^{BCD}	8.5 ABC	2	1.5^{BCD}	3.0 ^{ABC}	22.2 BCD
do34-1-1	0^{A}	9^{A}	80^{A}	19.0 ^{A}	77.1^{B}	148.1^{A}	CD	.6DE	5.6 ^{E}	2	5.1^{A}	5.6^{A}	25.3 A
do26-18-64	4^{BC}	8^{BCD}	71DE F	7.0 ^{E}	07.4 ^{G}	96.9 DE	CD	.5 ^{DE}	5.6 ^{E}	2	2.6^{ABC}	24.2 ^{AB}	23.4 ABC
do34-94-3,	0^{A}	5^{AB}	78^{AB}	07.0 ^{BCD}	67.3 ^{BC}	136.8 BCD	CD	.9 ^{BCD}	7.0 ^{C}	2	4.0^{AB}	4.0^{AB}	24.0 AB
do4-1-15	0^{A}	4^{AB}	77^{AB} C	8.0 ^{D}	52.4 ^{DE}	125.1 ^{CD}	1 ^{B}	.5 ^{ABC}	9.7 AB	1	9.2^{ED}	1.7 ^{DE}	20.4 DE
rfa Gadamak-8	4^{D}	7^{E}	60^{H}	15.0 ^{BCD}	56.8 ^{CD}	145.8 ^{AB}	4 ^{A}	0.7^{A}	12.3 A	1	7.2^{E}	8.9 ^{E}	18.0 E
Mean	4	70	72	03.4	151.2	131.2	.8	6.4	7.5	2	1.42	22.7	22.1
SE±	.54	.3	1.32	.38	.3	1.9	.53	.4	0.56	0	.43	.45	0.47
Sig. level	*	*	**	*	*	**	*	*	**	*	*	*	**
(C.V.%)	.9	.4	5.7	.3	.0	6.0	4.1	3.6	29.8	8	.0	.0	8.5

Means within the same column followed by the same letter (s) are not significantly different at the probability level of 0.05, and 0.0 (*, **) = significant at the 0.05 and 0.01 probability levels respectively. N.S = no significant at the probability level of 0.05.

During both seasons there were significant and highly significant differences of the combined data, among tested genotypes in their grain yield. This could indicate genetic variability. During the first season grain yield of sorghum entries ranged from 1000 to 1562.5 kg/ha. Most entries produced grain yield more than check, rather than Edo 34-1-1 that produced the highest (1562.5 kg/ha) yield, followed by Butana (1500 kg/ha), while the check Arfa Gadamak -8 (1000 kg/ha) produced the lowest yield. Grain yield during the second season ranged from 1355.5 to 2461.0 kg/ha, most of the entries produced grain yield more than the checks, Edo34-94-3 produced the highest (2461.0 kg/ha) yield, followed by Edo34-1-1 (2201.6 kg/ha), while the Edo 26-18-64 (1355.5 kg/ha) produced the lowest yield. In combined data grain yield of sorghum entries ranged from 1283.2 to 1933.6 kg/ha Edo34-94-3 produced the highest yield of (1933.6 kg/ha), followed by Edo34-1-1 (1882.0 kg/ha), while Edo26-18-64 was produced the lowest yield, (1283.2 kg/ha).The entries means were (1258.75, 1683.83 and 1493.90) at both seasons and combined respectively (Table 1). The variation in yield between the two seasons might be due to differences in climatic facters.

Estimates of variance components, genotypic and phenotypic coefficients of variation, heritability and genetic advance are presented in Tables 2, 3, and 4. In general, phenotypic coefficients of variation (PCV) were higher than genotypic coefficients of variation (GCV) in all traits under both seasons and combined. These results were in conformity with the findings of (Can *et al*., 1998 and Khan *et al.* 2005). The GCV and PCV were high for head exertion and number of grains per head (25.6, 34.9 and 15.4, 30.6%) respectively, the lowest GCV and PCV were obtained for days to 50% flowering and 100- grain weight (6.8, 7.5 and 7.3, 10.0 %) respectively, at the first seasons (Table 2).

Table 2: Estimates of range, genotypic and phenotypic variances, genotypic and phenotypic coefficients of variation, heritability and genetic advance in ten sorghum genotypes during (2012/13) season

Parameters	Range	Genotypic variation (σ^2g)	Phenotypic Variation (σ^2p)	GCV (%)	PCV (%)	Heritability (%)	Genetic advance
Days 50% flowering	64 -80	24.8	29.8	6.8	7.5	83.2 high	3.7
Plant height (cm)	85 - 119	113.3	143.8	10.3	10.4	78.8 high	9.0
Head exertion (cm)	6.4 - 14.0	5.2	9.7	25.6	34.9	53.6 moderate	3.1
Panicle length (cm)	17.2 - 25.1	5.2	8.2	10.6	13.4	63.4 high	2.3
Number of grains / head	1172-2274	64930.0	255760.8	15.4	30.6	25.4 low	228.4
100- grain weight (g)	2.7 - 3.6	0.1	0.1	7.3	10.0	55.5 moderate	0.24
grain yield (Kg/ha)	1000-1562.5	17183.6	87184.2	10.4	23.5	19.70 low	107.4

GCV: Genotypic Coefficient of Variation: PCV: Phenotypic Coefficients of Variation.

The GCV and PCV were high for100-grain weight and head exertion (60.5, 61.0 and 25.8, 34.8%) respectively and the lowest for panicle length and days to 50% flowering (7.8, 11.0 and 8.6, 11.4) respectively at the second season (Table 3).

Table 3: Estimates of range, genotypic and phenotypic variances, genotypic and phenotypic coefficients of variation, heritability and genetic advance in ten sorghum genotypes during season 2013/14

Parameters	**Range**	**Genotypic variation (σ^2g)**	**Phenotypic variation (σ^2p)**	**GCV (%)**	**PCV (%)**	**Heritability (%)**	**Genetic advance**
Days 50% flowering	57-75	35.7	62.4	8.6	11.4	57.2 moderate	6.6
Plant height (cm)	107.4 – 177.1	626.6	709.3	16.9	18.0	88.3 high	16.9

Head exertion (cm)	4.5-10.7	3.2	5.8	25.8	34.8	55.2 moderate	1.9
Panicle length (cm)	18.9 - 25.8	3.2	6.5	7.8	11.0	49.2 moderate	2.0
Number of grains / head	1545-2208	12527.9	458403.7	6.3	38.4	27.0 low	32.0
100- grain weight (g)	3.5 - 4.4	5.9	6.0	60.5	61.0	98.0 high	0.5
Grain yield (Kg/ha)	1355.5 - 2461.0	59706.5	223619.0	14.2	27.4	26.7 low	230.7

GCV: Genotypic Coefficient of Variation: PCV: Phenotypic Coefficients of Variation.

The GCV and PCV were high for plant height and head exertion (25.5, 27.0% and 21.9, 35.9 %) respectively and the lowest GCV and PCV were obtained for days to 50% flowering and panicle length (9.3, 10.9 and 11.5, 14.3%) respectively, at the combined over two season Table (4).

Table 4: Estimates of range, genotypic and phenotypic variances, genotypic and phenotypic coefficients of variation, heritability and genetic advance in ten sorghum genotypes in combined over two season 2012/13 and 2013/14

Parameters	**Range**	**Genotypic variation (σ^2g)**	**Phenotypic variation (σ^2p)**	**GCV (%)**	**PCV (%)**	**Heritability (h^2_B). (%)**	**Genetic advance**
Days 50% flowering	60 - 80	43.4	60.4	9.3	10.9	71.8 high	6.1
Plant height (cm)	97 - 148	1025.8	1150.8	25.5	27.0	89.0 high	14.0
Head exertion (cm)	6 - 12	3.0	8.1	21.9	35.9	37.3moderate	1.8
Panicle length (cm)	18.0-25.3	6.5	10.1	11.5	14.3	64.3 high	2.7
Number of grains / head	1466-2242	15051.6	361806.5	7.2	35.2	41moderate	44.9

100- grain weight (g)	3.2-3.9	0.4	0.6	18.0	22.0	66.6 high	0.3
Grain yield (Kg/ha)	1283.2-1933.6	52194.2	197511.4	15.3	29.	26.4 low	192.6

GCV: Genotypic Coefficient of Variation: PCV: Phenotypic Coefficient of Variation

The success of any breeding program depends upon the genetic variation in the material at hand. The greater the genetic variability, the higher would be the heritability. Hence the better the chances of success to be achieved through selection. In this study, most characters showed high broad sense heritability, indicating the possibility of a positive response to selection. The estimation of heritability is used to get information of the proportion of genetic variability compared to environment variability. Heritability is used as prediction for breeders about the possibility of character inheritance. Broad sense heritability of most agronomic characters of the sorghum genotypes were high and medium except for grain yield, which showed that all genotypes gave genetic contribution to the plant performance (Tables 2, 3 and 4). In addition, high heritability value indicating the selection of the promising entries can be effective. Study of genetic variability was done according to the standard deviation of genetic variance of each character. High heritability was observed for days 50% flowering (83.2%), followed by plant height (cm) (78.8%), panicle length (63.4%). Moderate heritability estimates were obtained for 100-grain weight (g) (55.5%), followed by head exertion (cm) (53.6%). Heritability estimates were lowest for grain yield (Kg/ha) (19.70%), followed by number of grains / head (25.4%) at the first season (Table 2). High heritability was observed for100-grain weight (g) (98%), followed by plant height (88.3%). Moderate heritability estimates were obtained for days 50% flowering (57.2%), followed by head exertion (55.2%) and panicle length (49.2%). Heritability estimates were low for test grain yield (26.7%), followed by number of grains / head (27%) at the second season (Table 3). High heritability was observed for plant height (89.0%), followed by days 50% flowering (71.8%), 100-grain weight (66.6%) and panicle length (64.3%). Moderate heritability estimates were obtained for number of grains / head (41%), followed by head exertion (37.3%). Heritability estimates were low for grain yield (26.4%), at combined over two season (Table 4).

High genetic advance was observed for grain yield, (107.4, 230.7 and 192.6). Genetic advance estimates were low for 100-grain weight (0.24, 0.45 and 0.32), at both seasons and combined respectively.

Conclusion

Based on the results of this study, there was significant large genetic variability of agronomic characters among sorghum genotypes. The variations could be effectively manipulated with appropriate breeding methods to develop improved varieties for use by farmers and industries. The estimation of broad sense heritability of agronomic characters observed ranged from medium to high except for grain yield which was consistently low. In general, phenotypic coefficients of variation (PCV) were higher than genotypic coefficients of variation (GCV) for all traits under both seasons and for combined.

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