Sudan University of Science and Technology
College of Graduate Studies

Phenotypic and Genotypic variability of Some Varieties (*Sorghum bicolor L. Moench)* for Yield and Yield Components.

التباين المظهري والوراثي في بعض أصناف الذرة الرفيعة من حيث الانتاجية ومكونات الانتاج

A Thesis Submitted in Partial Fulfillment for the Requirements
Of the Degree of M. Sc. in Agriculture (Agronomy)

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August, 2016

DEDICATION

To my family, my wife, my daughter

(Sadien),

My teachers and all friends

ACKNOWLEDGMENTS

First praise and thanks to **ALLAH** to spire me to work on this topic and giving me strength and patience to complete this work successfully. Would like to express my deepest and sincere gratitude and thanks to my Supervisor Dr. Abdelsalam Kamil Abdelsalam for his support ness kindness and wonderful care in directing and supervising this work. I also wish to express my gratitude to all the teachers who support me and giving me all dependents from the first step in my Academic journey till this moment. Thanks also to all who help me in my research.

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ABSTRACT

A field experiment was conducted at the experimental Farm of the Gezira Research Station of Agricultural Research Corporation, Wad Medani, Sudan in July 2015 to Study phenotypic and genotypic variations of some sorghum varieties for yield and yield related traits. The experiment was laid out in a randomized complete block design with three replicates. Data were collected on plant height, day to 50% flowering, head excretion, panicle length, 100-grain weight, grain yield. The phenotypic and genotypic variance, phenotypic and genotypic coefficient of variation between different characters was determined. The analysis of variance revealed highly significant differences ($P \leq 0.01$) for plant height, days to 50% flowering, head excretion and 100-seed weight. No significant differences were detected for panicle length, and grain yield. For phenotypic variance the results showed that the highest value was scored for grain yield and the lowest value for 100-seed weight. For genotypic variances the highest value was attained for grain yield and the lowest value was attained for 100-seed weigh. For phenotypic coefficient of variation, the highest value was for (head excretion, and the lowest value for Days to 50% flowering. For genotypic coefficient of variation the highest value was obtained for grain yield and the lowest value was obtained for panicle length .For heritability the highest broad sense heritability showed for (grain yield and the lowest result value for panicle length.

الخلاصه

أُ جريت الدراسه بالحقل التجريبي لهيئه البحوث الزراعيه ود مدني السودان في الفتره من الخامس عشر من يوليو 2015 بهدف تقييم التباين في بعض الاصناف من الذره الرفيعه من حيث الانتاجيه ومكوناتها. استخدم في هذه التجربه تصميم القطاعات العشوائيه الكامله بثلاثه مكررات. تم تجميع البيانات لسته صفات وهي: طول النبات, عدد الايام إلى 50% ازهار, طول رقبه القندول, طول القندول , وزن 100 حبه , انتاجيه الحبوب. تم تقدير كل من التباين المظهري, الوراثي, معامل التباين المظهري, الوراثي, ودرجه التوريث للصفات المدروسه. أظهر تحليل التباين وجود فروقات معنويه عاليه (P>0.01) بين الطرز لصفات نسبة طول النبات, وزن 100 حبه , عدد الايام الى 50% ازهار, طول رقبة القندول . بينما لم تظهر فروقات معنويه بين الطرز, فيما يختص طول القندول , انتاجية الحبوب. كذلك نجد أعلى قيمة للتباين المظهري كانت لانتاجية الحبوب, واقل قيمة كانت لنسبة وزن 100 حبه , بينما أعلى قيمة للتباين الوراثي كانت لانتاجية الحبوب وأقل قيمة كانت لصفه وزن 100 حبه أما بالنسبه لمعامل الاختلاف المظهري أعلى قيمة هي نسبة طول رقبة القندول وأقل قيمة كانت في عدد الأيام إلى 50% ازهار. بينما معامل التباين الوراثي أعلى قيمة في إنتاجيه الحبوب واقل قيمة في نسبه طول القندول. كذلك نجد أعلى قيمة لدرجه التوريث كانت لإنتاجيه الحبوب وأقل قيمة كانت لنسبة طول القندول .

CHAPTER ONE

INTRODUCTION

Sorghum *(bicolor L. Moench)* is an important cereal crop in Sudan. It is the main staple food crop especially in rural areas. In many parts of the country the crop is wholly utilized. The grains are used for making kisra (unleavened bread from fermented dough) a significant portion is also used as thick porridge (Assida). The straw and stalks are used as fodder and as building materials or as fuel. In Sudan, the area under irrigated sorghum is about 8% while 92% is under rain-fed (Fadlelmula, 2009).

In Sudan Sorghum is grown in an area ranges between 4.3 and 7.1million ha with an average of 5.2 million ha (Elzein and Elamin, 2006). The national average grain yield is about 600kg/ha which is very low compared to the world average of production 1288 kg/ha (Elzein, 2008). The low productivity is due to many constraints that limit sorghum production in Sudan such as erratic rainfall amount and distribution and subject to striga stress and other pest and diseases, poor adoption of technologies and lack of high yielding varieties. During the last few decades several improved sorghum varieties, viz; Ingaz,Feterita Wad Ahmed, Tabat (Osman and Mahmoud, 1992) and hybrids, Hageen Dura (HD-1, HD-2), Rabih and Sheikan **(**ARC/ICRISAT,_1983 Osman_and Mahmoud, 1992). Have been released by the Agricultural Research Corporation (ARC) for commercial use in irrigated area and under high rain-fall areas more than 500 mm per annum.Early maturing varieties including; Umbenien7 and Feterita Maatuog were also released but were no longer cultivated due to their poor grain quality preferences (easily threshable, large, white and medium–soft) **(**Mahmoud, 1977 and Osman *et al.*, 1998). Recently three early maturing varieties viz., Arfa Gadamak AG-8 (Mohamed, 2009). Bashayir and Butana (Elzein 2008) were released for low rainfall areas how ever there is still more potential for sorghum improvement through tapping the variable resource available.

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 react in similar way to change in environment and no two environments are exactly the same. Mean yield across environments is an adequate indicator for genotypic performance only in the absence of Genotype by Environment (GE) interaction. GE is differential genotypic response across environments. Most often GE complicates breeding, testing and selection of superior genotypes. It is important for plant breeders to identify specific genotypes adapted or stable to environment(s), there by achieving quick genetic gain through screening of genotypes for high adaptation and stability under varying environmental conditions prior to their release as cultivars (Ariyo, 1989; Flores *et al.,* 1998; Showemimo *et al.,* 2000; Mustapha *et al.,* 2001**;** Yan and Kang, 2003). As ninety percent of sorghum is produced in the dry , hot and variable rainfall conditions Need is pressing for new open pollinated varieties with high grain yield potential stable and with acceptable grain quality. Therefore, the objectives of this study include:

1-Evaluation of genetic variability in some advanced sorghum genotypes

2-Evaluation 0f heritability and advanced genetic gain from selection

CHAPTER TWO

LITERATURE REVIEW

2.1 Phenotypic variability in sorghum

Progress in plant breeding depends on the extent of genetic variability present in a population that permits effective selection procedures, based on locally adapted land races Busharan (1999) studied that, the genetic variability in seventeen parental lines together with crosses and recorded highly significant differences for plant height, leaf area index, stem diameter, head diameter, head length, days to 50% flowering, number of grains per head, days to maturity, 100-seed weight, grain yield per plant and grain yield (t/ha). Mohammed (1993) observed genetic variability in grain sorghum and scored highly significant differences among the genotypes for plant height, days to 50% flowering, grains number per head,100-seed weight, stem diameter, head diameter, head length and grain yield (t/ha) Hoveny (2001) studied the variability of 13 parental lines with their 30 crosses in grain sorghum and reported highly significant differences for number of days to 50% flowering, plant height, leaf number, leaf length, and panicle length and panicle weight Prabhakar (2001) studied the genetic variability of 11 parents and their crosses in grain sorghum and reported significant differences for number of day's to50% flowering, number days to maturity, 100-seed weight and grain yield per plant. Elagib (1999) studied the genetic variability of 8 parents and their16 crosses in grain sorghum and found significant differences for plant height, days to 50% flowering, stem diameter, 100-seed weight and grain yield Kumara Vadivel and Rangasany (1994) found significant differences among genotypes with regard to number of days to 50% flowering, panicle length and grain yield. In a study of 30 Sudanese grain sorghum genotypes Abu Elgasim and Kambal (1975) reported a wide range of variability for grain yield, number of grains per panicle, head exertion, leaf area and 100-seed weight. Asthana *et al.* (1995) observed maximum range of variability for grain yield. Ahmed (2000) studied variability in some sorghum genotypes collected from Nuba Mountains, and reported significant differences among genotypes for days to 50% flowering, plant height, 100-seed weight, and grain yield.

Lamb *et al.* (1987) reported that there were highly significant differences among entries for grain yield. Stemperier (1990) found a wide range of the variability for grain yield, plant height, days to 50% flowering and 100-seed weight, during the evaluation of several thousands of inbred lines in hybrid combinations. Geremew (1993) reported a wide range of variability for days to 50% flowering; stem thickness, seed size, and number of grains per head, yield per plant and yield per plot.

Bello *et al*. (2007) studied genetic variability in sorghum and reported significant differences among cultivars for days to 50% flowering, plant height, 100- seed weight and grain yield. Tadesse and Ejeta (2008) studied genetic variability of introduced sorghum parental lines and scored the male parents that exhibited considerable variability for plant height, panicle exertion, panicle length, 100-seed weight and grain yield.

Sindagi *et al.* (1970) observed that grain yield and fodder yield showed the maximum genotypic variability in some sorghum varieties. Sridhar *et al* (2003) studied the nature and magnitude of genetic variability for grain and fodder yields and its component traits in sorghum germplasm and reported highly significant differences among genotypes for plant height ,days to 50% flowering and grain yield. This indicated considerable variability in the experimental material.

Mohammed *et al*. (1999) studied 76 lines selected from an advanced random-mating sorghum population showed that heritability estimates were high for most of the studied characters except for grain yield. Patel *et al*. (1980) studied components of variability in sorghum and found that plant height and 100-seed weight had high estimate of heritability, 85.47% and 80.56%, respectively.

Babat and Shinde (1980) studied that genetic variability for grain yield in sorghum and reported estimates of heritability in broad sense ranging from 45.38% to 67.34%. Singh and Makne (1980) found that estimates of heritability in sorghum were high for plant height and number of days to 50% flowering. Mamdouh *et al.* (1971) studied heritability and expected genetic advance in five crosses in sorghum, and reported that seed weight exhibited relatively high heritability (75.6%).

Phul and Rang (1986) reported high broad-sense heritability estimate in sorghum for yield, bloom date and plant height, while Kulkarni and Shinde (1988) found low heritability in rabi sorghum for days to 50% flowering. Cheralu and Rao (1989) stated that high heritability estimate was obtained for grain yield in winter sorghum, total dry matter, and ear length and ear weight. Kumar and Singh (1986) revealed that high heritability estimate for plant height; inter node length and 1000 grains weight ranged from 85.30-93.99 %, indicating that selection for these traits should lead to improvement in sorghum.

Kumar and Singh (1986) analyzed that 40 diverse genotypes of grain sorghum for the data on grain yield/plant and 13 related traits and revealed that differences among genotypes for all traits were significant and the coefficient of variability ranged from 5.70 to 39.18%. Genotypic and phenotypic coefficients of variability were high for grain yield/plant as well as heritability (90.62%) and genetic advance (73.14%) and heritability for plant height, panicle weight, internodes length and 1000-

grain weight ranged from 85.30 to 93.99% indicating that selection for these traits would lead to crop improvement.

Nimbalkar *et al.* (1988) noticed the highest (11.6) and lowest (1.7) coefficients of variation for grain yield and number of days to 50% flowering while heritability was high for all characters except for number of leaves in sorghum .Cheralu and Rao (1989) observed high heritability for grain yield , total dry matter, ear length and ear weight in winter sorghum. Amrithadevarathinam *et al.* (1994) noticed high heritability and low genetic advance for plant height and leaf area among 30 genotypes of sorghum.

Asthana *et al.* (1995) studied 20 plant characters in 52 germless of sorghum and noticed a high magnitude of genetic coefficients of variability for seven quantitative characters *viz.*, tillers per plant, internodes size, leaf area, seed weight/panicle, seeds per head, gross panicle weight and dry fodder yield per plant. The heritability estimates were medium to high and higher genetic advance as percentage of mean was associated with the characters peduncle size, seed size, seed volume indicating the predominance of additive genetic variance.

Biradar *et al.* (1996) studied 128 sorghum genotypes involving restorers and maintainers in which they have noticed high value of genotypic and phenotypic coefficients of variation in internodes length, Panicle length, panicle breadth and grain yield per plant.

Nguyen *et al.* (1998) noticed that phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the 7 characters under study in 13 sorghum genotypes. The highest PCV and GCV were obtained for dry weight of leaves. High heritability estimates coupled with high genetic advance were observed for dry weight of leaves, plant height and 100-grain weight, indicating that these traits are controlled by additive gene action.

Amit *et al.* (1999) studied 34 genotypes of sorghum under two environments and noticed that estimates of genotypic coefficients of variation, heritability and genetic gain were of higher order for characters such as peduncle length, panicle weight, biological yield and harvest index.

Veerabadhiran and Kennedy (2001) studied the genetic variability in 75 genotypes of sorghum and noticed that 100-grain weight and grain yield showed high genetic and phenotypic coefficients of variation. The heritability estimates were higher for all the characters studied. The highest heritability was recorded in grain yield per plant (99.9%) followed by days to 50% flowering (96.9%). Among the characters studied 100-grain weight and grain yield exhibited highest heritability coupled with high genetic advance.

Narkhede *et al.* (2001) studied genetic variability for 22 yield related traits in 168 genotypes of sorghum and noticed that phenotypic coefficient of variation was higher than the genotypic coefficient of variation. However, variations of both estimates were within range, indicating the phenotypic variability is a reliable measure of genotypic variability. All the traits showed moderate to high estimates of broad sense heritability.

Tiwari *et al.* (2003) observed higher estimates of heritability and genetic advance for plant height, length of leaf, length of internode, days to maturity, grain yield per plant and test weight in 10 diverse genotypes of sorghum indicating contribution of additive genes in the expression of these traits.

Umakanth *et al.* (2004) studied range, phenotypic and genotypic coefficients of variation, heritability, genetic advance and the relationship between yield and yield components in 40 landraces of sorghum and three established lines. High heritability estimates coupled with high genetic advance were observed for panicle length and 100-seed weight.

Deepalakshmi and Ganesamurthy (2007) reported that, high heritability accompanied with high GA as per cent of mean was observed for the characters *viz*., days to 50% flowering, plant height, leaves per plant, leaf length, ear head weight, number of primaries per panicle, 100 grain weight, grain mould score and single plant yield suggesting that these characters are under additive gene action and thus gives better scope for selection in sorghum.

2.2 Heritability, genetic advance and gain from selection

Heritability describes the proportion of phenotypic variance caused by genotypic variance, heritability value near 100 indicated that, the phenotype is a good index of genotypic merits and genotypic gains from selection is easy, whereas heritability value near zero means, phenotype is poor as index of merits and it is difficult to gain from direct selection of that trait. Fadlalla and Abdalla (1994) in millet mentioned that, since grain yield has low heritability estimates, the indirect selection through its components assumes importance. 1000-grain weight, number of grains/spike proved to be the most reliable yield components.

Totok *et al*. (1998) reported that the heritability in pearl millet estimates of 0.74, 0.84, 0.65 and 0.50 for grain yield, seed weight, panicle weight and productive panicles, respectively. Giriraj and Goud (1983) pointed that, for the majority of characters; estimates of heritability were high in the F1 and low in the F2. Regarding that in first generation of selfing after random mating, each S_1 family is comparable to the F_2 generation of a conventional varietal cross in grain sorghum.

2.2.1 Heritability and genetic advance

The genes cannot cause a character to develop unless they have the proper environment and conversely, no amount of manipulation of the environment will cause a character to develop unless the necessary genes are present. Nevertheless, the variability observed in some characters is caused primarily by differences in the genes carried by different individuals, and that the variability in other characters is due primarily to differences in the environments to which individuals have been exposed. It would therefore, be useful to have a quantitative statement of the relative importance of heritability and environment in determining the expression of a character (Allard, 1960).

Johnson *et al.* (1955) indicated that, estimates of heritability along with genetic coefficient of variation are useful in predicting the resulting effect of selection than heritability values alone because of the effects of sample size, environment, the character and population on heritability estimates. Moreover, heritability value indicates the confidence with which selection of genotypes can be based on phenotypic performance. However, estimation of heritability in broad sense has limitations because it includes both additive and epistatic gene effects (Abraham *et al.*, 1989). Therefore, estimates of heritability in broad sense would be more meaningful if accompanied by that of genetic coefficient of variation.

2.2.2 Heritability of the studied traits

Harer and Karad (1999) in evaluation of twenty parents of pearl millet and their 75 F1 hybrids, reported a high genetic advance combined with high percentage of broad sense heritability for grain yield and plant height. *al.* (Sindagi *et* 1970) reported that, high broad-sense heritability estimates coupled with a high genetic advance for grain and fodder yields in sorghum. Eckebil *et al.* (1976); Naphade (1973); Govil *et al.* (1979) and Phul and Rang (1986) reported that, high broad-sense heritability estimates for yield ,bloom date and plant height, while Kulkarni and Shinde (1988) noticed low heritability for days to 50% flowering in rabi sorghum. Phul and Rang (1986) found high heritability estimate for 1000-grain weight in sorghum. Information on heritability was derived by Cheralu and Rao (1989) from data on nine yield components in 30 sorghum genotypes. High heritability estimates were obtained for grain yield, total dry matter, ear length and ear weight. Kumar and Singh (1986) revealed that high heritability in grain sorghum estimate for plant height, panicle, internodes length and 1000 grains weight ranged from 85.30 to 93.99 %, indicating that selection for these traits should lead to crop improvement. In contrast with millet Abraham *et al.* (1989) in his study of seven quantitative characters in 20 diverse genotypes of finger millet, indicated that estimates of heritability in broad sense ranged from 0.40 for effective tillers/plant to 0.995 for days to maturity. Grain yield/plant, 1000-grain weight and fingers/ear had high estimates for heritability accompanied by high genetic advance interpreting his findings perhaps owing to the predominance of additive gene effects. On the other hand, plant height had high heritability with low genetic advance, indicating that non-additive (dominance and epistasis) gene effects were predominant. He concluded that progress in the improvement of this character through selection would be slow.

HAPTER THREE

MATERIALS AND METHODS

3.1 Experimental site

The experiment was carried out for one season 2015/2016 at the demonstration farm of the Gezira Research Station of the Agricultural Research Corporation(ARC) Wad Medani (Latitude 13º30′ - 15º15́′ North and longitude 30º33′ East and 407 masl). The soil of the site is alkaline and has high clay content, poor structure, low organic content, low permeability but with high water holding capacity and a pH of 8. The gravimetric soil moisture contents at field capacity are above 40 % for the top soil, 20% is the permanent wilting point. Bulk density varies with depth and ranging from 1.12 to 1.46 in the deeper layers.

3.2 The climate

The climate is a typical semi-arid tropical environment, characterized by a short period of rainfall and a prolonged dry spell. Kharif season usually starts in July and extended to October. The total rain received is ranging from 190 mm to 395 mm and generally the rain fall received was low except in season 2015. The mean maximum temperature is 37^{0}C and the minimum is 23ºC. The daily evaporation ranges from 7 mm to 18 mm.

3.3 Experimental treatments and design

Twenty four sorghum genotypes were provided by the Sorghum Breeding Program of Agriculture Research Corporation (ARC). Accessions include released varieties viz., (Arfa Gadamak-8). The standard cultural practices were followed as recommended by agricultural research corporation. Treatments were laid out in a randomized complete block design with three replicates. The experiment was planted on the fifteenth of July. The crop was kept weed-free and irrigated every two weeks or when necessary. In the experiments, assessments were made in the central rows of each plot discarding one row or more at each side.

3.4 Source of seeds

The genetic material used in the study was consisted of twenty four varieties of sorghum. which were collected from agricultural research corporation Sudan (ARC).

Table (1): List of Sorghum genotypes used in the study

Entry No.	Genotype	ORGIN
1	HSD4201	(ARC)*
2	HSD 5585	(ARC)
3	HSD 5650	(ARC)
4	HSD6147	(ARC)
5	HSD 5585	(ARC)
6	HSD 5585	(ARC)
7	HSD 5650	(ARC)
8	HSD 7462	(ARC)
9	HSD 7619	(ARC)
10	HSD 7948	(ARC)
11	HSD 5585	(ARC)
12	HSD 5650	(ARC)
13	HSD6147	(ARC)
14	HSD 6444	(ARC)
15	HSD 6501	(ARC)
16	HSD7461	(ARC)
17	HSD 7462	(ARC)
18	HSD 7619	(ARC)
19	HSD7948	(ARC)
20	HSD10106	(ARC)
21	HS D5604	(ARC)
22	HSD3761	(ARC)
23	HSD10019	(ARC)
24	Arfa Gadamak8	Released variety(ARC)

*ARC: Agricultural Research Corporation.

3.5 Data collection

Various sample and observations as shown below were taken, random sample of five plants in each plot were taken to collect data on the following parameters.

3.5.1 Number of Days to 50% flowering

The number of days from emergence to the date when approximately 50% of the plants in the plot flowered.

3.5.2 Plant height (cm)

The average height of five plants taken at random from each entry, measured from the soil surface to the tip of the plant.

3.5.3 Head excretion (cm)

The length of the peduncle from the flag leaf to the base of the head, average for five plants per plot at physiological maturity was estimated.

3.5.4 Panicle length (cm)

The length of the panicle from the base to top was estimated for five plants and the average was considered.

3.5.5 100-grain weight (g)

A sample of 100-grains was taken from five plants at random from each plot, then weight to determined 100-seeds weight.

3.5.6 GainYield (kg/ha)

Weight of actual seed yield taken to estimate total seed yield in kg/ha.

Harvested area = 3.00×0.80 m^2. = 2.4 m^2

$$\text{Estimated seed yield (kg/ha)} = \frac{\text{(yield of area in grams)} \times 10000}{2.4 \times 1000}$$

3.6 Statistical analysis

3.6.1 Heritability ($h^2{}_B$)

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

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

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

3.6.2 Genotypic and phenotypic coefficients of variation

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

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\sqrt{\sigma^2 g}}{\bar{X}} \times 100$$

Phenotypic coefficient of variation (PCV) =

$$\frac{\sqrt{\sigma^2 p}}{\bar{x}} \times 100 \; \frac{\sqrt{\sigma^2 p}}{\overline{\mathrm{X}}} \times 100 \, \sigma^2 P = \frac{\sqrt{\sigma^2 p}}{\bar{x}} \times 100$$

Where:

$\sigma^2 g$ = genotypic variance

$\sigma^2 p$ = phenotypic variance

$\overline{\mathrm{X}}$ = 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.

CHAPTER FOUR

RESULTS

4.1 Growth, phenology and yield components

4.1.1 Plant height pH (cm)

The analysis of variance showed that there were high significant differences at ($P \leq 0.01$) among genotypes for plant height (Table 2). The highest value (165.6cm) was given by the genotype (10) and lowest value (99.2 cm) was obtained by the genotype (13). The overall mean for this character was 132.6 and the coefficient of variation (CV %) was 11.5% (Table 2).

4.1.2 Days to 50% flowering

The analysis of variance indicated that for the number of days to 50% flowering highly significant differences ($P \leq 0.01$) were detected among among genotypes (Table 2). The highest value (86 day) was obtained by genotype (21) and lowest value (63 day) was given by the genotype (5). The overall mean for this character was (73) and the coefficient of variation (CV %) was 7.3% (Table 2).

4.1.3 Head excretion (cm)

The results showed that highly significant differences ($P \leq 0.05$) were detected among genotypes for head excretion (Table 2). The highest value of head excretion (17.6cm) was given by the genotype (15) and the lowest value (3.5cm) was obtained by the genotype (3). The Overall mean for this character was (10.0) and the coefficient of variation (CV %) was (30%), (Table 2).

4.1.4 Panicle length (cm)

The results indicated no- significant differences ($P \leq 0.01$) were detected for panicle among Genotypes (Table 3). The highest value (21.8) was obtained by genotype (8) and the lowest value (16.5) was obtained by genotype (1). The overall mean for this character was (18.9) and the coefficient of variation was (11.8%), (Table 3).

4.1.5 100-grain weight (g)

The analysis of variance indicated for the mean 100-seed weight highly significant differences ($P \leq 0.01$) were detected among genotypes (Table 3). The Highest value (5.40g) was obtained by genotype (18) , lowest value (3.92g) was given by the genotype (22). The overall mean for this character was (4.7) and the coefficient of variation (CV %) was (10.1%), (Table 3).

4.1.6 Grain Yield (kg\ha)

The result showed that no-significant differences ($P \leq 0.01$) were found for grain yield among genotypes. The highest value (2150.3) was given by genotype (3), and the lowest value (1055) was obtained by genotype (13). The overall mean of this character was (1403.1) and the coefficient of variation (CV %) was 30.5% (Table 3).

4.1.7 Genotypic (∂2g) Phenotypic (∂2 ph), variances and Heritability (h2)

The results of this study revealed the highest genotypic variance (1591) was recorded by grain yield (kg\ha) and the lowest estimates of genotypic variance (0.53) were given by 100- seed weight. On the other hand, the highest estimate of phenotypic variance (185484) was recorded by grain yield (kg/h) and the lowest one (0.75) was obtained by 100- seed weight. The highest estimate of heritability (80%) was obtained by grain yield (kg\ha) and lowest value was (15.3) obtained by panicle length (cm), (Table 4).

4.1.8 Genotypic (GCV) Phenotypic (PCV), coefficients of variation

Genotypic coefficient variation (GCV) recorded highest value (29.3%) was for head excretion while panicle length show lowest value was (5%). The (PCV %) estimate highest value by head excretion it was (42.2%), lowest value obtained by days to 50% flowering (10.1%).

Table (2) Means of 50% flowering (days), plant height (cm) and head excretion of the different entries (2015-2016).

Name of line	50% flowering (days)	Plant height (cm)	Head exertion(cm)
1	83 A	159.1 AB	12.2 ABC
2	78 AB	132.8 BCDEF	12.1 ABC

3	85 A	108.9 FG	3.5 G
4	67 CD	159.9 AB	6.2 DEF
5	63 D	139.3 ABCDE	12.5 ABC
6	72BC	131.3 BCDEF	15.0 A
7	66 CD	142.9 ABCD	8.8 CDE
8	69 C	143.6 ABCD	11.4 BC
9	71 BC	113.6 DEFG	6.9 CDEF
10	75 B	165.6 A	10.6 BCD
11	74 B	133.6 BCDEF	11.1 BC
12	84A	112.5 EFG	10.2 BCD
13	74 B	99.2 G	7.6 CDE
14	71 BC	116.4 DEFG	7.6CDE
15	67 CD	149.7 ABC	17.6 A
16	72 BC	116.3 DEFG	6.2 EFG
17	74 B	111.2 EFG	6.0 EFG
18	68 C	124.8 CDEFG	9.0 BCDE
19	79AB	157.8 AB	13.4 AB
20	72BC	132.8 BCDEF	11.4 BCD
21	86 A	122.2 CDEFG	6.8DEFG
22	79 AB	118.1 CDEFG	7.1 CDE
23	75 B	159.0 AB	14.9 AB
24	67 CD	134.3BCDEF	11.6 BC
Mean	**73**	**132.6**	**10.0**
SE ±	**1.78**	**5.11**	**1.0**
F	**	**	**
CV %	**7.3**	**11.5**	**30.0**

**: Significant at P < 0.01
Entries followed by the same letter(s) were not significantly different as per Duncan multiple range test at 5%

Table (3) Means of panicle length, 100- grain weight and grain yield of the different entries (2015-2016)

Name of line	Panicle length (cm)	100- grain weight (g)	Grain yield (kg/ha)
1	16.5 C	4.76 ABCDE	1456.8 AB
2	17.6 ABC	5.11 AB	1354.1 AB
3	19.2ABC	4.00 EF	2150.3 A
4	18.3 ABC	4.59 ABCDE	1343.8 AB
5	19.4 ABC	4.24 CDEF	1585.7 AB
6	17.7 ABC	5.10 AB	1730.3 A
7	21.7 A	4.97 ABC	1467.3 AB
8	21.8 A	4.89 ABCD	1270.9 B
9	20.0 AB	4.83 ABCDE	1480.5 AB
10	21.2 A	4.15 DEF	1219.5 B
11	19.8 ABC	4.34 BCDEF	1502.5 AB
12	19.4 ABC	3.98 F	1095.5 B
13	20.2 AB	4.48 ABCDE	1055.0 B
14	16.6 C	4.38 BCDE	1387.8 B
15	17.5 ABC	5.21 A	1384.0AB
16	19.8 ABC	4.00 EF	1446.9 AB
17	17.6 ABC	4.88 ABCD	1373.6 AB
18	18.6 ABC	5.40 A	1143.1 B
19	18.0 ABC	4.69 ABCDE	1400.3 AB
20	20.4 AB	5.21 A	1543.8 AB
21	20.1 AB	4.0 EF	1401.8 AB
22	18.7 ABC	3.92 F	1885.3 A
23	18.9 ABC	5.0 AB	1358.6 AB
24	17.0 BC	5.29 A	1072.9 B
Mean	**18.9**	**4.7**	**1403.1**
SE ±	**0.75**	**0.15**	**142.9**
F	**N.S**	**	**N.S**
CV %	**11.8**	**10.1**	**30.5**

**: Significant at $P < 0.01$.

Entries followed by the same letter were not significantly different as per Duncan multiple range test at 5%

Table (4) Estimates of range, genotypic phenotypic variance, genotypic and Phenotypic Coefficients of variation, heritability in sorghum genotypes season (2015-2016).

Parameters	Range	Genotypic variation ($\sigma^2 g$)	phenotypic variation ($\sigma^2 p$)	GCV (%)	PCV (%)	Heritability (%)
Days to 50% Flowering	63-86	26.7	55.3	22.5	10.1	48.3
Plant Height(cm)	92.2-165.6	282.9	518.3	12.7	17.2	54.6
Head exertion(cm)	3.5-17.6	8.6	17.8	29.3	42.2	48.3
Panicle Length(cm)	16.6-21.8	0.9	5.9	5	12.8	15.3
100- grain weight (g)	3.92-5.40	0.53	0.75	15.5	18.4	70.6
grain yield (kg/ha)	1055-2150.3	1591	185484	28.4	30.7	85

GCV: genotypic Coefficients of variation: PCV: Phenotypic Coefficients of variation.

4.1.9 Genotypic, phenotypic variance and heritability

Estimates of genetic variance for plant height (cm), days to 50 % flowering, head excretion (cm), panicle (cm), 100- grain weight (g) grain yield (kg/ha) were 26.7, 282.9, 8.6, 0.9, 0.53 and 1591 respectively (Table 4).

High determined of genetic variance (1591) was recorded for grain yield (kg/ha), low estimated found for 100-grain weight (g) (0.53). Phenotypic variance determined for most of the character, high estimates of phenotypic variance 185484 was recorded for grain yield (kg/ha), low estimates were obtained for seed-100 weight. The high value of heritability was revealed for grain yield (kg/ha) (85%) and 100- grain weight (70.6), (Table 4), the low values of heritability was found for panicle length (15.3%), (Table 4).

CHAPTER FIVE

DISCUSSION

The amount of variation existing in population is of a great importance for any successful application of selection procedure used for improving plants. This selection does not create variability on that already existing. In this study, phenotypic variance was greater than the genotypic variance. The result of this study revealed highly significant differences among the genotypes for all the characters under study for number of days to 50% flowering, that, (the genotypes) obtained the lowest mean for number of days to flowering. Thus, they could use in breeding for early maturity genotype in any sorghum breeding program, plant height (cm), head excretion,100-seed weight except panicle length (cm) and grain yield (k/h). High magnitude of variation in the experimental material was also reflected by wider range for all the characters under study. Though, the phenotypic coefficient of variation (PCV %) was greater than genotypic coefficient of variation (GCV), for most the characters studied, the close resemblance between the corresponding estimates of (PCV %) and (GCV %) in almost all the characters except panicle length suggested that the environment had little role in the expression of these character. High (GCV%) and (PCV%) values were found for some characters such as grain yield per hectare and head exertion while moderate values were found for plant height and 100-grain weight and low values for panicle length and the number of days to 50% flowering similar results were reported by Mahjan *et al. (*2011); Seetharma and Ganeshmurthy(2013). While the number of days to 50% flowering reported moderate values of (GCV %) and (PCV %) by Seetharma and Ganeshmurthy (2013).

The heritability estimates were interpreted as low, medium and high as reported by Robinson *et al.* (1949). Heritability ranged from (85%) for grain yield to 15.3% for panicle length. The High heritability observed for grain yield per hectare, 100-grain weight indicated that these characters would respond positively to selection because of their broad sense heritability. For grain yield similar high broad sense heritability was reported by Seetharam and Ganeshmurthy (2013). Deep Lakshmi and Ganeshmurthy (2007**)** who also found similar high heritability for 100-grain weight. For panicle length similar result of low heritability were reported by Seethara and Ganeshmurthy (2013).while Moderate heritability was shown by the number of days to 50% flowering, plant height and head excretion found by(hhh00) .

CHAPTER SIX

CONCLUSION

Based on the results obtained from this study, it could be concluded that:

1. High phenotypic and genotypic variability was observed between the twenty-four sorghum verities, this variability could be of a great value in any genotype sorghum breeding programs.
2. The highest value of heritability was observed in grain yield. This character could be of a great benefit in selection of sorghum breeding for high grain yield and 100- grain weight.

4. The experiment shall be repeated for another season to confirm the results**.**

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