

CHAPTER ONE

INTRODUCTION

Maize (*Zea mays* L.) belongs to the tribe, Tripsereae (Maydeae) of the family Poaceae (Gramineae). This tribe consists of 8 genera, viz, Zea, Coix, Echinochloa, Tripsacum, Polytoca, Sclerachne, Chionachne, and Trilobachne. The genus Zea is monotypic and represented by the single species Zea mays, which is of great economic importance. (Panda, 2009).

The economic importance of the maize is the existence of different varieties of maize helped in its dissemination globally, moreover the crop is used for human being of about 20% of the total world production and also for live stock about 65% beside that, it is used in other industrial uses. The seed of maize crop consists of 64% Starch, from 9% to 12% portion plus 2% to 8% Fats. Maize is also used as a fence around the farm to decrease the flow of the wind and increase the moisture of the field. (Osman, 2007).

Maize ranks as one of the world's three most important cereal crops. It is cultivated in a wide range of environments more than wheat and rice because of its greater adaptability, currently, its global production is 140 million hectares, of which approximately 96 million hectares are in the developing countries, although 68% of the world maize production of 602 million tons is production in other areas. Low average yields in the tropics are responsible for the wide gap between the global share of area and of production. (Dagash; *et al*, 2014).

Maize hybrids yield in the United States of America hybrid acreage increased from 72 million acres in 1933 to nearly 143,000 million acres in 1956. Meanwhile, maize hybrids are rapidly replacing open-pollinated maize varieties in the European and Mediterranean countries. More than 23% of Italy's maize production is acreage is now hybrids (Robert 2009)

According to FAO data, the area planted to maize in west and center Africa also increased from 3.2 million in 1961 to 8.9 million in 2005. This phenomenal expansion of the land area devoted to maize resulted in

increased production from 2.4 million metric tones in 1961 to 10.6 million metric tones in 2005. (IITA, 2009).

In Sudan maize is considered as a minor crop, it is normally grown in Kordofan, Darfur and Southern states or in small irrigation areas in the northern state with average production of about 0.675 tons per hectare in the traditional farm of Sudan (Idris and Abuali, 2011). On the other hand, few studies were conducted to produce forage maize cultivars characterized with high yield and good quality. There has been an increasing interest in developing forage maize production in Sudan The adaptation of maize to different environments lead forage farmers to cultivate it in winter season at Khartoum state (Idris, 2006).

Therefore, the main objectives of this study are to:

1. Compare sixteen genotypes of forage maize in some yield and quality characters.
2. Select the most productive forage maize genotype in forage fresh and dry yield.

CHAPTER TWO

LITERATURE REVIEW

2.1. Phenotypic variability and uses:-

Maize (*Zea mays* L.) belongs to tribe Thipsereae (Maydeae) of the family Poaceae. The crop originated in Mexico and Central America. It is commonly cultivated in tropic areas and grown as summer crop in temperate regions. Tremendous diversity of maize is a result of centuries of selection, mutation and hybridization different kinds of grains recognized so far described as under. Many authors stated phenotypic variability in different maize cultivars and genotypes for different growth and yield characters (Idris *et al*, 2010). Maize is used as staple human food and feed for live stock and for fermentation and many industrial purposes some of the most common industrial uses are as described below (Dr.panda.2010).

2.2. Classification of maize:-

The maize was classified by Sturtevant in 1899 into seven groups on the basis of the endosperm of kernels they are pod corn, pop corn, flint corn, dent corn, flour corn, sweet corn and waxy corn. As presented by (Panda, 2010):

1-Pod corn (*Zea mays* truncate stunt): the kernel in a pod or husk, the ear formed is also enclosed in husk pod corn is also known as cow corn, forage corn and husk corn it is not grown commercially the Pod corn are characterized by having each kernel enclosed within a pod or husk it is a primitive type of corn and hence of no importance.

2-Pop corn (*Zea mays* everta stunt): its cultivation is mainly confined to the new world which has small kernels with hard corneous endosperm the grains are used for human consumption and are the basis of pop corn confection the kernels are small and possess a higher percentage of hard endosperm starch the ability to pop is due to rapid expansion of moisture in each individual starch grain upon the application of heat it is a popular snack food in many parts of the world.

3-Flint corn (*Zea mays* indurata strut): this is the type first discovered by Europeans which has an early maturity. The kernels of this type are rounded on the top. The kernels consist of endosperm with soft starch in the center

and completely enclosed by a very hard outer layer. The kernels shrink uniformly as they mature.

4. **Dent corn** (*Zea mays edentata* sturt): it is popularly known as dent corn because of dent formation on the top of the kernel having yellow or white colour. The kernels are characterized by a depression or dent in the crown. This group is the most widely cultivated corn in U.S.A. in United States, it accounts for 95% of all maize. The hard starch is confined to the sides of the kernel. It is used for livestock feeding. It may be yellow, white or red.

5. **Flour corn** (*Zea mays amylases* sturt): it resembles to the flint corn in appearance and ear characteristics. The grains are composed of soft starch and have little or not dent. Flour corn is one of the oldest types of maize grown widely in U.S.A. and South Africa. The kernels consist almost entirely of soft starch with a very thin layer of hard starch on the sides. They are also known as soft corn. Kernels are soft and of all colours, but white and blue are the most common. They are like flint kernels in shape.

6. **Sweet corn** (*Zea mays saccharata* sturt): the sugar and starch make the major component of the endosperm that result in sweetish taste of kernels before they attain the maturity and after maturity the kernels become wrinkled. Sweet corn is a good source of energy. About 20% of the dry matter is sugar, compared with only 3% in dent corn at green ear stage. It is also a good source of vitamin C and A.

7. **Waxy corn** (*Zea mays certain kulich*): the endosperm looks waxy adhesives and for textile and proper sizing. Waxy maize hybrids have been developed and are being grown to supply war materials for specially products of the wet milling starch industry for textile, paper sizing and corn oil. The endosperm of the kernel when cut or broken gives a waxy appearance.

8. **Baby corn** (*Zea mays*): grown for young babies (cobs) to be used for vegetable soup and salad. This is rich in minerals and vitamins and can be harvested within 45-50 DAS for marketing. Baby corn is used for culinary purposes, salad, soup, pagoda etc. it is notorious but contains less fat and carbohydrate, so preferred by cardiac and diabetic patients. (Dr. Panda. 2010).

2.3. Botanical characteristics:-

Maize as member of the grass family poaceae have many characteristics common to other grasses. Represented by Panda, 2010 as the following, this characteristics are:

2.3.1 Root System:-

The root system of maize is deep and fibrous. It consists of:

1. Seminal or temporary roots: consists of radical and number lateral roots which arise at the base of the first node of the stem under soil surface just above the scutellar node.
2. Crown or Coronal roots: they arise from the basal portion of the stem.
3. Brace, prop or aerial roots: they arise from second, third and sometimes fourth node above the soil surface. All may or may not enter the soil.

2.3.2. Shoot System:-

Shoot system comprises stem, leaves (including leaf sheath and leaf blade) and inflorescence.

2.3.3. Stem:

The stem is made up of nodes and internodes is filled with pith. The internodes parts are flattened on the sides next to the leaf sheath. The plant grows to the height of 1.5 to 3 meters depending up on variety. The also bear tillers, if the main shoot is damaged or over other wise, however, it is greatly influenced by soil and climatic conditions. The stem is made up of approximately 12-18 alternating nodes and internodes and is complexly filled with pith. The number of internodes and vary but on the average there are 14 internodes. A leaf is attached to each node, and often a bud or branch arises at a node, internodes are some what flattened or grooved on the side next to the leaf sheath.

2.3.4. Leaf:

The leaves grow alternately on the opposite sides of the stem. They bear small hairs on them and number of leaves varies from 10 to 20. The

width varies greatly with the varieties, fertility status of the soil, climatic conditions and management practices etc. each leaf consists of a thin, flat and expanded blade with a definite mid rib and smaller veins and thither, more rigid sheath each sheath surrounds the inter node above the node to which it is attached stomata are present on both the surfaces of the leaf.

2.3.5. Inflorescence:

The maize plant bears two types of inflorescence:

1. The staminate or tassel containing male flowers which is always terminal and there fore, only one tassel is found per stalk;
2. The distillate inflorescence or female inflorescence which develops into an ear and they are born at the side of the plant in to the axis of the leaves a short branch known as shank; they may be more than one per stalk depending up on variety and management practices. The shank consists of modified leaves enclosing ears and is collectively known as 'husk'. Maize is normally a monoecious plant/cross pollinated crop.

2.3.6. Tassel:

The tassel is branched inflorescence. It consists of a central spike (rachis) and about 10 to 50 lateral branches. The paired spikelet's (pedicel late and sessile). Occur in many ranks around the central spike. Each spikelet contains 2 flowers. The development of upper floret is about 2-3 days ahead of the lower floret measured at an thesis each floret is enclosed with a pair of thin scales, a lemma and a pelea. These lodigules well at an thesis allowing extrusion, anthers dangle down ward and shed pollens from opening at the tip.

2.4. Adaptation:

The maize can grew with in a temperature range of 14-40°C, with optimum temperatures of 18-21°C. they showed that maize grow in regions that receive 500-5000mm/annum. An optimal water supply can be secured in regions that have precipitation 500-1200mm/annum. The crop is sensitive to moisture stress from the beginning of flowering until the end of the grain formation i.e. 50-100 days after sowing.

2.4.1. Soil:

Maize can grow on wide rang of soil, on conditions that they are deep, well aerated, and well drained. The optimum growth rates are expected on

loams and salty loams with adequate organic mater. The pH range is 5.2-8.5 and the optimum pH 5.8-7.8.

2.4.2. Sowing:

The recommended optimum sowing forage maize during the winter season in Khartoum and River Nile State. The same author pointed that for optimum yield forage maize should be sown on ridges when grown on clay soils. Optimum plant population is 46000-61000 plant per hectare.

2.4.3. Fertilization:

Most of the soil in the Sudan is regarded as moderate or poor fertile. Thus, applying fertilizers containing nitrogen and phosphorous are expected to increase the yield of all irrigated crop. Reported that the application of nitrogen at the rate of 86 kg/ha as urea increased maize yield significantly. While the application of phosphorous as triple super phosphate up to 86 p₂O₅/ha did not affect the maize yield significantly.(Mohammed. 2015)

CHAPTER THREE

MATERIALS AND METHODS

3.1 The Field experiment site:

The field experiments was carried out to achieve the objectives of this study .The field experiment was conducted during winter season of 2016 & 2017, (in the period from November 2016 to February 2017.), at the experimental farm of College of Agricultural Studies, Sudan University of Science and Technology , Shambat (.32° 32' E. , Longitude, 15° 40' N Latitude, and 380 meters above the sea level). The climate of Shambat is characterized short – humid arid during the summer and cold - dry during the winter season. The soil of Shambat is highly saline -sodic clay. The soil particles proportions follow the order: clay, silt and sand. Where the clay comprises the higher proportion. Monthly mean maximum and minimum temperature and total rainfall were recorded for the side.

3.2 Forage Maize Genotypes used in the study:

Sixteen genotypes of forage Maize (*Zea mays* L.) were used in this study, they were provided from Agricultural Research Corporation (ARC), Wad-Madani, Sudan.(Table,1)

Table (1). Forage Maize genotypes used in the study and their origin.

Variety	Origin
TEEI 1	ARC-Wad edan5-S4dan
TEEI 4	ARC-Wad edan5-S4dan
TEEI 5	ARC-Wad edan5-S4dan
TEEI 10	ARC-Wad edan5-S4dan
TEEI 11	ARC-Wad edan5-S4dan
TEEI 29	ARC-Wad edan5-S4dan
TEEI 20	ARC-Wad edan5-S4dan
TEEI 21	ARC-Wad edan5-S4dan
0804-6STR.	ARC-Wad edan5-S4dan
TZ STR 150.	ARC-Wad edan5-S4dan
TZ STR 166	ARC-Wad edan5-S4dan
TZ STR 168.	ARC-Wad edan5-S4dan
TZ STR 179	ARC-Wad edan5-S4dan
TZ STR 185.	ARC-Wad edan5-S4dan
TZ STR 200.	ARC-Wad edan5-S4dan
TZ STR 220	ARC-Wad edan5-S4dan

ARC: Agricultural Research Corporation

3.3. Watering treatment:

Water stress applied at every 10-12 days intervals for the whole experiment.

3.4. Design and layout of experiments:

The Experiments were laid out in randomized complete block design (RCBD) with three replications . The experiment field was disc plowed; disc harrowed, leveled and ridged up east west, 70 cm apart. The land was divided into 2x3.5 m² plots each composed of 4 ridges two meters long. Seed were sown three seeds per hole spaced at 20 cm between holes. Thinning was carried out one week after sowing to raise two plants /hill. Sowing date was the 14 November 2016 at Shambat . Seed rate applied was 2.5 kg /fed, Nitrogen fertilizer(urea 46% N) 80kg/F was applied in two equal doses after three and six weeks from sowing date, respectively. Hand weeding was conducted when ever needs.

3.5. Data collection

For data collection, five plants from the two inner ridges at each plot separately were selected and from them data for the following growth and yield characters except days to 50% flowering were collected as the following:

3.5.1. Growth characters

3.5.1.1 Days to 50% Tasseling

Days to tasseling was taken as the number of days from sowing until 50% of the plants in the polt shed pollen.

3.5.1.2 Days to 50% Silking

Days to silking was taken as the number of days from sowing until 50% of the plants in the plot started to undergo silking, i.e silk emerged to 2 cm length.

3.5. 2 Yield traits (T/ha)

3.5.2.1 Forage fresh yield (T\ha)

The fresh plants in area of 0.7m² were harvested, weighted and from them the forage fresh weight in ton/hectare was estimated.

3.5.2.2 Forage dry yield (T\ha)

The above harvested fresh weight was dried under sun ways, weighted and from them the dry forage yield in ton/hectare was estimated.

3.5.3 Quality traits:

3.5.3 .1 Protein content%

It was determined at the Laboratory of Food Research Center, Shambat by using AACC (2000) method.

3.5.3 .2 Fiber content%

It was determined at the Laboratory of Food Research Center, Shambat by using AACC (2000) method.

3. 6. Statistical analysis:

The collected data were subjected to statistical analyses as:

According to the procedures described by Gomez and Gomez (1984) for a randomized complete block design.

3.6. 1.Coefficient of variance: (CV %)

It was determined for each character using the following formula

$$\text{CV\%} = \text{Mean square of error} \times 100\% / \text{Grand mean}$$

CHAPTER FOUR

RESULTS

4.1 Phenotypic variability:

4.1.1 Days to 50% Tasseling:

The statistical analysis of variance showed that there was non significant different for this character between the sixteen forage genotypes used in this study. The coefficient of variation for this character was 5.3 (table.1).

4.1.2 Days to 50% Silking:

The statistical analysis of variance showed that there was significant different for this character between the sixteen forage genotypes used in this study. The highest (70.30) and the lowest (62.60) means were obtained by the genotypes TZSTR150 and TEEI 4, respectively. The coefficient of variation was 5.3 for this character (table.1).

4.2 Yield traits:

4.2.1 Forage fresh weight (T/Ha):

The statistical analysis of variance showed that there was significant different for this character between the sixteen forage genotypes used in this study. The highest (3044.60) and the lowest (2308.30) means were obtained by the genotypes TZ STR168 and TZ STR 184, respectively. The coefficient of variation was 12.0 for this character (table.1).

4.2.2 Forage dry weight (T/Ha):

The statistical analysis of variance showed that there was significant different for this character between the sixteen forage genotypes used in this

study. The highest (897.50) and the lowest (705.80) means were obtained by the genotypes TZSTR168 and TZ STR 184, respectively. The coefficient of variation was 12.4 for this character (table.1).

4.3 Quality traits:

4.3.1 Protein content%:

The statistical analysis of variance showed that there was non significant different for this character between the sixteen forage genotypes used in this study. The highest (9.18) and the lowest (6.98) means were obtained by the genotypes TZSTR184 and TEEI 5, respectively. The coefficient of variation was 0.56 for this character (table.2).

4.3.2 Fiber content:

The statistical analysis of variance showed that there was non significant different for this character between the sixteen forage genotypes used in this study. The highest (31.34) and the lowest (24.83) means were obtained by the genotypes TZSTR179 and TEEI 1, respectively. The coefficient of variation was 0.84 for this character (table.2).

Table.1: The means of growth and yield traits in sixteen forage maize genotypes evaluated at Shambat winter season, 2016.

No	Genotypes	DT	DS	FW	DW
1	TEEI 1	62.00 ^a	70.00 ^a	2658.70 ^{ab}	821.30 ^{ab}
2	TEEI 4	56.60 ^a	62.60 ^c	2543.70 ^{ab}	730.10 ^{ab}
3	TEEI 5	59.60 ^a	67.60 ^{abc}	2410.20 ^b	739.90 ^{ab}
4	TEEI 10	57.60 ^a	64.60 ^{abc}	2578.90 ^{ab}	817.50 ^{ab}
5	TEEI 11	60.30 ^a	66.30 ^{abc}	2459.20 ^{ab}	739.90 ^{ab}
6	TEEI 29	59.00 ^a	68.00 ^{abc}	2415.00 ^b	788.20 ^{ab}
7	TEEI 20	59.00 ^a	67.00 ^{abc}	2522.70 ^{ab}	771.70 ^{ab}
8	TEEI 21	61.00 ^a	69.30 ^{ab}	2677.70 ^{ab}	836.90 ^{ab}
9	0804-6STR.	61.00 ^a	68.30 ^{abc}	2660.80 ^{ab}	805.60 ^{ab}
10	TZ STR 150.	62.30 ^a	70.30 ^a	2695.30 ^{ab}	816.40 ^{ab}
11	TZ STR 166	60.60 ^a	67.60 ^{abc}	2683.60 ^{ab}	837.90 ^{ab}
12	TZ STR 168.	60.60 ^a	68.60 ^{abc}	3044.60 ^a	897.50 ^a
13	TZ STR 179	58.30 ^a	65.60 ^{abc}	2550.30 ^{ab}	795.80 ^{ab}
14	TZ STR 185.	60.60 ^a	68.30 ^{abc}	2755.30 ^{ab}	858.10 ^{ab}
15	TZ STR 184	58.60 ^a	63.60 ^{bc}	2308.30 ^b	705.80 ^{ab}
16	Hudiba-2	59.60 ^a	66.30 ^{abc}	2263.50 ^b	688.20 ^b
	Mean	59.80	67.10	2576.70	790.60
	CV%	5.300	4.60	12.00	12.400
	F value	0.70 ^{n.s}	1.40*	1.1200*	1.0200*

DT=Days to 50% Tussling, DS=Days to 50% Sulking, FW=Fresh Weight,
DW= Dry Weight.

Table 2: The means of quality traits (protein and fiber) in sixteen forage maize genotypes evaluated for chemical composition in season, 2016.

No	Genotypes	PRO	FIB
1	TEEI 1	7.52k	24.83j
2	TEEI 4	7.70j	24.9j
3	TEEI 5	6.98m	27.32g
4	TEEI 10	7.16l	26.26h
5	TEEI 11	8.07h	26.24h
6	TEEI 29	9.12c	26.41h
7	TEEI 20	8.24g	28.50d
8	TEEI 21	8.64f	26.42h
9	0804-6STR.	9.12b	24.9
10	TZ STR 150.	8.86d	27.72f
11	TZ STR 166	8.74e	25.97i
12	TZ STR 168.	9.37b	28.00e
13	TZ STR 179	7.89i	31.34b
14	TZ STR 185.	8.23g	28.50c
15	TZ STR 184	9.18c	28.05d
16	Hudiba-2	10.09a	32.48a
	Mean	8.3	27.5
	CV%	0.56	0.48
	F value	984.1**	905.6**

PRO= protein content%, FIB= fiber content%.

CHAPTER FIVE

DISCUSSION

5.1. Phenotypic variability:

In this study significant difference was revealed among days to 50% silking, forage fresh weight, forage dry weight, protein content, and fiber content. Characters and non significant were detected for days to 50% tasseling, this variation could be attributed to genetic factors, environmental factors or to their interaction.

Phenotypic variability among forage or grain maize genotypes for growth, yield and quality characters was been stated by many workers (e.g. Skeman and Revering 1984) (Ishag, 2004), (Idris and Abuali, 2012) (Bello *et al*,2009)(Ahmad *et al*,200).

5.1.1. Days to 50% tasseling:

For days to 50% tasseling in this study the genotypes non significant different between forage maize. This result differs with Dagash, *et al* (2014).

5.1.2. Days to 50% silking:

For days to 50% silking, the highest and the lowest values were scored by the genotype TZ STR 150 and TEEI4. Similar findings were obtained by Idris and Abuali,(2012).

5.1.3. Fresh and dry weight:

The genotype TZ STR 168 scored the highest values of forage fresh and forage dry weight. The genotype could be of a great value in any forage maize breeding program.

5.1.4. Protein and Fiber content:

On the other hand, the genotype Hudiba-2 scored the highest values of protein and fiber. This indicates the highest nutrition of this genotype. And it could be used by farmers for feedings animals. Similar results were obtained by Idris and Abuali, (2012).

CHAPTER SIX

CONCLUSIONS

6.1. Conclusion:-

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

1. Wide ranges of genetic variability among the 16 forage genotypes of maize for most characters could be of a great benefit in any forage maize breeding program.
2. The Genotype (Hudiba-2) scored the highest protein and fiber contents, this indicate the highest nutritive value of this genotype.
3. The genotype TZSTR 168 scored the highest fresh and dry weight, therefore it could be used as a parental line in hybridization in any forage maize breeding program.

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