بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Agricultural Studies

Phenotypic Variability and Correlation Between Characters in Seven Forage Sorghum (*Sorghum bicolor* L. Moench) Genotypes

A Dissertation Submitted To the Sudan University of Science and Technology in Partial Fulfillment of the Requirements for Degree of B.Sc. in Agriculture (Honors)

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الآية

قال تعالى:

وَآيَةٌ لَهُمُ الْأَرْضُ الْمَيْتَةُ أَحْيَيْنَاهَا وَأَخْرَجْنَا مِنْهَا حَبًّا فَمِنْهُ يَأْكُلُونَ

الآية رقم (33) سورة يس

Dedication

To my beloved father who gave me hope and care,,,

To my great mother who gave me love,,,

To my Husband with love,,,,

To my dear brothers and sisters who were there when I'm in need,,,

To my teachers, friends and colleagues,,,

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Thanks and gratefulness firstly and lastly to *"Allah"* who gave me mind, determination and patience to carry out this study successfully.

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Abstract

A field experiment was conducted at the Demonstrated Farm, Agricultural Research Corporation Shambat during the season 2015-2016, to investigate the genetic variability and phenotypic correlation between yield and growth characters in Forage Sorghum (*Sorghum bicolor* L.) ghenotypes. The experiment was laid in a randomizd complete block design (RCBD) with three replications. Characters studied included: growth attributes (Plant height (cm), stem fresh weight (g), days to maturity, stem dry weight (g) and stem diameter (mm). The results showed that high significant variances were observed for all the studied characters, except stem dry weight, it was non significant. Negative correlation was observed between dry weight and plant height, stem diameter and days to harvest. The genotype Abjaro×Abnaffain gave the highest mean in dry weight.

ملخص البحث

أجريت تجربة حقلية بالمزرعة التجريبية لهيئة البحوث الزراعية شمبات لموسم 2015-2016م وذلك لدراسة التباين الوراثي والارتباط بين الإنتاجية وصفات النمو في الذرة الرفيعة العلفية. صممت التجربة باستخدام تصميم القطاعات العشوائية الكاملة مع ثلاثة مكررات شملت مقاييس النمو الخضري التي تمت دراستها طول النبات، وزن الساق الرطب، عدد أيام النضج، الوزن الجاف للساق وقطر الساق. أظهرت النتائج وجود فروقات معنوية لكل الصفات تحت الدراسة ما عدا الوزن الجاف للساق كما أظهرت النتائج وجود ارتباط سالبي بين الوزن الجاف وطول النبات وعدد أيام النضج وقد أعطى الطراز الوراثي Abjaro×Abnaffain وأعلى قيمة في الوزن الجاف.

CHAPTER ONE

INTRODUTION

1.1 Background

Sorghum (*Sorghum bicolor* L. Moench) is a member of the family Peaceae. It is thought to have been originated in North- Eastern of Africa around Ethiopia, Sudan and East Africa (Dogget, 1988, Kimber, 2000; Acquaah, 2007). Some researches argue for multiple centers of origin for the crop (Snowden, 1936; De Wet, 1967). Its distribution around the world is attributed to movement of people and its diversity to disruptive selection in different habitats specially in Northern East Africa (Kimber, 2000). Sorghum is a crop of world- wide. In the Sub- Saharan Africa it arguably the most important cereal crop. The world production of grain sorghum amounted to 63- 9million tons resulting from growing an area of about 97 million ha, 63% of which in the African continent (FAO, 2009).

In Sudan sorghum is the most important crop both grain and irrigated fodder production. As grain cereal, sorghum constitutes together with millet and wheat the stable diet of the Sudanese people, ranking first in both tonnage of grain produced and acreage cultivated. According to FAO statistics, 2006, the area planted to sorghum in 2005 amounted to more than 8 million hectares with average yield of about 565 kg\ha which is far below the world average yield of 1330 kg\ha. Growing of low – yielding genotypes is believed to be one of the major factors contributing to low productivity of grain sorghum in the Sudan. As irrigated fodder, records of acreage and tonnage at the national level were difficult to trace in the literature however, taking Khartoum State as an example, the statistics of the Ministry of Agriculture and Animal Wealth for the years 2007 through 2010 showed that the area cropped to forage sorghum

(Variety Abu Sabein) ranged 97 to 191 thousand feddans while that of Alfalfa (Var. Hijazi) ranged from 35 to 45 thousand feddans. (Mohammed, 2002). Initially, sorghum grain is used primary for food however, its use of grain as an animal feed has been an important stimulus to global use of sorghum (Dendy, 1995). Grain for feed was relatively minor until the mid 1960s when feed utilization over took that of food. Industrial uses of crop have been for feed, some for food, starch, the chemical industry and for fuel alcohol. Currently about 484 of world sorghum grain production is fed to livestock (Dowling *et al*., 2002) up to 97% of this use has established in many industrialized countries is likely to become more common in developing countries in which sorghum is mainly produced for human consumption (Dowling *et al*., 2002).

Recently forage sorghum with its essential components, has become an important research subject in the Sudan, according, study of variability among forage sorghum genotypes is needed in order to select forage sorghum genotypes characterized with high yield and good quality characters (Idris, 2006)

Therefore, the main objectives of this research were:

1. Study the genetic variability between seven genotypes of forage sorghum (*Sorghum bicolor* L. Moench) for some yield and growth character.
2. To estimate correlation between yield and growth characters.
3. To select the most high yield genotype.

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin and geographical distribution:

It is generally agreed that cultivated sorghums arose from the wild averticilliflorum (stead) piper (Dogget 1988). These wild forms were confined to Africa until recently, implying that domestication occurred in Africa. Both Dogget (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 latitude 25°E) and this was probably the center of 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.

2.2 Sorghum bicolor basic botanical description:

Sorghum bicolor black seeded. Sorghum is secondary noxious weed in low because it can cause problems in corn and soybean fields, but it is also planted as a crop for syrup and grain.

Horticultural selection has been made for color and height. Ornamental sorghum is an easily grown annually. The attractive seed heads can be used for fresh or dried arrangements. Many of the available selection are very tall and are a dramatic back drop for other plants.

Sorghum is a coarse, erect grass. Its growth characteristics can be very quite drastically and a fully matured plant can range in height from 0.95

to over 5m. Sorghum is often fed to lactating cows, while grazing of sorghum crops by beef cattle is done on a more limited basis.

Sorghum must be supplemented with protein, calcium and other minerals and must be cracked, rolled or steam flaked for best animal digestibility.

Habitat: Cultivated field- especially cereal crops life cycle: Annual growth habitat 8-9 feet tall resembles corn, but smaller.

Leaves: 1- 2.5 inch wide blades with white mid veins.

Inflorescence: July- October, large panicles of rounded shiny black or red seed that shatter easily.

Stem: Smooth.

Root: Fibrous root system often forms brace roots as well.

Similar plants: Shatter cane resembles forage sorghum and corn. It is also similar to Johnson grass (*Sorghum halepense*), but lacks of rhizomes and has tighter panicle and wider leaf blades. Shatter cane is an annual, while Johnson grass is a perennial. This is cane like grass, up to 6m tall with large branched clusters of grains the individual grains are small, about 3-4mm in diameter. They vary in colour from pale yellow through reddish brown to dark brown depending on the cultivar. Most cultivars are annual, few are perennials cultivated and most weedy sorghum is non-rhizomatous, culms nodes are either glabrous or shortly tomentose. The inflorescence is contracted the branches of the inflorescence alternate. (Harlan and De Wet, 1972)

Sorghum bicolor includes all cultivated sorghum as well as a group of semi wild plants often regarded as weeds.

Historical records and archeological data have been able to clearly state the origin and domestication of sorghum bicolor. Previously 571 cultivars were recognized however, these cross readily without barriers of sterility or difference in genetic balance, therefore it makes sense to group them into a single species. It is for this reason that it is not an easy task for taxonomists to work with species but it is an advantage to the plant breeders because they can manipulate the genetic make- up of this group to acquire best crops. Wild species are characterized by distinct ring of long hairs at the nodes, they have loose inflorescence with spreading branches, the branches of the inflorescence are whorled. The leaves look much like those of maize, they sometimes roll over. A single plant may have more than two leaves. The flower head carries two types of flowers, one type has no stalk and has both male and female parts and the other flower is stalked an is usually male. (Dogget, 1975)

Summer annual, coarse, erect with much variability in growth characteristics; culms solid or sometimes with spaces in pith, 06- 5m tall, depending on variety and growing conditions, 5 to over 30 mm in diameter, either dry at maturity or with sweet insipid juice; leaves broad and coarse, similar in shape to those of corn but shorter and wider; blades glabrous and waxy; sheath encircle column and have overlapping margins; panicle erect, sometimes recurred, usually compact in most grain sorghums and more open in forage types; seed covered by glumes that may or may not be removed by threshing; prop roots may grow from culms nodes; bud at each node from which a tiller grow; seed white, yellow, red, brown; panicle with up to 6,000 spikelet- seed 25,000 to 61,740\kg; grass sorghum 120,000 to 159,000\kg. Stunning, rich shiny black seed heads top this 8-9 tall heriloom broom corn. Stout, easy, vertical and drought tolerant, this sorghum bicolor has been grown as an

important grain source for over 7,000 years and is well known for making of brooms (Directions for handcrafting brooms are readily available on the internet). With its strong, arching, rich green corn like foliage and 8-12 very up righting stems per plant, it creates an outstanding architectural form in the garden and is really cool looking as a background to sunflowers. Starting out as tight arching clusters, the seed heads mature into interesting and lovely sprays that make fabulous dries arrangement material. The seeds can be popped like popcorn, the stem can be chewed, and best of all the birds love the seed. Rich soil for best show- sorghum (Sorghum vulgare or Sorghum bicolor) is a grass (family, the grasses: chiefly herbaceous but some woody plants including cereals' bamboo; sugar cane) the grain of which (food stuff prepared from the starchy grains of cereal grasses) grain is used for (Any solid substance as opposed to liquid that is used as a source of nourishment) fo0ds. (coarse food especially for cattle and horse composed of entire plants the leaves and stalks o a cereal crop) fodder and the production of (a liquor or brew containing alcohol as the active agent) alcoholic beverages. (Harlan and De Wet, 1972)

Sorghum is an important food crop in (the second largest continent; located south of Europe and bordered to the Wets by the South Atlantic and to the East by the Indian Ocean) Africa (the isthmus joining North America and South America; extends from the Southern border of Mexico to the Northern border of Colombia) Central America and (Clock link for more information about Southern Asia and is the fifth major grass whose starch grains are used as food: Heat; rice; rye; oat; maize; buckwheat; millet). Cereal crops grown in the world (970,000km^2 harvested in 1996). (A native or inhabitant of Africa) African (A person who is owned by someone) slaves introduced sorghum into the (North

American Republic containing 50 States- 98 Conterminous in North America plus Alaska in North West North America and the Hawaiian Islands in the Pacific ocean; achieved independence in 1776) U. S, in the early 17th century, where most of the world's sorghum is now produced. (Idris, 2006)

In China sorghum is the most important ingredient for the production of distill beverage such mao-tai (www. Mdidea. coman www. Mdidea. net).

2.3 Economic importance and uses of sorghum:

Sorghum is world's fifth most important cereal globally and is the dietary staple of more than 500 million people in 30 countries. It is grown on 40 million ha in 105 countries of Africa, Asia, Oceania and Americas. Africa and India account for the largest share (more than 70%) of global sorghum area while USA, India, Maxico, Nigeria, Sudan and Ethiopia are the major sorghum producers (Kimber, 2000). Sorghum is the only viable food grain crop for many of the world's most food insecure people, who live in sub-Saharan Africa. It's importance to food security in Africa is crucial owing to it's uniquely drought tolerance among cereals and can withstand periods of high temperature. In most of African drought prone countries it was estimated that per capita daily food intake averaged less than 2,000 calories whereas, according to the FAO a daily intake of less than 2,400 calories is indicative of widespread hunger (Taylor, 2003). The importance of sorghum grain as animal feed has been reviewed by many workers (Subramanian and Melta, 2000; Reddy *et al.*, 2000; Kriegshauer *et al.*, 2006). Sorghum grain is significant component of animal feed in the United States, South America, Australia and China and is becoming important in chicken feed in India. In the United States it

represents the second most important feed grain following maize. (Idris, 2006).

In Sudan, where the second largest animal wealth in Africa exists, sorghum (forage and residue) constitutes the bulk of the animal feed in the country. Forage sorghum (Abu Sabein) constitutes more than 75% of the area under fodder crops. Livestock in Sudan are traditionally fed on sorghum grain of feterita types produced under rain fed conditions. (Mohammed, 2004)

Uses of sorghum have been discussed by (Dendy, 1995). Much of the agricultural history of sorghum has been for food, beverage, feed and building materials. It has been used as an industrial crop during the last 100 years.

Mechanization of its cultivation and harvesting has occurred primarily during 1960s. Industrial uses of crop have been for feed, some for starch, the chemical industry and for fuel alcohol. The uses of grain as animal feed have been an important stimulus to global use of sorghum (Dendy, 1995).

2.4Environmental conditions:

Suits sweaters hot summer areas under irrigation or summer rain, but is unlikely to drought. There is strength in soil medium to heavy and week stress of salinity and alkalinity.

2.5 Cultural practices:

The cultural practices of forage sorghum has been expressed by Mohammed 2004 as the following.

2.5.1 Sowing date:

The early planting of sorghum as a forage in March and April gives a large number of cutting interval than of planting in May and June.

2.5.2 Land preparation:

Forage Sorghum needed good land preparation free of mass. It used deep plough disk plough at the beginning of the process of the texture modification. Then used disk harrow to modify the soil particle size, leveling and the final practice is ridging.

2.5.3 Sowing method:

Growing either in covering the seed or plant sprays or grown with planter and the distance between the lines, 25- 90cm tall at the cut of hay or green forage 80- 100cm tall at the cultivation of silage. The seeds are placed at a depth of 2.5- 5cm depending on soil type.

2.5.4 Seed rate:

15- 75 per hectare and increase the rate depending on soil fertility and availability of irrigation and the more significant was the legs lift and more palatable.

2.5.5 Fertilization:

You need to fertilize the rich to give the rich harvest add fertilizer before planting a full NPK and add nitrogen two weeks after germination. As well as after each inhospitable and vary the appropriate amounts of fertilizer by soil type.

2.5.6 Irrigation:

This can be conducted at sowing, after one week from sowing and then every after two weeks and shorten the periods of irrigation the land.

2.5.7 Harvesting:

Forgae sorghum varieties can be harvested when the height of plant is 155cm.

2.6 Cultivated races:

S. bicolor

Basic races

Race (1) bicolor (B).

Race (2) guinea (G).

Race (3) Candaium (C).

Race (4) Kafir (K).

Race (5) Dura (D).

International races (all combinations of basic races)

Race (6) guinea- bicolor (GB).

Race (7) Caudatum- bicolor (CB).

Race (8) Kafir- bicolr (KB).

Race (9) durra- bicolor (DB).

Race (10) Guinea- caudatum (GC).

Race (11) guinea- Kafir (GK).

Race (12) guinea durra (GD).

Race (13) Kafir- caudatum (KC).

Race (14) durra- caudatum (DC).

Race (15) kafir- durr (DK).

2.7 Sorghum breeding:

Grain sorghum: Mahmoud (1983) gave comprehensive review for sorghum breeding in Sudan since its inception and up to 1975. Although collection of Sudanese sorghum land recess was started by Punter as early as 1914, yet varietal improvement was not started until the early thirties with the introduction of the improved types from the USA. Research work on sorghum improvement really took off in 1952 with the foundation of the central Rain Land Research Station at Tozi. The objectives were to develop high yielding combinable varieties to meet the growing need of the mechanized schemes. Selection within the local stocks for high yielding grain types of the breeding program. Dwarf white Milo was released in the early sixties as a replacement to Wad Fahal, the popular but late maturing traditional variety. Three strains of Um Beneins (T. U. B. 7, 11 and 22), one of Wad Akar (W. Akar51/3) and one of Wad Yabis (W. Yabis 1) were distributed to the farmers. The transfer of sorghum breeding work to Wad Medani in early 1970s together with the cooperation of the international programs (ALAD, CRISAT and INSORMIL) gave sorghum breeding strong imputes.

Work on grain hybrid sorghum was done on a limited scale prior to the establishment of Tozi Research Station. Mahmoud (1983) attributed this to the absence of a full time sorghum breeder, limited supporting satff and shortage in research funds.

However, Mahmoud (1983) reported that in 1960 he made six experimental hybrids using male- sterile 602 as a female with six local parents.

Based on the results obtained, Mahmoud proposed an extended hybrid program but the proposal was rejected on the argument that farmers were

too illiterate to handle hybrids. Gadam Elhamam improved and Dabar improved were released in 1977.

One of the program objectives was the development of early to medium maturing hybrids for irrigation and rain- fed environments using introduce females (A lines) and adverse arrow of local and exotic pollinators. Short combinable types to meet the growing need of the mechanized sector were chosen. In 1983 one experimental hybrid (EEH-3) was officially released as the first commercial grain sorghum hybrid and renamed in Arabic "Hygeen dura-1".

Ibrahim (1997) and El Ahmadi (2013) gave some information about sorghum improvement during 1980s and 1990s. The period for 1985 to 1995 wiliness intensive sorghum breeding work and number at improved open pollinated varieties were released. Some of these include El'Inqoz, Wad Ahmed and Tabat.

According to Al Ahmady (2013) Tabat is the only improved white seeded cultivar annually produced by seed companies. The latest addition to the rather short list of improved white- seeded varieties is a striga- resistant version of Tabat. TIBC354 was released in 2011.

2.8 Dual fodder/ grain sorghum:

Sorghum varieties have been developed specifically for either grain, forage or stem sugar but not for dual- purpose combining grain and forage use. In the early days of cereal crop improvement, emphasis was placed on releasing dwarf high grain yielding varieties. Since recognition of the need for crop residues as feed for livestock, the emphasis has shifted to dual- purpose cultivars for grain and forage. Dual- purpose varieties could be beneficial to the resource- poor farmers by providing grain for human consumption and forage livestock feed (Chikuta and

Okori, 2012). Residues for sorghum and other cereals are becoming important feed source for livestock raised by resource- poor smallholders in Southern Asia and Sub- Saharan Africa (Mohanrgi *et al.*, 2011). Although crop residues (also known as Stover) have become the main source of feed for farm animals in developing countries, crop breeders have continued to focus their efforts solely on increasing grain yields and not on improving the yield and quality of Stover. This situation has been recently addressed in India within a framework of partnership between National Research Centres, ICRISAT- ILRI by focusing on sorghum, as an important staple crop in India that is growing on nearly 10 million hectares throughout the country. The researchers incorporated quality traits in India's sorghum crop breeding trials and in so doing, led breeders to identify sorghum varieties that give high yields of both grain and Stover, as well as improved Stover quality. The result is dual- purpose, food- plus- feed sorghum varieties that are now helping India's 208 million livestock farmers close the livestock feed gap and feed India's growing human population (CG/AR Annual Report, 2009).

2.9 Correlation between different characters in sorghum:

Correlations among characters are of interest to the breeders because they might help in identification of easily measured characters that could be used as indicators for more important, but more complex, characters. They are also useful in planting out the possibilities and limitations of simultaneous improvement of desirable characters (Abdalla, 1991). Correlation among traits could be utilized to enhance the rate of selection respnse in the primary traits (Moll and Stuber, 1974) and yield components (Grafius, 1969). Yassin (1973) attributed the association among characters to pleiotropy or linkage. Adam (1967) reported that, negative associations between different traits might be due to the

competition of two developing structures of plant for limited resources like nutrients and water supply.

There is strong evidence in the literature showing significant and positive correlation between grain yield and number of grains per ponical (Kambal and Wetster, 1966; Beil and Atkins, 1967; Liang *et al*., 1968; Dabholkar *et al*., 1970; Kambal and Abu- El gasim, 1976; Orozcomeza and Mendoza Onfre, 1983 and others).

Significant positive correlation between grain yield and kernel weight was reported by Malm, (1968); Sindagi *et al*., (1970); (Abifarin and Pickett 1976); However, Kirby and Atking (1968); Pasha and Munshi (1979) found no correlation between the two characters. Monommed, (1988) found that the grain yield per plant was significantly and positively correlated with number of grains per panicle, panicle diameter, stem diameter, threshing percentage, leaf width and leaf area per plant, were and insignificantly correlated with plant height, 1000- grain weight, panicle length and days 10 50% flowering. Grain yield had positive and significant association with plant height and leaves per plant (Arunkumar *et al*., 2009) and also with panicle weight, harvest index, 100 seed weight and panicle length (Kumar *et al*., 2012).

CHAPTER THREE

MATERIAL AND METHODS

3.1 Experimented site:

The experimental was conducted in field of Shambat (Lat 15-39^{o} N, Long 32-31^{o} E). Agricultural Research Corporation During season 2015-2016. The soil is clay- silty non saline, non- sodic with pH 7.8

3.2 Plant materials:

The source population of this study was based on breeding nursery established in 2015 in the experimental from of ARC were shown in table (3.1)

The traditional cultivar Abjaro was crossed as female parent with the following pollen SG.51, 53. Abu 70 and Abu-naffain. The crossing were made using plastic bag technige. Four crossen from Abjaro X s-3 Abu 70 on cross from Abjaro XSG.51 and two crosses from Abjaro X Abu-naffain (White and green midnib).

3.3 The design and layout of the experiments:

The design of the experiment was a randomized complete block design (RCBD) with three replication.

The land was disc ploughed, disck harrowed and leveled by scraper to obtain fine seed bed. The experiment was divided to plots, each plots contains 4 ridges. Sowin date was first of October 2015. Ridging was done at, 70 cm spacing. The plots were watred before sowing to ensure fine seed bed. Nitrogen fertilizer, urea was added at the second irrigation at the rate of 85 kg n/ha irrigation was applied at 10-12 days interval.

Weed population was kept at minimum by hand weeding. The sowing date was at 21 October 2015.

3.4 Data Collection:

3.4.1Plant height (cm):

Measured at harvest from ground level to the tip of the head.

3.4.2 Stem fresh weight (g):

The plants was taken from plots randomly (are m^2) then stem without leave reighting in kg.

3.4.3 Days to maturity:

The maturity date was at April 2016 with growing period of 180 days at the last experiment days from germination to maturity counted to every genotypes and record.

3.4.4 Dry weight kg:

Measured by balance taken as 500 gm from each plot and dryeid by oven (48 hours) then wight in kg.

3.4.5 Stem diameter (cm):

Taken as the Thickness of the stalk at the middle of the fourth internade from the plant base using vernier caliper.

3.5 Statistical Analysis:

The collected data were subjected to statistical analysis using randomized completely block design (RCBD) analysis of variance according (SAS) (Gomez and Gomez, (1984).

3.5.1 Coefficient of variation (C.V):

It was estimated according to the Following Formula:

$$\text{Cv:}\sqrt{ERROR\ MAEN\ SQURE}\ \frac{}{GRAND}\ MEAN$$

3.5.2 Phenotypic correlation:

It was used to estimate phenotypic covariance between two seasons .They were used further for computation of phenotypic correlation between different characters, using the formula suggested by Miller et al. (1958).

Phenotypic correlation coefficient (r ph) = σ^2phxy/ $\sqrt{}$ (σ^2 ph x)(σ^2phy)

Where as:

σ^2ph x y = phenotypic covariance between two traits (x,y)

σ^2phx =phenotypic variance for trait x, σ^2phy =phenotypic variance for traity.

Table 3.1: Forage Sorghum Genotypes Used in the Study

Genotypes	**Marks**
Abjaro × S. 3 Ab 70 I	Abjaro is the female and the other lines are males (polinatars)
Abjaro × S. 3 Ab 70 II	
Abjaro × S. 3 Ab 70 III	
Abjaro × S. 3 Ab 70 IV	
Abjro × Abnaffain I	
Abjaro × S.G51	
Abjro × Abnaffain I	

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Variability:

4.1.1 Plant height (cm):

There was a significant differences between genotypes in plant height. Genotypes (Abjaro × S. 3 Ab 70) and (Abjaro × S. 3 Ab 70) had the highest height (6.50cm and 6.13cm) respectively. The least height was observed from (Abjro × Abnaffain) and (Abjro × Abnaffain) (4.43cm and 4.00cm) respectively. The coefficient of variation (C. V.) for the plant height was reasonable (12.01%). Similar findings were observed by Idris, 2006. Abdallah, 1991 and Abu-Elgasim.

4.1.2 Stem fresh weight (g):

There was non significant differences between genotypes in stem fresh weight. Genotypes (Abjaro × S. 3 Ab 70) had the highest Stem fresh weight (449.7g). The least stem fresh weight was observed from (Abjro × Abnaffain) (216.9g). The coefficient of variation (C. V.) for the stem fresh weight was reasonable (11.78%). These results were in accordance with the results of Mohammed (2004).

4.1.3 Day to maturity:

There was a significant differences between genotypes in days to maturity. Genotypes (Abjro × Abnaffain) had the highest day to maturity (96.00 day). The least day to maturity was observed from (Abjaro × S. 3 Ab 70), (Abjaro × S. 3 Ab 70) and Abjro × Abnaffain) (90.5, 90.00 and 90.00), respectively. The coefficient of variation (C. V.) for the days to

maturity was reasonable (1.87%).Similar results were reported by Mohammed (2004).

4.1.4 Stem dry weight (gm):

There was a significant differences between genotypes in stem dry weight. Genotypes (Abjro × Abnaffain) had the highest stem dry weight (205.9g). The least stem dry weight was observed from (Abjaro × S. 3 Ab 70), (Abjaro × S. 3 Ab 70) and Abjro × S. G51) (179.7and 177.02), respectively. The coefficient of variation (C. V.) for the stem dry weight was reasonable (6.5%). Similar results were reported by Idris (2006).

4.1.5 Stem diameter (cm):

There was a significant differences between genotypes in stem diameter. Genotypes (Abjaro × S. 3 Ab 70) had the highest stem diameter (1.5cm). The least stem diameter was observed from (Abjro × Abnaffain), (Abjaro × S.G51), (Abjro × Abnaffain) and (Abjaro × S. 3 Ab 70) (1.3, 1.3 and 1.3), respectively. The coefficient of variation (C. V.) for the stem reasonable (5.66%). Similar results were reported by Mohammed (2004).

4.2 Phenotypic Correlation

The results of correlation between different forage dry yield and growth yield were shown in table 4.3 Negative correlation was appeared between dry weight and plant height, stem diameter and days to harvesting. Similar findings were observed by (Idris, 2006) and (Mohammed, 2004).

Table 1: Mean square from single ANOVA for forage yield and yield related rats of seven crossing Forage sorghum genotypes

		ms	ms	ms	ms	Ms
Source	**Df**	**Plant height**	**Day to maturity**	**Stem dry weight**	**Stem diameter**	**Stem fresh weight**
Replication	2	0.043	12.92	1.041	0.00893	1730.2
Genotypes	6	2.75**	17.53**	304.889ns	0.01464*	15737.9**
Error	12	0.42	3.0067	153.50	0.00560	1346.1
C. V. %		12.01	1.87	6.51	566	11.78

Table 2: Performance of seven crossing sorghum genotypes of the forage yield related rats and yield

Genotypes	Plant height	Stem fresh weight	Day to maturity	Stem dry weight	Stem diameter
Abjaro × S. 3 Ab 70	9.88bc	279.2bc	90.00c	190.3ab	1.3b
Abjaro × S. 3 Ab 70	6.5a	999.7a	94.00ab	179.7b	1.4ab
Abjaro × S. 3 Ab 70	6.00ab	328.6b	90.5c	192.5ab	1.4ab
Abjaro × S. 3 Ab 70	6.13a	311.4b	99.5ab	198.6ab	1.5a
Abjro × Abnaffain	9.93c	216.9c	90.00c	205.9a	1.3b
Abjaro × S.G51	5.88ab	326.2b	92.80bc	177.02b	1.3b
Abjro × Abnaffain	9.00c	268.3bc	96.00a	188.1ab	1.3b
L. S. D	1.15	65.3	3.1	22.042	0.133
C.V %	12.01	11.78	1.87	6.51	5.66

Means of the some letter are not significant at ($P \leq 0.05$) level

Table 3: Phenotypic Correlation between some yield and growth character in seven forage sorghum genotypes

	p.h	**Stem**	**Day to harv**	**Dry weight**
Stem	0.5320*			
Daytharv	0.1975 ns	0.1431 ns		
Dryweight	-0.5179 ns	-0.2794 ns	-0.3585 ns	
Stemdiame	0.5841 ns	0.1397 ns	0.4201 ns	0.2198 ns

CHAPTER FIVE

CONCLUSIONS

Based on the results obtained from this study, it could be contended as the following.

1. The results of this study showed that significant differences sorghum were observed between all studied characters. This variability could be of great value in any forage sorghum breeding program.
2. The results of correlation between different characters could be of a value in any forage sorghum breeding program.
3. The genotypes (Abjaro × Abnaffain) scored the highest value of the dry weight.

References

1- **Abdalla, H. A.** (1991). Evaluation of exotic and local parental lines of sorghum (*sorghum bicolor* L. Moench.). and their F1 hybrids at different environments, M.Sc., thesis, Faculty of Agriculture, Khartoum University, Sudan.

2- **Abifarin, A.O**. and Picket, R.C (1970). Combining ability and hetrosis for yield. Protein, lysine and certain plant characters in 18 diverse inbreds and 65 hybrids in (sorghum. Biclor L. Moench). African soils 15-399-416.

3- **Acquaah, G.** (2007). Principles of plant genetics and breeding. First edition Blackwell. Malden, UA.Pp509-518.

4- **Adams, M.W. (1967)**. basics of yield compensation in crop plants with special reference to the field bean, (*pahseolhus vulgaris* L.). crop Sci., 7:505-510.

5- **Arunkumar, B; Biradar**, B. D and Salimath, P. M (2004). Genetic variability and character association studies in Rabi sorghum. Khamataka. J. Agric. Sci, 17:471-475.

6- **Arunkumar, B; Biradar, B.D. and salimath, P.M** (2009). Genetic variability and character association studies in Rabi sorghum. Khamataka. J. Agric. Sci, 17:471-475.

7- **Beil, G. M** and **Atkins**, R.E (1967). Estimates of general and specific combining ability in FI hybrid for grain yield and its components in grain sorghum . (Sorghum, Vulgare Pers). J. . crop Sci, 7:225-28.

8- **CGLAR Annual Report** (2009)in: feed plus flood . Washington, DC 20433 USA. Pp30.

9- **Chikuta, S and Okori, P**. (2012). Development of dual purpose sorghum for grain and forage. Third Ruforum Biennial Meeting 24-28 sept. Pp 1363-1367.

10- **Dabholkar, A.R.; Telang, S. W**. and Patal, K.C. (1970) correlations in sorghum hybrid. J. Sci, cult. Pp 36: 466.

11- **De Wet, L. M. and** Huckabay, J. R. (1967). The origins of sorghum bicolor. II. Distribution and domestication. Evolution 211: 787-802.

12- **Dendy, D.A.V.** (1995) sorghum and the millet: production and importance evolution 4: 787-802.

13- **Dogget. H.D. (1988).** Sorghum. 2nd, edition Longman Group UK, Green and Co.Ltd London, Harlow, England, Pp512.

14- **Dowling, L. F**.; Amdt, C. and Hamaker, B.R(2002). Economic viability of high digestibility sorghum as feed for market broilers J. Agron, 94: 1050-1058.

15- **ElAhmadi, A. B. (2013).** Proposal for release of W. T-1: A new grain sorghum for the central irrigated clays of Sudan. A paper submitted to the Variety Release Committee, 23 July 2013. Khartoum.

16- **FAO, (2006)** FAO statistics division available from http//www.faostat. FAO. Org. /Site/408/Defau it. Aspx? ID: 408 accessed on august 2006.

17- **FAO. (2009).** FAOSTAT. Availablefromhttp: //fao.org/ site/ 567/destopdefault.Aspx?page ID= 567# ancor. accessed 09 November 2009

18- **Gomez, K. A**. **and A. A. Gomez** (1984). Statistical Procedures for Agricultural Research 2nd .Ed. Johon Wiley

And Sons, Inc. Newyork.Grain Yield Response Aust .J.Agric. Res 29: 897-912.

19- **Grafius. J. E. (1969).** Stress: A necessary ingredient of genotype by environment interaction. Pp 346-355 in 2nd int. Barely Genetics Symp.

20- **Grafius. J.E** (1969). Stress: A necessary ingredient of genotype by environment interaction. Pp 346-355 in 2nd int. Barely Genetics Symp.

21- **Harlan, JR** an Ddewet, J.M.J (1972). A simplified classification of cultivated sorghum. Grop Sci, 12: 172-176.

22- **Ibrahim, O.E. (1997)**. Research and production of dura sorghum in the Sudan. Annual agricultural. Forum. Federal minisr5ty of agriculture (in Arabic Khartoum Sudan).

23- **Idres, A.E. (2006).** Evaluation of some lince of forage sorghum (*sorghum bicolor* L. moench) for hybrids production in the Sudan. Ph.D. this , faculty of agriculture , university of Khartoum .

24- **Kambal , A.E.** and Webster, O.J (1966). Manifestation of hybrid vigor in rain sorghum and the relations among the components of yield, weight per bushel and hight. J. grop Sci, 6: 513-515.

25- **Kimber, C. (2000).** Origins of domesticated sorhum and its early diffusion to India and china. In W. C smith and R.A Frederickson (ed), sorghum: origin , history , technology and production. John Wiley . new York Pp3-98.

26- **Kirby, J.S** and R.E Atkins (1968). Hetrosis response for vegetative and mature plant characters in grain sorghum, (*Sorghum bicolor* L Moench) J . Grop Sci, 8:335-339.

27- **Kriegshauser, T.D.** tuinstra, M.R and hancock , J.D . (2006). Variation in nutritional value of sorghum hybrids with contrasting seed weight characteristics and comparisons with maize in broller chicks. J . crop Sci, 46:69-695.

28- **Kumar, A; Reddy,** B.V.S: ramahiah, B. and Sharma. R (2011). Heterosis in white – grained grain mold resistant sorghum hybrids. J. of SAT. Agric. Research 9:1-6.

29- **Kumar, N.V; Reddy** , C.V.C and Reddy, P.V.R (2012) study on character association in Rabi sorghum plant archives 12: 1049-1051.

30- **Liang, G.H.L; Heyne, EG**; change , J.H. and Koh, Y.O.(1968). The analysis of heritable variation for three agronomic traits in ab-variety

31- **Mahmud .M.A** (1983). Sorghum research and development in the Sudan before 1975. In G.Ejeta Ed ' Hybrid sorghum seed for Sudan Proceeding purder university. Pp7-10

32- **Malam, N.R (1968).** Exotic gemplasm use in grain sorghum improvement J. Crop Sci, 8:295-298

33- **Mann, JA; Kimber, C.T and Miller, F.R** (1983) the origin and eartly cultivation of sorghum in Africa. Texas Agric. Exp. Stn Bull 1454 Texas A and M University College Station.

34- **Mohammed (2004)**. Breeding for forage sorghum (*sorghum bicolor* L. moench) in the Sudan using stocks as males and

introudeced stocks as females. Ph.D there faculty of agriculture university of Khartoum.

35- **Mohammed Maarouf I.** (2002). Annual Research Report (2000/2001). Shambat Research Station ARC, W. Medani, Sudan.

36- **Mohammed, Maarouf, I**. (1988). Agronomic performance and genetic variability or some Venezuelan sorghum mutants and some local sorghum cultivars. (*sorghum bicolor* L. Moench). M.Sc thesis faculty of agriculture U. of K.

37- **Mohanraj, K; Gopalan**, A. Anna, D, and Ravinder, K (2011). Genetic variability for grain cum folder yield and contributing traits in F2 generations of dual purpose sorghum plant archives 11:151-156..

38- **Moll, R. H.** and Stuber, C.W (1974) quantitative genetics. Empirical results relevant to plant breeding. Adv. Agron. 26:313-317 .

39- **Pasha, M.A.M.** and Munshi, Z.A. (1974). Correlation stuies in sorghum (sorghum bicolor. L. Moench). Agriculture Pakistan.. 24: 245-259.

40- **Reddy, B.V.S.** and Sanjana, S.P (2003) sweet sorghum: characteristic and potential. International Sorghum and millets. Newsletter 44:26-28.

41- **Snowden, J.D.** (1936). The cultivated races of sorghum. Adlard and son London.

42- **Subramnium, V.** and Metta V.C. (2000) sorghum grain for poultry feed. In: technical and institutional options for sorghum grain mold management (eds) Chandrashekar, A,

Bandyopadhyay R, and Hall, A.J proceeding of an international consultation, 18-19 may 2000, ICRISAT india Pp242-247.

43- **Taylor, (2003)**. overview importance of sorghum in Africa available from: www.afripro.org.uk/papers/paper01taylor.pdf.

44- **Yasnin, T.E** .(1973). Genotypic and phenotypic variances and correlations in faba bean (*Vicia Faba* L) J. agric.Sci. (camb) 81:445-448.