**Sudan University of Science and Technology**

**College of Graduate Studies**

# Evaluation of Some Maize ( *Zea mays* L.) Genotypes for Growth, Grain Yield and Resistance to Stem Borers.

# تقييم بعض الطرز الوراثيه للذره الشامية لصفات النمو وانتاجية الحبوب والمقاومة لثاقبات الساق.

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

**By**

**Mohamed Ali Mohamed**

B.Sc. Sudan University of Science and Technology-

College of Agricultural Studies, Agronomy, 2013

**Supervisor**

**Dr. Atif Elsadig Idris**

Department of Agronomy

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# Dedication

**TO my great mother.**

**TO my father soul, (Allah mercy him)**

**To my lovely family.**

# Acknowledgment

First praise and thanks to **ALLAH for** 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 support and kindness and wonderful care in directing and supervising this work. My thanks extended to **Dr. Mohammedein BabekerAlhussein** (ARC) for providing me with materials used in this study and to **Mudawi Hassan Hamalon**, **Mohammed Komsari**, **Esameldeen Ahmed** and to my teachers and colleagues at Department of Agronomy, College of Agricultural Studies, Sudan University of Science and Technology.

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Abstract

In Sudan maize (*Zea mays* L.) subjected mainly to two Lepidopteran stem borers, *Chilo partellus* and *Sesamia cretica*, causing considerable decrease in yield at the end of the season. A field experiment was conducted at Agricultural Research Corporation (ARC), Gezira Research Station Farm, Wad Medani, Sudan, during winter season of 2016. The experiment was arranged in Randomized Complete Block Design (RCBD) with three replications. A thirteen maize genotypes were evaluated for growth, yield and it‘s components and insect infestation of stem borers which included (leaves damage, number of holes per plant and tunnels length). Phenotypic correlation between different characters was calculated. The results showed that there were significant differences among maize genotypes for some growth, yield characters and insect infestation. Phenotypic correlation between plant heights, stem diameter, number of holes and tunnels length was positive and significant. The higher level of leaves damage (4.6) and the lower (2.6) were obtained for the genotypes 2014E 37 and 2014E 92, respectively .The higher and lower level of number of holes /plant was (2.71) and (1.7 ) and scored for the genotypes 2014E 79, LONGS and BOMU, respectively .The higher and lower level of tunnels length ranged between (3.24 ) and (1.34) and obtained by genotypes LONGS and 2014E 98 respectively. The genotypes LONGS and 2014E 98 scored the highest grain yield of (1286.3 kg/ha) and (946.7 kg/ha), in respect of their obtaining high of leaves damage (3.6) and (3.3) and high the number of holes /plant of (2.7) and (1.71) and high tunnels length of (3.24 ) and (1.34), respectively. This result illustrate the ability of these two genotypes to obtain high yield coupled with their tolerant to insect infestation .Therefore, they could be of high benefit in any maize breeding program for resistance to stem borer in future.

# المستخلص

الذرة الشامية في السودان تتعرض بشكل اساسي لنوعين من ثاقبات الساق مسببه نقصان مقدر في الانتاجية نهاية الموسم. اجريت هذه التجربة بهيئة البحوث الزراعية ، بمحطة ابحاث الجزيره ، ود مدني ، السودان في الموسم الشتوي 2016م. حيث تم استخدام تصميم القطاعات الكاملة العشوائية بثلاث مكررات وذلك لتقييم 13 طراز وراثي من الذرة الشامية الحبوب لصفات النمو، الإنتاجية ومكوناتها والاصابة بثاقبات الساق و التي تضمنت (تلف الاوراق ، عدد الثقوب في الاوراق وطول الانفاق في الساق). تم حساب الارتباط المظهري بين الصفات المختلفة. اظهرت النتائج فروقات معنوية بين طرز الذره الشامية في بعض صفات النمو والإنتاجية وفي صفات الاصابة بثاقبات الساق. الارتباط بين كل من طول النبات وقطر الساق، عدد الثقوب وطول النفق كان معنويا وموجباُ. اعلى واقل قيمة تلف للاوراق هي (4.6) و (2.6) واحرزت للطرز 2014E 92 و 2014E 37 على التوالي. اعلي واقل قيم لعدد الثقوب في الاوراق تراوح بين (2.71) و (1.71) واحرزت للطرز BOMU و2014E 79، LONGS على التوالي. اعلى واقل قيم لطول الانفاق في الساق كان (3.24) و (1.34) و احرزت للطرز 2014E 98 , LONGS على التوالي . الطرز الوراثية LONGS , 2014E 98 سجلت اعلى قيم انتاجية (1286.3 كيلو جرام /هكتار ) و (946.7 كيلو جرام / هكتار ) على الرغم من احرازها قيم عالية لتلف الاوراق تراوح بين (3.6) و (3.3) و عدد كبيرمن الثقوب في الاوراق تراوح بين (2.71) و (1.71) وايضا اطول طول الانفاق في الساق تراوح بين (3.24) و (1.34) على التوالى. هذه النتيجة اوضحت مقدرة هذين الطرازين في الحصول على انتاجيه عالية متزامنة مع اصابتها بثاقبات الساق ولذلك يمكن ان تكون ذات فائدة عالية في اي برامج تربية ذرة شامية بهدف مقاومة ثاقبات الساق في المستقبل .

# CHAPTER ONE

# INTRODUCTION

Maize (*Zea mays* L.) is as an important cereal crop in many developing countries. It grows over a wide capital ranges and various environments than any other cereal crop. It is considered as the third most important cereal crop on a global basis (CIMMYT and EARO, 1999). To the fact that, it is cultivated and adapted to a wide range of environment more than wheat and rice the world's top ranking food crop (Koutsika-Sotiriou, 1999). Maize originated in Mexico about 6,000 to 7,000 years ago (Smith 1995). A major differences and primary center of origin of maize is considered by most authorities to be central America and mexico where many diverse types of maize are found (Panda, 2010). The closest relative of domesticated maize is the annual teosinte, which grows in Mexico, Guatemala and Nicaragua and is thought to be the ancestor of maize as it has the same number of chromosomes. It has no known wild relatives of the same genera. Teosinte and maize can hybridize and produce fertile progeny under some circumstances, although gene flow from maize to teosinte is very limited due to a genetic barrier (Evans and Kermicle 2001). Maize was introduced into Africa in the 1500s and has since become one of Africa's dominant food crops. Maize is the most important cereal crop in sub-Saharan Africa (SSA) and it is the most staple food for more than 1.2 billion people in SSA and Latin America. All parts of the crop can be used for food and non-food products. Nowadays, there is an increasing interest in maize production in Sudan to be cultivated in the agricultural irrigated schemes, especially in the Gezira state. In addition, maize can occupy an important position in the economy of the country due to the possibility of blending it with wheat for making bread (Nour *et al*., 1997; Meseka, 2000).

The maize is attacked by different species of stem borer, but the most the important species is the spotted stem borer, Chilo partellus(Swinhoe), which belong to *Lepidoptera, Pyralidae.*The first instars Sesamia cretica larvae feed in the whole seedlings, making rows of oval perforations. Later instars tunnel into the mid-ribs and cause damage to the growing point leading to the conditioning of the dead hart. Usually stop reproductive growth and produce more tillers without heads (khan *et al*., 1997). The second generation feed on the tender tassels and enters the stalk. Heavy lodging may occur due to stem boring the stalk tunneling which caused to reduce grain yield (Marra *et al*. 2012) by interfering with physiological processes, physically weakening the stalk and ear shoot and providing points of entry for pathogens associated with stalk rot (Marra *et. al* 2012). Substantial yield losses are caused by heavy infestation of the plant by stem borrers (Ostlie *et. al 2008).* In Sudan maize is subjected mainly to two Lepidopteran stem borers, Chilo partellus and Sesamia cretica. Damage by Chilo partellus and Sesamia cretica to young plants ranges from feeding on the whorl leaves causing dead-hearts, older plants causing longitudinal tunnels into the stems, tassels and ears and severe damage to the infested plants causing considerable decrease in yield by the end of the season (Isa *et. al.*, 1969; El-Wakeil, 1997; Ahmad and Akhtar, 1979 and Awan and Abdul Khaliq, 2003).

The maize genotypes characterized with high ability to resist and/or tolerate stem borer incidence can play a great role in maize breeding programs and economics costs of different pests control methods.(Kumar 1997).Therefore the specific objectives of this study were:

1. To evaluate some grain maize (Zea mays L.) genotypes for growth, yield and resistance to stem borer.

2. To study the interrelationship among maize genotypes traits and their infestation parameters.

# CHAPTER TWO
# THE LITERATURE REVIEW

## 2. 1 Historical background

Maize or corn (*Zea mays* L.) belong to family and it is one of the most important cereal crops worldwide not only as human nutrient but also as a basic element for feed animals and raw material for manufacturing of many industrial products. These products include corn starch, maltodextrins, corn oil, corn syrup and products of fermentation and distillation industries and recently being used as biofuel (Mohammed, 2004). This linear-growth production is relatively constant for the major cereals, sustaining production parallel to population increase; though other reports present a decline in the global stock-to-usage ratio since 2005 of about 7%. This indicates an increase in the consumption but not in the production of maize, due to new uses found for the crop (Karvy-Comtrade limited , 2007).There is conflicting evidence to support the hypothesis that maize yield potential has increased over the past few decades this suggests that change in yield potential are associated with leaf angle lodging resistance,tolerance of high plant density disease,pest tolerance and other agronomic traits rather than increase of yield potential per individual plant . (Duvic , and Cassman , 2009).

## 2.2 Uses of Maize

Maize is used for two main purposes animal feed and human food. Animal feed represents 65% of the total world maize production, while 15% is used for food and the remainder 20% has different industrial uses. The trend for global cereal demand in the next decade is expected to increase, and in the case of maize it is expected to surpass the demand of wheat and rice. Considering FAO's latest estimations and (CIMMYT) predictions that “the shift (to maize) will be reflected in a 50% increase in the demand from 1995 (558 million tons) to (837 million tons) by 2020 (CIMMYT, 1999).

**2.3 Maize in Sudan**

— Maize is a promising cereal crop in Sudan with the potential usefulness for both human beings and livestock (Salih et al., 2008). It ranks the fourth important cereal crop in Sudan after sorghum, wheat and pearl millet. In the Sudan, Maize grown in small scales under rain fed conditions in Kordofan, Darfour, and Southern states, under irrigation in Northern States and under flood irrigation in Kassala State (Ali, 1991). The total cultivated area of maize in the Sudan increased from 80 thousand hectares in 1989/91 to 187 thousand hectare sin 1998. Average yield was 632 kg/ hectare (FAO. 1998). Maize has a lower priority in agricultural development plans in the Sudan due to low yield potential, limited local uses and low market price. However (Ajala, 1997) have the opinion that the lack of adapted lines with high yield potential and good resistance to water stress are the major limiting factors for maize production in the Sudan. The optimum planting date of maize in Sudan is one of the key components for farmers and growers to get better maize yields. The warm mean daily temperature and the stem borer infestation are the two major abiotic and biotic stresses that limit maize production in northern and other parts of Sudan. Earlier investigators research in northern Sudan showed that maize could be grown all the year round. In this regard, El karouri and Mansi (1980) reported that the mean daily temperature is the most important environmental factor that greatly influences maize final yields. While, Babiker (1997) reported that poor or no yields were obtained with delayed sowing dates due to stem borer damage at Rahad Research Station. In contrast, El Karouri and Mansi (1980) obtained high maize forage yield from winter sowing (November- December) in Khartoum area. In northern Sudan, although research on maize in the past focused more on breeding aspects, however, Imam (1965) found that the optimum planting time for maize under Hudeiba Research Station conditions would be from the last week of September to the end of October, 1 Hudeiba Research Station, (ARC) 2 Gezira Research Station,. while, Ibrahim (1995) on the same site obtained high maize grain yield from November sowing as compared with that of December or January, which could be attributed to the suitable low temperatures at the nicking stage. Long- term maize sowing date experiment was conducted during 1999- 2000 season at Hudeiba Research Station by the first author. It showed that maize could be grown all the year round, However, substantial maize grain yields were obtained when sown from the first week of August to the end of January. The recommendation for maize to be grown as a winter crop showed that, the optimum sowing date was the first week of October (Abdel Rahman *et al*., 2003). However, their results were obtained from three planting dates (October, November and December). Furthermore, the Husbandry Committee argued that one month sowing interval is too long and it is better to use the 15-days interval. Therefore, in this study 13 sowing dates were used to determine the optimum planting time for maize in such a way that maize growers will have optional sowing dates and also, to fine- tune the previous optimum sowing date recommended for northern Sudan.

## 2.4 History of Maize Breeding

The Prior to 1909, nearly all maize breeding was done by farmers or farmer/seeds men, who used mass selection as their main breeding method (Hallauer *et, al.* 1988). In 2011, herbicide-resistant GM corn was grown in 14 countries (James, 2011, Hogan, 2012) .Bt corn is a variant of maize that has been genetically altered to express one or more proteins from the bacteria, Bt (California University, 2010). The protein is poisonous to certain insect pests and is widely used in organic gardening. (Marra *et. al.,* 2012) .It the Bt protein is expressed all through the plant. When a targeted insect eats the Bt-containing plant, the protein is activated in the gut of the insect, in the alkaline environment the protein partially unfolds and is cut by other proteins, forming a toxin that paralyzes the insect's digestive system and forms holes in the gut wall.

According to Laurie *et al*.,( 2004) maize have very wide and variety utilization ,because of that, the main goal of all maize breeding programs is to obtain new open pollinated verities and hybrid, that will outperform the existing hybrids with respect to a number of traits, by desirable dominant genes can be accumulated while the undesirable ones are eliminated (Gallais,1989; Saleh *et al.,* 1993). Breeding of high yield crops require information on the nature and magnitude of variation in the available materials, relationship of yield with other agronomic characters and the degree of environmental influence on the expression of these component characters. Since grain yield in maize is quantitative in nature and polygenic ally controlled, effective yield improvement and simultaneous improvement in yield components are imperative (Bello, O.B.and G.Olaoye, 2009). Although maize is emerging as an important cereal crop in Sudan, the vast majority of farmers still practice recycling seeds of open pollinated varieties (OPVs) without continuous maintenance measures. Some of the farmers believe that there is a small or no difference in yield between hybrids and OPVs and instead rely on saved seeds from their own harvest or obtain from other farmers. Farmers who grow maize and retain the seed from year to year are growing OPVs of their own selection (landraces). An estimated 95% of maize area in Sudan is being planted under routine recycled OPVs. Recycling of maize varieties would lead to seed contamination, loss of vigour and consequently reduction in yield potential (Setimela and Kosina, 2006). Pixley and Bänziger (2004) assessed the yield reduction of cultivar types incurred by planting recycled seeds relative to fresh seeds of cultivar types across locations. Meseka et al. (2002) used some maize collections in Sudan for varietal crosses at Gezira Research Farm (GRF) and found that some local OPVs such as VAR 113 released in 1970s had good combining ability in hybrid combination with yield advantage of 8% over their parent OPVs. Correjado and Magulama (2008) compared topcross hybrids with their parental OPVs and found that the top-crosses had yield advantage of 17% over their parental OPVs. They also observed significant differences among the top-cross hybrids with yield ranging from 3.8 to 6.2 t ha-1. These studies (Meseka et al., 2002; Pixley and Bänziger, 2004; Correjado and Magulama, 2008) suggested that moving from recycled OPVs to varietal cross and top-cross hybrids will increase the productivity of maize in Sudan. The cheap seed price for nonconventional hybrids as compared to conventional hybrids will be of an advantage for the majority resource poor farmers in Sudan. Most of the local varieties in the Sudan are named after locations where they are commonly grown (Meseka, 2000). Some of these local varieties include Dallenge (in Nuba Mountains), Sennar and Damazin (in Sennar and Southern Blue Nile States). Until recently, most farmers all over the world widely believed that the yield advantage of hybrids is expressed only with good management (Heisey et al., 1998), under optimum conditions. Others urged that under conditions of low fertility or in presence of abiotic stresses (heat, drought, water logging),hybrids perform more poorly than OPVs or even local varieties (Friis-Hansen, 1989). Most of these instances involve hybrids that were either introduced without adequate testing to ensure their suitability for local production conditions or developed using only exotic germplasm which were not well-adapted to the local environment. Maize hybrids developed from well-adapted germplasm are profitable and can significantly outyield local varieties or improved OPVs even when grown in marginal production environments under low levels of management (Heisey et al., 1998), typically of resource poor farmers in Sudan.

**2.5 Problems of Production of Maize**

Maize is most vulnerable to *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) which causes severe losses to maize crop. It is an important pest in Asian and African countries (Arabjafari and Jalali, 2007). Maize production is severely affected by maize stem borer to the degree of 15 -60%. A loss of 24-75% has been reported by the attack of this pest alone (Kumar, 2002). Farid et al. (2007) reported 10-50% damage by maize stem borer in Peshawar valley. Yield losses caused by stem borers in Africa are as high as 80% for maize alone, while in Kenya, 18% yield losses was attributed to *C. partellus* and *C. orichalocociliellus* in maize. Maximum stalk damage in maize by *Chilo partellus* were reported in 20 days old crops, whereas, similar infestations induced no significant loss when plants were infested soon (6 days) after emergence (Van den berg, 2009). Most of the increase in production has come from expansion in the area harvested rather than from increases in yield on none expansive acreages (Ahmad *et al*., 2000).Various species of stem borers rank as the most devastating maize pests in Sub-Saharan Africa (SSA).They can cause 20-40% losses during cultivation and 30-90% losses postharvest and during storage. Other pests in SSA include ear borers, armyworms, cutworms, grain moths, beetles, weevils, grain borers, rootworms, stem borers and white grubs. The parasitic striga weed is another maize pest. In fact, weed-related yield losses ranging from 65 to 92% have been recorded in the Nigerian savanna alone (Maddonni *et al*., 2006). Maize diseases in SSA include downy mildew, rust, leaf blight, stalk and ear rots, leaf spot, and maize streak virus (MSV) (Muasya and Diallo, 2006)

## 2.6 Stem borers

In the Sudan the moth occurs mainly in the drier, irrigated parts, especially in the northern and central Sudan. In the south it seems to be rather rare, if present at all. It is occurring rows of irregular holes on the plant leaves. Older larvae penetrate into the heart or the stem of the host plant. Nearly fully-grown caterpillars quite often bore in the base of sorghum heads which are still covered by a leaf sheath.They thus prevent the head form leaving the sheath completely, Badly attacked maize plants produce a low yield .They often collapse during storms as their heads and stems are weakened by the mines and bore holes of the pest. Schumutterer, (1969). The spotted stalk borer (*Chillopartellus*) geographic distribution in native Asia where it is considered to be a pest of maize and sorghum. It was reported in Africa in 1930 in Malawi, and has since spread to most countries in eastern and southern Africa, including Ethiopia, Kenya, Malawi, Mozambique, Somalia, South Africa, Sudan, Tanzania, Uganda (CABI 1977).

### 2.6.1 Damage Symptoms of Stem borers

Stem borers damage plants by feeding on the leaves and in the stems and cobs. Early instars of larvae of *Chilo spp*. and *B. fusca* typically migrate from the ovipositor site to the whorl where they feed for the first two or three instars on the young succulent leaf tissue the damage becomes quite evident as the leaves mature and expand out of the leaf sheath. *Sesamia spp*. feed for a few days in the leaf sheath and then tunnel into the stem. The entrance holes chewed by larvae when entering the stem can often be seen, and in moist plants may be accompanied by fracases pushed out (Overholt *et. al*., 2001). Prior to pupation, stem borer larvae chew an exit hole for the emergence of the moth. The hole is sometimes referred to as a window because it is not chewed completely through the stem but leaves the transparent leaf epidermis. At the reproductive stage of maize, stem borers may be found feeding in the maize cobs (Overholt *et. al.*, 2001).

### 2.6.2 Management of Stem borers

Control measures have been devised to minimize the economic impact of the damage caused by stem borers. Stem borers have been controlled by cultural, biological, host plant resistance and chemical methods (Bosque-Perez, 1995). Cultural control methods include agronomic practices such as crop rotation, planting and harvesting dates (Bosque-Perez, 1995). Chemical control methods under severe infestation, it can provide an effective means of managing stem borers. However, chemical application is only effective if pest scouting and monitoring have been successful prior to crop damage. Furthermore as stem borers burrow into the stem, they are often protected from insecticides applications. This control includes the use of insecticide as well as other chemicals such as attractants and repellents (Bosque-Perez, 1995). The best methods as the integrated pest management (IPM), this is the term used to describe the management of pests by integrating compatible control methods in an environmentally sound manner. Integrated pest management of stem borers combines cultural biological, host plant resistance and chemical control methods to manage them. The use of insecticides is always the last resort in IPM control (Bosque-Perez, 1995). Host plant resistance to insects is the genetic property that enables a plant to avoid, minimize, tolerate or recover from injury caused by insects (Bosque-Perez, 1995). Therefore, plant resistance to stem borers is also a genetic trait which manifests itself as antibiosis, in which the biology of the pest is adversely affected after feeding on the plant; non-preference, where by the plant is not desirable as a host and the stem borer seeks alternative hosts; and tolerance, where the plant is able to withstand or recover from stem borer damage (Mugo, *et al.,* 2005).

## 2.7 Variability in Maize

Genetic improvement in traits of economic importance along with maintaining sufficient amount of variability is always the desired objective in maize breeding programs (Hallauer,1972). Grzesiak (2001) observed considerable genotypic variability among various maize genotypes for different trait. Ihsan *et al*. (2005) also reported significant genetic differences for morphological parameter of maize genotypes. This variability is a key to crop improvement. Most breeders in maize breeding programs depend on the direction of the association between yield and its components and other factors involved. As that agriculturally, path analysis used by breeders to assist in traits to improve crop yield (Milligan *et al*, 1990). Mani *et al.,* (1999) suggested that a grain per row was the best direct contributor to grain yield/plant. Hence, maize breeders should give more importance to grains/row as selection criteria for yield improvement.

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1 Experiment site

A field experiment was conducted in the winter season of 2015 in the period from November 2015 to February 2016 at wad-madani, Gezira Research Station Farm (GRSF) located in central clay plain in the Sudan ($14^0$ $24^'$ N, $33^0$ $29^'$ E and 408 meters asl), the soil was characterized by heavy cracking clay vertisol, very low permeability, pH (8.5), organic matter (0.4%), nitrogen (0.038%) and phosphorus(ESP,$^4$ ppm) (Abdrhman. G, 2015).

## 3.2 Experimental material and 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 maize genotypes obtained from Gene Bank, Agricultural Research Corporation (ARC), be used in this study to determine their yield and resistance to stem borer (Table,1).The 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 which spaced 0.80 m between rows and 0.25 m between holes the and harvested area was 16.0 $m^2$ .

## 3.3 Cultural practices:

Sowing date was the third week of November, after land preparation was done as the following: deep plowed first using chisel, harrowed by disc harrow, leveling and ridging. Three seeds per hill were sown. Thinning was carried out two weeks after seedling emergence to one plant per hill. A dose of fertilizer application, 2N (100kg /ha) was added in split dose after emergence of two weeks and before flowering. Hand weeding was done to keep the plot free of weeds. At physiological maturity, when the leaves and husks of the plant started to turn yellow and dry, the central rows were harvested in each plot then grain weight per plot after threshing, were done.

## 3.4 Data collection:

### 3.4.1 Days of 50% flowering

Days of 50% tassaling (DT), were taken as the number of days from sowing to the time when 50% of plants within a plot had shed pollens. And days of 50% silking( DS ) were taken as the number of days from sowing to the time when 50% of the plants within a plot had exerted silks about 1-2 cm long from the ear tip.

### — 3.4.2 Ear height ( cm)

— Measured in centimeter as an average height of the random sample of five plants in the harvest area . It was measured from the soil surface to the node bearing the upper most ears.

### 3.4.3 Ear length (cm)

Ear length was measured in centimeter as an average of random sample of five ears from the base to the tip of ear.

#### 3.4.3.1 Effective ear length (cm)

Effective ear length was measured in centimeters as an average of random sample of ears, for the effective length where kernels were produced on the ear.

### 3.4.4 Ear diameter (cm)

Ear diameter was measured in centimes using venire caliper , measurements were taken on deferent positions on the ear (the top, middle and bottom) and the average from sample of five plant in the harvested area.

**3.4.5 Number of grains per row**

It was determined from harvested area as three grains rows taken randomly from each three ears and then number of grains per row, as average was determined.

**3.4.6 Weight of 100 seeds (g)**

The average weight of 100 kernels was taken at random from the bulk of kernels from a random samples of ears harvested in each plot by grams .

**3.4.7 Grain yield (kg/ha)**

After ear dried and threshed, the dry weight of grains from all the harvested ears per plot was obtained. The grain yield was obtained by converted the yield of the actual harvested to kg/h.

**3.4.8 Leaf number per plant**

Leaves number taken as averages of random sample of five plants from each plot.

3.4.12 **Leaf damage per plant**

The average of the leaves damage was taken of random sample of five plants from each plot.

3.4.13 **Plant height (cm)**

It was measured by centimeter as an average height of random sample of the five plants in the each plot. It is measured from the soil surface to the node bearing the upper most ears.

**3.4.11 Number of holes per plant**

Number of holes per plant was determined as a number of holes a counted on the leaves an average counts from five plant taken at random sample from each plot.

3.4.13 **Stem diameter(cm)**

Stem diameter was measured by using venire caliper from stem of five plants in each plot measurement taken on different positions on the stem ( the top, middle and bottom ) and then the determined.

**3.4.13 Tenniel length (cm)**

Tenniel length was measured in centimeters as an average of random sample of five plant stems from each plot.

**3.5 Statistical analysis**

Analysis of the variance was carried out on data collected used statistical analysis system, with SAS version 9.1 ( SAS Institute, 2003 ) computer package to detected differences among the maize genotypes resistant to stem borer infestation and the means were compared by applying Duncans Multiple Range Test (DMRT), at both levels 0.05 and 0.01.

**3.6 Phenotypic and genotypic correlation**

Phenotypic correlation coefficients between pairs of different traits were determined, according to the formula suggested by miller *et al.* (1958)

$$\mathrm{rp} = \frac{\mathrm{cov\ xyp}}{\sqrt{(\sigma 2\ \mathrm{phx})(\sigma 2\ \mathrm{phy})}}$$

(Phenotypic correlation of coefficient)

Where:

$\sigma phxy$ is the phenotypic covariance between two pairs, x and y

$\sigma 2ph\ x\ and\ \sigma 2ph\ y$ are the phenotypic variance for traits x and y

**Table (1) The studied genotypes in Gezira Research Station Farm winter season, 2016.**

| Number | Genotype name | Origin |
|---|---|---|
| 1 | 2014E 37 | ARC-Sudan |
| 2 | 2014E 63 | ARC-Sudan |
| 3 | 2014E 74 | ARC-Sudan |
| 4 | 2014E 79 | ARC-Sudan |
| 5 | 2014E 80 | ARC-Sudan |
| 6 | 2014E 92 | ARC-Sudan |
| 7 | 2014E 95 | ARC-Sudan |
| 8 | 2014E 98 | ARC-Sudan |
| 9 | 2014E 104 | ARC-Sudan |
| 10 | PDU | ARC-South Sudan |
| 11 | LONGS | ARC- South Sudan |
| 12 | BOMU | ARC- South Sudan |
| 13 | GBAYA Red | ARC- South Sudan |

# CHAPTER FOUR
# RESULTS

## 4.1 Days to 50% flowering

### 4.1.1 Days to Tasseling

The statistical analysis of variance showed that there were non-significant between maize genotypes for days to tasseling. The means of this character ranged between 59 to 73 days recorded for the genotypes 2014E37 and PDU, respectively. The coefficient of variation (C.V) for this character was (4.0).

### 4.1.2 Days to Silking

The statistical analysis of variance showed that there were significant between maize genotypes for days to silking. The means of this character ranged between 71 to 76 days recorded for the genotypes 2014E79 and PDU, respectively. The coefficient of variation (C.V) for this character was (2.0).

## 4.2 Ear Height (cm)

The statistical analysis of variance showed that there were significant between maize genotypes for ear height. The means of this character ranged between 57 to (40.3) recorded for the genotypes PDU and 2014E95, respectively. The coefficient of variation (C.V) for this character was (16.9).

## 4.3 Ear length (cm)

The statistical analysis of variance showed that there were significant between maize genotypes for ear length.The means of this character ranged between 17 to 12 recorded for the genotypes LONGS and 2014E92, respectively. The coefficient of variation (C.V) for this character was (10.1).

## 4.4 Ear Diameter

The statistical analysis of variance showed that there were significant between maize genotypes for ear diameter. The means of this character ranged between (4.1) to (3.2) recorded for the genotypes BOMU and 2014E92, respectively. The coefficient of variation (C.V) for this character was (9.3).

## 4.5 Number of grains per row

The statistical analysis of variance showed that there were significant between maize genotypes for number of grains per row. The means of this character ranged between (14.3) to (12.6) recorded for the genotypes 2014E79 and GBAYA RED, respectively. The coefficient of variation (C.V) for this character was (9.2).

## 4.6 100 Grain weight (g)

The statistical analysis of variance showed that there were significant between maize genotypes for 100 grain weight. The means of this character ranged between (29.9) to (15.8) recorded for the genotypes BOMU and 2014E92, respectively. The coefficient of variation (C.V) for this character was (11).

## 4.7 Maize grain yield (kg/ha)

The statistical analysis of variance showed that there were significant between maize genotypes for maize grain yield. The means of this character ranged between (1286.3) to (426) recorded for the genotypes LONGS and 2014E92, respectively. The coefficient of variation (C.V) for this character was (11).

**Table (2) The mean performance of thirteen maize genotypes evaluated in Gazira winter season (2015).**

| Genotype | Days to 50% Tassling | Days of 50% Silking | Ear Height (cm) | Ear lengths (cm) | Ear Diameter | Number of Grain /row | Hundred Grain Weight (gm) | Grain Yield (Kg/ha) |
|---|---|---|---|---|---|---|---|---|
| 2014E37 | 59.0a | 73.0bc | 45.0ab | 13.4bc | 3.4ab | 14.0a | 21.4cde | 699.3ab |
| 2014E63 | 69.0a | 73.0bc | 53.6ab | 14.1bc | 4.0a | 14.0a | 23.1bcd | 802.7ab |
| 2014E74 | 71.0a | 75.0ab | 48.0ab | 13.7bc | 3.7ab | 13.6a | 21.7cde | 686.7ab |
| 2014E79 | 71.0a | 71.0c | 43.3ab | 15.0ab | 3.8ab | 14.3a | 23.4bcd | 712.7 |
| 2014E80 | 73.0a | 73.0abc | 49.0ab | 13.8bc | 3.7ab | 14.0a | 19.6def | 681.7ab |
| 2014E92 | 71.0a | 75.0abc | 52.3ab | 12.0bc | 3.2b | 13.6a | 15.8f | 426b |
| 2014E95 | 70.0a | 74.0abc | 40.3b | 13.6bc | 3.8ab | 14.3a | 18.0ef | 582.7ab |
| 2014E98 | 69.0a | 72.0bc | 51.6ab | 14.0bc | 3.9a | 14.0a | 22.1bcde | 946.7ab |
| 2014E104 | 71.0a | 75.0abc | 50.0ab | 15.8ab | 3.7ab | 13.3a | 25.1bc | 634ab |
| PDU | 73.0a | 76.0a | 57.6a | 13.8bc | 3.7ab | 13.6a | 21.4cde | 625ab |
| LONGS | 68.0a | 75.0ab | 51.3ab | 17.0a | 3.7ab | 13.3a | 26.2abc | 1286.3a |
| BOMU | 71.0a | 75.0ab | 56.3ab | 15.7ab | 4.1a | 13.0a | 29.9a | 794ab |
| GBAYA Red | 70.0a | 73.0abc | 56.0ab | 15.7ab | 3.8ab | 12.6a | 26.8ab | 745.7ab |
| Mean | 70 | 74 | 50 | 14.4 | 3.7 | 13 | 22.6 | 740.3 |
| CV% | 4 | 2.4 | 16.9 | 10.1 | 9.3 | 9.2 | 11 | 51 |
| F value | 0.78ns | 1.9* | 1.1* | 2.4* | 1.23* | 0.5ns | 6.9** | 0.9* |

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

*,**,*** Significant at 0.05, 0.01 and 0.001 probability levels, respective.

### 4.8 Leaf number per plant

The statistical analysis of variance showed that there were significant between maize genotypes for Leaf number per plant. The means of this character ranged between 12 to 10 recorded for the genotypes GBAYA RED, 2014E74 and PDU,LONGS, respectively. The coefficient of variation (C.V) for this character was (9.3).

### 4.9 Leaf damage per plant

The statistical analysis of variance showed that there were significant between maize genotypes for leaf damage per plan. The means of this character ranged between (4.6) to (2.6) recorded for the genotypes 2014E37 and 2014E92, respectively. The coefficient of variation (C.V) for this character was (20.9).

### 4.10 Plant height (cm)

The statistical analysis of variance showed that there were significant between maize genotypes for plant height. The means of this character ranged between (132.3) to (101.6) recorded for the genotypes PDU and 2014E95, respectively. The coefficient of variation (C.V) for this character was (12.8).

### 4.11 Number of holes per plant

The statistical analysis of variance showed that there were significant between maize genotypes for number of holes per plant. The means of this character ranged between (2.71) to (1.04) recorded for the genotypes 2014E 79, LONGS and BOMU, respectively. The coefficient of variation (C.V) for this character was (61).

### 4.12 Stem diameter

The statistical analysis of variance showed that there were significant between maize genotypes for stem diameter. The means of this character ranged between (1.40) to (1.36) recorded for the genotypes 2014E 98 and2014E 80, PDU, respectively. The coefficient of variation (C.V) for this character was (14).

### 4.13 Tunnel length

The statistical analysis of variance showed that there were significant between maize genotypes for stem diameter. The means of this character ranged between (3.24) to (1.34) recorded for the genotypes LONGS and 2014E98, respectively. The coefficient of variation (C.V) for this character was (58).

**Table (3) The stem infestation rate of thirteen maize genotypes evaluated in Gezira winter season, 2016.**

| Genotypes | Leaf number/plant | Leaf damage/plant | Plant height | Number of holes/plant | Stem diameter | Tenniel length |
|---|---|---|---|---|---|---|
| 2014E 37 | 11.0a | 4.6a | 103.0ab | 2.37a | 1.03b | 2.54a |
| 2014E 63 | 11.0a | 3.3ab | 114.0ab | 2.04a | 1.23ab | 2.11a |
| 2014E 74 | 12.0a | 4.0ab | 121.0ab | 1.71a | 1.30ab | 2.04a |
| 2014E 79 | 11.0a | 3.6ab | 114.3ab | 2.71a | 1.33ab | 1.74a |
| 2014E 80 | 11.0a | 3.6ab | 112.0ab | 1.71a | 1.36ab | 2.41a |
| 2014E 92 | 11.0a | 2.6b | 114.0ab | 1.37a | 1.33ab | 2.04a |
| 2014E 95 | 11.0a | 3.6ab | 101.6b | 2.37a | 1.03b | 2.57a |
| 2014E 98 | 11.0a | 3.3ab | 118.3ab | 1.71a | 1.40a | 1.34a |
| 2014E 104 | 11.0a | 3.3ab | 107.6ab | 1.37a | 1.30ab | 3.01a |
| PDU | 10.0a | 4.0ab | 132.3a | 1.71a | 1.36ab | 3.11a |
| LONGS | 10.0a | 3.6ab | 127.6ab | 2.71a | 1.30ab | 3.24a |
| BOMU | 11.0a | 4.0ab | 111.6ab | 1.04a | 1.13ab | 2.01a |
| GBAYA Red | 12.0a | 4.3a | 128.6ab | 1.71a | 1.10ab | 2.54a |
| Mean | 10.8 | 3.7 | 115.8 | 1.88 | 1.24 | 2.40 |
| CV% | 9.3 | 20.9 | 12.8 | 61 | 14 | 58 |
| F value | 0.57 | 1.26* | 1.22* | 0.59 | 1.61* | 0.88 |

The means with the same later in Colum was no significant different according to Duncan Multiple Range Test (DMART).*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respective.

### 4.14 Phenotypic correlation

The results of phenotypic correlation between some growth, yield and stem borer infestation characters are presented in table 4. Days to tasseling was positively and significant correlated with days to silking, while was positively correlated with tunnels length , but negatively correlated with plant height, grain yield, number of exit hole and stem diameter. Days to silking was positively correlated with tunnels length and negatively correlated with plant height, grain yield, number of hole, stem diameter . Plant height was positively high significant correlated with stem diameter, but negatively correlated with number of exit hole , while was positively correlated with grain yield and tunnels length. Grain yield was positively significant correlated with number of hole but negatively correlated with tunnels length , while was positively with stem diameter. Number of hole was positively and high significant with tunnels length, while was positively correlated with stem diameter. Stem diameter was positively correlated with tunnels length.

**Table (4) The correlation among thirteen maize genotypes traits resistant to stem borer infestation in winter season, 2016.**

| | TNL | SD | NH | GY | PH | DS | DT |
|---|---|---|---|---|---|---|---|
| DT | 0.146 | -0.004 | -0.099 | -0.207 | -0.068 | 0.373* | |
| DS | 0.156 | -0.172 | -0.175 | -0.223 | -0.046 | | |
| PH | 0.071 | 0.468** | -0.223 | 0.267 | | | |
| GY | -0.025 | 0.157 | 0.291* | | | | |
| NH | 0.592** | 0.092 | | | | | |
| SD | 0.035 | | | | | | |
| TNL | | | | | | | |

DT= Days to 50% Tasseling, DS= Days to 50% silking, PH =Plant Height, GY = Grain Yield, NH= Number of exit Hole, SD= Stem Diameter and TNL= Tunnels length.

# CHAPTER FIVE

# DISCUSSION

The mean performance of the studied maize genotypes, the results showed wide range of variation was detected among them for plant height ,ear height and grain yield (Kg/ha). This variation could be of a great value in any maize breeding program aiming for obtaining maize genotypes resistant to stem borer or any other maize breeding object. The variation in maize was reported by many researchers ( Idris *et al* 2011; Abuali *et al* 2011 ). Plant height and ear placement are important traits for obtaining plant vigor, on the other side these two traits (tall plant and higher ear placement) subjected maize genotypes to lodging especially under high infestation of stem borer caused a complete damage to the crop and acute reduction in grain yield (Ahmad and Akhtar, 1979; De Groote,2002 ). The maize grain yield is considered as the ultimate object for any maize breeding program, (Hallauer and Miranda, 1988; Ishag, 2004).The analyses of variance result indicated significance difference between genotypes for the grain yield. The results were showed that a significant difference between genotypes in the infestation rate for leave damage. The genotypes LONGS and 2014E 98 scored the highest grain yield (1286.3 kg/ha) and (946.7 kg/ha) respectively despite of a higher leves of the leave damage infestations this result confirms the higher ability of these genotypes to tolerate and/or to resistant stem borer infestation. This result in same with the findings of ( Mohammedein *et al.*, 2012).The results infestation caused by the two stem borers indicated not significant difference between genotypes in the mean number of entry/exit holes and tunnel length values and also correlated significantly with plant height. This results are in line with the findings of (Mwimali *et al*., 2015), (Munyiri *et al.*, 2015) (Rajasekhar *et al.*, 2013 ) .

The stem diameter was statistically analysis conducted between maize genotypes was significantly difference , negatively correlated with days to50% flowering, positively with grain yield, number of exit holes and tunnels length, and plant height ,these results indicate that variation could be played a role in conferring resistance.

As the larvae borers into the stem for more feeding awaiting pupation, more damage was caused on soft stems than on hard stems causing increased stem pith tunneling. The maize stem borer damages the stem through feeding on the pith and the vascular tissues placing the plant under physiological stress. The importance of stem diameter resistance was reported by Santiago *et al* (2003)as the prevention of larvae feeding on the stem pith during plant development which causes weakening and lodging of the plants.

Days To 50%flowering . All the genotypes were not significant different between them, this results agreement with the study of ( Mohammedein *et al.* (2012).

Data recorded for ear height showed significant difference among genotypes. It may be due to expression of deleterious alleles at any locus or due to genotypic interaction to environment which might have caused reduction in ear height. Similarly were the findings of Halluar and Sear (1973).

All the genotypes were significantly different in ear-length, it may be concluded that deleterious alleles for yield components got together in the same genotype in homozygous state and expressed themselves or there was no dominant allele in the combination to enc, the result matched with the findings of Mehboob *et al*. (2010), actually yield components have effect on each other in positive way which may due to same genes controlling these traits. Bellon (1991) reported that kernels obtained from the largest ears, the depth of the kernels on the ears, and larger kernels from the middle part of the ear gave the highest yields. Ear length is a good indication of biomass allocation into the ear (Tracy, 1990, Otegui and Melon, 1997) and hybrid maize with long ears give high yields.

Ear Diameter (cm): Significant difference among genotypes was observed. This result was consistent and in agreement with the findings Mehboob *et al*. (2010).

Number of kernels/Row.

# Conclusions and Recommendations

The results indicated the following:

- The occurrence of a great genetic variability between genotypes for susceptibility and tolerance/resistance to stem borer infestation.
- Differences in grain yield values Between maize genotypes .
- Some genotypes as (2014E 92, BOMU and 2014E 98) could be considered as potentially susceptible or tolerance, based on the stem borrer infestation.
- Difference correlation among thirteen maize genotypes traits resistant to stem borer infestation.

**Recommendations:**

1. Based on grain yield, the genotypes LONGS and 2014E 98 and BOMU should be further screened for resistance/tolerance.
2. Differences between maize genotypes in all parameter this consider index to susceptibility crop to any program breeding could be done.
3. Future research on the physiological, biochemical or genetic basis of the tolerance should be done.

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