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Variability Study of Grain Yield and Quality Traits in Maize (*Zea mays* L.) Genotypes

دراسة التباين لصفات انتاجية وجودة الحبوب فى بعض الطرز الوراثية للذرة الشامية

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By

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Dedication

This thesis is dedicated tO my amazing father, TO my great mother and brothers TO support me. I would like to dedicate the thesis to my teachers, colleagues and friends with lovely.

Acknowledgment

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. I would like to express my deepest and sincere gratitude and thanks to my great Supervisor: **Dr. Atif. Elsadig Idris** for his supportness and kindness and wonderful care in directing and supervising this work. My thanks extended to Dr. Mohammedein Babeker Alhussein (ARC) for providing me with materials used in this study and to Dr. Nawal Abdel-Gayoum, Food Research Center for helping me in laboratory experiment and to my teacher and colleagues at Department of Agronomy, College of Agricultural Studies, Sudan University of Science and Technology.

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Abstract

Tow field and laboratory experiments were conducted to study variability of grain yield and quality traits in thirteen maize genotypes. The field experiment was conducted in the winter season of 2015 in the period from November 2015 to February 2016. Gezira Research Station Farm (GRSF), Wad-Madani, Sudan. A randomized complete block design (RCDB) with three replications was used and grain yield (t/ha) was studied. The laboratory experiment was conducted at the laboratory of food research center (FRC), National Council of Research (NCR), Khartoum North, Shambat, Sudan. The thirteen maize genotypes were investigated to determine their chemical compositions, minerals contents and physical properties. Completely randomized design (CRD) was used for lab. experiments. The results showed that there were significant differences ($P \geq 0.5$) between the 13 maize genotypes for all yield the quality studied traits. The genotype BOMU scored the highest yield 1286.30 (t/ha). The results of chemical compositions showed that, the highest values of Caloric value (417.21 Kcal/ 100g), carbohydrates (84.76%), protein(13.41%), moisture (6.36%), fats (4.58%), fiber (2.89%) and ash (1.5%) were obtained by the genotypes 2014E98, Hudiba-2, 2014E92, 2014E104, 2014E104, 2014E79 and LONGS, respectively. The means of the minerals in (mg/kg) showed that, the highest values of Ca (8.04), P (403.33), Fe (2.46), K (358.33), Zn (3.06), Na (2.08) were obtained by the genotypes 2014E74, 2014E95, GBAYA Red, 2014E80, 2014E95 and GBAYA Red, respectively. The highest granule size (77mm) and weight of 100 seeds (31.2 gm) were obtained by genotypes 2014E37 and BOMU, respectively. Most of the 13 maize genotypes were characterized with yellow and/or different ranges of yellow color mixed with other colors. Nine maize genotypes included 6 local and three genotypes introduced from South Sudan exhibit bitterness taste. The variability in maize genotypes

scored high values of yield and quality traits could be used in any maize breeding program in Sudan in the future.

المستخلص

اجريت تجريتين حقلية ومعملية لدراسة التباين لصفات انتاجية وجودة البذور فى ثلاثة عشر طراز وراثى من الذرة الشامية التجربة الحقلية اجريت بمزرعة هيئة البحوث الزراعية – ود مدنى – السودان. للموسم الشتوى 2015 فى الفترة بين شهرى نوفمبر2015 الى فبراير2016 . حيث تم استخدام تصميم القطاعات الكاملة العشوائية بثلاث مكررات لدراسة صفة الانتاجية. اجريت التجربة المعملية بالمركز القومي لأبحاث الأغذية- السودان – الخرطوم بحرى - شمبات لتقدير خصائص الجودة فى المكونات الكيميائية، محتوى المعادن والخصائص الفيزيائية لـثلاثة عشر طراز وراثى من محصول الذرة الشامية، حيث تم استخدام التصميم العشوائي الكامل لعينات التجربة بثلاث مكررات اظهرت النتائج بأن هنالك فروقات معنوية بين الثلاثة عشر طرز وراثى للذرة الشامية لكل صفات الانتاجية والجودة المدروسة. الطرز الوراثى 2014E37 احرز اعلى قيمة للانتاجية بالطن هكتار وكانت (1286.30). أظهرت نتائج التحليل الكيميائى ان اعلى قيم للسعرات الحرارية (417.21 سعر حراري/ 100 جرام) و الكربوهيدرتات (84.76%) و البروتين (13.41%) و الرطوبة (6.36%) و الدهون (4.58%) والألياف (2.89%) والرماد (1.5%). احرزت بواسطة الطرز 2014E98، حديبة-2، 2014E92، 2014E104، 2014E104, 2014E79 و LONGS بالتتابع. كذلك أظهرت النتائج للمحتوى المعدنى ان اعلى قيم بـ (ملجرام/ كلجم) كانت كالآتي: الكالسيوم (8.04)، الفسفور (403.33)، الحديد (2.46)، البوتاسيوم (358.33)، الخارصين (3.06) والصوديوم (2.08). احرزت للطرز 2014E74، 201E495، GBAYA Red، 2014E80, 2014E95 و GBAYA Red بالتتابع. أظهرت النتائج اكبر حجم للبذرة (77ملم) ووزن المائة بذرة (31.2 جرام) أعطيت من الطرز 2014E37 و BOMU بالتتابع أغلب الطرز المستخدمة في التجربة أعطت اللون الأصفر و/أو درجات مختلفة من اللون الأصفر مخلوطة مع ألوان أخرى. تسعة طرز من بينها ست طرز محلية وثلاث استجلبت من جنوب السودان أعطت طعم مر. التباين فى صفات الانتاجية والجودة والذى تم الحصول عليه من من خلال هذه الدراسة يمكن ان يكون ذو قيمة لاستخدامه فى اى برامج التربية للذرة الشامية فى السودان مستقبلاً .

CHAPTER ONE

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop after wheat and rice in the world, it was originated in Mexico (Smith, 1995). It is can be grown in a wide range of environments (Farnham *et al*. 2003). This ability of maize to grow in a wide range of environments is reflected in the high diversity of its morphological and physiological traits. Maize is a multipurpose crop which has wide range of uses than any other cereals. It can be utilized as human food, feed grain and a fodder. (Dowswell *et a*l., 1996). The use of maize varies in different countries. In Latin America and Africa the main use of maize is for food while in Asia it is used for food and animal feed. In fact in many countries it is the basic staple food and an important ingredient in the diets of people. Globally, it has been estimated that approximately 21% of the total grain produced is consumed as food. Corn starch can be fermented into alcohol, including fuel ethanol, while the paper industry is the biggest non-food user of maize starch. The oil and protein are often of commercial value as by-products of starch production and are used in food manufacturing (Boyer & Hannah 1994; Paliwal 2000h; Hobbs 2003).

The United States, China, Brazil, India and Argentina are considered as the highest producing countries of maize, their production is estimated by (377.5), (224, 9), (83) and (42.3) million metric tons, respectively (World atlas 2014).

In the Sudan maize is the fourth cereal crop in cultivated areas and production after sorghum, millet and wheat (Ahmed *et al*, 2008). It is grown as a rain-fed crop in the Nubian mountains, Blue Nile and Southern Sudan. It also grown under irrigation in Central, Eastern and Northern States (Ahmed *et al*, 2008).

Globally, many Maize breeding programs conducted to improve or alter traits such as plant height, ear number, yield, maturity, kernel properties, and disease and pest resistance (Paliwal *et al*. 2000; Sleper & Poehlman 2006). In addition, maize plant breeding programs is also aimed to increase nutrient content in cultivated field maize varieties (Zhu *et al*., 2007). Specialty maize varieties are also being bred for sweet corn, high-oil content, high-quality protein, popcorn and silage. In developing countries, farmers select and maintain maize varieties adapted to specific local uses and conditions (Paliwal 2000a). In the 1940s, local maize varieties were collected in countries of Central and South America by scientists from the USA and Mexico, and those with similar morphological characteristics were grouped into land races. This classification allowed breeders to easily access maize germplasm with a particular trait of interest. However, many of these collections have been lost and new collections have been made. Currently, over 13,000 germplasm accessions are stored at CIMMYT in Mexico, with duplicate storage elsewhere (Darrah *et al*. 2003; Sleper & Poehlman 2006).

Maize is a highly cross pollinated crop and C4 type plant which is highly responsive to fertilizers resulting in high per day productivity. It offers tremendous scope for the plant breeders for genetic improvement. Several million people, particularly in the developing countries, derive their protein and calorie requirements from maize (Mbuya *et al*., 2011). With its high content of carbohydrates, fats, proteins, some essential minerals and vitamins, maize acquired a well-deserved reputation as a nutrient crop. Maize grain accounts for about 15 to56% of the total daily calories in diets of people in about 25 developing countries, particularly in Latin America and Africa, where animal protein is expensive and consequently, unavailable to a vast sector of the population (CIMMYT, 1999; Vasal *et al*, 2000).

Maize is commonly used in animal feed as an energy source for its high starch content (Oliveira *et al*., 2006). Some of the most important traits of interest in the maize market are protein and oil content. The protein content (PC) is a quantitative trait and several studies have pointed out that there is a great number of genes involved in its control (Mittelman *et al*., 2003). Protein is an expensive but necessary constituent of both food and feed. Grain protein quantity in ordinary maize is relatively low (80–110 g 1kg) and of poor quality because of low levels of amino acids, lysine and tryptophan (Bjarnason and Vasal, 1992). In the Sudan, meager studies were done to investigate quality traits and nutritive value of maize grains, therefore. The objectives of this study were:

1. To study and compare 13 maize genotypes in grain performance yield.

2. To investigate chemical composition which included Carbohydrates, protein, moisture, fiber, fats and ash of the 13 maize genotypes?

3. To measure minerals contents and physical properties which included Granule size, weight of 100 seeds, Taste of the 13 maize genotypes.

CHAPTER TWO

LITERATURE REVIEW

2.1 Historical background:

Maize (*Zea mays* L.) is one the mainly important cereal crop, most excellent intentional and most tractable genetic system among monocotyledons (Drinic *et al*, 2009). Maize it has high grain yield and great adaptation over a wide range of environmental conditions. Internationally, 67% of maize is used for livestock feed 25% for human expenditure and the rest for manufacturing purpose. Morphologically maize exhibits larger diversity of phenotypes than any other grain crop, and is extensively grow in different climates, subtropical and tropical regions of the globe. (Rajesh *et al*, 2013).

2.2 Maize taxonomy

Maize belongs to the tribe Maydeae of the grass family Poaceae. “Zea” (zela) was derived from an old Greek name for a food grass. The genus Zea consists of four species of which Zea mays L. is economically important. The other zeal spreferred to as teosintes, are largely wild grasses native to Mexico and Central America Zea (Doeblay, 1990). The number of chromosomes in mays is 2 n = 20. Tribe Maydeae comprises seven genera which are recognized, namely Old and New World groups. Old World comprises Coix (2n = 10/20), Chionachne (2n = 20), Sclerachne (2n = 20), Trilobachne (2n = 20) and Polytoca (2n = 20), and New World group has Zea and Tripsacum. It is generally agreed that maize phylogeny was largely determined by the American genera Zea and Tripsacum, however it is accepted that the genus Coix contributed to the phylogenetic Zea mays (Radu *et al*. 1997).

2.3 Uses of maize

The use of maize varies in different countries. In USA, EU, Canada and other developed countries, maize is used mainly to feed animals directly or sold to feed industry and as raw material for extractive/ fermentation industries (Morris, 1998). In developing countries use of maize is variable. In Latin America and Africa the main use of maize is for food while in Asia it is used for food and animal feed. In fact in many countries it is the basic staple food and an important ingredient in the diets of people. Globally, it has been estimated that approximately 21% of the total grain produced is consumed as food. Maize is a crop par excellence for food, feed and industrial utilization. (Gopalan *et al*, 2007).

2.4 Maize Research in Sudan

In Sudan, maize is normally grown as a rain-fed crop Kordofan, Darfur and Southern States or in small in irrigated areas in the Northern States. Since the yield of rain-fed maize is low and erratic, many studies have been carried out to determine the yield potential under different irrigation levels. Most of these studies were conducted during summer (Ahmed and El Hag, 1999).However, the total cultivated area of maize in the Sudan is increased from 17 thousand hectares in 1971 to 37 thousand hectares in 2010 (Ahmed, 2011).

2.5 Genetic variability in maize yield and quality

The success of any crop improvement program dependent on the amount o f genetic variability present in the population but also on the extent to which it is heritable, which sets the limit of progress that can be achieved through selection (Shanthi, *et al,* 2011).Genetic variability for agronomic characters therefore is a key component of breeding programmers for broadening the gene pool of crops (Ahmad, *et al*,. Khan S, Ghaffar M and Ahmad, F 2011).

Understanding the genetic variability is the starting point for gaining better knowledge of the biochemical, biophysical and genetic basis of host-plant resistance; this is essential in ensuring that traits being selected meet consumer demands. The exploitation of maize inbred lines for the generation of hybrids resistant to postharvest insect pests requires a detailed knowledge of the genetics among the lines in response to maize weevil and larger grain borer attack would form a basis for a stable breeding program towards addressing postharvest losses. The different genotypic components of variance and heritability are important in determining selection efficiency (Omoigui *et al.*, 2006). Genetic improvements in traits of economic importance, along with maintaining sufficient amount of variability are always the desired objectives in maize breeding programs (Ali, 1991; Hallauer and Miranda, 1988). Grzesiak, (2001) observed considerable genotypic variability among various maize genotypes for different traits. Ihsan et al. (2005) also reported significant genetic differences for morphological parameters in maize genotypes. This variability is a key to crop improvement.

2.5 Quality characters:

Maize is a major cereal crop for both livestock feed and human nutrition worldwide. With its high content of carbohydrates, fats, proteins, some of the important vitamins and minerals, maize acquired a well-deserved people, particularly in the developing countries; derive their protein and calorie requirements from maize. The typical mature kernel as a whole is composed of 70 – 75% starch, 8 – 10% protein and 4 - 5% oil (Boyer & Hannah 1994). However, there are large differences in relative concentrations of these components between different parts of the kernel . The two major structures of the kernel are the endosperm and the germ (embryo), constituting about 80% and 10% of the mature kernel dry weight, respectively. The endosperm is largely starch (approximately 90%) while the germ contains high levels of fat (approximately 33%) and protein (approximately 18%). These differences become a significant consideration when maize is processed for consumption. (Boyer & Hannah 1994).

2.5.1 Moisture:

Moisture dependent physical properties of maize kernels were investigated However, literatures on the combined effects of moisture variations on physical properties of maize kernels appear to be scanty. the moisture content effect on the geometric properties such as length, width, thickness, geometric and arithmetic mean diameter, surface area and sphericity, gravimetric properties like volume, kernel weight, bulk density, true density, porosity and frictional properties such as angle of repose and coefficients of friction of maize kernels.(Sangamithra, *et al.*, 2016).

2.5.2 Protein:

The second largest component in the maize kernel is protein which ranges from 8 to 11 percent (Iken *et al.*, 2002; Singh *et al.*, 2004; Orhun, 2013). Discussion of maize kernel proteins can be found in a number of articles (Boyer & Hannah 1994; Woo *et al*. 2001). Storage protein (a 7S globulin) is found in the embryo and in the endosperm. The relative amount of protein is highest in the embryo but, because the endosperm occupies a greater part of the kernel, it contributes the greatest total amount of protein (FAO 1992). The endosperm proteins can be divided into proclaims, collectively referred to as seines, and comprising about52% of kernel nitrogen; glutelins Ca 25% of kernel nitrogen); albumins (Ca7%); and globulins (Ca5%).

2.5.3 Fiber:

The traditional uses of corn fiber processing largely include animal feed, which does not command a high price. Therefore research is constantly under way to expand the use of these products. Lucrative applications of these products would provide much needed economic relief for farmers by increasing revenue and would benefit manufacturers and consumers by decreasing fuel and food costs (Dhugga KS, 2007). Much of the research concerning the utilization of corn fiber has centered on its conversion to fuel ethanol; however, food applications of these co-products may also provide added value (Gaspar M, *et al.*, 2007). Therefore in this review the composition of corn fiber will be discussed and then current and prospective research surrounding the utilization of corn fiber and corn in the production of food components. (Devin J Rose, George E Inglett and Sean X. Liu.2009).

2.5.4 Fats:

The third largest component in the maize kernel is oil which ranges from 3 to 18 percent Lipids (oil) is found mainly in the embryo, specifically in the scutellum. They comprise 40% of the dry weight of the scutellum and are used for gluconeogenesis to support the developing embryo following germination (Oaks&Beevers1964). The embryo contains approximately 33% oil while a typical whole kernel contains approximately4% oil.However, the amount and composition of oil in the kernel is under genetic control and, for ex ample, selection in one line (Illinois High Oil) after 106 generations, over more than 100 years, has continuously increased the percentage of kern el oil to over 20% (Dudley 2007).

2.5.5 Ash:

Ash is generally affected by hybrid variety, soil type, fertilization practices, and maturity (Samson, R.; Mehdi, B.1998). Reported that corn stove had high natural ash content (5.1%) compared to wood (0.5% to 1.7%). However, most harvested biomasses have a higher ash level than their natural content due to soil contamination (Hoffman, P.C. 2005). Ash content of corn stove in round bales was measured as high as 23.0% (Wright, C.L 2005) .A low ash-to-energy ratio is therefore desirable and may be improved by appropriate handling of biomass in the field.

2.5.6 Carbohydrates:

In maize seed the carbohydrate is present in high than the other chemical components. In carbohydrate amount the amount of starch is 72 to 73 percent in the maize kernel and the amount of other carbohydrates such as glucose, sucrose and fructose are 1 to 3 percent in the maize kernel (FAO., 1993; Iken *et al*., 2002; Orhun, 2013).

2.6 Minerals:

Most cereals contain minerals like calcium (Ca), copper (Cu), Iron (Fe), zinc (Zn), phosphorus (P), potassium (K), and nitrogen (N). With all the essential amino acids required by man except for lysine and tryptophan and when consumed with other food items, these can supplement for the low nutrients or even those lacking in the cereals (Ihekoronye and Ngoddy, 1995). However, deficiency in essential nutrients is not confined to cereals alone because most food consumed in developing countries either lack these nutrients (Hui 1992) or the information about their nutrient contents are lacking.

2.9 Physical properties:

The physical properties of a given biomass material such as corn cobs, leaves and stalks greatly influence the design and operation of thermochemical conversion systems. High moisture content decreases the heating value of fuel, which in turn reduces the conversion efficiency as a large amount of energy would be used for the initial drying step during the conversion processes (Mansaray and Ghaly, 1997). The particle size distribution affects the flowability, heating, diffusion and rate of reaction (Guo *et al*., 2012; Hernandez *et al*., 2010). Therefore, a full understanding of the physical properties of cobs, leaves and stalks is essential for the design and operation of efficient thermochemical conversion systems such as gasifies and combustors.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Field experiment:

3.1.1 Field

Afield experiment was conducted in the winter season of 2015 in the period from November 2015 to February 2016 at Gezira Research Station Farm (GRSF), Wad-Madni, Sudan (14° 24′ N, 33° 29′ E) and 408 meters asl), the soil is characterized by heavy cracking clay vertisol, very low permeability, PH (8.5), organic matter (0.4%), nitrogen (0.038%) and phosphorus (ESP, 4 ppm).

3.1.2 Experimental material and field Design:

The genetic material used in this study consisted of thirteen advance genetic maize lines with one local check as presented in table 1. These 13 maize genotypes were obtained from Gene Bank Agricultural Research Corporation (ARC) and used in this study to determine their quality and chemical composition, mineral content and physical properties (Table,1).

The field experiment was carried out in randomized complete block design (RCBD) with three replicates, planting was done manually in plots consisted of 4 rows, 5 meters long and spaced 0.80 m between rows, 0.25 m between holes .

3.1.3 Cultural Practices:

Sowing date was the done in first week of November, after land preparation was by: deep plowed first using chisel, harrowed by disc harrow, leveling and ridging. Thinning was carried out two weeks from sowing to one plant per hill. A dose of fertilizer application, 2N (100 kg/ha) was add in split dose after emergence of two week and before flowering. Hand weeding was done to keep the plot free of weeds. Irrigation was done every 10-14 days till the plants at each plot reached physiological maturity.

3.1.4 Data collection

Data were collected for grain yield trait of the 13 maize genotypes when they reached physiological maturity from the central rows in each plot as the following:

3.1.5 Grain Yield per Hectare (kg/ha)

For each plot the grain yield was determined of all the harvested ears in the harvest area, threshed and weighted. The grain yield was obtained by converting the yield of the actual harvested area 4.0 m^2 in to kg/ha.

3.2.1 Lab. Location and seeds preparation:

The laboratory experiment was conducted at the laboratory of food research center (FRC), National Council of Research (NCR), Ministry of Higher Education and Scientific Research (HESR) Khartoum North, Shambat, Sudan. The seeds of 13 maize genotypes were manually and separately cleaned to take away dust, broken seeds and other not pertinent materials, then the dry samples were later milled and the processing of the samples was carried out in a randomized complete design (RCD) with 3 replicates.

3.2.2Chemical analyses (proximate composition analysis):

Chemical analyses which included: moisture, protein, fiber, fats, ash and carbohydrates were carried out according to methods described in AACC (2000). The moisture content at 105ºC/12h, Crude protein was determined by the Kjeldhal’s method (N x 5.95), as well as ash content at 550ºC/5h, Crude fat in Sox let apparatus (solvent ether) and crude fiber was carried out according to method given in above reference.

Available carbohydrates were calculated by subtracting the sum of fat, protein, fiber and ash as a percentage from 100 as described by West *et al.* (1988).

The caloric values of the different samples were calculated by summing the values obtained through multiplying the contents of fats, protein and carbohydrates by the coefficients recorded bellow as IMNA (2002).

Fat factor = 8.37

Protein factor = 3.87

Carbohydrate factor = 4.12

1 K cal = 4.184 K

3.2.3 Minerals profile:

The mineral content included Ca, P, Fe, K, Zn and Na, the samples were extracted and determined by using atomic absorption spectrophotometer (model: Instrument shimadzu - AA - 6800) according to method given in AOAC (2000).

3.2.4 Physical properties:

The physical properties in this study included seed colour, granule (seed) size (mm), 100 seed weight (g) and taste. The granules size of the 13 maize seeds was recorded using vernier caliper.

3.3 Statistical analysis:

The collected data of yield character was statistically analyzed according to procedure of a randomized complete block design (RCBD) as described in SAS (2004). The statistical analysis of variance for the collected data of the chemical analysis, minerals content and physical properties was carried out for a randomized completed block design (RCD) according to SAS (2004).

The means were separated according to Duncan multiple range test at 5% level of probability (Duncan, 1955).

Table 1. List of maize genotypes used in the study.

Number	Genotype name	Origin
1	2014E37	ARC-Sudan
2	2014E63	ARC-Sudan
3	2014E74	ARC-Sudan
4	2014E79	ARC-Sudan
5	2014E80	ARC-Sudan
6	2014E92	ARC-Sudan
7	2014E95	ARC-Sudan
8	2014E98	ARC-Sudan
9	2014E104	ARC-Sudan
10	LONGS	ARC-South Sudan
11	BOMU	ARC- South Sudan
12	GBAYA Red	ARC- South Sudan
13	Hudiba-2	ARC- Sudan

ARC= Agricultural Research Corporation, Wad-Madani, Sudan.

CHAPTER FOUR

RESULTS

4.1.2 Grain yield (kg/ha):

The analysis of variance shows that there were significant differences in the thirteen maize genotypes in yield character. The highest (1286.30) and lowest (426.0) kg/ha values of yield were obtained by the genotypes BOMU and 2014E92 respectively. The grand mean was 740.3 and the coefficient of variation (C.V) was 51%. (Table, 2).

4.2 Chemical composition:

4.2.1 Moisture content%:

The analysis of variance shows that there were significant differences in the thirteen maize genotypes in moisture content. The highest (6.36%) and lowest (5.41%) obtained by the genotypes 2014E104 and Hudaiba-2 respectively. The grand mean was 5.94 and the coefficient of variation (C.V) was 2.29% (Table,3).

4.2.2 Protein content%:

The analysis of variance shows that there were significant differences in the thirteen maize genotypes in protein percent. The highest (13.42%) and lowest (9.30%) obtained by the genotypes 2014E92 and 2014E79 respectively. The grand mean was 12.0 and the coefficient of variation (C.V) was 1.80%. (Table,3).

4.2.3 Fiber content%:

The analysis of variance shows that there were significant differences in the thirteen maize genotypes in fiber content. The highest (2.89%) and lowest (0.87%) obtained by the genotypes 2014E79 and 2014E95 respectively. The grand mean was 1.65 and the coefficient of variation (C.V) was 4.39%. (Table, 3).

4.2.4 Fats content%:

The analysis of variance shows that there were significant differences in the thirteen maize genotypes in fats content. The highest (4.58 %) and lowest (2.0%) obtained by the genotypes 2014E104 and 2014E63 respectively. The grand mean was 3.32 and the coefficient of variation (C.V) was 3.45%. (Table, 3).

4.2.5 Ash content%:

The analysis of variance shows that there were significant differences in the thirteen maize genotypes in ash content. The highest (1.5%) and lowest (0.87%) obtained by the genotypes LONGS and 2014E98 respectively. The grand mean was 1.39 and the coefficient of variation (C.V) was 6.17%. (Table,3).

4.2.6 Carbohydrate content%:

The analysis of variance showed that there significant differences in the thirteen maize genotypes in carbohydrates percent. The highest (84.76%) and lowest (78.42%) obtained by the genotypes Hudiba-2 and 2014E92 respectively. The grand mean was 81.64 and the coefficient of variation (C.V) was 1.14%. (Table,3).

4.3 Minerals content:

The analysis of variance shows that there were significant differences in the thirteen maize genotypes in minerals content. The genotype GBAYA Red had higher Na (2.08) and the lowest is 2014E37 (0.93), 2014E80 had higher potassium content (358.33) and lowest (271.67) obtained by the genotypes 2014E80 and 2014E37, the highest Phosphorus content (403.33) and lowest (263.33) obtained by genotypes 2014E95 and 2014E37 respectively. Highest content of iron (2.4667) a lowest (1.46) obtained by GBAYA Red and 2014E104 respectively. The Highest content of Zn (3.06) and lowest (1.4) obtained by 2014E95 and 2014E104 respectively.

4.4 Physical properties of 13 maize genotypes:

4.4.1 Particle Size Distribution:

The genotype 2014E37 had highest particles (77mm), and lowest 2014E 95had particles (30 mm).

4.4.2 Grain colour:

Among the 13 maize genotypes, 7 genotypes shown Bright yellow to yellow grain colour,3 genotypes shown Bright yellow to dark yellow, one genotype shown Bright yellow to dark yellow, 2014E 63 shown Bright yellow to dark yellow, and GBAYA Red shown Bright yellow + red to dark red.

4.4.3 Weight of 100 grains (gm):

The weight of 100 seeds of the13 maize genotypes seeds ranged from18.4 to 31.2 gm obtained by genotypes 2014E 92 and LONGS, respectively.

4.4.4 Taste:

The taste assessment of the 13 maize genotypes seeds was alienated in this study to three ranges of facts: 5 signify desirable taste, 3-4 signify normal taste and 1-2 signify bitterness taste. 9maize genotypes included 6 local and three genotypes introduce from south Sudan exhibit bitterness taste, 4 maize genotypes integrated three local and one establish from south Sudan exhibited normal taste.

Table 2. The Mean yield of thirteen maize genotypes evaluated in Gezira winter season, 2016.

Genotypes	Grain Yield (kg/ha)
2014E37	699.3[ab]
2014E63	802.7[ab]
2014E74	686.7[ab]
2014E79	712.7[b]
2014E80	681.7[ab]
2014E92	426.0[b]
2014E95	582.7[ab]
2014E98	946.7[ab]
2014E104	634.0[ab]
LONGS	625.0[ab]
BOMU	1286.3[a]
GBAYA Red	794.0[ab]
Hudiba-2	745.7[ab]
Mean	740.3[b]
CV%	51.0
F value	0.9*

The mean with the same latters was not significant different according to Duncan Multiple Range Test (DMART).

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respect

Table 3. Means of chemical composition genotypes

Genotype	Moisture %	Protein %	Fiber%	Fats%	Ash %	CHO %	Caloric value (Kcal/100g)
2014E37	5.90^{DEF}	13.413^{A}	2.1600^{C}	3.3100^{D}	1.3800^{ABC}	80.010^{DE}	409.24^{CDEF}
2014E63	6.1067^{BCD}	13.017^{BC}	1.12 ^{BD}	2.01^{H}	1.473^{AB}	82.37^{BC}	406.20^{F}
2104E74	6.290^{AB}	12.99^{BC}	1.020^{EF}	2.4183^{G}	1.493^{A}	82.08^{BC}	408.7^{DEF}
2014E79	5.860^{EF}	9.07^{H}	2.896^{A}	3.346^{CD}	1.243^{CD}	83.44^{AB}	406.61^{EF}
2014E80	5.89^{DEF}	12.6^{D}	1.026^{EF}	2.756^{F}	1.383^{ABC}	82.23^{BC}	410.63 ^{ECDE}
2014E92	6.260 ^{AB}	13.417^{A}	2.6200^{B}	4.0567^{B}	1.3367^{BCD}	78.42^{F}	408.98^{DEF}
2014E95	5.9667^{CDE}	11.173^{F}	0.8733^{G}	3.0067^{E}	1.4167^{AB}	83.52 ^{AB}	412.53 ^{BCD}
2014E98	6.1367^{ABC}	12.880^{CD}	0.973^{FG}	4.1033^{B}	1.2133^{D}	80.83 ^{CD}	417.21^{A}
2014E104	6.363 ^{A}	12.853^{CD}	1.153^{DE}	4.5800^{A}	1.4233^{AB}	78.9 ^{EF}	413.51^{ABC}
LONGS	5.5967^{GH}	12.027^{E}	2.1567^{C}	4.1400^{B}	1.5000^{A}	80.17 ^{DE}	414.00^{AB}
BOMU	5.7633^{EFG}	13.273^{AB}	2.0567^{C}	3.353^{CD}	1.4400 ^{AB}	79.8 ^{DEF}	408.60^{DEF}
GBAYA Red	5.6867 ^{FG}	9.320^{H}	1.2467^{D}	3.5200^{C}	1.3933^{AB}	84.520^{A}	413.75^{AB}
Hudiba-2	5.4133^{H}	10.417^{G}	2.1767^{C}	2.6533^{F}	1.4700^{AB}	84.760^{A}	405.58^{F}
Grand mean	5.9413	12.035	1.6523	3.3273	1.3974	81.635	410.43
CV%	2.29	1.80	4.93	3.45	6.17	1.14	0.63

For each character, different letters indicate means are significantly different (P<0.05).

Table 4. Means of minerals (mg/kg) of genotypes:

Genotype	Ca	P	Fe	K	Zn	Na
2014E37	1.54^{B}	263.33^{I}	2.29^{ABD}	271.67^{I}	2.51^{B}	0.93^{I}
2014E63	1.6^{B}	323.33^{E}	1.8^{F}	291.67^{G}	1.52^{FG}	1.5^{FG}
2104E74	8.04^{A}	273.33^{H}	2.20^{BCD}	316.67^{E}	1.46^{GH}	1.43^{GH}
2014E79	2.30^{B}	355^{C}	2.40^{AB}	346.67^{B}	3.02^{A}	1.7^{D}
2014E80	1.45^{B}	331.67^{E}	1.91^{EF}	358.33^{A}	1.63^{E}	1.41^{H}
2014E92	1.63^{B}	290^{G}	1.51^{GH}	278.33^{H}	1.42^{H}	1.8^{C}
2014E95	2.23^{B}	403..33^{A}	2.11^{CDE}	323.33^{D}	3.06^{A}	1.48^{FGH}
2014E98	1.96^{B}	341.67^{D}	2.0^{DEF}	305.^{F}	1.5^{F}	1.6^{E}
2014E104	2.62^{B}	306.67^{F}	1.46^{H}	341.67^{B}	1.40^{H}	2.01^{AB}
LONGS	2.26^{B}	313.33^{F}	2.2^{BDD}	311.67^{E}	2.53^{B}	1.53^{EF}
BOMU	2.21^{B}	283.33^{G}	1.91^{EF}	283.33^{H}	1.81^{C}	1.81^{C}
GBAYA Red	2.04^{B}	360^{C}	2.46^{A}	331.67^{C}	1.73^{D}	2.08^{A}
Hudiba-2	2.32^{B}	404.33^{A}	1.75^{FG}	301.67^{F}	1.73^{D}	1.95^{B}
Grand mean	2.47	326	2	312.4	1.95	1.63
CV%	116.86	1.55	7.68	1.07	1.76	2.87

For each character, different letters indicate means are significantly different ($P<0.05$)

Table 5. Physical properties of 13 maize genotypes:

Genotype	Color	Granule size (mm) *	Weigh of 100 seeds (g)	Taste**
2014E37	Bright yellow to yellow	1.1x10x0.7	22.7	3
2014E63	Bright yellow to dark yellow	1.1x0.9x0.5	24	4
2014E74	Bright yellow to yellow + red	0.9x0.8x0.6	26.6	1
2014E79	Bright yellow to yellow	0.9x0.8x0.5	18.4	2
2014E80	Bright yellow to yellow	1x0.9x0.5	23.2	2
2014E92	Bright yellow to yellow	0.8x0.8x0.6	18.4	1
2014E95	Bright yellow to yellow	1x0.6x0.5	19	2
2014E92	Bright yellow to yellow	1.2x0.8x0.5	28	1
2014E104	Bright yellow to yellow	0.8x0.8x0.9	22	3
LONGS	Bright yellow	1.1x9x6	24.2	2
BOMU	Bright yellow to dark yellow	0.9x0.9x0.7	31.2	1
GBAYA Red	Bright yellow to dark yellow	1.1x0.9x0.7	26.5	2
Hudiba-2	Bright yellow + red to dark red	1x0.9x0.7	29.4	3

* LengthXwidthXthickness
** 5: Desirable, 4-3: Normal, 2-1: bitterness (Off taste).

CHAPTER FIVE

DISCUSSION

The grains of maize are comparatively highly nutritive value more than the grains of other cereals, especially in carbohydrates, fats and minerals contents. Endosperm occupies a greater part of the kernel, it contributes the greatest total amount of protein (FAO, 1992). In this study high significant differences were observed between genotypes in yield and quality traits. Variability in growth, yield and quality characters was observed by many investigators (Idris and Mohamed, 2011), (Idris and Mohamed, 2012), (Idris *et al*., 2012), (Abuali *et al*., 2012). The average of protein which is intermediary between that of rice and wheat. However, the quality is poor due to low content of two essential amino acids, tryptophan and lysine, and high concentration of leucine, which causes an imbalance of amino acids. The protein content of maize products can be improved through technological processes by moving gene responsible for protein synthesis from the ribosomal DNA of high protein plants, high values of protein content observed in this research could be of a great value for human nutrition specially for people depend on maize as a main diet. In other cereals, it is indicated that maize protein is similar to millet protein rather than that of grain sorghum in the distribution of lycine content (Elsadig *et al*., 2016). The carbohydrate content of maize and maize products obtained in this study varies, that old maize genotypes (Hudaiba-2 and GPAYA Red) having the highest carbohydrate content, then new maize genotypes similar to these findings were reported by of Ujabadenyi and Adebolu (2005). The percentage ash content falls within the range reported in the literature, Duxton *et al*., (2000) reported ash content of maize in the range of 1.4 – 3.3%. The ash content of maize bran is however, lower. Mlay *et al*., (2005) reported ash content of maize/bran as 5.1%. The lower moisture content is important as it enables long storage by minimizing fungal contamination and spoilage of the maize products. Maize bran is an important source of protein supplement and energy for ruminant (Ghol, 1981). Percentage fiber was put at a range of 0.8 – 2.32%, this result was in agreement with the findings of (Ajabadenyi and Aebolu 2005). The percentage fat obtained for maize and maize products in this study was consistent and in agreement with other researchers (Iken *et al*., 2002), the observed differences may possibly genetically or environmental factors. Crude fiber was found to be the fourth largest chemical present in maize grain after carbohydrate, protein fat and moisture content. Elsadig *et al*., 2016 reported the fats of maize are less than that millet and approximately equal to that of wheat and rice. The mineral composition of maize and maize products showed that higher percentages of magnesium, phosphorus, potassium, but with a low concentration of calcium, manganese, zinc, iron, copper, and sodium which is in agreement with the findings Oshodi *et al*., (1990). They concluded that these element are the most abundant mineral. Similarly Hussaini *et al*. (2008) showed that Nitrogen fertilizer application up to 60kg/Na ha-1 significantly increased the concentration of Nitrogen, phosphorous magnesium and potassium. This observed higher concentration of these elements in our study may possibly be due to application of fertilizer during crop growing season. However, the observed differences in mineral composition in these products may be due to genetic factor and environmental factors like irrigation frequency, soil composition and fertilizer used (Ikram *et al*. 2010). The variations in particle size distribution among the three corn residues observed in this study could be due to variations in their compositions. (Yaning Zhang *et al*. 2012). Most of the 13 maize genotypes were characterized with yellow and/or different ranges of yellow color mixed with other colors.

CHAPTER SEX

CONCLUSIONS

Based on the results obtained from this study, it could be conducted as the following:

1. The wide range of variability among thirteen genotypes of maize in yield, quality traits, chemical composition, physical properties, minerals content and grain could be of a great value in any maze breeding program aiming to obtain grain maize characterized by high yield and good quality traits.
2. Determination of proximate and mineral element compositions of maize varieties will go a long way in providing substantive nutritional information on maize, for effective guide on dietetics.
3. The genotype 2014E37 scored the highest yield (t/ha), therefore it can be selected to cultivated by farmers and/or to be a parent line in any maize hybridization program.
4. The genotype 2014E92 scored the highest value in protein, 2014E79 scored high value in fiber, 2014E104 scored the highest value in moisture, LONGS scored the highest value in fats, LONGS scored the highest in ash and Hudiba-2 scored the highest value in carbohydrate.
5. The genotype LONGS scored the higher yield and quality.

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