

**SUDAN UNIVERSITY OF SCIENCE & TECHNOLOGY**



**College of Agricultural Studies**



**Study of Variability of & in some Grain Sorghum  
(*Sorghum bicolor* L.moench) Genotypes for  
Growth and Yield Characters**

A Dissertation submitted to the Sudan University of Science and Technology  
the partial Fulfillment of the Requirements for degree of Bachelor of Science  
in Agronomy.

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# الآية

بسم الله الرحمن الرحيم

قال تعالى:

وَالَّذِينَ يُؤْمِنُونَ بِمَا أُنزِلَ إِلَيْكَ وَمَا أُنزِلَ مِنْ قَبْلِكَ وَبِالْآخِرَةِ هُمْ يُوقِنُونَ ﴿٤﴾

صدق الله العظيم

سورة البقرة الآية (4)

# ***DEDICATION***

*To my mother*  
*To my father*  
*To my brothers*  
*To my sisters*  
*To my friends*  
*To my teachers*

## **ACKNOWLEDGEMENT**

First and Lastly the Thanking to the ALLAH who helped me to complete this research. Also my thanks reach to all teachers whom they teach me at College of agricultural studies . Thanks very much to my supervisor Dr. Atif Elsadig Idris for his enormous assistance, guidance, criticism, advice and supervision through the progress of this study; thanks are also due to my friends and my brothers

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## ABSTRACT

A field experiment was conducted at the Experimental Farm of the College of Agricultural Studies, Sudan University of Science and Technology, Shambat during the winter season of 2016-2017. A randomized complete block design (RCBD) with three replications was used in this study. A twenty two sorghum genotypes were evaluated for growth, yield and its components. The results showed that there were significant differences among sorghum genotypes for all growth and yield characters. The highest grain yield was (1.94t/ha) was obtained by the genotype (SAR-8). Therefore, this genotype could be of high benefit in any sorghum breeding program for increasing the yield.

## ملخص الدراسة

أجريت تجربة حقلية بكلية الزراعة. جامعة السودان للعلوم والتكنولوجيا في الخرطوم (شمبات) في العروة الشتوية في موسم 2016- 2017 تم استخدام تصميم القطاعات الكاملة العشوائية بثلاث مكررات وتم تقييم اثنين وعشرون طرز وراثي من الذرة الرفيعة الحبوب اخذت منها قياسات النمو والإنتاجية وهي اظهرت النتائج ان هنالك فروقات معنوية بين الطرز الوراثية لكل الصفات المدروسة , واحرز الطرز الوراثي (SAR -8) اعلي قيم انتاجية (1.94 طن/هكتار) ولذلك يمكن ان يكون ذو فائدة عالية في اي برنامج تربية ذرة رفيعة بهدف زيادة الانتاجية .

# CHAPTER ONE

## INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) belongs to the family Poaceae (*Gramineae*). It is an annual plant, self pollinated, and has a chromosome number of  $2n = 20$  (Poehlman, 1987). It is used primarily as a grain crop, as food for human and as feed for animals. However, in sorghum forage varieties the stems and foliage are used for green chop, hay and silage. Poehlman (1987) reported that the cultivated sorghums (*S. bicolor* L. Moench) originated in Africa 5000 years ago, the greatest genetic diversity in sorghums is found in Ethiopia and adjacent areas of East Africa.

From the area of its origin, sorghum was carried to Africa, India and China, where several distant races have evolved. It is difficult to develop a simple taxonomic classification of sorghums due to their extreme genetic and morphologic diversity (Poehlman, 1987).

Harlan and De Wet (1972) recognized 15 races of *S. bicolor*, 5 primary races (bicolor, guinea, caudatum, kafir and durra) and 10 intermediate races originating from the 10 possible hybrid combinations among the primary races (bicolor – guinea, bicolor – cundatum, ...etc).

The five primary races of *S. bicolor* are identified as the following:

- 1- Bicolor race:** It contains several subraces, primarily sorgos (sweet sorghums), broomcorn, and Sudan grass.
- 2- Guinea race:** It is grown for food in the savanna of West Africa.
- 3- Caudatum race:** It is grown in Nigeria, Chad, Sudan and Uganda, it consists of feterita and hegari types.
- 4- Kafir race:** It is the major race of East and South Africa .
- 5- Durra race:** It is grown in Ethiopia and the Middle East and includes the variety milos.

Variability is essential in any crop breeding program and any sorghum breeding program must not be successful unless a wide range of variability is existed in the



material under study. (Idris, 2012). Therefore the main objectives of this study are:

1. To evaluate and study variability in twenty two grain sorghum for some yield and growth characters.

- 2.To select the sorghum genotype among the studied genotypes which scored the highest yield.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Botany and evaluation of sorghum

Sorghum belongs to the family Poaceae, tribe Andropogoneae and subtribe Sorghinae (Dogget, 1988). Sorghum is self-pollinated with 2 – 20% outcrossing (Rai *et. al.*, 1999). Genus Sorghum is categorized into three species; *Sorghum halepense* (L.) Pers., and *S. propinquum* (K.) Hitch., are native tetraploid perennials of India and South-Eastern Asia. *Sorghum bicolor* (L.) Moench,  $2n = 2x = 20$  comprise of domesticated taxa derived from interbreeding domesticated sorghums and their closest wild relatives (Sally *et. al.*, 2007). Sorghumbicolor has a small genome (735 Mbp), larger than rice (389 Mbp) but smaller than wheat (16900Mbp) and maize (2600 Mbp) (Sally *et. al.*, 2007). The last genome duplication for *S. bicolor* genome could have occurred prior to the divergence of major cereals.

The genome of *S. bicolor* was successfully sequenced and information is utilized in enhancing understanding of evolution in cereals and diversity studies (Paterson *et. al.*, 2009). Information on whole genome sequences propels development of molecular markers for precise genetic mapping and molecular study of genome structure and function (Elshire *et al.*, 2011). Domestication of sorghum started in East Africa, Ethiopia and the surrounding countries in 1000BC (Dogget, 1988). Improved sorghum types then spread to other regions of Africa, India, Middle East and America (Olembo *et. al.*, 2010). Cultivated sorghums evolved from wild *Sorghum bicolor* subsp. *arundinaceum* (Dogget, 1988).

Cultivated sorghums are divided into five basic races: bicolor, guinea, caudatum, kafir, and durra, and ten intermediate races of any two or more basic races (Harlan and de Wet, 1972).

Sorghum being an indigenous crop has evolutionary benefits associated with wide adaptability and tolerance to a biotic and biotic stresses common in Africa.

## **2.2 Economic importance of sorghum**

Sorghum is the fifth most important cereal crop after wheat, rice, maize and barley in the world (Markus and Gurgling, 2006). The crop is a staple to more than 500 million people in arid and semi arid tropics in Africa and Asia (Charles et al., 2006). In Africa, about 25 million 2tons of sorghum are produced per annum and translates to one-third of the world crop (FAOSTAT, 2008). In sub Saharan Africa, sorghum is primarily a crop of resource-poor, small-scale farmers (Mace et al., 2009). In East Africa, sorghum has recently become an important industrial crop for the manufacture of beer and its starch has potential in bio-energy production (Taylor, 2010). In Kenya, sorghum is ground into flour and mixed with other types of flour for baby food. Stalks are used for fuel, thatching huts and as animal feed (Charles et al., 2006).

Sorghum is cultivated in East and Horn of Africa where rainfall is intermittent and characterized by short periods of high rainfall (Charles et al., 2006). In East Africa, the crop grows well in a wide range of environments between 500 meters and 1700 meters above sea level with seasonal rainfall of 300mm and above. Sorghum is drought tolerant thus has become an alternative crop in several areas in Kenya like Eastern, Nyanza and Coast provinces where major staples like maize fail due to lack of enough rain (Taylor, 2010).

Sorghum utilizes C4 photosynthetic pathway thus has greater efficiency of dry matter production relative to water use (Charles et al., 2006).

The crop also tolerates longer durations of water logging better than maize (Dillon et al., 2007). These unique characteristics make sorghum an ideal crop in arid, semi arid and areas at risk of desertification. In the face of global warming and climate change, sorghum is a promising alternative for enhanced food and income security, compared to

commodity staples such as maize that often fail due to drought. Sorghum improvement through breeding is essential to enhance the crop's potential in food and income security in sub Saharan Africa. The potential for sorghum to propel economic development in Africa is enormous.

### **2.3 Origin and geographic distribution**

It is generally agreed that cultivated sorghums arose from the wild *Sorghum bicolor* subspecies *verticilliflorum* (Stead.) (Doggett, 1988). These wild forms were confined to Africa until recently, implying that domestication occurred in Africa. Both Doggett (1965) and Mann et al. (1983) argued that the greatest variability in the crop and wild sorghums is found in the north-east quadrant of Africa (north of the equator, east of longitude 25°E) and this was probably the centre of the first domestication, approximately 5000 years ago. However, Harlan and De Wet (1972), using archaeological, palaeobotanical, anthropological and botanical evidence, suggested that domestication occurred at different times in an area extending from the Ethiopian border, west through Sudan and up to Lake Chad.

#### **2.3.1 Nutritional composition and health benefits of sorghum as food**

Sorghum is an excellent source of energy, proteins, fiber, fat and vitamin B complex essential in energy metabolism (Charles et al., 2006). Sorghum is rich in calcium, iron, zinc, copper, phosphorus, potassium, magnesium, sodium, manganese, folate and vitamins A, C and E (Mohammed et al., 2010). Sorghum is gluten-free and has been recommended for people with

diabetic, celiac disease or other gastrointestinal disorders (Ciacci et al., 2007). Celiac diseases characterized by mal-absorption of nutrients as a result of gut sensitivity to gluten protein in wheat, rye, barley and oats. Sorghum is an excellent source of phytochemicals such as phenolic

acids, anthocyanins, phytosterols and policosanols which prevent colon cancer and reduce the risk of getting heart attacks by lowering cholesterol levels (Awika and Rooney, 2004; Dykes and Rooney, 2006).

Sorghum is processed into a variety of nutritious traditional foods in different parts of the world. Fermented bread such as „kisra“ and „dosa“ are found in Africa, Sudan, and India, while „injera“ is popular in Ethiopia (Charles et al., 2006). Unfermented bread, such as „chapatti“ and „roti“ are common in East Africa and India (Taylor, 2010). Stiff porridge also known as „ugali“, „tuwo“, „karo“, and „mato“ are found throughout Africa, India and Central America (INTSORMIL, 2010). Thin porridges such as „uji“, „ogi“, „koko“, and „akasa“ are popular in East and West Africa. Boiled whole or pearled sorghums are consumed in Africa, India, and Haiti. Couscous, beer and other alcoholic beverages are is popular in West and east Africa (INTSORMIL, 2010).

# **CHAPTER THREE**

## **MATERIALS AND METHODS**

### **3.1. Plant material**

The plant material to be used in this study consisted of Twenty tow grain sorghum genotypes as shown in Table (3.1). The 15 genotypes are exotic materials maintained in the Forage Improve Program – Shambat (FIP). 8 genotypes provided by the sorghum Breeding Program of Agriculture Research Corporation (ARC) - Wed madani .

### **3.2 The experimental site:**

The study conducted in the Experimental Farm of the College of Agricultural Studies , Sudan University of Science and Technology, Shambat ( longitude 32° :31" E ; latitude (15°:39" N;altitude 380 m above sea level ) during the winter of 2016/2017.

### **3.3. Design and Description of the Experiment**

A Randomized Complete block Design (RCBD) was used in this study, the field experiment was conducted during winter season of 2017 at the Experimental Farm of the College of Agricultural Studies , Sudan University of Science and Technology, Shambat.

#### **3.3.1 Field experiment**

##### **3.3.1.1 Cultural practices and layout of the experiment:**

The land was disc plough, disc harrowed and leveled by scraper to obtain a flat and fine seed bed. Ridiging was done at 0.70m spacing . Sowings were effected on 15/11/2016 for the winter sowings,The experimental design was randomized complete blocks design (RCBD) with three replications , four rows with 2m long and 70cm abart, 20 cm between hills and two plants were remained per hill . Five seeds were placed in holes spaced at 20 cm along the eastern side of the ridge and the seedlings were later thinned too approximately 2 plant/hole. Nitrogen fertilizer (urea46% N) was added at the

second irrigation at rate of 80kg /fedan. No chemical can uses.. Irrigation was applied at 7 to 10 days interval. Weed population was kept at minimum by hand weeding.

The randomized complete block design (RCBD) was used in this experiment (GenStat,2011) .

### **3.4. Agronomic data**

#### **3.4.1 Characters studied:**

##### **3.4.1.1. Measurements of growth attributes:**

. Five plants were randomly selected from each plot after leaving 50% cm at each end of the plot. The selected plants were tagged. To avoid bird damage . the emerged heads on tagged plants were covered by cloth bags. Data were recorded for the following parameters in the season.

##### **3.4.1.2. Stem diameter (mm)**

Measured at the middle of fixed internodes (third from the bottom using digital vernier caliper.

##### **3.4.1.3. Leaves number per plant:**

The five plants used for the measurement of plant height were also used for counting the leaves per plant and the average numbers of leave were recorded. ) (cm<sup>2</sup>):

##### **3.4.1.4. Leaf area (LA):-**

Leaf area for three leaves per plant of the five plants per plot was measured. For each leaf, the maximum length was

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multiplied by the maximum width and then multiplied by 0, 75 to obtain the leaf are (Sticker, 1961).

Leaf area = Maximum length× Maximum

##### **3.4.1.6. Number of Days to Maturity (days):**

The number of days from harvesed the plants .

#### **3.4.2 Grain yield and related traits**

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#### **3.4.2.1. Grain yield/plant(g):**

The panicles were left to dry in the laboratory, threshed in bulk and the average weight was determined. In the PYT, 5 panicles were randomly chosen in each plot and bagged. The panicles were harvested at physiological maturity and taken to the laboratory to assess grain yield and related traits as follows.

#### **3.4.2.2. Grain yield (t/ha)**

Estimated in the AYT by harvesting heads representing 25% of area of each plot omitting the edge plants. The panicles were covered by cloth bags prior to seed setting to avoid bird damage. At grain maturity, the panicles were harvested, left to dry in the lab, threshed in bulk and weighted.

The grain yield per plot thus obtained was transformed to grain yield t/ha.

#### **3.4.2.3. 1000 seeds weight(g);**

Estimated from the bulk seed of the five plants chosen to obtain grain yield per plant. 1000 seeds were randomly taken and their weight was recorded

#### **3.5. Statistical analysis:**

The analysis of variance (ANOVA) FOR Randomized complete blocks Design (RCBD) . with three replications was carried out on the collected data which analyzed by using Genestat version 4 software package, while correlation acquired by using Genestat.



**Table (1) Sorghum genotypes used in the study(2016-2017shambat)**

<b>Entry code</b>	<b>Genotypes</b>	<b>Source</b>
<b>1</b>	Tabat	*(FIP) – Shambat
<b>2</b>	Ajeb Sedo	(FIP) – Shambat
<b>3</b>	Abu Teman	(FIP) – Shambat
<b>4</b>	F. Wad AKAR	(FIP) – Shambat
<b>5</b>	SAR-2	(FIP) – Shambat
<b>6</b>	f3 -6	(FIP) – Shambat
<b>7</b>	SAR -6	(FIP) – Shambat
<b>8</b>	SAR -8	(FIP) – Shambat
<b>9</b>	SAR -9	(FIP) – Shambat
<b>10</b>	SAR -10	(FIP) – Shambat
<b>11</b>	SAR -11	(FIP) – Shambat
<b>12</b>	Serena	(FIP) – Shambat
<b>13</b>	f3 -13	(FIP) – Shambat
<b>14</b>	f3 -14	(FIP) – Shambat
<b>15</b>	Ajeb Sedo	(FIP) – Shambat
<b>16</b>	1.1.4	** (ARC) - wed madani
<b>17</b>	1.1.16	(ARC) - wed madani
<b>18</b>	2.13.5	(ARC) - wed madani
<b>19</b>	1.1.13	(ARC) - wed madani
<b>20</b>	Tabat	(ARC) - wed madani
<b>21</b>	W.Ahmad	(ARC) - wed madani
<b>22</b>	Gadam	(ARC) - wed madani

\*Forage Improvement Program .Shambat Research Station,Sudan

\*\*Agriculture Research Corporation (ARC) - wed madani

# **CHAPTER FOUR**

## **RESULTS AND DISCUSSION**

### **4.1. Phenotypic variability:**

The statistical analysis of variance showed that there were significant differences between sorghum genotypes for all studied growth and yield characters. This variability could be attributed to genetic factors, environmental factors or to their interaction. Similar findings were reported by (Mohammed, Marouf 2010) and (Khair, 1995).

### **Growth characters:**

#### **4.1.1. Stem diameter (cm)**

The results showed significant differences between sorghum genotypes for stem diameter the highest stem diameter (23cm) was obtained by genotype (SAR-2) and the minimum diameter (11cm) was given by genotype (1.1.16). Similar findings were reported by (Mohammed, Marouf 2010) and (Khair, 1995).

#### **4.1.2 Number of leaves /plant**

The result showed the genotypes (Ajab sedo) recorded the maximum leaf number mean value (15.3). On the other hand the minimum leaf number mean value (7.8) were observed on (W –Ahmed) Similar result were obtained by (Idris, 2006).

#### **4.1.3 Leaf area (cm<sup>2</sup>)**

The result showed the genotypes (SAR-8) recorded the maximum leaf area mean value (465.3). On the other hand the minimum leaf area mean value (314.0) were observed on (SAR-11) This result are in agreement with (Ibrahim, 1997).

#### **4.1.4 Days to maturity (days)**

Significant difference was reported on means for days to maturity for sorghum genotypes in ranged between 90.6 – 117 days table (2).

### **4.2 Grain yield characters**

#### **4.2.1 Thousand seed weight (g)**

The genotypes showed significant difference in the 1000 seed weight . the heaviest weight was obtained by 1.1 .13 found (44.9 g ) and the lowest weight was attained by Gadam found (21.6 g ).

#### **4.2.2. Grain yield (Ton/ha)**

The result were shown the mean grain yield are presented in table (2). The results revealed that the genotype (SAR- 8) scored the maximum grain yield (1.93 t/ha).Where as the minimum grain yield recoded by the genotype Gadam (0.74 t/ha).

**Table: The mean performance of 22 Sorghum genotypes in Shambat winter season(2016/2017)**

<b>Var. Name</b>	<b>STD</b>	<b>No.L/P</b>	<b>LA</b>	<b>1000GW</b>	<b>Day Maturing</b>	<b>Yield ton/ha</b>
Tabat	21.5	13.8	432.4	34.2	98.7	1.22
Ajeb Sedo	16.5	13.3	382.3	37.3	117	1.12
Abu Teman	19.8	13.0	387.7	44.1	95.3	1.28
F. Wad AKAR	17.6	13.5	427.2	38.7	117.6	1.03
SAR -2	23.0	13.9	406.4	34.6	105.3	1.08
f3 -6	18.4	13.5	416.3	42.1	100	1.36
SAR -6	18.6	14.4	353.9	32.3	106.6	1.02
SAR -8	19.2	13.3	465.3	43.5	94	1.93
SAR -9	19.2	12.7	380.2	35.9	99.3	1.18
SAR -10	16.5	14.6	405.4	46.6	108	1.01
SAR -11	11.2	12.0	314.0	35.9	112.6	1.06
Serena	16.8	13.6	407.3	44.2	108	1.35
f3 -13	13.8	14.3	423.7	30.1	110	0.81
f3 -14	14.3	14.0	405.3	41.5	100	0.86
Ajeb Sedo	16.0	15.3	445.3	42.0	112.6	1.02
1.1.4	14.3	13.8	341.6	45.2	106	1.14
1.1.16	11.0	9.4	404.5	30.3	117	0.87
2.13.5	13.1	8.5	391.5	42.0	96	0.92
1.1.13	14.7	8.8	371.5	44.9	102.6	1.06
Tabat	14.8	9.2	422.5	43.0	96	1.06
W.Ahmad	11.8	7.8	398	30.3	102	0.96
Gadam	14.2	8.5	410.7	21.6	90.6	0.74
<b>CV</b>	<b>14.56</b>	<b>12.45</b>	<b>14.31</b>	<b>8.11</b>	<b>3.99</b>	<b>15.21</b>
<b>LSD</b>	<b>3.8964</b>	<b>2.5367</b>	<b>94.27</b>	<b>5.1076</b>	<b>6.8666</b>	<b>0.0933</b>
<b>SE</b>	<b>1.3652</b>	<b>0.8888</b>	<b>33.031</b>	<b>1.7896</b>	<b>2.406</b>	

## **CHAPTER FIVE**

### **CONCLUSION AND RECOMMENDATIONS**

Based on the result obtained from this study it could be concluded and recommended that:

1. The wide range of variability obtained in the study could be of great value in any grain sorghum breeding program .

2. The high value of leaf area (465-4) and high yield; (1-94 t/ha), were obtained for the genotype (SAR)-8). Therefore, this genotype could be used as parental line in any hybridization program for the object of obtaining sorghum hybrids characterized with high yield.

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