Sudan University of Science and Technology

College of Graduate Studies

Effect of Sowing Methods, Intra-row Spacings' on Growth, Yield and Yield Components of Three Maize (*Zea mays L.*) Varieties, at Gash Scheme, Sudan

تأثير طرق الزراعة، تباعد النباتات داخل الصفوف على صفات النمو والانتاجية ومكوناتها لثلاثة اصناف من محصول الذرة الشامية بمشروع القاش الزراعي، السودان

A Thesis submitted to the Sudan University of Science and Technology in Fulfillment of the Requirements for the Degree of Ph.D. in Crop Science

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DEDICATION

To the soul of My parents ALLAH mercy them, and to my brother Mohammad Ahmed, my sisters Buthyna and Mahasin Elsadig Ibrahim. Also my dedication is extended to my small Family, Sincere wife Mrs. UM Na'aeem Mohammad Ali Elkhaleefa and to my sons Elsadig, Mohammad, Asim and Sabah for their valuable support and unlimited patience.

With Loyality

and Love

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Abstract

Two field experiments were conducted at Kassala Research Station Experimental Farm at Takroof , during two successive winter seasons of 2015 and 2016, to study the effect of three sowing methods namely: ridge, flat and methods practiced by farmers, three Intra-row spacing (20, 30 and 40 cm) between plants and three maize varieties namely Hudeiba-1, Hudeiba-2 and Vari113. The design used was factorial Randomized Complete Block Design (RCBD) based on split-spilt arrangement with three replications. The sowing methods were assigned as the main plot, intra-row spacing as the subplot and the varieties as the Sub-sub-plot. The data recorded during both seasons after emergence were population density/plot, at flowering data was recorded for days to 50% tasselling, and days to 50% silking, then at harvest data was recorded for plant height (cm), number of leaves/plant, leaf length (cm), leaf width (cm), leaf area index (LAI), stem diameter, number of ears/plot, number of rows/ear, number of seeds/row, number of seeds/ear, ear length (cm), effective ear length (EEL) (cm), ear width (cm), 100 seed weight (g), grain yield (ton/ha), biological yield, hay yield (ton/ha) and harvest index. The results revealed that ridge method was the best one compared with the other two methods, and scored higher levels of grain yield of, 1.73 and 1.74 ton/ha during both seasons, respectively. Variety113 scored higher rates of grain yield of, 1.68 and 1.77 ton/ha, respectively compared with other varieties. Grain yield was significantly affected by intra-row spacing of 20 cm and scored 1.77 ton/ha, during the first season, while 30 cm intra-row spacing scored higher grain yield of, 1.68 ton/ha during the second season. Accordingly, Variety113, grown on ridge and with intra-row spacing range from 20 to 30 cm between plants gave the highest maize grain yield in Gash Scheme.

المستخلص

اجريت تجربتان حقليتان بمزرعة محطة بحوث كسلا والقاش، لموسمين شتويين متتاليين للعامين 2015 و2016 لاختبار اثر ثلاثة طرق للزراعة (الزراعة فى السرابات، الزراعة فى الارض المسطحة وطريقة زراعة المزارعين)، والتباعد بين النباتات فى داخل الصفوف للمسافات (20، 30 و40 سم) وثلاثة اصناف من محصول الذرة الشامية (الصنف حديبة 1،حديبة2 والصنف 113). وقد وضعت معاملات التجربة فى تصميم القطاعات العشوائية المتكاملة المنشقة- المنشقة بثلاثة مكررات. و وضعت طرق الزراعة فى الاحواض الرئيسية، وتباعد النباتات داخل الصفوف فى الاحواض الفرعية والاصناف فى الاحواض الفرعية الفرعية. وقد سجلت بيانات التجربة كالاتى: الكثافة النباتية بالحوض، عدد الايام للوصول ل 50% ازهار ، 50% مرحلة الحرير. وعند الحصاد اخذت القياسات الاتية: طول النبات، طول ارتفاع القندول، عدد الاوراق، طول الورقة، عرض الورقة، معامل مساحة الورقة، عرض الساق، عدد القناديل فى الحوض، عىدد الصفوف فى القندول، عدد البذور فى الصف ، عدد البذور فى القندول، طول القندول، الطول الحقيقى للقندول، انتاج البذور، وزن المائة بذرة، الانتاج الكلى للمادة الجافة, انتاج العلف ومعامل الحصاد. وقد اثبتت نتائج التحليل الاحصائى فروقات معنوية فى كل من المعاملات: الزراعة فى سرابات ادت الى زيادة فى انتاجية البذور بمعدل (1.73-1.74) طن/هكتار للموسمين على التوالى مقارنة مع طرق الزراعة الاخرى. وقد احرزت العينة 113 معدلات عالية من انتاج البذور بلغت (1.68-1.77) طن/هكتار على التوالى مقارنة مع العينات الاخرى. وقد ادى تباعد النباتات بين الصفوف الى تاثير معنوى على انتاجية البذور. وقد احرز التباعد بين النباتات 20سم انتاجية بلغت 1.78 طن/هكتار خلال الموسم الاول، اما التباعد 30 سم قد احرزانتاجية بذور بلغت 1.68 طن/هكتار فى الموسم الثانى. لذلك وكخاتمة لهذه الدراسة فان زراعة العينة 113 فى سرابات وبتباعد نباتات 20 او 30سم. هى الحزمة المثلى لزراعة محصول الذرة الشامية فى مشروع القاش، السودان.

CHAPTER ONE

INTRODUCTION

Maize (*Zea mays* L.) a member of the family Poaceae (Gramineae) is the third most important cereal crop after wheat (*Triticum spp*.) and rice (*Oryza spp*.) (FAO.1995). Maize has become a staple food in many parts of the world, with total production surpassing that of wheat or rice. Maize is a cereal grain, also known as corn, domesticated by indigenous people of South Mexico before 10,000 years ago. Worldwide production of maize is 785 million tons. According, to FAO 2007, about 158 million hectares of maize are harvested worldwide, and the total consumption of maize is more than 116 million tons, with Africa consuming 30% and sub-Saharan Africa 21%, at (http.nue.uk.edu.). However, not all maize production is consumed directly by human, a considerable amount of it is used for corn ethanol, animal feed and other maize products, (Wikipedia, 2017). The United States in 2014 produced approximately 40% of the crop. However, 130 million tons of the Genetically Modified (GM), maize- which approved during 2011- was used for corn ethanol production. Maize is widely cultivated throughout the world, and a greater weight of maize is produced each year than any other grain, (International Org, 2013). In 2014, total world production was 1.04 billion tons, led by the United States with 35% amounted 361.1 million tons. Global cereal demand in 2020 is estimated at 2.1 billion MT and will be for first time show a major shift in favor for maize. Demand for maize is estimated at 852 million MT compared to780 million MT for wheat and 503 million MT for rice (Sabo, et., al., 2016). Maize is grown throughout a wide range of climates, and is a basic food grain in many areas and several cultures. In developed countries, maize is consumed mainly as second-cycle product, in the form of meat, eggs and dairy products. Maize is desired for its multiple purpose use as human food, animal feed, and industrial raw material of many substances. Maize is the world primary source of coarse grain representing 55% of the world consumption of animal feed (Chaudhary *et al*, 2012). Maize is the only crop among nonleguminous crops fodder that combine better nutritional quality, which is far much better than sorghum and millet which possesses toxic materials such HCN and oxalate, as reported by (Chaudhary *et al,*2012*;*. Dahmardeh *et al* 2009). Thus, maize became a major constituent of ruminant rations in recent years, where its inclusion in dairy cow diets improved forage intake, increased animal performance and reduced production cost (Anil and Phipps ,2000)

Maize in the Sudan is the fourth in importance, after wheat, sorghum and millet. It is grown mainly as food and feed crop (both forage and grain). In Sudan Maize is of minor importance, it is only grown in River Banks, in small batches and in "Jobraka" system of farming around houses in rural areas, in irrigated schemes and in modern irrigation systems in Khartoum and River Nile States. Due to the increasing of poultry production and establishment of many poultry and dairy farms, the demand for maize is increasing; this makes it imperative to boost the yield per unit area. Maize optimum cultural practices should be determined to satisfy increasing demand for the crop. Gash scheme with its most fertile soil in the world constitutes a high potential to satisfy needs for the crop, rarely as food crop (Mohammed *et al*, 2015). Sudan has a great potential for animal production, ranking first in the Arab World. Increasing demand for animal products as a result of ever rising population in urbanized sector. In Sudan, area cropped with maize amount to 126 thousand acre (121,500 Feddans), which is 82% of that of 2013, (Food Security Annual Report, 2015). The area is expected to increase due to the fact that more attention was put to maize due to expanding poultry and dairy industries *(*Mohammed, *et al* 2015).

Successful maize crop production depends on the correct application of production inputs that will sustain the environment as well as agricultural production. These inputs are adapted cultivars, plant population, soil tillage, fertilization, weed, insect and disease control, harvesting, marketing and financial resources. Maize crop was characterized by low tillers, this poses that

Population density should be manipulated to compensate the spaces created by the low tillering character; therefore, studying population density will be of vital importance. Other cultural practices like optimum sowing methods, and suitable varieties which achieve economical yield are also crucial. Introducing maize to Gash Scheme will give farmers more options to increase their income and enhance their livelihoods, (i.e. better access to education, better access to health care and better access to good quality food). The increase of maize crop yield adds up to the satisfaction of the growing demand of the increasing livestock and poultry industry. Meagre studies were conducted to select the best cultural practices that increase maize production in the Sudan and specially in Gash Scheme. Therefore, the overall objective of this study aimed at introducing a new cash and food crop to Gash Scheme, and testing the effect of sowing methods, intra-row spacing on three varieties of maize for growth and yield of the crop.

CHAPTER TWO

LITERATURE REVIEW

2.1 Geographical Distribution

Maize is an annual grass belongs to the family Poaceae or (Gramineae). It is cultivated in a wide range of climates more than wheat and rice, due to its greater adaptability to various environmental conditions as reported by (Koutsika-Sotiriou, 1999). It is grown at latitudes from equator to north and south latitude 50^{o} , from sea level to over 3000 meters above sea level, under heavy rainfall to semi-arid conditions and cool to very hot climates. According, to FAO 2017 about 158 million hectare of maize are harvested worldwide and produced 785 million tons. Maize has become a staple food in many parts of the world, like Mesoamerica, Latin America and some parts of North America, West and east African, and some of Asian countries. However, not all of this maize is consumed directly by humans. A considerable part of maize production is used for corn ethanol, animal feed and other maize products.

2.2 Maize Origin:

There were a lot of controversial reports about the origin of maize. Many authors believed that Mexico is the early site of domestication of many food crops, including teosinte, which was the ancestor of maize as reported by Benz, (2005). Before domestication of maize plants, they grew only one cob/plant of 25 mm in length, this maize was thought to be developed by inter-planting of maize with teosinte or by artificial selection by indigenous people resulted in the development of plants capable of growing several cobs/plant (Spielvogel *et al.,*(2005). . Maize is the domesticated variant of teosinte (Corn genetic study, 2014). The two plants have dissimilar appearance, maize having a single tall stalk with multiple leaves and teosinte being a short, bushy plant. The difference between the two is largely controlled by differences in two genes.

Archeological records suggested that maize domesticated in the highlands of Mexico and spread to the lowlands. (Dolores,(2011). There are two major species of the Zea genus: *Zea mays* (maize) and Zea diploperennis, which is a perennial type of teosinte. The annual teosinte variety called *Zea mays mexicana* is the closest botanical relative to maize. It still grows in the wild as an annual crop in Mexico and Guatemala.

2.3 Plant Description:

Maize was described as a tall, determinate annual plant producing large narrow, opposing leaves (about a tenth as wide as they are long), borne alternately along a length of a solid stem. Maize varieties range from 0.5 to 5 meters in height at flowering, mature in 60 to133 days after planting, produce 1 to 4 ears/plant, 435 kernels/ear yield from 0.5 to 23.5 tons/ha. Kernels may be colorless (white) or yellow, red blue or variegated with these colors in mottled patterns, or striated. Maize is a monoecism plant with male and female flowers separated on the same plant. The leafy stalk of the plant produces separate pollens and ovuliferous inflorescences or ears, which are fruits yielding kernels or seeds. Globally, although the crop is 95% cross-pollinated, self-pollination may reach up to 5%. This feature has contributed a lot to its broad morphological variability and geographical adaptability. The various stages of maize growth as described by Plessis, (2003) are broadly divided into vegetative and reproductive stages as follows:

2.4 Growth stages:

1: Vegetative growth:

i. **Stage 1:** (Emergence) During germination, the growth point and the entire stem are about 25 to 40 mm below soil surface. Under warm moist conditions seedling takes 6 to10 days, but under cool or dry conditions this may take two weeks or longer. The optimum temperature range for germination is between 20 to 30 ^{o} C, while optimum moisture content of the soil should be approximately 60% of the soil capacity.

ii. **Stage 2: (four leaves incompletely unfolded):** The maximum number of leaves and lateral shoots is predetermined and a new leaf unfolds more or less every three days. The growth point at this stage is still below soil surface and aerial parts are limited to the leaf sheath and blades. Initiation of tasselling also occurs at this stage.

iii. **Stage 3:** (eight leaves completely unfolded): During this period, leaf area increases from 5 to 10 times. While stem mass increases 50 to 100 times. Ear initiation has already commenced. Tillers begin to develop from nodes below the soil surface. The growth point at this stage is approximately 5.0 to7.5 cm above the soil surface.

iv. **Stage 4:** (twelve leaves completely unfolded) : The tassel in this growth point begins to develop rapidly. Lateral shoots bearing cobs develop rapidly from the sixth to eighth nodes above the soil surface and the potential number of seed buds of the ear has already been determined.

v. **Stage 5:** (Tasselling): The stem lengthens rapidly and the tassel is almost fully developed. Silks begin to develop and lengthen from the base of upper ear.

2: Reproductive stages:

i. **Stage 1:** (Silking): all leaves are completely unfolded and the tassel is being visible for two or three days. The lateral shoot bearing the main ear as well as bracts has almost reached maturity. At this point demand for nutrients and water is high.

ii. **Stage 2:** (Green mealier Stage): The ear, lateral shoot and bracts are fully developed and starch begin to accumulate in the endosperm.

iii. **Stage 3:** (Milky stage): Grain mass continues to increase and sugars are converted to starch.

iv. **Stage 4:** (Hard dough stage): Sugars in the kernels disappeared rapidly. Starch accumulates in the crown of the kernel and extends downwards.

v. **Stage 5:** (Physiological maturity): When the kernel has reached its maximum dry mass, a layer of black cells develops at the kernel base.

Grains are physiologically mature and only the moisture content must be reduced.

vi. **Stage 6:** (Biological maturity): Although grains have reached physiological maturity, they must dry out before reaching biological maturity. Under favorable conditions, drying takes place at approximately 5% per week up to 20% level after which there is a slowdown.

2.5. Maize Types: Maize has been classified into several types based on the endosperm of the kernel. These have been described by Chaudhary *et al*, (2012) as follows:

1**. Dent Corn (*Zea mays indentata*):** It is popularly known as dent corn because dent formation on the top of the kernel having white or yellow colour. The depression or dent in the crown of the seed is the result of rapid drying and shrinkage of the soft starch. This type is extensively grown in U.S.A.

2**. Flint corn (*Zea mays indurata*):** This type was firstly developed by Europeans. This type is early in maturity. Kernels of this type are rounded on the top. It is grown in Europe, Asia, Central and South America. It is a principle type of grain grown in India.

3**. Pop corn *(Zea mays everta*):** Its cultivation is mainly confined to the new world. It has small kernel with hard corneous endosperm. The grains are used for human consumption and as a base for pop corn confections.

4**. Flour corn (*Zea mays amylacea*)**: It resembles Flint corn in appearance and ear characteristics. The grains are composed of soft starch and have little or no dent. Flour corn is one of the oldest types of corn grown in U.S.A. and South Africa

5. **Sweet corn (*Zea mays saccharata*):** The starch makes the major component of the endosperm that result in the sweetish taste of kernel before they attain maturity and after maturity the kernels become wrinkled. Nowadays the crop is

widely cultivated in peri-urban regions. The cobs are picked up green for canning and table purposes.

6**. Waxy corn (*Zea mays certina*):** the kernels look to have waxy appearance with gummy starch because of high amylopectin (up to 100%) whereas common maize starch is about 70% of amylopectin. Its origin is supposed to be in China, but many waxy hybrids developed in the U.S.A. are producing similar starch and are grown commercially.

7**. Baby corn:** is the young ear of female inflorescences of maize plant harvested before fertilization when the silk has just emerged. It is consumed as human food attracting the fancy of rich people in hotels, restaurants and malls. The stalks are used as fodder. Farmers can grow 3-4 crops of this type of corn per year as reported by (Sawsan, 2017).

2.6 Environmental Requirements

1. **Water and Nutrients requirements:**

Approximately 10 to 16 kg of maize grains are produced for every millimeter (mm) of water used. A yield of 3.15 ton/ha requires between 350 and 450 mm of rain per annum. At maturity, each plant will have used 250 L of water in the absence of moisture stress. The total leaf area at maturity may exceed one square meter per plant. The assimilation of nitrogen, phosphorus and potassium reached its peak during flowering. At maturity the total nutrient uptake of a single maize plant is 8.7 g of nitrogen, 5.1 g of phosphorus, and 4.0 g of potassium. Each ton of grain produced removes 15.0 to 18.0 kg of nitrogen, 2.5 to 3.0 kg of phosphorus and 3.0 to 4.0 kg of potassium from the soil. No other crop utilizes sunlight more effectively than maize, and its grain yield per ha is the highest of all grain crops. At maturity, the total energy used by one plant is equivalent to that of 8152 KJ. (Wikipedia 2017).

2. **Climatic requirements: Temperature requirements:**

Maize is a warm weather crop and is not grown in areas where the mean of the daily temperature is less than 19 ºC, or where the mean of the summer months is less than 23 ºC. Although the minimum temperature for germination is 10 ºC, germination will be faster and less variable at soil temperatures of 16 to 18 ºC. At 20 ºC, maize should emerge within five to six days. The critical temperature detrimentally affecting yield is approximately 32 ºC and above this temperature pollination is drastically affected which results in poor yield. Frost can damage maize at all growth stages and a frost-free period of 120 to 140 days is required to prevent damage. While the growth point is below the soil surface, new leaves will form and frost damage will not be too serious. Leaves of mature plants are easily damaged by frost and grain filling can be adversely affected.

3**. Soil requirements**

The most suitable soil for maize is that one with a good effective depth, favorable good internal drainage, an optimal moisture regime, sufficient and balanced quantities of plant nutrients and chemical properties that are favorable specifically for maize production. Although large-scale maize production takes place on soils with a clay content of less than 10 % (sandy soils) or in excess of 30 % (clay and clay-loam soils), the texture classes between10 and 30% have air and moisture regimes that are optimal for healthy maize production.

2.7 Maize Production in Sudan:

Maize is a promising cereal crop in Sudan with a potential for both human food and animal feed (Salih *et al*, 2008). It is a fourth crop in importance after sorghum, wheat and millet.(Mohammed, *et al*. 2015). It is grown mainly as feed crop (both grain and forage) and rarely as food crop. Recently, the demand for maize as a grain is greatly increased due to the flourishing poultry industry and animal fattening (Mohammed et al, 2015). Blending maize flour with that of wheat for bread making has been largely considered because of the increasing bill of importing wheat and wheat flour. Importing of maize have been doubled, rising from >20000 MT during the 1990'S to <40000 MT during 2000s (FAO-Statistics, 2011). In the past the cultivated area of maize was confined to small batches in irrigated schemes, river banks and "Jobraka" system of household farmers in rural areas. The low area put to maize was mainly due to the sensitivity of maize to both drought and water logging and competition with important food security crops such as sorghum and wheat. Moreover, the limited use of the end users coupled with low market prices aggravated to less priority of maize production in the country, (Ali *et al*, 2009). Therefore, maize cultivation in the past and until recently was neglected by decision makers and farmers who used to grow sorghum and wheat as cash and staple crops. However, the crop plays an increasing role in food security for people in Blue Nile and South Kordofan States. It is grown in these two States by traditional farmers in small holdings and around houses in what is known as "Jobraka" farming system, under rain-fed cultivations. Nowadays, some companies and individuals started to grow the crop at a large scale under modern systems of irrigation and rain-fed systems in different parts of the Sudan. Moreover, the total area cultivated with maize in Sudan is still small. According, to FAO statistics (Facfish, 2015), the area under maize increased from 17 thousand hectares in 1971 to 37 thousand hectares in 2010.

2.8 Maize Research In Sudan

Maize research in Sudan is very limited, it was only confined to forage maize. Imam (1971) reported that summer planting of maize resulted in very poor yields compared to winter planting, in contrast to forage sorghum (Abu 70). Kambal, (1984) found that dry matter production of the crop sown in winter, summer and rainy seasons were 3.0, 1.7 and 1.0 ton/ha respectively. However, another trail at Shambat (Salih. 1994) reported that dry matter yield of forage maize sown at five different sowing dates viz: November, January, March, May and July were 3.74, 5.53, 6.62, 9.88 and 7.66 ton/ha respectively.

Mohammed (2006) tested 11 maize genotypes from CIMMYT against one local check (Mugtama'45) for grain yield. Many of CIMMYT genotypes significantly outyielded the best yielder averaging 5.54 and 5.34 ton/ha, respectively. The local Mugtama 45 averaged 3.17 ton/ha all genotypes were significantly earlier than the local check. Abdel Rahman *et al,* in late 2008 conducted a study at Hudeiba Research Station Farm to determine the appropriate sowing time for maize. The results fully supported that previous recommendation of maize as a winter crop in Northern Sudan. Elkarori and Mansi (1980) found that the optimum sowing period of sorghum variety Abu Sabin and maize variety113 were found to be February to October and November to January respectively. Khair and Salih (2007) evaluated different cereal forages for yield and quality traits. They found that maize and Abu Sabin were second to barley with respect to dry matter yield. But maize had higher organic matter digestibility and metabolizable energy yield and lower crude fiber percentage.

2.9 Agricultural Research Corporation (ARC) Contribution to Maize Research:

Agricultural Research Corporation (ARC) released three open pollinated varieties of maize namely Hudeiba-1, Hudeiba-2 and Vari113. ARC also conducted a lot of work regarding maize various aspects addressing different maize traits even in most of ARC research stations in the different Sudanese environments and different irrigation systems.

1. ARC Research in the Rain-fed Sector:

Maize research in rain-fed farming was assigned to Gedarif, Kassala, Kadogli, Elobied, Elfashir, Ginana, Nyala, Eda'an and Damazeen research stations, in which genotypes and varieties testing, nitrogen fertilization, population density, inter-cropping, stem borer and some breeding traits were conducted in these stations. The main constraints facing maize production in the rainfed sector was the drought spells that took place during the rainy season which may result in lowering yield or complete loss of the crop. Secondly the Hazard of Witch weed *Striga hermonthca* which constitute a great threat for maize in the rainfed sector, dwarf mosaic virus also constituting one of the constraints lowering maize yield in the rainfed sector. If these constraints are to be overcome, the rainfed sector will play a great role in maize production in Sudan. Recently, there is a program to introduce maize to low rainfall marginal areas in Northern and Southern Kordofan States through applying water harvesting techniques.

2. ARC Irrigated Maize Research:

Maize research in the irrigated sector was assigned to Gezira, Rahad, New Halefa, Shandi, Hudeiba, Marawi and Soba saline sodic soils reclamtion research stations. The approved ARC maize breeding program comprises of breeding for different aspects including, evaluation and assessment of genotypes, improvement of grain yield and quality, breeding for striga, stem borer resistance and for drought tolerance and other different abiotic stresses. The program also comprises screening of imported maize genotypes obtained from International Centers for yield, quality and other stress tolerance.

2.10 Maize Hybrids in Sudan:

Till now no evidence in the literature of developing any hybrid in the Sudan, for both grain or fodder maize. Recently, ARC launched a program for Hybrid Industry in Sudan but till now researchers are searching their paces in the way. However, research work in Sudan was confined to introduction of exotic hybrids. According, to the records of the Seed Administration (Appendix 1), 24 exotic maize cultivars were released in Sudan since 1975 of which 19 are hybrid cultivars introduced for grain production. Seeds of most released hybrids are not available in the market, due to the low market demand, and low area put to maize in Sudan. Hybrid importing companies are running after profit and since there is no or limited demand for maize imported hybrid seeds, the hybrid seeds are not going to be available in the market. (Sawzan, 2017).

The introduction of any crop to a new environment had to be preceded by exploration of its cultural practices starting by the agronomic aspects to achieve the maximum economic return. These aspects include sowing methods, intra-row spacing, varieties, financial resources, harvesting time and techniques suitable to that environment to obtain the maximum yield. Hereunder are some attributes and the historic background of work carried out by researchers in this regard:

2.11 Effect of sowing methods, intra-row spacing and varieties on growth and yield of maize (Zea mays L) :-

1. **Effect of sowing methods on mean growth and yield components:**

The performance of maize under different sowing methods i.e. ridge, flat and local farmers' methods were studied by different researchers to see the effect of these sowing methods on growth and yield of maize crop. Anjum, *et al*, (2014) showed that tillage practices and sowing methods had a significant effect on germination count/m^2, leaf area/plant, leaf area index, crop growth rate, 50% tasselling and 50% silking. Economically maize sown on ridge under deep tillage gave maximum net income. Attia. *et al*, (2012), Gobeze, *et. al*, (2012) reported that planting maize in ridges 80 or 90 cm apart produced the highest values of all the studied characters. Attia *et al*, (2012), and El-Mekser (2009), showed that increasing ridge spacing significantly reduced number of days to 50% tasselling and silking, plant and ear heights were in the same direction. Planting on the 80 cm ridge was associated with a significant increase in ear length, number of kernels/row 1000 kernel weight and grain yield. Gokman *et al*, (2001) showed that maize planted in paired ridges performed better than that grown on single rows. Shaikh *et al*.,(1994) , Majid *et al*., (1986) while studying the effect of different sowing methods demonstrated and reported that plant height, total biomass production test, grain weight, grain yield were maximum with ridge sowing, and it also decreased the number of days to tasseling, silking and maturity. In recent work, Borras *et al*., (2003) concluded that a less leaf area index, leaf area duration could be a resulted of response to increased plant population in the field due to more leaf senescence rate during grain filling. Leilah *et. al*., (2013) found that SC 128 produced the highest value when planted in ridges 80 cm apart 22 cm between hills and one plant/hill. Mohammadein (2005), reported that sowing fodder maize on flat sowing methods resulted in higher final yield of dry matter at harvest. Ridge SM scored greater rates of 100 seed weight (SW) and hay yield during both seasons amounted to (18.0 and 17.9 grams for 100 SW and 9.62 and 11.8 ton/ha for hay yield, respectively). Meanwhile local farmers' method scored the second higher level with respect to grain yield during both seasons (1.63 and 1.58 ton/ha, respectively). The same author reported that both ridge and mustaba had no significant effect on all measured parameters, on the other hand ridge and flat were superior to mustaba in producing taller plants and leaf to stem ratio.

2. **Effect of Intra-row Spacing on Growth and yield of maize:**

Growth and grain yield of maize is more affected by variation in hill spacing than other members of grass family due to no or low number of tillers. Hill spacing affected many agronomic characteristics and grain yield. Many investigators studied the effect of plant density of maize as a spacing between hills, in this regard Sharifai *et al*., (2012) ,Attia *et al*, (2012), described that highest grain yield and harvest index were obtained at 10 plants/m^2 i.e.12.5 cm hill spacing. The highest number of grains/ear, stem diameter, and cob length were recorded to be higher at 8 plants/m^2 ie. 15.5 cm hill spacing. Highest values of plant height were recorded at12 plants/m^2 (ie.10.5cm hill spacing. Abuzar, *et. al*., Bisht *et. al*., (2012) reported that grain yield increased in the narrow rows due to limited intra-row competition for light, nutrient and water. Population above the optimum level has resulted in lodging that caused reduction in maize production. Sharifai *et al*., (2012), Leilah *et al*.,(2013) showed that increase in intra-row spacing from 20 to 25 cm significantly increased number of rows/ear, ear diameter, 100 kernel weight and grain yield. Sadegi (2013) reported that highest grain yield for some hybrids was obtained at plant density of 8 plants/m^2 reached their maximum grain yield and its components. Therefore, this is the best option to achieve the highest grain yield. Ukonze. *et. al*., (2016) showed that the 70*30 cm and 60*30 spacing gave higher values of morphological parameters than 80*20 cm. With regard to yield, 80*20cm gave the highest average cob weight and 1000 grain weight. Mohammad *et al*., (2002) reported that maximum grain yield was recorded at 20 cm intra-row spacing, while leaf area index and number. grains/cob were greater at 25 and 20 cm intra row spacing, while 1000 grain weight at 25 and 20 cm level and lowest at 15 cm intra-row spacing. Lakew *et al*., (2016) reported that highly significant difference due to the main effect of intra-row spacing was observed on leaf area, leaf area index, number of ears/plant, above ground dry biomass yield/ha, number. of kernels/ear, 1000 kernel weight and harvest index. 1000 kernels weight, and number of kernels/ear highly significantly increased with decreased intra-row spacing, and concluded that spacing combination of 65*25 cm responded favorably in attaining higher grain yield in the area. Radma *et.al*., (2013) showed that maize hybrids significantly different in final grain yield and yield components as ear yield and number of grains/ear. Sharifai *et al*., (2012), Attia *et al*,(2012), described that highest grain yield and harvest index obtained at 10 plants/m^2 i.e.12.5cm hill spacing The highest number of grains/ear, stem diameter, and cob length were recorded at 8 plants/m^2 (ie. 15.5 cm hill spacing. Highest values of plant height were recorded at 12 plants/m^2 (ie. 10.5 cm hill spacing). Abuzar, (2011) Bisht *et. al*., (2012) stated that grain yield increased in the narrow rows due to limited intra-row competition for light, nutrient and water. Population above the optimum has resulted in lodging that caused reduction in maize production. Sharifai *et al*., (2012), Leilah *et.al*.(2013) showed that increase in intra-row spacing from 20 to 25 cm significantly increased number of rows/cob, cob diameter, 100 kernel weight and grain yield.

3. **Effect of Variety on Growth and yield of Maize:**

Main constraints to enhance maize productivity are lack of specific production technology, the selection of unsuitable cultivar under a given set of environmental conditions is the major factor responsible for low yield. Sharifai *et al*., (2012), Attia *et al*, (2012), summarized that for obtaining a higher maize yield and net income maize cultivars had different responses to agronomic characters and grain yield. Alias *el. al*.,(2010) showed a significant difference between maize cultivars with respect to plant height, number of ears/plant, leaf area index, number. of kernels/row, grain weight/ear and grain yield/plant. Zamir *el. Al*., (2011) initiated that hybrid 30Y87 was early in maturity, produced more number of row/cob, less number of grains/row and less cob length than hybrid 31R88. Similarly, hybrid 30Y87, 1000 kernel weight, grain yield, and straw yield were significantly greater than hybrid 30R88. Mashiqa *et. al*., (2012). noticed that hybrid SiPAA-444 surpassed hybrid Ts-13 for grain yield. Leilah, El-kalla, El-Douby and Abd Rabbon, *et.al*., (2013) found that S. C 128 produced the highest values of some attributes when planted on ridges 80 cm apart and 22cm between hills. Zeng *et.al* (2015) and Panison *et. al* (2016) showed that the harvests performed after physiological maturity decreased the real grain productivity, especially for the early hybrids.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental site

The experiments were conducted at Kassala Research Station Experimental Farm located within the boarders of Kassala locality in Takroof area which lies between latitude 15° 43' N and longitude 36° 38' East, elevation 596 meter above sea level. There are two types of soil known locally as Lebad and Padobe soils, Labad is rich in silt and constitutes major soil type of Gash area, The experiment was carried out in Labad soil, Appendix Table 2: showed the soil analysis of the experimental site at Takroof. The analysis revealed that the soil is mild alkaline with pH range of 7.5 to 8.1. None saline non sodic alluvium soil with silt range of 49% -54%, clay range from 37% to 41% and sand range 7% to12%. The Electrical Conductivity (EC) decreased with the depth, while Exchangeable Sodium Percentage (ESP) increased with the depth for R1 and R2, while P3 and P4 are equal. Fertility level is low. The climatic data for the period from September 2015 to January 2016 and from September 2016 to January 2017 showed that maximum and minimum temperatures for September and October 2015 were greater than that of 2016, while the maximum temperature. for the period November 2015 follow the same trend as the period of 2016. While during December 2015 compared with that of 2016 the maximum temperature deceased while that of minimum temperature increased. The evaporation increased with the increase in temperature. It was also noticed that the relative humidity % (R.H.%) was higher during September and it started to decrease during November, and to increase during December, during September October the sun shine duration was low due to the presence of clouds while during November December sun duration was higher because of the absence of clouds during that period. The field study was carried out in winter in one site by irrigation for two consecutive seasons during the period from September to December 2015 and 2016. respectively.

3.2 Plant materials

The three open pollinated varieties of grain maize (*Zea mays* L.) used in this study were obtained from Agricultural Research Corporation (ARC). The experiments were conducted to study the effect of sowing methods, intra-row spacing on three maize varieties namely: Hudeiba-1, Hudeiba-2 and variety113.

3:3 The Experimental Location and treatments

The experiment was conducted during the winter season of two consecutive seasons (2015 and 2016), at the experimental Farm of Kassala Research Station at Takroof. The cultural practices were conducted as recommended by ARC during both seasons. The land was disc ploughed, disc harrowed and leveled using the scraper to obtain fine seed bed. Ridging was done at 0.8 m spacing. The plot consists of four ridges of three meters long, and intra-row spacing was (20 ,30 and 40 cm), then the plough used to execute the third local farmers method in which three ridges were made with inter-row spacing of one meter. Sowing date was at September and the experiment was extended from September to December each year. Two to three seeds were put per hole, then after establishment thinned to one seedling/hole, weeding was carried out manually three times at 2^{nd}, 6^{th} and 8^{th} weeks after planting.

3.4 **Experimental Design:**

The design used was a factorial Randomized Complete Block Design (RCBD) with three replications, the treatments were arranged in split –split type of arrangement, with sowing methods (M) at the main plot, intra-row spacing (S) at subplot and the varieties (V) at the sub-sub plot.

3.5 Treatments:

Treatments were designed to test the effect of sowing methods, intra-row spacing on growth, yield and yield components of three maize open pollinated cultivars. Three sowing methods viz Ridge, Flat and Farmers' practice (which means that the plough used to make three ridges/plot with 1 m inter-row spacing which is known as the local farmer's method in all Gash area). Three intra-row spacing viz (20, 30 and 40 cm), between hills were used in all types of sowing methods.

3.6 Data Collection:

After establishment the following growth and yield attributes were recorded:

1. **Population density per plot:** Three replicate samples of plants/m2 was counted for each plot and divided by three to get the mean number of plants/m2 then multiplied by 9 (9= to area of the plot) to calculated number of plants /plot.

2. **50% Tasselling:** When maize plants started tasselling a close observation was carried out to determine the number of days from sowing date to 50% tasslling. All plots were closely observed to estimate the number of plants reached tasselling, when the number of plants reached 50% then the number of days is registered for each plot which equal to 50% tessalling.

3. **50% Silking:** The same as 50% tasselling when the plants in each plot started silking all plots were closely observed to estimate the number of days from sowing date till 50% silking of each plot and registered as 50% silking.

4. **Number of leaves/plant:** A replicated samples of five plants were taken from each plot, and the number of leaves/plant was counted for each sample and then summed to get the total number of leaves for the whole sample/plot, and then divided by five to get the mean number of leaves/plant.

5. **Leaf length:** A replicated samples of five plants were taken from each plot, then the number of leaves/plant of the five plants sample was counted and summed. Then all leaves length from the starting of the petiole to the leaf tip was measured for the five plants, then summed to get the total leaves lengths of

all plants in the sample. Then the total leaves lengths divided by the number of leaves/plant for the five plant sample to get the mean leaf length/plant.

6. **Leaf width:** A replicated samples of five plants were taken from each plot. Then the number of leaves/plant was counted width of all the five plant leaves samples were taken to get the total leaves width, then the total leaves width was divided by the number of leaves/sample then divided by five to get the mean leaf width.

7. **Leaf area index (LAI):** A replicated samples of five plants were taken from each plot, then LAI was calculated by counting the total area of leaves ie the mean leaves number/plant multiplying by the mean leaf length and mean leaf width then multiplied by the LAI coefficient which equal (0.72), this area of leaves should be related to the area of land on which the individual plant grown. To get the LAI the following formula can be used: Number of leaves/plant*leaf length*Leaf width*LAI coefficient i.e. (0.72)/Inter-row spacing* Intra-row spacing (for each individual plot separately).

At harvest time five plants were harvested from each plot to measure the following parameters:

8. **Plant height (cm):** A replicated samples of five plants were taken from each plot then the plant height of each plant in the sample was measured from ground level up to the end of the tassel, then the total plant height of the five plants sample counted and divided by the sample size to get the mean plant height (cm).

9. **Ear height (cm):** A replicated samples of five plants were taken from each plot, then the ear height for each plant in the sample was measured from the ground level up to the first ear height, then replicated for the five plant, then summed and divided by five to get the mean ear height.

10. **Stem diameter:** A replicated samples of five plants were taken from each plot. Then the stem diameter was measured for all the sample using the Vernea

for the five plants sample, then summed and divided the sample size to get the mean stem diameter/plant.

11. **Number of ears/plot:** Three replicated samples for number of ears/m2 were taken from each plot to estimate the number of ears/m2, the three samples were summed and divided by three to get the mean number of ears/m2, then multiplied by 9 m2 (=the area of the plot) to get the mean number of ears/plot.

12. **Ear length (cm):** A replicated samples of five ears was taken from each plot to estimate ear length, number of e plants were taken from each plot measure the length of the ear of the five plants sample and then get the average to get the mean ear length (cm).

13. **Ear width (cm) :** A replicated samples of five ears were taken from each plot, to measure the ear width, a ruler or Vernia was used in measuring the width of the five ears sample, then the five ear width was summed, and the total width was divided by five to get the mean ear width (cm).

14. **Effective ear length (EEL) (cm):** A replicated samples of five ears were taken from each plot First the ears were cleaned from the sheath cover, then the length from the upper end of the seeds was measured up to base of the ear for the five ears sample, then the total of the effective ear lengths divided by five to get the mean EEL (cm)..

15. **Number of rows per ear:** A replicated samples of five ears were taken from each plot The number of rows/ear of all five ears sample were taken and summed, then the total number of rows of the five ears was divided by five to get the mean number of rows/ear.

16. **Number seeds per row:** A replicated samples of five ears were taken from each plot then count the number of rows for all the five ears sample to get the total number of rows/al rows then count the number of seeds/row for all the five ears, the total number of seeds were divided by the total number of rows to get the number of seeds/row.

17. **Number of seeds per ear:** A replicated samples of five ears were taken from each plot, then number of rows of the five ears sample were counted, to get the total number of seeds/ per the five ears then the whole seeds/ear were obtained then divide by five to the mean number of seeds/ear.

18. **Grain yields (ton/ha):** A replicated samples of three square meters from each plot were harvested and air dried then threshed, each meter square weight separately to get the total weight of the three meters then divide them by three to get the mean yield kg/meter square. The grain weight of the meter square was multiplied by 10,0,00 to get grain yield kg/ha and divided by 1000 to get the yield ton/ha.

19. **100 Seed weight (g):** A replicated five samples of 100 seeds were taken from the lot, then the total weight of the five samples was taken to get the total weight of the five 100 seeds weight. Then this total was dived by five to get the mean 100 seeds weight in grams.

20. **Biological yield (ton/ha):** The biological yield is defined as all the dry mater produced by the plant. A replicated samples of five meters were harvested (Hay+ heads) from each plot. Then First determine the biological yield/m^2 by cutting a replicate samples of one meter square of hay + heads, from the ground level to tassel, then after getting the dry weight, the biological yield was determined by multipying the biological yield/m2 by 10,000 to get the biological yield kg/ha then divide by 1000 to get biological yield ton/ha. Hay yield was determined after getting the biological yield, the heads were removed and hay was weighted alone to obtained hay yield ton/ha then, using the same procedure as biological yield.

21. **Harvest Index:** The harvest index is defined as the a measurement of the efficiency of plant or crop to convert dry matter to economic yield. The harvest index was obtained by dividing the economic yield by the biological yield. Grain yield of each plot was divided by the biological yield of the same plot to get the harvest index.

3.7 Statistical Analysis

All compiled data of each season were analyzed separately. The data for the two seasons were analyzed using Statiatics10 Computer Based program. Analysis of variance for each variable was attained and means were separated using least significant difference Test (LS.D). According to (Gomez and Gomez, 1984).

Chapter Four

Results and Discussion

4.1 The Effect of Sowing Methods (M) on growth and yield parameters for 2015 season:

The effect of sowing methods on population density, plant height, ear height, leaf number, leaf length, leaf width, leaf area Index (LAI) and stem diameter during the first season presented in tables 1 to 8. Statistical analysis revealed that only plant height was significantly affected by sowing methods. Ridge M scored the highest level of Ms was (188.5, 186.2 and 182.3 cm) for ridge, local farmers' method and flat sowing methods. This report is in conformity with the findings of Attia *et al*, (2012), Gobeze, *et. al*, (2012) who reported that planting maize in ridges 80 or 90 cm apart produced the highest values of all the studied characters; Attia *et al*,(2012), El-Mekser (2009), showed that increasing ridge spacing significantly reduced number of days to 50% tasselling and silking, plant and ear heights were in the same direction, planting on the 80 cm ridge was associated with a significant increase in ear length, number of kernels/row, 1000 kernel weight and grain yield. Effect of M on days to 50% tasselling, days to 50% silking, number of ears/plot, ear length cm, ear diameter cm, effective ear length (EEL), number of rows/ear, number of kernels/row, number of kernel/ear, seed yield kg/ha, 100 kernel weight, hay yield and harvest index are presented in tables 9 to 21. Statistical analysis of variance showed that number of ears/plot, ear length, ear diameter, number of kernels/row, number of kernels/ear, hay yield and harvest index were significantly affected by SMs during the first season. SM scored (1.73, 163 and 1.55) ton/ha of seed yield, and (17.42, 17.27 and 18.0) grams of 100 seed weight and (10.0, 8.03, and 9.62) ton/ha for hay yield for flat, local farmers' methods and ridge SMs respectively, during the first season. Ridge SM scored higher rates during the first season with respect to 100 seed weight. Shaikh *et al*.,(1994) , Majid *et al*., (1986) while studying the effect of different sowing methods demonstrated that plant height, total biomass production test grain weight, grain yield were maximum with ridge sowing, and it also decreased the number of days to tasseling, silking and maturity. In recent work Borras *et al*., (2003) concluded that a less leaf area index (LAI) duration could be a result of response to increased plant population in the field due to more leaf senescence rate during grain filling. Leilah *et. al*., (2013) found that SC 128 produced the highest value when planted in ridges 80 cm apart 22 cm between hill and one plant/hill. Mohammadein (2005) reported that sowing fodder maize on flat resulted in higher final yield of dry matter at harvest. Ridge SM scored greater rates of 100 seed weight and hay yield during both seasons that amounted to (18.0 and 17.9 for 100 SW and 9.62 and 11.8 ton/ha for hay yield, respectively).

Table 1: Means of interaction effects of M, S and V on Maize (*Zea mays L.*): for plant population

Treatment	***V1***	***V2***	***V3***	Mean	**S1**	**S2**	**S3**	Mean	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M1	42.0 A	42.6 A	41.3 A	42.0 A	57.6 A	38.4 C	29.9 D	42	56.3 A	39.7 C	30.0 EFG	58.7 A	39.3 C	29.7 EFG	57.7 A	36.3 CDE	30.0 EFG	41.9
M 2	40.9 A	38.0 AB	40.7 A	39.9 A	48.0 B	40.1 C	31.4 D	39.8	50.3 AB	37.0 CDE	35.3 CDEF	41.0 BC	42.3 BC	30.0 EFG	52.3 A	41.0 C	29.0 EFG	33.2
M 3	33.2 BC	29.8 C	30.2 C	31.2 B	38.8	30.8 D	24.1 E	31.2	42.3 BC	35.0 CDEF	23.7 G	35.0 CDEF	30.3 DEFG	24.0 G	29.0	27.0 FG	24.7 G	30.1
Mean	38.9 A	36.8 A	37.4 A		48.1 A	36.4 B	28.5 C		49.7 A	37.2 B	29.7 CD	45.1 A	37.3 B	27.9 D	49.6 A	34.8 BC	27.9 D	
LSD0.05 for																		
LSD0.05 for M	2.708 Ns																	
LSD0.05 for V				2.885 Ns														
LSD0.05 for S								3.0481 *										
LSD0.05 for M *V				**4.997 NS**														
LSD0.05 for M *s								**5.279 ***										
LSD0.05 for V*S																		5.279 Ns
LSD0.05 M *V*S																		9.145 Ns

M =Sowing methods (=M1=Ridge, M2=Flat, SM 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20cm,,S2=30 cm and S3=40 cm) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S *V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 2:- Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*): for plant height (cm):

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	**Mean**	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M1	A 185.6	186.4 A	192.4 A	188.5 A	169.4 B	192.9 A	191.9 A	184.7	169.6 BC	188.3 ABC	193.4 A	176.0 BC	200.7 A	188.3 ABC	162.5 C	189.7 ABC	193.1 ABC	184.6
M2	184.1 A	188.3 A	181.8 A	184.7 A	182.3 A	190.2 A	193 A	188.5	180.8 ABCD	181.1 ABCD	197.3 AC	188.3 ABC	186.0 ABC	184.9 ABC	177.8 ABC	202.9 A	196.6 ABC	188.4
M3	184.8 A	181.8 A	192.7 A	186.2 A	182.3 A	186.3 A	188.7 A	185.	180.0 ABCD	193.9 ABCD	180.5 ABCD	172.3 BCD	184.0 ABCD	187.3 ABCD	198.8 A	181.0 ABCD	198.3 AC	186.2
Mean	184.16 A	185.3 A	188.9 A	*****	178.5 B	A 189.8	191.2 A		176.8 B	.188 B	190.7 AB	178.9 B	190.3 AB	186.9 AB	179.7 AB	191.7 AB	196.0 AC	
LSD0.05 for																		
LSD0.05 for M	5.2106 Ns																	
LSD0.05 for V				9.8322 Ns														
LSD0.05 for S								8.7697 ***										
LSD0.05 for M *V				17.030 NS														
M*S								15.190 Ns										
LSD0.05 for V*S																		15.19 Ns
LSD0.05 for M *V*S																		26.55 NS

M =Sowing methods (=M 1=Ridge, M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20 cm,S2=30 cm and S3=40cm) between plants. SM *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S *V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 3:- Means of interaction effects of M, S and Varieties on Maize (Zea mays L.): for ear height (cm):

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	**Mean**	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M1	18.1 CD	19.4 ABC	19.4 ABC	19.0 A	17.1 D	17.0 CD	20.4 A	18.2	14.3 B	16.0 B	19.7 AC-EG	18.3 ACD	13.7 BD	19.0 AF	18.7 ACDEG	21.3 ADEG	22.7 ABCEF	18.2
M2	17.3 D	18.4 BCD	20.3 AB	18.7 AB	17.28 D	18.9 BC	19.4 AB	18.5	18.7 ACDEG	15.7 ABCE-G	17.7 ACDEG	16.3 ABCE-G	20.0 ADEG	19.0 ADEG	18.3 ACDEG	21.0 ADEG	21.7 ADFG	18.7
M3	16.7 D	17.3 D	20.9 A	18.19 B	18.3 BCD	19.3 AB	19.3 AB	19.0	17.3 ACDEG	18.7 ACDEG	18.3 CDEG	18.7 ACDEEG	20.3 ADEG	19.3 ADEG	19.0 ADEG	19.0 ADEG	20.3 ADG	19.0
Mean	17.4 B	18.3 B	20.2 A	18.4	17.7 B	18.4 B	19.4 A		16.8 D	16.8 D	18.6 CD	17.8 CD	18.0 CD	19.1 BC	18.7 C	20.4 AB	21.6 A	
LSD .05 FOR																		
LSD0.05 for M	0.2134 *																	
LSD0.05 for V	1.2665 NS			1.2665 Ns														
LSD0.05 for S	0.9117 *							0.9117 *										
LSD0.05 for M *V	2.1937 NS			2.1937 Ns														
M*S	1.5792							2.1937 Ns										
LSD0.05 for V*S																		1.5792 Ns
LSD0.05 for M *V*S																		2.7352 Ns

M =Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. SM *V interaction between ridge and variety, V*S interaction between Varieties and spacing, SM*S *V interaction between sowing methods, spacing's and varieties, LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 4:- Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*): for leaf number:

Treatment	***V1***	***V1***	***V1***	**Mean**	**S1**	**S2**	**S3**	Mean	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	***mean***
M1	12.33	12.22	11.78	12.11	11.78	12.44	12.11	12.15	12.00	12.67	12.33	12.00	12.33	12.33	12.33	12.33	11.67	12.22
M2	12.00	11.79	12.44	12.07	11.78	12.00	12.33	12.0	12.OO	12.67	12.33	11.67	12.00	11.67	12.00	12.33	13.00	12.19
M3	11.78	12.39	12.17	12.19	12.44	12.11	12.00	12.22	12.33	12.00	11.67	12.50	12.33	12.33	12.00	12.00	12.00	12.1
Mean	12.11	12.13	12.13		12.04	12.9	12.15		12.11	12.11	12.11	12.06	12.22	12.11	11.94	12.22	12.00	
LSD0.05 for																		
LSD0.05 for M	0.5457 Ns																	
LSD0.05 for V				0.3919 NS														
LSD0.05 for S								0.5762 NS										
LSD0.05 for M *V				0.6788 NS														
M*S								0.9979 NS										
LSD0.05 for V*S																		0.9938 NS
LSD0.05 M *V*S																		1.7285 NS

M =Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S *V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 5:- Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*): for leaf width:

Treatment	***V1***	***V1***	***V1***	**Mean**	**S1**	**S2**	**S3**	**Mean**	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	***mean***
M 1	7.39 AB	7.20 B	7.81 A	7.47 A	7.24 B	7.64 A	7.51 A	7.41 A	7.03 B	7.80 A	7.33 B	7.20 B	7.53 B	6.9 B	7.50 B	7.6 A	8.33 A	7.47
M2	7.64 AB	7.78 AB	7.41 AB	7.61 A	7.63 A	7.38 A	7.82 A	7.61 A	7.53 A	8.00 A	7.40 B	7.93 A	7.00 B	8.4 A	7.43 B	7.1 B	7.67 A	7.61
M3	7.47 AB	7..40 AB	7.24 AB	7.4 A	7.29 B	7.36 A	7.47 A	7.37 A	7.27	7.2 B	7.87 A	7.60 A	7.27 B	7.3 B	7.00 B	7.5 A	7.20 B	7.36
Mean	7.5 A	7.45 A	7.49 A		7.39 A	7.46 A	7.60 A		7.3 A	7.69 A	7.53 A	7.6 A	7.67 A	7.5 A	7.5 A	7.4 A	7.73 A	
LSD0.05 for																		
LSD0.05 for M	0.3855 Ns																	
LSD0.05 for V				0.326 Ns														
LSD0.05 for S								0.297 Ns										
LSD0.05 for M*V				0.59 *														
LSD0.05 for V*S								0.515 *										0.515 Ns
LSD0.05 for M *V*S																		0.8923 *

M =Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 6:- Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*): for leaf length (cm):

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	Mean	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	***Mean***
M1	67.5 A	66.1 B	70.4 A	68.0 A	69.1 A	68.1 A	66.8 A	68.0	68.8 A	65.0 A	68.6 A	68.4 A	65.9 AB	63.9 B	70.0 A	73.5 A	67.8 A	68.5
M2	70.4 A	68.8 A	69.1 A	68.6 A	65.3 A	69.6 A	70.6 A	68.6	64.9 A	68.2 A	73.3 A	63.6 A	70.3 A	68.5 A	67.5 A	70.7 A	69.2 A	68.5
M3	72.2 A	66.4 B	69.4 A	69.4 A	70.3 A	69.5 A	68.6 A	69.5	75.9 A	69.5 A	71.2 A	64.9 A	68.7 A	66.5 A	70.0 A	70.5 A	67.7 A	69.4
Mean	69.6 A	66.7 A	69.6 A		68.0 A	68.2 A	69.1 A		69.9 AB	67.6 AB	71.0 AB	65.6 AB	68.3 AB	66.3 AB	69.2 AB	71.6 A	68.2 AB	
LSD0.05 for M	8.2106 Ns																	
LSD0.05 for V				2.7678 Ns														
LSD0.05 for S								3.285 Ns										
LSD0.05 for M *V				4.7940 *														
S*V	5.6901 Ns							5.690 Ns										
LSD0.05 for V*S																		5.6901 *
LSD0.05 for M*V*S																		9.8556 Ns

M=Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S *V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 7:- Means of interaction effects of M, S and Varieties on Growth and Yield of Maize (*Zea mays L.*): for leaf area index (LAI):

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	Mean	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	***Mean***
M1	1.82 B	2.00 A	1.93 A	1.92 A	1.61 C	2.06 AB	2.08 AB	1.94	1.61	2.00 A	1.93 A	1.84 A	1.99 A	2.18 A	1.69 ABF	2.06 AB	2.06 A	1.93
M2	1.93 B	2.01 A	2.05 A	2.00 A	2.02 AB	1.85 BC	2.11 A	1.99	2.06 A	2.00 A	1.95 A	1.99 A	1.83 A	2.20 AB	2.12 AB	1.84 AD	2.19 AB	2.02
M3	2.05 A	1.95 A	1.94 A	1.98 A	2.02 AB	1.94 AB	1.99 AB	1.98	2.02 A	1.95 A	1.94 AB	2.11 AB	1.79 A	1.94 ABC	3.8 A	1.97 A	2.03 A	2.17
1.97 A	1.97 A	1.93 B	1.99 A	1.97 A	1.88 B	1.95 AB	2.06 A		1.79 C	2.02 AB	1.99 ABC	1.98 ABC	1.87 BC	2.11 A	1.88 BC	1.96 ABC	2.09 A	
LSD0.05 for																		
LSD0.05 for M	0.2227 Ns																	
LSD0.05 for V				0.1076 *														
LSD0.05 for S								0.1187 *										
LSD0.05 for M*V				0.1863 *														
M*S								0.1863 Ns										
LSD0.05 for V*S																		0,2056 Ns
LSD0.05 for M*V*S																		0.3562 Ns

M=Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S*V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 8:-: Means of interactions effects of M, S and Varieties of Maize (*Zea mays L*.): for stem diameter (cm):

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	**Mean**	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	***mean***
M1	2.23 A	2.19 A	2.24 A	2.21 A	2.14 B	2.30 A	2.18 B	2.21 A	2.24 A	2.18 A	2.24 A	2.09 A~DFG	2.35 A	2.09 A~DG	2.11 A~DG	2.33 A	2.14 A	2.2 A
M2	2.28 A	2.24 A	2.25 A	2.26 A	2.19 B	2.35 A	2.23 BC	2.26 A	2.11 A~DG	2.31 A	2.35 A	2.18 A	2.43 A~D	2.23 A	2.14 A	2.39 A~DF	2.23 A	2.26 A
M3	2.24 A	2.18 B	2.21 A	2.21 A	2.16 B	2.17 B	2.23 BC	2.19 A	2.14 A	2.18 A~EG	2.18 A~F	2.07 A~EG	2.16 A	2.30 A	2.18 A	2.26 A	2.19 A	2.18 A
Mean	2.25	2.20	2.22		2.16 B	2.27 B	2.23 AB		2.24 ABC	2.18 C	2.34 A	2.11 C	2.31 AB	2.18 C	2.14 C	2.33 A	2.18 BC	
LSD0.05 for M	0.1275 Ns																	
LSD0.05 for V				0.086 Ns														
LSD0.05 for S								0.0686 *										
LSD0.05 for M*V				0.149 Ns														
LSD of M*S								0.1187 NS										
LSD0.05 for V*S																		0.119 Ns
LSD0.05 for M*V*S																		0.206 NS

M=Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S*V* interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance

4.2 The Effect of intra-row spacing (S) or (Hill spacing) on mean growth, yield and yield components of maize during 2015 season.

The effect of intra-row spacing on mean population density, plant height, ear height, leaf number, leaf length, leaf width, leaf area index and stem diameter during the first and second seasons are presented on tables 1 to 8. Statistical analysis of variance revealed that population density, plant height, ear height and stem diameter during the first season were significantly affected by the intra-row spacing. 20 cm intra-row spacing scored higher significant level of population density of 48.1, compared 30 and 40cm hill spacing amounted (36.4 and 29.5) respectively. 40 cm intra-row spacing scored high significant level of plant height and ear height of (191.2 cm and 19.4 cm) compared with 20 cm amounted (178.5 and17.7) and (189.4 and 18,4) for 30 cm hill spacing. While 30 cm hill spacing scored higher significant level of stem diameter of (2.24 cm) compared with 20 cm and 40 cm during the first season Effect of hill spacing on days to 50% tasselling, days to 50% silking, number of ears/plot, ear length, effective ear length, ear diameter, number of rows/ear, number of kernels/row, number of kernel/ear, Seed yield, 100 kernel weight, hay yield and harvest index as presented in tables 9 to 21. Statistical analysis of variance showed that days to 50% tasselling, days to 50% silking, number of ears/plot, ear length, ear diameter, effective ear length (EEL), number of kernels/row, number kernels/ear,100 kernel weight, seed yield and hay yield were significantly affected by the hill spacing during the first season, Hill spacing of 30 cm and 40 cm scored higher significant levels of most of the measured parameters with exception of seed yield and 100 seed weight in which 20 cm hill spacing scored higher rates of (1.77, 1.64 and 1.5 ton/ha) for seed yield and (17,06, 17.21 and 18.43 grams) for 100 seed weight, with respect to 20, 30 and 40 cm hill spacing respectively, during the first season.. Hill spacing of 20 cm scored higher yield ton/ha because of denser plant intercepted more sun light which led to more dry matter production and more yield. Abass *et. al*.,(2010) reported that increasing population density caused significant decrease in stem diameter. And a significant increase in LAI fresh and dry weight of forage and leaves dry weight, decreasing intra-row spacing increase population density. Ali *et al*, (2014) reported that conventional methods of sowing maize out yielded no till and reduce tillage. Abuzar *et al*. (2011), reported that maximum population density of 40000 plants/ha produced maximum number of grains/row (32.33), and number of grains/ear (447.3). However, 60000 plants/ha produced maximum number ears/plant (1.33), maximum number of grains/row (15.440, biomass yield (16.89 ton/ha) and grain yield of (2.6 ton/ha). Mohammed *et.al* (2006) reported that maize grain yield improved by planting methods, seed density and fertilizer level. Abuzar, *et. al*.. Bisht *et. al*., (2012) established that grain yield increased in the narrow rows due to limited intra-row competition for light, nutrient and water. Population above the optimum has resulted in lodging that caused reduction in maize production. Sharifai *et al*., (2012), Leilah *et al*.,(2013) showed that increase in intra-row spacing from 20 to25 cm significantly increased number. of rows/cob, cob diameter, 100 kernel weight and grain yield. Sadegi (2013) reported that highest grain yield for some hybrids was obtained at plant density of 8 plants/m^2 reached their maximum grain yield and its components. Therefore this is the best option to achieve the highest grain yield. Ukanze *et. al*., (2016) showed that the 70*30 cm and 60*30 cm spacing gave higher values of morphological parameters than 80*20 cm. with regard to yield 80*20cm gave the highest average cob weight, 1000 grain weight. Mohammad *et al*., (2002) reported that maximum grain yield was recorded at 20 cm intra-row spacing, while LAI and number. grains/cob were greater at 25 and 20 cm intra-row spacing, while 1000 grain weight at 25 and 20 cm level and lowest at 15 cm intra-row spacing. Lakew *et al*., (2016) reported that highly significant difference due to the main effect of intra-row spacing was observed on LA, LAI, number of ears/plant, above ground dry biomass yield/ha, number.

of kernels/ear, 1000 kernel weight and harvest index. 1000 kernels weight, and number of kernels/ear highly significantly increase with decreased intra-row spacing, this may due to the fact that maize is least crop with respect to tillering, this could be compensated by reduced intra-row spacing. He concluded that spacing combination of 65*25 cm responded favorably in attaining higher grain yield in the area. Radma et.al., (2013), showed that maize hybrids significantly different in final grain yield and yield components as cob yield and number. of grains/cob due to the genetically constituents of each hybrid.

4.3 The effect of Varieties on mean growth and yield characters for 2015 and 2016 seasons:

The effect of varieties on mean population density, plant height, ear height, leaf number, leaf length, leaf width, leaf area index (LAI) and stem diameter during the first season presented in tables 1 to 8. Statistical analysis of variance revealed that only leaf area index during the first season was significantly affected by the varieties. Effect of varieties on 50% tasselling, days to 50% silking, number of ears/plot, ear length, effective ear length, ear diameter, number of rows/ear, number of kernels/row, number of kernel/ear, Seed yield, 100 kernel weight, hay yield and harvest index as presented in tables 9 to 21. Statistical analysis of variance showed that number of ears/plot, ear length, effective ear length, ear diameter, number of seeds/row, number of seeds/ear, 100 seed weight and hay yield, were significantly affected by the varieties during the first season. Variety113 scored higher significant levels of most measured characters with exception of 100 seeds weight.in which Hudeiba2 scored higher rate of (18.77 grams) compared with variety113 which scored 16.31 grams. Vari113 scored the highest level of almost all characters measured. This means that it is the most suitable variety for this environment as mentioned by Sadeghi *et. al*.,(2012), Attia, *et. al*., (2012) summarized that for obtaining a higher maize yield and net income maize cultivars had different responses to agronomic characters and grain yield. Alias et. al.,(2010), Al-Metwally *et. al*.,(2011), showed that a significant difference between maize cultivar with respect to plant height, number. of ears/plant, LAI, number. of kernels/row, grains weight/ear and grain yield/plant. . Zamir *et. al*., (2011) initiate that hybrid 30Y87 was early in maturity, produced more number of rows/cob, less number of grains/row and less cob length than hybrid 31R88. Similarly hybrid 30Y87 1000 kernel weight, grain yield, and straw yield of hybrid 30Y87 was significantly greater than hybrid 30R88.Selecting the suitable variety is considered to be crucial for obtaining a good, varieties are different in earliness this could in favour of good yield and yield components.

4.4 Effect of interaction of methods of sowing, intra-row spacing and the varieties on means of growth, yield and yield components of maize:

The effect of interaction of sowing methods (M), spacing (S) and varieties (V) on means of growth, yield and yield components of maize shown on tables 9 to 21. During the first season. statistical analysis revealed that the interaction between the treatments resulted in the fact that the ear length, effective ear length and seed yield were affected by the interaction of sowing methods and varieties (M*V), and scored higher levels as follows: ear length scored 17.8 (cm) by the combination M_2V_3, while effective ear length scored 15.2 (cm) by the combination M_1V_3, and seed yield of 1.93 ton/ha by the combination M_1V_3.. The effect of the interaction between sowing method and spacing M*S was significantly affected population density and scored higher levels of 48.1 plants/plot by the combination M_1V_1. ,The spacing variety interaction (S*V) significantly affected number of ears/plot, number of rows/ear and number of seeds/row, and scored higher levels of these parameters as follows: number of ears/plot scored 30.1 by the combination scored by S_1V_2, while number of rows/ear scored 15.8 by the combination of S_2V_3, the seeds/row scored 35.4 by the combination S_2*V_1. The interaction between M*S*V significantly affected number of ears/plot, ear length, grain yield, hay yield and harvest index and scored 43.7 for number of ears/plot by the combination $M_1S_1V_2$, while ear length scored 22.6 (cm) by the combination of $M_1S_3V_3$, grain yield scored 2.28 ton/ha by the combination $M_3S_3V_3$, for hay yield scored 13.6 ton/ha by the combination of $M_1S_2V_3$, while the harvest index scored 35.6 through the combination $M_1S_3V_3$. It was well established ridge sowing method was superior to the other sowing methods, because M_1 was over dominated all the combinations between sowing methods and the varieties and spacing. With respect to spacing S_1 which was 20 cm intra-row spacing and S_2 which was 30 cm were considered to be superior intra-row spacing with respect to method practiced by farmers. Variety 113 was superior to Hudeiba1 and Hudeiba 2 with respect to most of parameters measured in the work.

Table 9:- Means of interaction effects of method of sowing, Spacing and Varieties on Maize (*Zea mays L.*): for 50% tasselling

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	**Mean**	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	***mean***
M1	58.44 A	59.22 A	59.89 A	59.19 A	57.67 B	59.78 A	60.00 A	58.8	56.67 A	58.67 A	60.00 AC	57.68 A	60.00 AC~G	60.00 AC~G	58.67 A	61.00 A	60.00 A	59.19
M2	59.22 A	60.00 A	59.33 A	59.19 A	58.00 B	59.78 A	58.33 A	58.7	57.67 A	60.00 AC~G	60.00 AC~G	59.00 A	60.00 AC~G	61.00 A	57.33 ABC	59.33 ACEFG	58.33 A	59.18
M3	59.33 A	59.22 A	60.00 A~F	59.52 A	58.78 AB	60.11 A	59.67 A	59.5	59.00 A	60.00 AC~G	59.00 A	57.33 ABCE	60.33 AC~G	60.00 AC~G	60.00 AC~G	60.00 AC~G	60.00 AC~G	59.52
Mean	59.00 A	59.48 A	59.41 A		58.15 B	59.93 A	59.82 A		57.78 D	59.56 ABC	59.66 AB	59.00 BCD	60.11 AB	60.33 A	58.67 BCD	60.11 AB	59.44 ABC	
LSD0.05 for																		
LSD0.05 for M	1.1011 Ns																	
LSD0.05 for V				0.9663 Ns														
LSD0.05 for S								0.8663 *										
LSD0.05 for M*V				**1.1673 Ns**														
LSD0.05 for M*S								1.5004 Ns										
LSD0.05 for V*S																		1.5004 Ns
LSD0.05 for M*V*S																		2.7031 Ns

M=Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S*V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 10:- Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*): for 50% silking:

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	Mean	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M1	62.4 A	63.3 A	63.8 A	63.2 A	61.7 B	63.8 A	64.0 A	63.1	60.7 B	62.7 ABCD	64.0 ABC	61.7 BCD	64.0 ABC	64.0 ABC	62.7 ABCD	64.7 A	64.0 ABC	63.2
M2	63.2 A	63.9 A	62.3 A	63.1 A	61.7 B	63.8 A	63.8 A	63.1	60.7 B	64.0 ABC	64.3 AB	63.0 ABCD	64.0 ABC	64.7 A	61.3 CD	63.3 ABCD	62.3 ABCD	63.1
M3	63.3 A	63.4 A	63.8 A	63.5 A	62.8 AB	63.9 A	63.9 A	63.5	63.0 ABCD	64.0 ABC	63.0 ABCD	61.3 BCD	64.0 AB	64.7 A	64.0 ABC	63.0 ABCD	64.0 ABC	63.4
Mean	62.9 A	63.5 A	63.3		62.0 B	63.8 A	63.9 A		61.4 D	63.6 ABC	63.8 AB	62.0 CD	64.1 AB	64.4 A	62.7 BCD	63.8 AB	63.4 ABC	
LSD0.05 for																		
LSD0.05 for M	0.8480 Ns																	
LSD0.05 for V				0.9916 Ns														
LSD0.05 for S								0.851 *										
LSD0.05 fo M*V				1.7175 Ns														
M*S								1.4739 Ns										
LSD0.05 for V*S																		1.4739 Ns
LSD0.05 for M*V*S																		2.5528 Ns

M=Sowing methods (=M1=Ridge,M2=Flat, M3= local Farmer's methods), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S *V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 11: Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*):: for number of ears/plot:

Treatment	***V1***	***V1***	***V1***	**Mean**	**S1**	**S2**	**S3**	Mea n	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M1	26.6 B	32.2 A	29.1 AB	29.3 A	33.0 A	26.7 AB	28.2 AB	29.3	24.0 B	25.7 B	30.0 C	43.7 A	23.3 D	29.7 B~F	31.3 BCDG	31.3 B~DG	25.0 B~DF G	29.3
M2	24.7 BC	24.8 BC	24.7 BC	24.7 B	25.6 AB	24.6 AB	24.0 AB	24,7	27.7 B-DFG	20.7 B-DF	25.7 B-D~G	27.0 B~D~ G	27.3 B~D~G	20.0 B-DF	22.0 B~DF	25.7 B-D~G	26.3 B~DF G	24.7
M3	20.9 C	19.8 C	27.9 AB	22.9 B	23.7 AB	25.7 AB	19.4 AG	22,9	21.0 BCF	23.3 B~DFG	18.3 BCFG	19.7 B~CF	20.7 BCF	19.0 BCF	30.3 B~DFG	32.3 BCDG	21.0 BCF	19.3
Mean	24.0 B	25.6 AB	27.2 A		27.4 A	25.6 AB	23.9 B		24.2 BC	23.2 C	24.7 BC	30.1 C	23.8 C	22.9 C	27.9 AB	29.7 A	24.1 BC	
LSD0.05 for																		
LSD0.05 for M	3.7083 *																	
LSD0.05 for V				2.4846 *														
LSD0.05 for S								2.285 *										
LSD0.05 for M*V				4.3035 *														
M*S								3.958 *										
LSD0.05 for V*S																		3.9583 *
LSD0.05 for M*V*S																		6.8560 ***

M=Sowing methods (=R1=Ridge,R2=Flat, R3=local Farmer's method), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=30) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S *V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 12:- Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*):for ear length:

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	**Mean**	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M1	16.7 D	17.0 D	20.9 A	18.19 B	17.1 D	17.0 D	20.4 A	18.2	14.3 A	16.00 AB	19.7 A	18.3 ACD	13.7 ABC	19.0 ACDE	18.7 ACDE F	21.3 A~G	22.6 AD	18.2
M2	17.3 D	18.4 BCD	20.3 AB	18.7 AB	17.8 CD	18.9 BC	19.4 AB	18.7	18.7 ACDEG	15.7 ABCEF	17.7 ABDE G	16.3 A~G	20.0 ADEG	19.0 ADEG	18.3 ACDE G	21.0 ADEG	21.7 ADG	18.8
M3	18.1 CD	19.4 ABC	19.4 ABC	19.0 A	18.3 BCD	19.3 AB	19.3 AB	19.0	17.3 ACDEG	18.6 ACDE G	18.3 ACDE G	18.7 ACDEG	20.3 ADEG	19.3 ADEG	19.0 ADEG	19.0 ADEG	20.3 ADE G	18.98
Mean	17.0 B	18.3 B	20.2 A		17.7 B	18.4 B	19.7 A		16.8 D	16.8 D	18.6 C	17.8 CD	18.0 CD	19.1 BC	18.7 C	20.4 AB	21.6 A	
LSD0.05 for																		
LSD0.05 for M	0.6339 *																	
LSD0.05 for V				1.266 *														
LSD0.05 for S								0.912 ***										
M*,V				2.193 NS														
LSD 0.05 M*S								2.193 7 NS										
LSD0.05 for V*S																		1.5792 *
LSD0.05 for *V*S M																		2.7352 **

M =Sowing methods (=R1=Ridge,R2=Flat, R3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S *V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance

Table 13:- Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*): for effective ear length (EEL)(cm):

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	**Mean**	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	***mean***
M 1	15.3 B	15.6 AB	16.8 AB	15.9 A	15.9 ABC	14.2 BC	17.6 A	15.9	15.3 B~F	14.3 C~F	16.3 A~E	16.3 A~E	12.7 EF	17.7 ABC	16.0 A~E	15.7 B~F	18.7 AB	15.9
M 2	15.2 B	15.3 B	17.8 A	16.1 A	14.0 C	17.3 A	17.0 A	16.1	13.7 DEF	15.7 B~F	16.3 A~D	12.0 F	18.0 ABC	16.0 A~E	16.3 A~E	18.3 AB	18.7 AB	14.0
M 3	16.6 AB	15.9 AB	17.4 AB	16.6 A	16.3 ABC	16.7 AB	16.9 A	16.4	16.3 A~D	16.7 A~D	16.7 A~D	16.7 A~D	16.7 A~D	14.3 C~F	16.0 A~E	16.7 A~D	19.7 A	16.6
Mean	15.7 B	15.6 B	17.3 A	16.2	15.4 B	16.1 AB	17.2 A		15.1 B	15.6 B	16.4 B	15.0 B	15.8 B	16.0 B	16.1 B	16.89 AB	19.0 A	
LSD0.05 for																		
LSD0.05 for M	1.6980 NS																	
LSD0.05 for V				2.2105 *														
LSD0.05 for S								1.2762 *										
LSD0.05 for M *V				2.2105 *														
LSD0.05 for M *S								2.2105 *										
LSD0.05 for V*S																		2.2105 *
LSD0.05 for M *V*S																		3.8286 NS

M =Sowing methods (=M1=Ridge,M2=Flat, M3= local Farmer's methods), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M *V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 14:- Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*):: for ear diameter (cm):

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	**mean**	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M 1	4.47 A	4.76 A	4.77 A	4.66 A	4.89 C	4.61 BC	4.89 AB	4.80	4.23 A	4.30 E	4.87 A~D	4.70 A~F	4.80 A~E	4.77 A~D	4.53 A~E	4.73 A~E	5.03 AB	4.67
M 2	4.86 A	4.63 A	4.77 A	4.75 A	4.61 ABC	4.77 ABC	4.80 ABC	4.73	5.10 A	4.47 BCDE	5.00 ABC	4.60 A~E	4.73 A~E	4.57 A~E	4.37 CDE	5.10 A~E	4.83 A~E	4.8
M 3	4.78 A	4.83 A	4.84 A	4.82 A	4.67 ABC	4.80 ABC	5.00 A	4.8	4.60 A~E	4.73 A~E	5.00 ABC	4.67 A~E	4.73 A~E	5.00 ABC	4.73 A~E	4.83	4.97 ABC	4.81
Mean	4.7 A	4.74 A	4.79 A		4.61 A	4,73 AB	4.89 A		4.64 AB	4.50 B	4.96 A	4.66 AB	4.77 AB	4.78 AB	4.54 B	4.89 AB	4.94 A	
LSD0.05 for M	0.1935 *																	
LSD0.05 for V				0.2820 **														
LSD0.05 for S								0.1990 ***										
LSD0.05 for M*S				0.4884 NS														
LSD0.05 for M *S								0.4884 NS										
LSD0.05 for V*S																		0.3445 NS
LSD0.05 for M *V*S																		0.3445 NS

M =Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M *V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 15 : Means and interaction effects of M, IR S and Varieties on Maize (*Zea mays L.*): for number of rows/ear:

Treatment	***V1***	***V1***	***V1***	**Mean**	**S1**	**S2**	**S3**	**mean**	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M 1	13.8 BC	14.0 BC	14.2 ABC	14.0 A	13.4 B	14.8 AB	13.8 B	14.0	13.7 A	13.7 AB	14.0 ABC	14.3 A~D	15.0 A~E	12.7 A~F	12.3 A~EG	15.7 A~F	14.7 A~G	14.01
M 2	13.7 C	15.0 AB	14.4 ABC	14.4 A	13.8 B	15.1 AB	14.2 AB	14.37	14.7 A~G	12.7 A~G	13.7 A~G	13.7 A~G	16.7 A~F	15.0 A~G	13.0 A~G	16.3 A~F	14.0 A~G	14.42
M 3	14.8 ABC	14.7 ABC	15.6 A	15.0 A	14.7 AB	14.6 AB	15.1 A	14.8	14.3 A~G	14.0 A~G	16.0 A~F	15.3 A~G	14.3 A~G	14.3 A~G	14.3 A~G	15.3 A~G	17.0 AEF	13.39
Mean	14.1 A	14.6 A	14.7 A		14.0 A	14.8 A	14.6 A		14.2 BC	13.4 C	14.6 ABC	14.4 ABC	15.2 AB	14.0 BC	13.2 C	15.8 A	15.2 AB	
LSD0.05 for																		
LSD0.05 for M	1.1619 NS																	
LSD0.05 for V				0.7203 NS														
LSD0.05 for S								0.9210 NS										
LSD0.05 for M *V				1.2475 NS														
SM*S								1.2475 NS										
LSD0.05 for V*S																		1.5952 *
LSD0.05 for M *V*S																		2.7630 NS

M =Sowing methods (=M1=Ridge,M2=Flat, M3= local Farmer's method), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S*V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 16:- Means interaction effects of M, S and Varieties of Maize (*Zea mays L.*): for number of seeds/row:

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	Mean	***V1S1***	***V1 S2***	***V1 S3***	***V2 S1***	***v2 S2***	***v2 S3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M 1	29.5 A	29.6 A	34.1 A	31.0 A	29.8 ABC	31.0 A	32.3 A	31.03	24.1 EFG	31.9 A~D	32.0 A~D	29.3 B~F	28.2 C~F	31.1 A~E	36.0 ABC	33.0 A~D	33.1 A~D	30.97
M 2	32.5 A	24.3 B	29.6 A	28.8 B	25.8 C	29.8 ABC	30.6 AB	28.73	28.9 B~F	37.9 A	30.8 A~E	18.3 G	22.4 FG	32.3 A~D	30.1 A~F	29.7 B~F	28.9 B~F	21,47
M 3	31.6 A	28.7 B	31.1 A	30.0 AB	27.5 BC	33.0 A	30.9 AB	30.45	26.1 DEF	36.3 AB	32.2 A~D	26.8 DEF	31.3 A~E	27.9 DEF	29.7 B~F	31.3 A~E	32.4 A~D	30.44
Mean	31.2 A	27.5 A	31.6 A	20.89	27.7 B	31.3 A	31.2 A		26.00	35.4 A	31.9 AB	24.8 E	27.3 CDE	30.4 BCD	31.9 AB	31.3 ABC	31.5 ABC	
LSD0.05 for M	2.056 *																	
LSD0.05 for V				2.744 *														
LSD0.05 for S								2.563 **										
LSD0.05 SM*V				4.752 NS														
LSD0.05 M*S								4.752 NS										
LSD0.05 for V*S																		4.441 *
LSD0.05 M *V*S																		7.871 NS

M =Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S*V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 17 : Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*) :for number of seeds per ear:

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	Mean	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M1	405. CD	409.0 BCD	48. A	437.. AB	394 CD	457. ABC	445.5 ABC	432.2	326.8 FG	435.3 A~F	453.8 A~F	415.8 B~F	417.8 B~F	393.6 B~F	441.9 A~F	519.7 AB	487. A~ E	432.4
M2	439. ABC	365. D	424 ABCD	410 B	354 D	439. ABC	434.8 ABC	409.3	421.1 B~F	476.2 A~E	420.5 B~F	252.2 G	364.5 EFG	479.4 A~E	390.1 C~F	478.8 A~E	405 B~F	409.8
M3	467 AB	424. ABCD	485 A	458. A	404 ABc	480.8 AB	491 A	458.6	376.1 D~G	508.7 A~D	515.9 ABC	411.3 B~F	456.8 A~E	408.8 B~F	425.9 A~F	476.9 A~E	552. 9 A	459.3
Mean	437. AB	399. B	459 A		384 B	459.4 A	456.8 A		374.7 C	473.4 AB	463.4 AB	359.8 C	413.0 B~F	425.6 ABC	419.3 ABC	491.7 A	481. AB	
LSD0.05 for																		
LSD0.05 for M	27.07 *																	
LSD0.05 for V				39.11 *														
LSD0.05 for S								45.69 NS										
LSD0.05 for M*V				67.73 NS														
LSD0.05 for M*S								67.73 NS										
LSD0.05 for V*S																		69.13 NS
LSD0.05 for M*V*S																		137.8 NS

M=Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 18:- Means and interactions effects of M, S and Varieties of Maize *(Zea mays L.*): for grain yield (ton/ha):

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	Mean	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M1	1.53 BC	1.64 ABC	1.47 C	1.55 A	1.88 A	1.43 BC	1.32 C	1.55	1.77 B~G	1.45 D~H	1.38 E~H	2.25 AB	1.41 E~H	1.26 H	1.63 D~H	1.44 E~H	1.33 FGH	1.55
M2	1.53 BC	1.81 AB	1.87 A	1731 A	1.74 A	1.6 0 AB	1.74 A	1.71	1.59 D~H	1.33 FGH	1.65 D~H	1.66 D~H	1.82 A~G	1.94 A~D	2.14 ABC	1.83 A~G	2.28 A	1.80
M3	1.65 ABC	1.52 BC	1.72 ABC	1626 A	1.62 ABC	1.83 S	1.43 C	1.69	1.77 B~G	1.75 C~G	1.43 E~H	1.49 D~H	146. D~H	1.60 D~H	1.60 D~H	2.28 A	1.27 H	1.63
Mean	1.57 A	1.65 A	1.68 A		1.77 A	1.64 AB	1.50 B		1.71 ABC	1.51 CD	1.49 CD	1.80 AB	1.56 BCD	1.60 A~D	1.79 AB	1.85 A	1.41 D	
LSD0.05 for																		
LSD0.05 for M	212.07 NS																	
LSD0.05 for V				164.26 NS														
LSD0.05 for S								155.91 **										
LSD0.05 for M *V				284.50 NS														
LSD0.05 for M *S								284.50 NS										
LSD0.05 for V*S																		270.04 *
LSD0.05 for M *V*S																		467.72 *

M =Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 19:- Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*): for 100 seed weight:

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	**mean**	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M1	17.51 BCD	19.54 A	16.97 BCD	18.00 A	16.68 B	17.72 B	19.62 A	18.01	15.63 EFG	16.73 D~G	20.57 ABC	17.07 DEF	20.57 AB	21.00 A	17.33 C~F	15.87 EFG	17.7 B~F	18.1
M2	16.92 CD	18.70 AB	16.63 CD	17.42 A	17.17 B	17.27 B	17.82 AB	17.42	15.47 FG	17.70 B~F	17.40 B~F	18.63 A~E	18.43 A~E	19.03 A~D	17.40 CDF	15.77 EFG	16.7 D~`G	17.3
M3	17.83 ABC	18.06 ABC	15.92 D	17.27 A	17.34 B	16.63 B	17.83 AB	17.27	17.93 A~F	16.90 DEF	18.67 A~E	17.67 B~F	19,13 A~D	17.37 C~F	16.43 D~G	13.87 G	17.4 C~F	17.3
Mean	17.42 B	18.77 B	16.51 C		17.06 A	17.21 B	18.43 A		16.34 CD	17.08 BC	18.84 AB	17.79 ABC	19.48 A	19.13 A	17.06 C	15.1 D	17.3 BC	
LSD0.05 for																		
LSD0.05 for M	1.2973 NS																	
LSD0.05 for V				0.9025 ***														
LSD0.05 for S								0.9210 *										
LSD0.05 for M *V				1.0245 NS														
LSD0.05 for M *V								1.0245 NS										
LSD0.05 for V*S																		1.5632 *
LSD0.05 for M *V*S																		3.0736 NS

M =Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S *V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance

Table 20:-Means of interaction effects of Ms, S and Varieties of Maize (*Zea mays L.*): for hay yield ton/Ha

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	mean	***V1s1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***v3 s1***	***v3 s2***	***v3 s3***	Mean
M1	7.82 CD	9.02 B	12.02 A	9.62 A	11.14 A	9.33 B	8.39 B	9.62	10.67 B~F	6.40 KL	6.40 KL	10.77 B~F	8.03 G~L	8.28 F~K	12.00 A~D	13.57 A	10.53 B~F	9.63
M2	8.81 BC	9.33 B	11.76 A	10.0 A	9.64 AB	11.00 A	9.36 B	10.0	7.07 JKL	10.13 C~G	9.23 E~J	12.13 C~G	9.97 D~I	6.20 KL	9.73 D~I vvv	12.90 AB	12.63 AB	10.0
M3	7.37 D	CD7.40	9.43 B	8.03 B	8.66 B	6.56 C	9.1 B	8.11	7.20 JKL	5.67 L	9.23 E~J	7.40 IJKL	7.30 IJKL	7.50 H~K	11.37 A~E	6.10 KL	10.53 B~F	8.03
Mean	8.0 C	8.62 B	11.03 A		9.81 A	8.91 B	8.94 B		8.31 B	7.40 B	8.29 B	10.0 A	8.43 B	7.32 B	11.03 A	10.86 A	211.2 A	
LSD0.05 for																		
LSD0.05 for M	1.1566 *																	
LSD0.05 for V				0.5921 ***														
LSD0.05 for S								0.8425 *										
LSD0.05 for M *V				1.0255 *														
LSD0.05 for M *S								1.0255 *										
LSD0.05 for V*S																		1.4593 *
LSD0.05 for M *V*S																		2.5275 ***

M =Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S*V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significant

Table 21:- Means of interaction effects of M, S and Varieties of Maize (*Zea mays L.*): for harvest index (HI)

Treatment	***V1***	***V2***	***V3***	**Mean**	**S1**	**S2**	**S3**	**Mean**	***V1s 1***	***V1 s2***	***V1 s3***	***v2 s1***	***v2 s2***	***v2 s3***	***3 s1***	***v3 s2***	***v3 s3***	Mean
M1	30.63 AB	29.41 ABC	30.87 AB	30.30 A	30.53 AB	29.02 AB	31.36 A	30.3	28.37 C~G	32.00 A~F	31.53 A~F	34.47 ABC	26.87 D~G	28.73 C~G	28.8 C~G	26.87 D~G	35.63 AB	30.36
M2	26.06 C	27.68 BC	30.11 AB	27.95 B	26.91 B	26.96 B	29.98 AB	27.95	24.00 G	26.20 FG	28.07 C~G	27.0 D`G	27.3 DEFG	20.0	29.77 B~G	27.43 D~G	33.13 A~D	26.99
M3	30.20 AB	32.58 A	29.44 ABC	30.74 A	29.98 AB	32.63 A	30.39 AB	31.0	28.6 C~G	30.90 A~F	31.10 A~F	32.67 A~E	36.37 A	28.70 C~G	26.3 EFG	30.63 A~F	31.37 A~F	30.71
Mean	28.96 A	29.89 A	30.14 A		28.88 A	29.54	30.57		26.99 C	29.67 ABC	30.23 ABC	31.37 AB	30.19 ABC	28.11 BC	28.29 BC	28.77 BC	33.38 A	
LSD0.05 for																		
LSD0.05 for M	2.2024 *			2.0142 NS														
LSD0.05 for V								2.2383 NS										
LSD0.05 for S				3.4887 *														
LSD0.05 for M *V								3.4887 *										
LSD0.05 for M *S																		
LSD0.05 for V*S																		3.8768 *
LSD0.05 r M *V*S																		6.4952 *

M =Sowing methods (=1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*S*V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

4.5 Effect of Sowing Methods on mean growth and yield parameters for 2016 season:

The effect of sowing methods on means growth and yield characters namely: population density (popD), plant height (PH), ear height, leaf number, leaf length, leaf width, leaf area index (LAI) and stem diameter, for the second season are presented on tables 22 to 29. Days to 50% Tasselling, days to 50% silking, ear number, ear length, effective ear length (EEL), ear diameter, number of rows/ear, number of kernels/row, number of kernels/ear, seed yield, 100 kernel weight, hay yield and harvest index are shown on tables 30 to 42. Statistical analysis showed that only plant height and days to 50% silking, number of ears/plot and effective ear length were significantly affected by sowing methods. Method of farmers practice (M) scored the highest level of plant height amounted (177.5 cm), ridge sowing method scored the highest rates for the rest of parameters i.e. 50% silking, number of ears/plot and effective ear length amounted of (57.9.3 days, 33.8 plants/plot and 14.1 cm) respectively. Raised ridges give more chance for water to infiltrate in the soil and make it available for the crop to attain more height and delay tasselling and silking this why the height of plants and number of days to 50% silking is higher in ridge sowing method compared with the others. Shaikh *et al*.,(1994) while studying the effect of different sowing methods demonstrated that plant height, total biomass production test grain weight, grain yield was maximum with ridge sowing, and it also dec reased the number of days to tasseling, silking and maturity. In recent work Borras *et al*., (2003) concluded that a less leaf area index (LAI) duration could be a resulted of response to increased plant population in the field due to more leaf senescence rate during grain filling. Leilah *et. al*., (2013) found that SC128 hybird produced the highest value when planted in ridges 80 cm apart 22 cm between hills and one plant/hill. Mohammadein (2005) reported that sowing fodder maize on flat resulted in higher final yield of dry matter at harvest. Ridge SM scored greater rates of 100 seed weight and hay yield during both seasons amounted (18.0 and 17.9 (g) for 100 SW and 9.62 and 11.8 (ton/ha) for hay yield respectively).

4.6 Effect of intra-row spacing (S) on growth yield and yield components of maize (*Zea maize L.*) for 2016 season:

The effect of intra-row spacing (Hill spacing) on both growth and yield characters namely: population density, plant height, ear height, leaf number, leaf length, leaf width, LAI and stem diameter, are presented on tables 22 to 29. The days to 50% tasselling, days to 50%

. 2016: Table 22: means of interaction effects of M, S on three varieties on Maize (*Zea maize L.*): for population density

Treatment	V1	V2	V3	Mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	53.2 A	47.7 A	48.1 A	49.7 AB	37.9 B	40.9 B	40.7 B	39.8	33.3 D	34.7BD	43.3 B	33.7 B	50.7 A	48.7 BC	46.7 BC	37.3 B	39.3 B	40.82
M2	34.1 B	44.3 AB	41.0 AB	39.8 B	47.3 AB	54.4 A	47.2 AB	49.63	47.3 B	58.7 A	54.0 A	54.3 A	46.3 BC	42.3 BC	40.7 BC	58.3 A	45.3 BC	50.39
M3	41.4 B	33.3 B	38.3 B	37.7 B	36.2 B	40.3 A	36.6 B	37.7	39.7B	43.3 C	41.3 BC	31.3 BCD	37.0 B	31.7 BCD	37.7 BCD	40.7 B	36.7 BC	37.14
mean	42.9 A	41.8 A	42.5 A		40.5 B	45.2 A	41.5 AB		40.0 A	45.6 A	43.2 A	39.8 A	44.5 A	40.5 A	41.7 A	45.4 A	40.3 A	
LSD0.05 for M	13.5 NS																	
LSD0.05 for V				7.94 NS														
LSD0.05 for S								4.71 NS										
LSD0.05 f SM* V				13.8 NS														
LSD0.05 f SM* S								13.8 NS										
LSD0.05 for VS																		8.17 NS
LSD0.05 M*S* V																		14.1 *

M=Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, *S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 23:- Means of interaction effects of M, S and Varieties on Maize (*Zea mays L.*): for plant height (cm):

Treatment	V1	V2	V3	mean	S1	S2	S3	mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	mean
M1	173.6 A	167.2 A	164.1 A	168.1 A	173.4	165.	165.9	168.1 A	182.7 A	174.0 A	162.3 A	170.3 A	160.3 A	161.7 A	167.3 A	160.7 A	173.7 A	168.1
M 2	125.1 B	121.7 B	130.3 B	125.7 B	117.2 B	135.1 A	124.8 A	119.7 B	110.3 B	134.7 B	130.3 B	127.2 B	144.0 B	119.7 B	114.0 B	126.7 B	124.3 B	125.7
M 3	175.0 A	177.8 A	179.6 A	177.5 A	177.1 A	176.7 A	178.6 A	177.5 A	174.0 A	175.7 A	175.4 A	177.0 A	144.0 B	119.7 B	114.0 B	126.7 B	124.3 A	147.9
mean	157.7 A	155.6 A	158.0 A		155.9 A	158.9 A	156.4 A		155.7 B	161.4 A	156.0 B	158.2 B	161.0 A	154.8 B	153.9 B	154.4 B	158.9 B	
LSD0.05 for M																		
LSD0.05 for M	3.909 *																	
LSD0.05 for V				1.581 NS														
LSD0.05 for S								1.197 NS										
LSD0.05 for M*V				2.738 *														
LSD0.05 for SM *V								2.738 NS										
LSD0.05 V*S																		1.073 NS
M*V*S																		3.591 NS

M =Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30 and S3=40) between plants. SM *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance..

Table 24:- Means and interactions effects of M, S and Varieties on Growth and Yield of Maize (*Zea mays L.*) : for ear height (cm):

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	55.2 A	55.5 A	55.4	55.4 A	57.8 A	54.2 A	53.1 A	55	58.0 A	58.7 A	52.0 B	59.0 A	52.1 B	55.3 A	56.3 A	54.7 A	55.0 A	55.7
M2	55.2 A	51.8 A	53.8 A	53.6 A	53.6 A	55.1 A	53.2 A	54	54.1 A	52.7 B	59.0 B	52.7 A	56.3 A	46.3 C	50.7 C	56.4 A	54.3 A	52.9
M3	64.9 A	60.9	64.8 A	63.5 A	63.5 A	64.6 A	63.1 A	63.5	58.7 A	68.3 A	67.7 A	66.0 A	60.7 A	56.0 A	64.3 A	64.7 A	65.5 A	62.9
mean	58.5 A	56.0 A	58.0 A		57.8 A	58.0 A	56.8 A		56.9 AB	58.9 AB	59.6 A	59.2 A	56.4 AB	52.6 B	57.1 AB	58.6 AB	58.3 Ab	
LSD0.05 for M																		
LSD0.05 for: M	23.55 NS																	
LSD0.05 for V				5.51 NS														
LSD0.05 for S								2.71 NS										
LSD0.05 M *V				9.56 NS														
LSD0.05 M *V								9.56 NS										
LSD0.05 for V*S																		4.66 *
LSD0.05 M *V*S																		8.116 *

M =Sowing methods (M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M *V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 25:- Means of interaction effect of M, S and Varieties on Maize (*Zea mays L.*) : number of leaves per plant:

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	12.0 A	12.1 A	12.1 A	12.1 A	11.4 B	12.0 AB	12.0 AB	11.8	12.1 A	11.7 A	11.9 A	11.3 A	12.0 A	12.1 A	10.8 B	12.3 A	12.0 A	11.8
M2	11.7 A	12.0	11.8 A	11.8 A	11.4 B	11.9 AB	12.1 AB	11.8	11.2 A	12.4 A	11.3 A	11.4 A	11.9 A	12.7 A	11.7 A	11.3 A	12.3 A	11.8
M 3	11.9 A	11.8 A	11.7 A	11.8 A	12.0 AB	11,7 B	12.9 A	12.2	11.9 A	11.4 A	12.7 A	12.1 A	12.2 A	12.1 A	12.0 A	11.3 A	13.0 AC	12.1
mean	11.9 A	12.0 A	12.0 A		11.6 B	11.86 AB	12.2 A		11.7 ABC	11.9 ABC	12.0 ABC	11.6 BC	12,1 ABC	12.3 AB	11.49 C	11.7 BC	12.5 A	
LSD0.05																		
LSD0.05 for M	0.668 NS																	
LSD0.05 for V				0.429 NS														
LSD0.05 for S								0.442 *										
LSD0.05 M*V				0.744 NS														
LSD0.05 M*S								0.744 NS										
LSD0.05 for V*S																		0.765 NS
LSD0.05 M *V*S																		1.324 6NS

M =Sowing methods (M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M *V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 26:- Means of interaction effects of M, S and Varieties on Maize (*Zea mays L.*) : for leaf width(cm):

Treatment	V1	V2	V3	mean	S1	S2	S3	mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M 1	8.1 A	8.2 A	7.8 A	8.0 A	8.0 A	8.1 A	8.1 A	8.1	7.9 B	8.0 A	8.4 A	7.9 B	7.9 B	7.5 B	7.9 B	8.2 A	8.4 A	8.0
M2	7.9 A	7.7 A	8.0 A	7.8 A	7.9 A	7.9 A	7.6 A	7.8	8.2 A	7.8 B	7.6 B	8.3 A	7.7 B	7.9 B	7.4 B	8.1 A	7.5 B	7.83
M3	8.1 A	8.6 A	8.1 A	8.0 A	8.0 A	7.8 A	8.1 A	8.0	8.3 A	8.2 A	7.8 B	7.7 B	8.3 A	8.4 A	7.9 B	7.0 A	8.0 A	7.96
mean	8.0A	7.8A	8.0A		8.0 A	7.9 A	7.9 A		8.1 A	8.0 A	7.9 A	8.0 A	8.0 A	7.9 A	7.7 A	7.8 A	8.0 A	
LSD0.05 for M	0.831 NS																	
LSD0.05 for V				0.3644 *														
LSD0.05 for S								0,282 NS										
LSD005 M*V				0.631 NS														
LSD0,0 5 M*S								0.631 NS										
LSD0.05 for V*S																		0.488 NS
LSD0.05 M*V*S																		0.845 *

M=Sowing methods (M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 27:- Means of interaction effects of M, S and Varieties on Growth and Yield of Maize (*Zea mays L.*) : for leaf length (cm):

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	67.6 A	63.0 A	66.9 A	65.8 A	66.6 A	64.3 A	63.1 A	64.7	64.3 A	67.0 A	66.8 A	66.1 A	62.6 A	60.9 A	68.6 A	63.,4 A	61.7 A	64.6
M2	65.8 A	64.1 A	65.5 A	65.1 A	66. 6 A	64.4 A	64.4 A	65.1	68.4 A	67.0 A	62.0 A	64.4 A	63.9 A	64.0 A	67.0 A	62.3 A	67.2 A	65.1
M3	66.0 A	63.2 A	64.5 A	64.6 A	66.5 A	64.8 A	66.2 A	65.8	70.4 A	66.7 A	65.6 A	62.2 A	61.5 A	65.5 A	66.9 A	66.4 A	67.4 A	65.4
mean	66.5 A	63.5 B	65.7 AB		66.5 A	64.5 A	64.6 A		67.7 A	66.9 AB	64.8 AB	64.2 AB	62.7 B	63.5 AB	67.5 A	64.0 AB	65.5 AB	
LSD0.05 for M																		
LSD0.05 for M	4.8515 NS																	
LSD0.05 for V				2.519 *														
LSD0.05 for S								2.519 NS										
LSD0.05 f M *V				4.363 NS														
LSD0.05 f M *V								4.363 NS										
LSD0.05 for V*S																		4.7687 NS
LSD0.05 *V*S SM																		8.26 NS

M=Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M *V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 28:- Means of interaction effects of M, S and Varieties on Maize (*Zea mays L.*) : for leaf area index (LAI):

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	1.39 A	1.38 A	1.50 A	1.42 A	1.86 A	1.29 B	0.93 C	1.35	1.92 A	1.28 B	1.03 B	1.84 A	1.25 BD	0.87 BCDE	1.82 ABCE	1.33 BCD	0.97 BCD	1.37
M2	1.37B A	1.32 A	1.41 A	1.37 A	1.87 A	1.26 B	0.93 C	1.15	1.95 ABC E	1.36 BCDE	0.83 BCDE F	1.89 A~F	1.23 B~F	1.00 BD	1.78 ACDE	1.18 BCDEF	0.96 BCE	1.35
M2	1.31A A	1.37 A	1.38 A	1.35 A	1.98 A	1.23 B	1.05 BC	1.42	2.17 ADE F	1.30 BCF	1.10 BCE	1.79 ADE	1.30 BDF	1.04 BCE	1.98 BCEF	1.10 BCEF	1.09 BCEF	1.43
mean	1.36 B	1.35 B	1.43 A		1.91 A	1.26 B	0.98 C		2.02 A	1.32 C	0.96 D	1.84 B	1.26 C	0.97 C	1.86 AB	1.20 C	1.01 D	
LSD0.05 for M	0.212 5 NS																	
LSD0.05 for V				0.068 *														
LSD0.05 for S								0.103* **										
LSD0.05 M *V				0.116 NS														
								0.116 NS										
LSD0.05 M *V																		
LSD0.05 for V*S																		0.179 NS
LSD0.05 M *V*S																		0.310 NS

M =Sowing methods (M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M *V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 29:- Means of interaction effects of M, S and Varieties on Maize (Zea mays L.): for stem diameter (cm):

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
R1	2.2	2.2	2.2	2.3	2.2	2.31	2.2	2.24	2.2	2.2	2.3	2.2	2.4	2.1	2.1	2.3	2.2	2.23
R2	2.2	2.2	2.28	2.2	2.2	2.4	2.3	2.3	2.3	2.2	2.4	2.20	2.4	2.2	2.2	2.4	2.3	2.29
R3	2.18	2.21	2.24	2.21	2.16	2.17	2.29	2.21	2.24	2.08	2.39	2.07	2.16	2.30	2.39	2.26	2.19	2.22
mean	2.21	2.22	2.25		2.18	2.28	2.28		2.24	2.29	2.34	2.15	2.31	2.16	2.14	2.33	2.17	
LSD0.05 M	0.247 NS																	
LSD0.05 for V				0.174 NS														
LSD0.05 for S								0.135 NS										
LSD.05 M *V				0.301 NS														
LSD.05 M *V								0.301 NS										
LSD0.05 V*S																		0.234 NS
LSD.05 M VS																		0.405 0NS

M=Sowing methods (M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significanc silking, ear number, ear length, effective ear length (EEL), ear diameter, number of rows/ear, number kernels/row, number of kernels/ear, seed yield (ton/ha), 100 kernel weight , hay yield (ton/ha) and harvest index as shown on tables 30 to 42 Statistical analysis showed that only population density (popD), number of leaves/plant leaf area index (LAI), of growth characters while number of ears/plot, effective ear length (EEL) and number of seeds/ear were significantly affected by intra-row spacing.. 20 cm intra-row spacing scored higher rate amounted of, (45.2, 12.2, 1.91, 33.5, 14.1 and 311.2) for population density, number of leaves/plant and LAI number of ears/plot effective ear length and number of seeds/ear.. This increase in these parameters might be due to the fact that 20 cm spacing increased plant population which result in more effect utilization of sun light which converted in more dry which permits more growth. Abass *et. al.*, 2010 reported that increasing population density caused significant decrease in stem diameter. And a significant increase in LAI fresh and dry weight of forage and leaves dry weight, decreasing intra-row spacing increased population density. Ali *et al*, (2014) reported that conventional methods of sowing maize out yielded no till and reduce tillage. Abuzar *et al*. (2011), reported that maximum population density of 40000 plants/ha produced maximum number of grains/row (32.33), and number of grains/ear (447.3). However, 60000 plants/ha produced maximum number ears/plant (1.33), maximum number of grains/row (15.440, biomass yield (16890 Kg/ha) and grain yield of (2.60 /ha). Mohammed A. et.al (2006) reported that maize grain yield improved by planting methods, seed density and fertilizer level. Abuzar, *et. al*., Bisht *et. al*., (2012) stated that grain yield increased in the narrow rows due to limited intra-row competition for light, nutrient and water. Population above the optimum has resulted in lodging that caused reduction in maize production. Sharifai et al., (2012), Leilah *et al*.,(2013) showed that increase in intra-row spacing from 20 to25 cm significantly increased number of rows/cob, cob diameter, 100 kernel weight and grain yield. Sadegi (2013) reported that highest grain yield for some hybrids was obtained at plant density of 8 plants/m2 reached their maximum grain yield and its components. Therefore, this is the best option to achieve the highest grain yield. Ukonze *et. al*., (2016) showed that the 70*30 cm and 60*20 spacing gave higher values of morphological parameters than 80*20 cm. with regard to yield 80*20cm gave the highest average cob weight 1000 grain weight. Mohammad *et al*., (2002) reported that maximum grain yield was recorded at 20 cm intra-row spacing, while LAI and no. grain/cob were greater at 25 and 20 cm intra row spacing, while 1000 grain weight at 25 and 20 cm level and lowest at 15 cm intra-row spacing. Lakew *et al*., (2016) reported that highly significant difference due to the main effect of intra-row spacing was observed on LA, LAI, of ears/plant, above ground dry biomass yield/ha, number of kernels/ear, 1000 kernel weight and harvest index. 1000 kernels weight, and number of kernels/ear highly significantly increased with decreased intra-row spacing. They concluded that spacing combination of 65*25 cm responded favorably in attaining higher grain yield in the area. Radma *et.al*., (2013) showed that maize hybrids were significantly different in final grain yield and yield components as cob yield and number of grains/cob. There is a well established fact that maize is characterized by low tillering character, which poses the importance of population densiteny manipulation to select the appropriate population density to compensate the spaces between the plants

4.7 Effect of varieties (V) on mean growth and yield parameters for the 2016 season:

The effect of varieties on both growth and yield characters namely: population density, plant height, ear height, leaf number, leaf length, leaf width, LAI and stem diameter, of the second season, are presented on tables 22 to 29. The days to 50% Tasselling, days to 50% silking, ear number, ear length, effective ear length (EEL), ear diameter, number of rows/ear, number of kernels/row, number of kernels/ear, seed yield (kg/ha), 100 kernel weight, hay yield and harvest index as shown in tables 30 to 42. Statistical analysis showed that Leaf length, leaf leaf area index, number of seeds/ears, EEL, and harvest index were significantly affected by the varieties and scored higher levels amounted of (66.5, 1.43, 17.3, 324.9 and 13.8 respectively). V3 i.e. Vari113 scored higher rates of almost all measured characters, followed by Hudeiba1.Therefore, vari113 is considered to be the most suitable variety for the environment of the Gash Scheme due to it highest rates of almost all measured attributes, this is because of its more adaptability to this environment, and to its high potential for seed yield, which scored (1.91, 1.67 and 1.7 ton/ha when combined with sowing methods of M1, M2 and M3 respectively.) as mentioned by Sadeghi *et. al*.,(2012), Attia, *et. al*., (2012) summarized that for obtaining a higher maize yield and net income maize cultivars had different responses of agronomic characters and grain yield. Alias *et. al*.,(2010), Al-Metwally *et. al*.,(2011), showed a significant difference between maize cultivars with respect to plant height, number of ears/plant, LAI, number. of kernels/row, grain weight/ear and grain yield/plant. Zamir et. al., (2011) initiate that hybrid 30Y87 was early in maturity, produced more number of rows/cob, less number of grains/row and less cob length than hybrid 31R88. Similarly hybrid 30Y87 1000 kernel weight, grain yield, and straw yield of hybrid 30Y87 was significantly greater than hybrid 30R88. This result indicated that varieties and hybrids have different genetic composition which have different responses to the environmental conditions and agronomic traits, and also interacted with the sowing methods and spacing to show how they are different in their genetically constituents.

4.8 Effect of interaction of methods of sowing, intra-row spacing and the varieties on means of growth, yield and yield components of maize:

The effect of interaction on sowing methods (M), spacing (S) and varieties (V) on means of growth, yield and yield components of maize are shown on tables

22 to 42, during the second season. Statistical analysis revealed that plant population, leaf length, 50% silking, number of ears/plant ear length, effective ear length, number of seeds/ear and harvest index were significantly affected by the interaction between sowing methods and the varieties (M*V), population density (53.4 plants/m2) (67.6 cm) leaf length, , and 59 days silking and scored the scored by the combination M_1*V_1. While number of ears/plot scored 36.3, ear length scored 17.8 cm and effective ear length scored 13.7 cm are resulted from the combination $M_1V_{3,}$ while number of seeds/ear scored 356 and harvest index scored 19 resulted from the combination of M_2 and M_3*V_1. From the above results of the interaction we can concluded that ridge sowing method together with the variety 113 led to the increase of the rates of the different treatment mostly through its interaction effect. M*S interaction affected treatments resulted in the fact that the ear length, and seed yield were affected by the interaction of sowing methods and varieties (M*V). scored higher levels as follows: ear length scored 17.8 (cm) by the combination M_2V_3, while effective ear length scored 15.2 (cm) by the combination M_1V_3, and seed yield of 1.93 ton/ha by the combination M_1V_3. The effect of the interaction between sowing method and spacing M*S was significantly affected population density and scored higher levels of 47.3 plants/m2 by the combination M_2S_1, number of leaves/plants and scored12.9 leaves by the combinationM3S3, LAI scored 1.98 by the combination of M_2S_1, 50% silking scored 58.6 days by the combination M_2S_1, number of ears/plot of 45.2 by the combination M_3S_1, number ears/plot 45.2 by the combination M_3S_1, ear length scored 17.6 by the combination M_1S_1, EEL scored 14.8 cm by the combination14.8 M_3S_3, ear diameter scored 5.0 by the combination M_3S_1, number of rows/ear 14.0 by the combination of M_2S_1, number of seeds/row by the combination M_3S_3, number of seeds/ear 328.7 by the combination of M_1S_3, 100 kernal weight scored 20.2g by the combination M_1S_2, hay yield 14.9 ton/ha by the combination of M_1S3 and harvest index3. scored 20.5 by the combination M_3S_3. The spacing variety interaction (S*V)

significantly affected plant and scored 158.2 by the combination of S1V2, ears height 59.6 cm by the combination S_1V_2, number of leaves/ plant 12.5 by the combination of S_3V_3, Leaf area index of 2.02 by the combination of S_1V_1. The interaction between M*S*V significantly affected population density scored. by the combination $M_1S_2V_3$, plant height and scored 177.0 by the combination $M_3S_2V_1$, ear height 68.0 by the combination of $M_3S_2V_1$, leaf length 67.7 by the combination $M_3S_1V_1$, LAI scored 2.17 by the combination of M_3S1V_1, ears length 19.7 by the combination $M_1S_1V_1$, number seeds/row of 26.8 by the combination $M_3S_3V_3$, number seeds/ear 419.9 by the combination $M_2S_1V_1$, grain yield scored 2.19 ton/ha by the combination $M_2S_1V_3$, and harvest index scored 25.7 by the combination $M_3S_2V_3$. It was well established ridge sowing method was superior to the other sowing methods, because M_1 was over dominated all the combinations between sowing methods and the varieties and spacing. With respect to spacing S_1 which was 20 cm intra-row spacing and S_2 which was 30 cm were considered to be superior the method practiced by farmers. Variety 113 was mostly scored higher rates of most parameters measured in the work compared to Hudeiba1 and Hudeiba 2.

Table 30:- Means of interaction effects of M, S and Varieties on Maize (*Zea mays L.*): 50% tasselling

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	42.9 A	41.7 A	40.4 A	41.7 A	41.5 A	41.9 A	41.6 A	41,7	39.3 A	41.1 A	40.7 A	43.8 A	41.8 A	43.0 A	41.3 A	42.8 A	41.0 A	41.46
M 2	44.0 A	41.6 A	43.7 A	41.8 A	42.2 A	40.9 A	42.1 A	41.73	45.1 A	42.8 A	43.2 A	39.5 A	39.8 A	40.8 A	42.2 A	40.2 A	42.5 A	41.7
M 3	43.3 A	43.3 A	44.6 A	43.7 A	44.1 A	43.7 A	42.4 A	43.4	45.5 A	44.1 A	44.1 A	44.2 A	41.1 A	44.7 A	42.6 A	45.8 A	41.3 A	43.7
mean	42.1 A	42.2 A	42.9 A		42.6 A	42.2 A	42.4 A		43.3 A	42.7 A	42.6 A	42.5 A	40.9 A	42.8 A	42.0 A	43.0 A	41.6 A	
LSD0.05 for M	4.6211 NS																	
LSD0.05 for V				2.373 NS														
LSD0.05 for S								1.7490 NS										
LSD0.05 M *V				4.110 NS														
LSD0.05 M *V								4.1100 NS										
LSD0.05 for V*S																		3.0294 NS
LSD0.05 M *V*S																		5.247 NS

M =Sowing methods (M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M *V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance..

Table 31:- Means of interaction effects of M, S and Varieties on Maize (*Zea mays L.*): 50% silking:

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	59.0 A	57.6 AB	57. AB	57.9 A	56.6 AB	56.2 B	56.5 B	56.43	56.7 A~E	56.2 A~E	55.3 CDE	56.9 A~E	55.6 CDE	57.1 A~E	56.9 A~E	56.9 A~E	57.0 A~E	56.5
M2	56.0 B	56.3 B	57 AB	56.4 B	58.6 A	57.8 AB	57.4 AB	57.9	58.8 ABC	59.5 A	58.8 ABC	57.7 A~E	56.7 A~E	58.5 ABCD	59.4 AB	58.1 A~E	55.0 DE	58.1
M3	55.6 B	56.2 B	57 AB	56.3 B	56.0 B	56.4 B	56.7 AB	56.	55.4 CDE	54.6 E	56.7 A~E	56.5 A~E	56.4 A~E	56.7 BCDE	56.2 A~E	58.1 A~E	57.3 A~E	56.4
mean	56.9 A	56.7 A	57. A		57.1 A	56.8 A	56.8 A		57.0 A	56.8 A	56.9 A	56.9 A	56.2 A	57.1 A	57.5 A	57.4 A	56.4 A	
LSD0.05																		
LSD0.05 M	1.292 *																	
LSD0.05 for V				1.325 NS														
LSD0.05 for S								1.2189 NS										
LSD0.0 M*V				2.296 NS														
LSD0 M*V								2.296 NS										
LSD0.05 V*S																		2.111 NS
LSD0.0 M*VS																		3.657 NS

M =Sowing methods (=SM 1=Ridge, SM =Flat, SM 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M *V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 32:- Means of interaction effects of M, S and Varieties on Maize (*Zea mays L.*): for number of ears/plot

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	30.4 ABCD	34.6 AB	36.3 A	33.8 A	11.2 BCD	25.3 BCD	25.8 BCD	20.77	29.7 BCDE	32.0 BCD	27.8 BCDE	38.0 BC	30.0 BCDE	34.0 BCD	14.0 CDE	14.0 CDE	15.7 CDE	26.13
M2	11.8 D	17.2 BCD	31.3 ABCD	20.1 B	28.1 BC	17.4 CD	14.6 D	20.0	50.4 AB	18.0 CDE	25.3 CDE	17.3 CDE	22.5 CDE	11.7 DE	16.7 CDE	11.7 DE	7.0 E	20.12
M3	14.6 CD	34.0 ABC	29.8 ABCD	26.1 A	45.2 A	30.9 B	25.3 BCD	33.8	27.7 A	23.0 CDE	20.0 CDE	25.3 CDE	34.3 BCD	33.3 BCD	33.5 BCD	35.3 BCD	22.5 CDE	28.23
mean	18.9 B	28.6 AB	32.5 A		33.5 A	24.5 B	21.9 B		48.7 A	24.3 BC	24.3 BC	30.4 BC	28.9 BC	26.4 BC	21.4 BC	20.3 BC	15.1 C	
$LSD_{0.05}$																		
$LSD_{0.05}$ for M	9.77 *																	
$LSD_{0.05}$ for V				11.5 *														
$LSD_{0.05}$ for S								6.70 **										
$LSD_{0.05}$ M *V				19.8 NS														
$LSD_{0.05}$ M *S								19.8 NS										
$LSD_{0.05}$ for V*S																		11.6 *
$LSD_{0.05}$ M*V*S																		20.1 NS

SM =Sowing methods (=SM 1=Ridge, SM 2=Flat, SM 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M *V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance

Table 33:- Means of interaction effects of SM, S and Varieties on Maize (*Zea mays L.*): for ear length (cm) :

Treatmet	V1	V2	V3	eanm	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	16.6 AB	15.9 AB	17.4 AB	16.6 A	17.6 A	14.2 BC	15.9 ABC	15.9	16.3 B~F	14.3 C~F	16.3 A~E	**16.3 A~E**	12.6 EF	17.7 ABC	16.0 A~E	15.7 B~F	18.7 AB	15.99
M2	15.2 AB	15.3 B	17.8 A	16.1 A	17.3 A	17.3 A	14.0 C	16.2	13.7 C~F	15.7 B~F	16.3 A~E	12.0 F	18.0 ABC	16.0 A~E	16.3 A~E	18.3 AB	18.7 AB	16.1
M3	15.3 B	15.6 B	16.8 AB	15.6 A	16.9 A	16.7 A	16.3 ABC	16.6	16.3 A~E	16.3 ABCD	16.7 A~D	16.7 A~D	16.7 A~D	14.3 C~F	16.0 A~E	16.7 A~D	19.7 A	16.4
mean	15.7 B	15.6 B	17.3 A		17.1	16.1	15.4		15.1 B	15.6 B	16.4 B	15.0 B	15.8 B	16.0 B	16.1 B	16.9 AB	19.0 A	
LSD0.05 for M	3.909 NS																	
LSDfor V				1.581 NS														
LSD for S								1.20 NS										
LSD for M*V				2.738 NS														
LSD for M*S								2.74 NS										
LSD for V*S																		1.07 *
LSD0.05 M*V*S																		3.59 *

M=Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 34:- Means of interaction effects of M, S and Varieties on Maize (Zea mays L.) : for effective ear length (EEL):

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	12.5 B	14.7 A	15.2 A	14.1 A	11.7 A	11.6 A	13.0 A	12.1	13.5 A	11.9 AB	16.5 AB	14.6 A	12.1 AC	14.5 A	10.9 AC	10.8 AC	13.9 A	13.13
M2	13.9 A	11.9 A	13.7 A	13.2 A	14.7 A	14.0 A	14.1 A	14.3	13.9 A	12.0 A	11.5 A	14.2 A	14.5 A	17.0 A	14.3 A	15.4 A	14.4 A	14.02
M3	14.4 A	12.2 A	13.4 A	13.2 A	12.2 B	12.1 B	14.8 A	13,01	14.3 A	14.2 A	14.7 A	16.5 A	11.2 A	12.6 A	13.5 A	10.8 A	12.2 A	13.33
mean	13.6 A	12.9 A	14.1 A		14.1 A	12.6 B	14.0 A		13.5 ABC	12.7 BC	14.2 ABC	15.1 A	12.6 BC	14.7 AB	12.9 ABC	12.3 C	13.5 ABC	
LSD0.05 for M	1.698 *																	
LSD0.05 for V				1.228 *														
LSD0.05 for S								1.276 *										
LSD.05 M*V				2.412 NS														
LSD0.0 M*S								2.412 NS										
LSD0.05 for V*S																		2.211 NS
LSD.05 M *																		3.829 NS

M =Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing M *V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 35:- Means and interactions effects of M, S and Varieties on Maize (*Zea mays* L.) : ear diameter (cm):

Treatment	V1	V2	V3	mean	S1	S2	S3	mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	2.3 A	2.7 A	5.1 A	3.4 A	2.5 A	2.2 A	2.2 A	2.3	2.3 B	2.2 B	2.6 B	2.1 B	2.3 B	2.2 B	2.3 B	2.2 B	2.6 B	2.13
M2	2.3 A	2.3 A	2.7 A	2.3 A	2.1 A	2.3 A	1.9 A	2.1	2.1 B	1.8 B	1.8 B	2.1 B	1.7 B	2.0 B	1.1 B	2.1 B	2.3	1.89
M3	1.9 A	2.3 A	2.0 A	2.0 A	5.00 A	2.6 A	2.5 A	3.4	2.7 B	2.6 B	2.0 A	2.3 B	2.5 B	2.2 B	2.8 B	2.5 B	2.7 B	2.48
mean	2.2 A	2.4 A	3.2 A		3.2 A	2.3 A	2.2 A		2.5 B	2.2 B	4.8 A	2.2 B	2.2 B	2.2 B	2.3 B	2.3 B	2.5 B	
LSD0.05 for M	2.447 NS																	
LSD0.05 for V				1.648 NS														
LSD0.05 for S								1.445 NS										
LSD0.05 M *V				2.411 NS														
LSD0.05 M *V								2.411 NS										
LSD0.05 for V*S																		2.210 NS
LSD0.05 for M *V*S																		3.828 NS

M=Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 36:- Means and interactions effects of SMs, S and Varieties on Growth and Yield of Maize (*Zea mays L.*): for number of rows /ear:

Treatment	V1	V2	V3	mean	S1	S2	S3	mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	13.4 A	13.8 A	13.0 A	13.4 A	12.9A A	11.7 B	14.0 A	12,87	13.0 A	11.6 B	15.5 A	13.0 A	12.8 A	13.0 A	12.8 A	10.9 B	13.4 A	12.89
M2	12.3 A	12.9 A	13.3 A	12.9 A	14.0 A	13.5 A	12.5 A	13.3	14.8 A	12.7 A	11.7 B	13.5 A	14.0 A	14.0 A	13.8 A	13.8 A	12.7 A	13.44
M3	12.7 A	12.7 A	12.6 A	12.6 A	12.7 A	12.5 A	12.8 A	12.67	12.1 BC	12.0 BC	13.7 A	13.0 A	12.2 A	12.8 A	12.9 A	13.2 A	12.0 B	12.66
Mean	12.8 A	13.1 A	13.0 A		13.2 A	12.6 A	13.2 A		13.3 A	12.1 A	13.6 A	13.2 A	13.0 A	13.2 A	13.2 A	12.6 A	12.7 A	
1.618 NS	2.467 NS																	
2.805 NS				0.944 NS														
LSD0.05 for S								0.934 NS										
LSD0.05 for M*V				1.634 NS														
LSD0.05 for M*S								1.634 NS										
LSD0.05 for V*S																		1.618 NS
LSD0.05 M*V*S																		2.805 NS

M=Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 37:- Means of interaction effects of M, S and Varieties on Maize (*Zea mays L.*): for number of seeds/ row:

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
SM1	21.7 A	25.1 A	23.2 A	23.3 A	23.6 A	22.3 A	23.7 A	23.2	25.9 A	25.0 A	22.4 A	22.5 A	25.2 A	26.7 A	22.2 A	16.7 AE	21.9 A	23.17
SM2	24.9 A	20.3 A	23.5 A	22.9 A	22.5 A	18.4 B	15.8 B	18.9	26.8 A	20.2 A	15.6 A	18.1 A	17.7 A	11.2 A	22.6 A	17.3 A	20.6 A	18.92
SM3	15.6 A	20.2 A	20.9 A	18.9 A	22.8 A	21.6 A	24.5 A	21.47	25.3 A	22.4 A	22.0 A	17.4 A	22.9 ABE	24.8 A	28.7 A	19.6	26.8 A	23.3
mean	20.7 A	21.9 A	22.5 A		23.3 A	20.8 A	21.3 A		26.0 A	22.6 ABC	20.0 BC	19.4 BC	21.9 ABC	20.9 ABC	24.5 ABC	17.9 C	23.1 ABC	
LSD0.05 for R	7.522 NS																	
LSD0.05 for V				3.153 NS														
LSD0.05 for S								3.195 NS										
LSD0.05 for SM *V				5.461 NS														
LSD0.05 for SM *S								5.461 NS										
LSD0.05 for V*S																		5.510 *
LSD0.05 SM *V*S																		9.536 NS

R=Sowing methods (=R1=Ridge,R2=Flat, R3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=30) between plants. R*V interaction between ridge and variety, V*S interaction between Varieties and spacing, P*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 38:- Means of interaction effects of M, S and Varieties on Maize (*Zea mays L.*): number of seeds/ear:

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	326.6 A	320.8 A	250.6 B	299.3 A	302.8 A	266.5 AB	328.7 A	299.2	334.1 A	299.0 A	346.6 A	295.7 A	319.6 A	347.0 A	278.5 A	180.8 AEF	292.6 A	299.4
M2	356.0 A	216.4 BD	270.9 B	281.1 A	317.4 A	246.6 B	279.2 A	281.1	395.2 A	252.9 A	419.9 A	245.4 A	247.3 A	156.5 ACEF	311.7 A	239.6 A	261.4 A	281.1
M3	292.1 A	287.4 A	317.0 A	298.8 A	313.5 A	269.4 AB	313.6 A	298.8	301.3 A	270.7 A	304.2 A	269.9 A	277.1 A	315.3 A	369.4 A	260.3 A	321.4 A	298.8
mean	324.9 A	274.9 B	279.5 B		311.2 A	260.8 B	307.2 A		343.5 AB	274.2 CD	356.9 A	270.3 CD	281.3 BCD	272.2 CD	319.8 ABC	226.9 D	291.8 ABCD	
LSD0.05 for M	94.342 NS																	
LSD0.05 for V				41.58 *														
LSD0.05 for S								38.08 *										
LSD0.05 M *V				70.29 *														
LSD0.05 M *S								70.29 *										
LSD0.05 V*S	65.954 NS																	
LSD0.05 M*S*V	114.24 NS																	

M =Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M *V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance

Table 39:- Means and interactions effects of M, S and Varieties on Maize (*Zea mays L.*): for grain yield ton/ha:

Treatment	V1	V2	V3	mean	S1	S2	S3	mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
M1	1.50 A	1.77 A	1.93 A	1.74 A	1.64 A	1.62 A	1.47 A	1.68	1.43 A	1.45 A	1.43 A	1.29 A	1.78 A	1.82 A	1.70 A	1.64 A	1.66 A	1.58
M2	1.46 A	1.63 A	1.67 A	1.58 A	1.69 A	1.80 A	1.74	1743	1.43 A	1.12 ABC	1.96 A	1.62 A	1.90 A	1.83 A	2.19 A	2.06 A	1.55 A	1.73
M3	1.64 A	1.46 A	1.70 A	1.58. A	1.69 A	1.56 A	1.60 A	1608	1.86 A	1.49 A	1.56 A	1.34 A	1.25 A	1.78 A	1.49 A	2.06 A	1.56 A	1.60
mean	1.53 A	1.63 A	1.77 A		1.68 A	1.6 A	1.60 A		1.57 A	1.35 A	1.65 A	1.42 A	1.64 A	1.81 A	1.79 A	1.92 A	1.59 A	
LSD0.05 for M	541.4 NS																	
LSD0.05 for V				319.2 NS														
LSD0.05 for S								267.9 NS										
LSD0.05 M *V				551.1 NS														
LSD0.05 M *S								551.1 NS										
LSD0.05 V*S																		468.9 NS
LSD0.05 M *V*S																		809.6 NS

M =Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M *V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 40:- Means of interaction effects of M, S and Varieties on Growth and Yield of Maize (*Zea mays L.*) :for 100 Seed Weight (g):

Treat ment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Meam
M1	17.5 A	16.8 A	19.4 4 A	17.9 A	16.9 A	20.2 A	16.6 A	17.9	18.6 A	15.6 A	18.1 A	15.8 A	22.0 A	12.2 B	16.3 B	22.8 A	19.2 A	15.7
M2	16.9 A	15.7 A	19.0 A	17.2 A	16.6 A	18.4 A	16.8 A	17.2	16.4 A	16.5 A	17.9 A	17.5 A	15.8 A	13.9 B	15.9 B	22.8 A	18.2 A	17.2
M3	14.9 A	17.6 A	17.4 A	16.6 A	16.0 A	16.1 A	17.7 A	16.6	14.0 B	13.0 B	17.3 A	18.1 A	17.7 A	16.9 A	16.0 A	17.3 A	18.7 A	15.5
mean	16.4 A	16.7 A	18.6 A		16.5 A	18.2 A	17.0 A		16.3 BC	15.2 BC	17.8 ABC	17.1 BC	18.5 AB	14.4 C	16.2 BC	21.0 A	18.9 AB	
LSD0. 05 m	3.7600 NS																	
LSD0. 05 V				2.3115 NS	.													
LSD0. 05 S								2.0175 NS										
LSD M*V				4.0036 NS														
LSD. M*S								4.0036 NS										
LSD.0 5 V*S																		3.4944 NS
LSD.05 M*S* V																		6.4113 NS

M =Sowing methods (=M 1=Ridge, M 2=Flat, M 3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table 41:- Means and interaction effects of M, S and Varieties on Maize (*Zea mays* L.) : for hay yield (ton/ha):

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
SM1	14.32 A	9.10 A	12.02 A	11.82 A	11,23 A	9.33 A	14.89 A	11.82	10.67 A	6.40 A	25.90 A	11.0 A	8.04 A	8.27 A	12.00 A	13.57 A	10.5 A	11.8
SM2	8.70 A	9.43 A	11.77 A	9.96 A	9.64 A	11.00 A	9.24 A	9.96	7.07 A	10.13 A	8.90 A	12.1 A	9.97 A	6.20 A	9.73 A	12.90 A	12.6 A	9.96
SM3	7.37 A	7.40 A	9.33 A	8.03 B	8.67 A	6.36 B	9.09 A	8.04	7.20 A	5.67 A	9.23 A	7.40 A	7.30 A	7.50 A	11.37 A	6.10 A	10.5 A	8.03
mean	10.13 A	8.65 A	11.04 A		9.84 A	8.90 A	11.07 A		8.31 A	7.40 A	14.68 A	10.2 A	8.43 A	7.32 A	11.03 A	10.86 A	11.22 A	
LSD0.05 for SM	5.0621 NS																	
LSD0.05 for V				3.669 NS														
LSD0.05 for S								3.7016NS										
LSD0.05 SM *V				6.701 NS														
LSD0.05 SM *V								6.701 NS										
LSD0.05 V*S																		6.41 NS
LSD0.05 *V*S SM																		11.1 NS

R=Sowing methods (=R1=Ridge,R2=Flat, R3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=30) between plants. R*V interaction between ridge and variety, V*S interaction between Varieties and spacing, P*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Table42 - Means and interaction effects of M, S and Varieties on Maize (*Zea mays* L.): for harvest index:

Treatment	V1	V2	V3	mean	S1	S2	S3	Mean	V1S1	V1S2	V1S3	V2S1	V2S2	V2S3	V3S1	V3S2	V3S3	Mean
SM1	14.5 AB	15.6 AB	12.5 B	14.2 A	11.6 C	15.5 ABC	15.5 ABC	14.2	12.0 E~H	10.0 A~G	14.0 C~G	10.4 FGH	18.1 A~G	18.3 A~G	12.4 E~H	11.0 D~H	14.0 C~G	13.36
SM2	15.0 AB	17.0 A**B**	14.5 AB	15.5 A	15.8 ABC	17.4 AB	13..1 BC	15.43	17.2 A~G	17.6 GH	18.0 E~H	11.8E~ H	15.9 B~G	23.2 AB	18.3 A~F	14.1 C~G	11.1 E~H	16.36
SM3	19.0 A	16.5 AB	14.1 B	16.2 A	16.2 ABC	12.9 BC	20.5 A	15.53	21.6 ABC	21.1 A~D	14.4 A~G	15.4 B~G	14.8 B~G	19.3 A~E	11.6 C~G	25.7 A	4.9 H	16.53
mean	16.2 AB	16.4 A	13.7B		14.5 A	15.3 A	16.5 A		16.9A B	16.2 AB	15.5 B	12.5 **BC**	16.3 AB	16.1 A	14.1 BC	20.3 AB	10.0 C	
LSD0.05 for SM	4.2524NS																	
LSD0.05 for V				2.626 *														
LSD0.05 for S								2.760 NS										
LSD0.05 SM *V				4.549 NS														
LSD0.05 SM*S								4.549 NS										
LSD0.05 for V*S																		4.761 **
LSD0.05 SM*S*V																		8.281 *

SM=Sowing methods (=SM1=Ridge,SM2=Flat, SM3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=30) between plants. SM*V interaction between ridge and variety, V*S interaction between Varieties and spacing, SM*S*V interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Conclusion

From the above discussion we can conclude that:

The three sowing methods, ridge, flat and farmers practice affected the attributes measured differently. Ridge method affect almost all measured characters positively, result in increasing the levels of most parameters. The varieties used namely Hudeiba-1, Hudeiba-2 and variety113 have different response for measured attributes. However, variety113 and hudeiba-1 scored higher rates of almost all measured characters during both seasons. Different hill spacing which were (20, 30, and 40 cm) affected measured characters in such a way that 30 cm intra-row spacing scored higher rates of grain yield as. (1767kg/ha) followed by 40 cm hill spacing significantly affected grain yield and scored (1684 kg/ha), and (11.1 ton/ha and 18.4 g) of hay yield and 100 SW respectively. The interaction between the different factors in most cases significantly resulted in higher rates of the some parameters. Finally, Variety113 grown on ridge 80cm apart with intra-row spacing of 30 cm between plants gave higher plant growth components and higher yields and yield components of maize at Gash Scheme.

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Appendices

Appendix 1: List of released maize cultivars open pollinated and hybrids in Sudan:†

Serial No.	Varity	Type	Year of Release	Breeder Maintainer	Source
1	Stock 113 (Fodder)	OPV*	1975	ARC	-
2	Mexican June	OPV	1975	ARC	-
3	Bafrewa	OPV		ARC	-
4	Hudeiba 1	OPV	1975	ARC‡	CIMMYT
5	Hudeiba 2	OPV		ARC‡	CIMMYT
6	PAN 6480	Hybrid	1975	ARC	PANAR CO. SA
7	PAN 6578	Hybrid	1975	ARC	PANAR CO. SA
8	PAN 6966	Hybrid	2009	ARC	PANAR CO. SA
9	PAN 6026	Hybrid	2009	ARC	PANAR CO. SA
10	PAN 6568	Hybrid	2010	ARC	PANAR CO. SA
11	Yai 1	Hybrid	2010	ARC	CIMMYT
12	Yai 2	Hybrid	2012	ARC	CIMMYT
13	Konsur	Hybrid	2012	ARC	Spiero Co. Greek
14	Turkey 1	Hybrid	2012	ASSCO	Progen Seed Co.Turky
15	Turkey2	Hybrid	2013	ASSCO	Progen Seed Co.Turky
16	Hytech 2055	Hybrid	2013	ARC	Misr Hytech Co Eygpt
17	Galaxy	Hybrid	2013	ARC	Advanta Co India
18	Golden 1	Hybrid	2015	ARC	Zheng Co.
19	HYTECH2066	Hybrid	2015	ARC	Misr Hytech Co Eygpt
20	HYTECH1100	Hybrid	2016	ARC	Misr Hytech Co Eygpt
21	SIMON	Hybrid	2016	SUDARCAD	Polen Seed Co. Turky
22	PL71	Hybrid	2016	SUDARCAD	Polen Seed Co. Turky
23	PL712	Hybrid	2016	SUDARCAD	Polen Seed Co. Turky
24	PL508	Hybrid	2016	SUDARCAD	Polen Seed Co. Turky

† Source: Seed Administration, Federal Ministry of Agriculture, Khartoum. Sudan

* : OPV : Open pollinated Variety

‡ : Presently Maintained by the Arab Sudanese Seed Co. (ASSCO).

Appendix 2: Gash Soil Analysis:

Soil name	pH	EC Ds/m^{-1}	SAR %	ESP %	OC %	N ppm	P Ppm	K ppm	Sand ppm	Clay Ppm	Silt Ppm
R1	8.1	o.83	1.2	1.9	0.20	340	2.4	37.5	9	37	54
R2	7.8	o.80	1.6	2.3	0.05	215	2.3	31.3	11	35	54
F1	7.9	1.1	2.1	3.0	0.05	401	2.3	37.3	12	39	49
F2	7.5	0.84	2.1	3.0	0.73	211	2.3	12.5	7	41	52

EC-Electrical conductivity, SAR=Sodium Absorption Ratio, ESP=Sodium exchangeable %, OC=Organic Carbon

Appendix 3: Climatic Data from September to January for 2015 and 2016 Season: min., maxi and mean temperature, R.H.%, Evaporation (Piche mm), R.F mm, Sunshine/day, Hours of Sunshine, Wind direction and speed.

Month	Maxi. Temp.	Mini. Temp.	Mean Temp.	Mean RH%	Evap Piche mm	Rain Fall mm	Sunshi-ne D.	Suns-hine Hours /day	Wind Direction	Wind Speed Knots
Sept 2015	38.3	25.1	31.7	47	10.1	2.5	79	9.7	S	0.3
Sep. 2016	35.7	23.8	29.8	59	-	2.0	-	-	S..SW	03
Oct 2015	39.9	26.0	33.2	37	13.0	2.5	79	10.1	A.D.	03
Oct 2016	39.1	24.9	32.1	41	-	13.9	-	-	A.D	03
Nov 2015	38.1	23.5	30.9	37	12.9	0	92	10.5	N. N	03
Novr2016	38.1	23.0	30.8	33	-	Nil	-	-	E	03
Dec 2015	32.9	18.3	25.5	45	10.1	0	86	09.6	N.NW	03
Dec 2016	36.3	21.3	28.7	45	-	Nil	92	10.5	N.,NE	03
Jan 2016	34.1	16.9	26.0	42	11,4	Nil	90	10.1	N.	0.3
Jan 2017	33.4	16.6	29.8	42	10.7	Nil	86	9.8	NW	0.3

Appendix Table 4: means of single treatments as affected by sowing methods, intra-row spacing and varieties on yield compoents of maize (*Zea mays* L.) for 2015 season.

Treatment	Days to 50% Tasselling	Days to 50% Silking	Ear length (cm)	Ear diameter (cm)	Effectiv -e ear length (cm)	Ear number /m^2	No. of rows/ Ear	No. of Seed/ row	No. of Seeds/ ear	Hay yield (ton/ha)	Harvest index	100 Seeds weight (g)	Seed yield (ton/ha)
SM1v1S1	56.7	60.7	14.3	4.23	15.33	24.0	13.7	24.1	330.2	10.67	28.37	15.63	1.77
SM 1v1S2	58.7	62.7	16.0	4.30	14.33	25.7	13.7	31.9	437.0	6.40	32.00	16.73	1.45
SM 1v1S3	60.0	64.0	19.7	4.87	16.33	30.0	14.0	25.9	362.6	6.40	31.53	20.17	1.38
SM 1v2S1	57.7	61.7	18.3	4.70	16.33	43.7	14.3	29.3	419.0	10.77	34.47	17.07	2.25
SM 1v2S2	60.0	64.0	13.7	4.80	12.67	23.3	15.0	28.2	423.0	8.03	26.87	20.57	1.41
SM 1v2S3	60.0	64.0	19.0	4.77	17.67	29.7	12.7	31.1	395.0	8.27	26.90	21.00	1.26
SM1V3S1	58.7	62.7	18.7	4.53	16.00	31.3	12.3	32.6	401.0	12.00	28.77	17.33	1.63
SM 1v3s2	61.0	64.7	21.3	4.73	15.67	31.0	15.7	33.0	518.1	13.57	28.20	15.87	1.44
SM 1v3s3	60.0	64.0	22.7	5.03	18.67	25.0	14.7	33.1	486.6	10.50	35.63	17.70	1.33
SM 2v1s1	57.7	60.7	18.7	5.10	13.67	27.7	14.7	28.9	424.8	7.07	24.00	15.47	1.59
SM 2v1s2	60.0	64.0	15.7	4.47	15.67	20.7	12.7	31.0	393.7	10.13	26.10	17.60	1.33
SM 2v1s3	60.0	64.3	17.7	5.00	16.33	25.7	13.7	20.1	275.4	9.23	28.07	17.70	1.65
SM 2v2s1	59.0	63.0	16.3	4.60	12.00	27.0	13.7	18.3	250.7	12.13	26.97	18.63	1.66
SM 2v2s2	60.0	64.0	20.0	4.73	18.00	27.3	16.3	28.3	461.3	9.97	27.33	18.43	1.82
SM 2v2s3	61.0	64.7	19.0	4.57	16.00	20.0	15.0	32.1	481.5	6.20	28.73	19.03	1.95
SM2v3s1	57.3	61.3	18.3	4.37	16.33	22.0	13.0	30.1	391.3	9.73	29.77	17.40	2.14
SM 2v3s2	59.3	63.3	21.0	5.10	18.33	25.7	16.3	34.0	554.2	12.90	27.43	15.77	1.83
SM 2v3s3	58.3	62.3	21.7	4.83	18.67	26.3	14.0	28.9	404.6	12.63	33.13	16.73	1.63
SM 3v1s1	59.0	63.0	17.3	4.60	16.33	21.0	14.3	26.1	373.2	7.20	28.60	17.93	1.77
SM 3v1s2	60.0	64.0	18.7	4.73	16.67	23.3	14.0	36.3	508.2	5.67	30.90	16.90	1.75
SM 3v1s3	59.0	63.0	18.3	5.00	16.67	18.3	16.0	32.2	515.2	9.23	31.10	18.67	1.42
SM 3v2s1	57.3	61.3	18.7	4.67	16.67	19.7	15.3	26.8	410.0	7.40	32.67	17.67	1.49

SM 3v2s2	60.3	64.3	20.3	4.83	16.67	20.7	14.3	31.3	447.6	7.30	36.37	19.13	1.45
SM 3v2s3	60.0	64.7	19.3	5.00	14.33	19.0	14.3	27.9	399.0	7.50	28.70	17.37	1.60
SM 3v3s1	60.0	64.0	19.0	4.73	16.00	30.3	14.3	29.6	423.3	11.37	26.33	16.43	1.60
SM 3v3s2	60.0	63.3	19.0	4.83	16.67	32.3	15.3	34.8	n532.4	6.10	30.63	13.87	2.28
SM 3v3s3	60.0	64.0	20.3	4.97	19.67	21.0	17.0	24.1	409.7	10.53	31.37	17.47	1.27
G mean	59.296	63.247	26.617	18.630	16.210	4.7444	14.46	30.16	433.57	9.2185	15.404	17.565	1.64
CVa	2.30	1.89	19.16	4.50	13.86	5.40	10.54	9.03	8.26	16.60	36.53	9.77	1.72
CVb	2.58	2.82	16.36	11.46	12.78	10.02	8.40	15.37	15.21	10.83	28.75	8.66	1.69
CVc	2.48	2.60	16.16	8.87	14.26	7.60	11,54	15.43	19.09	16.56	32.47	10.57	1.73
SM	NS	NS	*	*	NS	*	NS	*	*	*	*	NS	NS
LSD	1.1011	0.8480	0.6339	0.1935	1.6980	3.7083	1.1619	2.053	27.023	1.1566	2.2o24	1.2973	212.07
Spacing	*	*	***	***	NS	*	NS	**	NS	*	NS	*	**
	0.8663	.8509	0.9117	0,2820	1.2762	2.2853	0.9210	2.744	45.685	0.8425	2.2383	0.9201	155.91
SM*S	NS	NS	NS	NS	NS	*	NS	*	NS	*	*	*	NS
LSD	1.1673	1.7175	2.1937	0.4884	2.1274	4.3035	1.2475	4.752	67.733	1.0255	3.4887	1.0245	284.50
Variety	NS	NS	*	**	NS	*	NS	*	*	***	NS	***	NS
LSD	0.9663	0.9916	1.2665	0.2820	1.2283	2.4846	0.7203	2.752	39.108	0.5921	2.0142	0.9025	164.26
SM*V	NS	NS	NS	NS	NS	*	NS	NS	NS	*	*	*	NS
LSD	1.1673	1.7175	2.1837	0.4884	2.1274	4.3035	1.2475	4.752	67.733	1.0255	3.4887	1.0245	284.50
S*V	NS	NS	*	NS	*	*	*	*	NS	*	*	*	*
LSD	1.5004	1.4739	1.5792	0.3445	2.2195	3.9583	1.5952	4.441	69.120	1.493	3.8768	1.5632	270.04
SM*S*V	NS	NS	***	**	NS	***	NS	NS	NS	***	*	NS	*
LSD	2.7031	2.5528	2.7352	0.5969	3.8286	6.9560	2.7652	7.871	137.75	2.5275	6.4952	3.032	467.72

Appendix 5: means of single treatments as affected by SMs, intra-row spacing and varieties on growth components of maize (Zea mays l.) for 2015 season.

Treatments	Plant population/m^2	Plant Height (cm)	Ear Height (cm)	Number of leaves/Plant	Leaf Length (cm)	Leaf Width (cm)	Leaf Area Index	Stem Diameter (cm)	
SM1 V1S1	33.3	182.7	58	12.1	64.3	7.9	1.9	2.2	
SM1 V1S2	34.7	174.0	55.7	11.7	67.0	8.0	1.3	2.2	
SM1 V1S3	34.3	162.3	52.0	11.9	66.8	8.4	1.0	2.3	
SM1 V2S1	33.7	170.3	59.0	11.3	66.1	7.9	1.8	2.2	
SM1 V2S2	50.7	160.3	52.1	12.0	62.6	7.9	1.2	2.3	
SM1 V2S3	48.7	161.7	55.3	12.1	60.9	7.5	0.9	2.1	
SM1 V3S1	46.7	167.3	56.3	10.8	68.6	7.9	1.8	2.1	
SM1 V3S2	37.3	160.7	54.7	12.3	63.4	8.2	1.3	2.3	
SM1 V3S3	39.0	173.7	55.0	12.1	61.7	8.4	1.0	2.1	
SM 2 V1S1	47.0	110.3	54.1	11.2	68.4	8.2	2.0	2.3	
SM 2 V1S2	58.7	134.7	52.7	12.4	67.0	7.8	1.4	2.2	
SM 2 V1S3	54.0	130.3	59.0	11.3	62.0	7.6	0.8	2.3	
SM 2 V2S1	54.3	127.2	52.7	11.4	64.4	8.3	1.9	2.2	
SM 2 V2S2	46.3	144.0	56.3	11.9	63.9	7.7	1.2	2.4	
SM 2 V2S3	42.3	119.7	46.3	12.7	64.0	7.9	1.0	2.1	
SM2 V3S1	40.7	114.0	50.7	11.7	67.0	7.4	1.8	2.1	
SM 2 V3S2	58.3	126.7	56.4	11.3	62.3	8.1	1.2	2.4	
SM 2 V3S3	45.3	124.3	54.3	12.3	67.2	7.5	1.0	2.2	
SM 3 V1S1	39.7	174.0	58.7	11.9	70.4	8.3	2.2	2.2	
SM 3 V1S2	43.3	175.7	68.3	11.4	66.7	8.2	1.3	2.1	
SM 3 V1S3	41.3	175.4	67.7	12.7	65.6	7.8	1.0	2.4	
SM 3 V2S1	31.3	177.0	66.0	12.1	62.2	7.7	1.8	2.1	
SM3 V2S2	37.0	178.7	60.7	12.2	61.5	8.3	1.3	2.2	

SM3 V2S3	31.7	183.0	56.0	12.1	65.5	8.4	1.0	2.3	
SM3 V3S1	37.7	180.4	64.3	12.0	66.9	10.5	2.0	2.2	
SM3 V3S2	40.7	175.7	64.7	11.3	66.4	9.9	1.1	2.3	
SM 3V3S3	36.7	177.3	65.5	8.7	67.4	10.9	1.1	2.2	
G. mean	19.64	186.49	37.68	18.63	12.12	7.48	1.96	1.96	
CVa	15.00	4.36	9.51	4.50	5.96	6.82	15.00	15.00	
CVb	9.24	5.96	12.91	11.46	5.45	7.70	9.24	9.24	
CVc	10.95	8.61	14.66	8.88	8.61	7.20	10.95	10.95	
SM sig L	NS	**	NS	NS	NS	NS	NS	NS	
LSD	2.7083	5.2106	0.6339	0.5457	8.2106	0.3855	0.2227	0.1275	
Spacing	*	***	*	NS	NS	NS	NS	*	
LSD	3.0481	8.7697	0.9117	0.5762	3.2852	0.3416	0.1187	0.0686	
SM*S	*	NS	NS	NS	NS	NS	NS	NS	
LSD	5.2794	15.190	2.1937	0.9938	5.6901	0.5915	0.1863	0.1485	
Variety	NS	NS	NS	NS	NS	NS	*	NS	
LSD	2.8852	9,8322	2.1937	0.3919	2.7852	0.3416	0.1076	0.0856	
SM*V	NS	NS	NS	NS	NS	NS	NS	NS	
LSD	4.9973	17.030	1.5792	0.6788	4.7901	0.5915	0.1963	0.1485	
S*V	NS	NS	NS	NS	NS	NS	NS	NS	
LSD	5.2794	15.190		0.	5.6901	0.5152	0..2056	0.1187	
SM*S*V	NS	NS	NS	NS	NS	NS	NS	NS	
LSD	9.1443	26.5528			9.8556	0.8923	0.3562	0.2057	

Appendix Table 6: Means of all single treatments as affected by sowing methods, intra-row spacing and varieties on yield components of maize (*Zea Mays* L.) for 2016 season.

Treatments	50% Tassling	50% Silking	Ear L (cm)	Ear D (cm)	EEL cm)	Ear No /plot	No of rows/ear	No of Seeds /row	No of Seeds /ear	Hay Yield (ton/ha)	Yield (ton/ha)	100 Seeds weight (g)	Harv-Est index
SM1v1s1	56.67	60.67	14.33	4.23	15.33	24.00	13.67	25.9	351.3	10.67	1.77	15.63	28.37
SM 1v1s2	58.67	62.67	16.00	4.30	14.33	25.67	13.67	25.0	354.1	6.40	1.45	16.73	32.00
SM 1v1s3	60.00	64.00	19.67	4.87	16.33	30.00	14.00	22.4	313.2	6.40	1.38	20.17	31.53
SM 1v2s1	57.67	61.67	18.33	4.70	16.33	43.67	14.33	22.7	320.4	10.77	2.25	17.07	34.47
SM 1v2s2	60.00	64.00	13.67	4.80	12.67	23.33	15.00	25.2	375.2	8.03	1.41	20.57	26.87
SM 1v2s3	60.00	64.00	19.00	4.77	17.67	29.67	12.67	26.7	346.0	8.27	1.26	21.00	26.90
SM1V2S3	58.67	62.67	18.67	4.53	16.00	31.33	12.33	22.2	268.7	12.00	1.63	17.33	28.77
SM 1v3s2	61.00	64.67	21.33	4.73	15.67	31.00	15.67	16.7	255.4	13.57	1.44	15.87	28.20
SM 1v3s3	60.00	64.00	22.67	5.03	18.67	25.00	14.67	21.9	321.3	10.50	1.33	17.70	35.63
SM 2v1s1	57.67	60.67	18.67	5.10	13.67	27.67	14.67	26.8	392.3	7.07	1.59	15.47	24.00
SM 2v1s2	60.00	64.00	15.67	4.47	15.67	20.67	12.67	20.3	252.6	10.13	1.33	17.60	26.10
SM 2v1s3	60.00	64.33	17.67	5.00	16.33	25.67	13.67	15.6	491.8	9.23	1.65	17.70	28.07
SM 2v2s1	59.00	63.00	16.33	4.60	12.00	27.00	13.67	18.1	248.4	12.13	1.67	18.63	26.97
SM 2v2s2	60.00	64.00	20.00	4.73	18.00	27.33	16.33	17.7	286.9	9.97	1.82	18.43	27.33
SM 2v2s3	61.00	64.67	19.00	4.57	16.00	20.00	15.00	11.2	168.8	6.20	1.94	19.03	28.73
SM2v3s1	57.33	61.33	18.33	4.37	16.33	22.00	13.00	22.6	293.2	9.73	2.14	17.40	29.77
SM 2v3s2	59.33	63.33	21.00	5.10	18.33	25.67	16.33	17.3	283.8	12.90	1.83	15.77	27.43
SM 2v3s3	58.33	62.33	21.67	4.83	18.67	26.33	14.00	20.6	295.5	12.63	1.63	16.73	33.13
SM 3v1s1	59.00	63.00	17.33	4.60	16.33	21.00	14.33	25.3	356.5	7.20	1.77	17.93	28.60
SM 3v1s2	60.00	64.00	18.67	4.73	16.67	23.33	14.00	22.4	315.8	5.67	1.75	16.90	30.90
SM 3v1s3	59.00	63.00	18.33	5.00	16.67	18.33	16.00	22.0	356.2	9.23	1.42	18.67	31.10

SM 3v2s1	57.33	61.33	18.67	4.67	16.67	19.67	15.33	17.4	318.3	7.40	1.48	17.67	32.67
SM 3v2s2	60.33	64.33	20.33	4.83	16.67	20.67	14.33	22.9	296.2	7.30	1.46	19.13	36.37
SM 3v2s3	60.00	64.67	19.33	5.00	14.33	19.00	14.33	24.7	353.5	7.50	1.60	17.37	28.70
SM 3v3s1	60.00	64.00	19.00	4.73	16.00	30.33	14.33	28.7	410.7	11.37	1.60	16.43	26.33
SM 3v3s2	60.00	63.33	19.00	4.83	16.67	32.33	15.33	19.6	303.8	6.10	2.28	13.87	30.63
SM 3v3s3	60.00	64.00	20.33	4.97	19.67	21.00	17.00	26.8	455.3	10.53	1.27	17.47	31.37
G. mean	59.30	63.25	18.63	4.74	16.210	25.62	14.46	21.8	325.4	9.9375	1.64	17.725	9.9375
CVa	1.89	2.30	4.50	5.40	13.86	19.16	10.54	9.03	8.26	67.41	1.72	28.89	67.41
CVb	2.82	2.58	11.46	10.02	12.78	16.36	8.40	15.37	15.21	65.65	1.7o	22.63	65.65
CVc	2.60	2.48	8.87	7.60	14.26	16.16	11,54	15.43	19.09	67.48	1.73	21.22	67.48
M	NS	*	NS	NS	*	*	NS	NS	NS	NS	NS	NS	NS
LSD	4.6211	1.2921	3.9089	2.4474	1.6980	9.7627	2.4669	7.5215	94.342	5.0621	541.41	3.7600	2.7604
Spacing	NS	NS	NS	NS	*	**	NS	NS	NS	NS	NS	NS	*
LSD	1.7490	1.2189	1.1970	1.4457	1.2762	6.6962	0.9436	3.1945	41.583	3.7016	267.86	2.0175	4.5487
M*S	NS	NS	NS	NS	NS	*	NS	NS	*	NS	NS	NS	NS
LSD	4.1199	2.2957	2.7382	2.4117	2.4117	19.841	1.6344	5.4606	70.292	6.7011	551.14	4.0036	4.5487
Variety	NS	NS	NS	NS	*	**	NS	NS	*	NS	NS	NS	NS
LSD	2.3729	1.3254	1.5809	1.6483	1.2283	11.455	0.9343	3.1526	41.583	3.6689	319.2	2.3115	2.6262
M*V	NS	NS	NS	NS	NS	*	NS	NS	*	NS	NS	NS	NS
LSD	4.1100	2.2990	2.7382	2.4117	2.4117	19.841	1.6344	5.4606	70.292	6.7011	551.14	4.0036	4.5487
S*V	NS	NS	*	NS	NS	NS	NS	*	NS	NS	NS	NS	**
LSD	3.0294	2.1111	1.073	2.2105	2.2105	11.598	1.6182	5.5099	65.954	6.4113	468.9	3.4944	4.7612
M*S*V	NS	NS	*	NS	NS	NS	NS	NS	*	NS	NS	NS	*
LSD	5.2470	3.6566	3.5909	3.8286	3.8286	20.089	2.8046	9.5364	114.24	11.105	809.58	6.4113	8.2813

Appendix Table 7: Means of all single treatments as affected by Sowing Methods, Intra-row spacing and Varieties on Growth components of Maize (*Zea Mays* L.) for 2016 season.

Treatment	Plant pop/m^2	Plant height (cm)	Ear height (cm)	No of leaves/ plant	Leaf length (cm)	Leaf width (cm)	LAI	Stem Diameter (cm)
SM1v1s1	56.33	169.60	12.00	12.00	66.5	12.3	1.31	2.21
SM 1v1s2	39.67	188.33	12.67	12.67	64.3	12.7	2.12	2.21
SM 1v1s3	30.00	194.33	12.33	12.33	62.3	14	2.02	2.27
SM 1v2s1	58.67	176.00	12.00	12.00	64.7	11	1.84	2.09
SM 1v2s2	39.33	200.67	12.33	12.33	66.9	11	1.99	2.35
SM 1v2s3	29.67	188.33	12.33	12.33	69.1	13.3	2.18	2.12
SM1V2S3	57.67	162.53	11.33	11.33	66.0	11	1.69	2.11
SM 1v3s2	36.33	189.67	12.33	12.33	64.6	12.7	2.06	2.33
SM 1v3s3	30.00	193.13	11.67	11.67	64.4	12.3	2.04	2.14
SM 2v1s1	50.33	180.80	12.00	12.00	66.6	11.7	1.96	2.25
SM 2v1s2	37.00	181.67	11.67	11.67	69.3	12.3	1.88	2.24
SM 2v1s3	35.33	197.33	12.33	12.33	68.6	11.3	1.95	2.35
SM 2v2s1	41.67	188.33	11.67	11.67	70.2	11	1.99	2.18
SM 2v2s2	42.33	186.00	12.00	12.00	70.9	12	1.83	2.43
SM 2v2s3	30.00	184.93	11.67	11.67	65.9	14	2.20	2.11
SM2v3s1	52.00	177.80	12.00	12.00	66.7	12.7	2.12	2.14
SM 2v3s2	41.00	202.93	12.33	12.33	60.7	11	1.84	2.39
SM 2v3s3	29.00	196.60	13.00	13.00	64.2	12.3	2.19	2.23
SM 3v1s1	42.33	180.00	12.33	12.33	67.4	11.7	2.11	2.24
SM 3v1s2	35.00	193.87	12.00	12.00	71.2	13	2.05	2.08
SM 3v1s3	23.67	180.53	11.67	11.67	66.9	14	1.99	2.39
SM 3v2s1	35.00	172.33	12.50	12.50	67.6	13	2.11	2.07

SM 3v2s2	30.33	184.00	12.33	12.33	65.9	13	1.79	2.16
SM 3v2s3	24.00	187.33	12.33	12.33	60.0	13	1.94	2.30
SM 3v3s1	39.00	198.83	12.50	12.50	63.8	12	1.83	2.18
SM 3v3s2	27.00	181.00	12.00	12.00	64.9	11	1.97	2.26
SM 3v3s3	24.67	198.27	12.00	12.00	62.8	14	2.03	2.19
G. mean	42.4	157.1	57.5	11.9	65.2	12.34	1.96	2.23
CVa	42.09	39.71	54.21	7.42	9.85	13.87	20.36	14.66
CVb	31.60	13.88	16.19	6.09	6.52	7.75	8.33	13.17
CVc	20.14	8.92	8.52	6.72	7.65	6.43	13.54	10.98
SM	NS	*	NS	NS	NS	NS	NS	NS
LSD	13.453	3.9089	23.554	0.6677	4.8515	0.8312	0.2125	0.2476
Spacing	NS	NS	NS	*	NS	NS	**	NS
LSD	4.7129	1.1970	2.7052	0.4416	2.5192	0.2816	0.1032	0.1350
SM*S	NS	NS	NS	NS	NS	NS	NS	NS
LSD	13.760	2.7382	9.5604	7.443	4/3633	0.6311	0.1162	0.3013
Variety	NS	NS	NS	NS	NS	*	NS	NS
LSD	7.9442	1.5809	5.5197	0.4297	2.5192	0.3644	0.0683	0.1739
SM*V	NS	NS	NS	NS	NS	NS	NS	NS
LSD	13.760	2.7382	9.5604	0.7443	4.3533	0.6311	0.1162	0.3013
S*V	NS	NS	*	NS	NS	NS	NS	NS
LSD	8.1650	1.0732	4.6650	0.7648	4.7687	0.4877	0.1788	0.2338
SM*S*V	*	NS	*	NS	*	*	NS	NS
LSD	14.139	3.5909	8.1155	1.3245	8.2597	0.8447	0.3097	0.4050

Appendix (8): Mean squares of interactions between all treatments for growth components for 2015:

	mean squares									
Varibles	Df	Plant population/ m^2	Plant Height (cm)	Ear Height (cm)	Leaf number/ Plant	Leaf width (cm)	Leaf length (cm)	Leaf Area Index (LAI)	Stem Diameter (cm)	Harvest index
Rep	2	0.1119ns	339.60ns	22.38ns	10.78ns	0.55864ns	5.225ns	42.858ns	0.112ns	34.0ns
R method	2	0.0491ns	96.44**	874.31ns	4.593ns	0.08642 ns	0.396ns	13.691ns	0.049ns	60.92*
Error (a)	4	0.0868ns	66.13ns	12.85ns	0.704ns	0.52160 ns	0.260ns	118.06ns	0.087ns	8.50ns
Variety V	2	0.0211ns	125.37ns	30.53ns	57.2***	0.00309 ns	0.012ns	65.684*	0.021ns	10.4ns
R*V	4	0.6045ns	195.12ns	18.44ns	9.24***	0.07716 ns	0.648ns	24.96ns	0.605ns	28.3ns
Error (b)	4	0.0329ns	310.12ns	23.67ns	4.56***	1.07716 ns	0.332ns	21.79ns	0.033ns	11.5ns
Spacing S	2	0,21620 *	1315.0***	2631.79*	28.0***	0.43673 ns	0.312ns	5.716ns	0,21620 *	19.7ns
R*S	4	0.292***	304.70***	138.25ns	7.98***	0.16049 ns	0.291ns	43.043ns	0.29***	24.06*
V*S	4	0.0731ns	54.56ns	29.25ns	2.59***	0.90123 ns	0.381ns	43.043ns	0.073ns	51.5ns
R*V*S	6	0.0496ns	306.37ns	32.08ns	10.85ns	0.06790 ns	0.613*	12.093ns	0.050ns	15.4ns
Error ©		0.0462ns	271.67ns	30.49ns	2.728ns	0.23920 ns	0.291ns	35.352ns	0.046ns	16.4ns
Total	80									
Grand mean		1.9641	186.49	37.679	18.630	12.123	7.4827	1.9641	1.9641	29.7
CV a		15.00	4.36	9.51	4.50	5.96	6.82	15.00	15.00	9.83
CV b		9.24	5.96	12.91	11.46	5.45	7.70	9.24	9.24	11.45
CV c		10.95	8.61	14.66	8.8787	8.61	7.20	10.95	10.95	13.67

M=Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Appendix (9): Mean squares of interactions between all treatments for yield and yield components for 2015:

	Mean squares MS												
Varibles	Df	50% Tasselling	50% Silking	Number of Ears/plot	Ear length	Effective Ear Length (cm)	EarD (cm)	Number of rows/ ear	Number of seeds/ ear	Number of seeds/ Row	Seed Yield (kg/ha)	100 SW (g)	Hay Yield (ton/ha)
Replic	2	3.4198ns	2.259ns	70.605ns	10.56ns	6.2716	0.3100ns	1.642ns	3655ns	4.75ns	28055ns	2.276ns	0.323ns
R (Ridge m	2	1,5309ns	1.000ns	297.235*	4.5926ns	3.901ns	0.1644*	6.901ns	1616*	36.85*	2317ns	4.104ns	29.4078 Ns
Error (a)	4	2.124ns	1.259ns	24.086ns	0.7037ns	5.049ns	0.0656ns	2.364ns	1283ns	7.38ns	788ns	2.947ns	2.343ns
Vari V	2	2.4198ns	1.814ns	68.494*	57.148*	25.642*	0.0582**	3.198ns	2847**	137.1*	9675ns	34.87ns	69.55ns
R*V	4	3.7901ns	5.370ns	89.031*	9.2407ns	2.031ns	0.1632ns	1.697ns	5687ns	51.4ns	1832ns	2.698*	2.827ns
Error (b)	12	2.6667ns	2.796ns	17.556ns	4.5617ns	4.290ns	0.2261ns	1.475ns	4349ns	21.4ns	7673ns	2.317n	0.997ns
Spac S	2	296790ns	26.778*	83.642*	28.000ns	20.827*	0.528***	5.275ns	4865ns	116.*	486**	15.135*	7.216ns
R*S	4	1.1605ns	1.222ns	52.735ns	7.9815ns	17.604*	0.0577*	3.669ns	947*	14.2ns	3510**	4.661ns	18.40ns
V*S	4	1.9938ns	1.482ns	66.660*	2.5926ns	2.957ns	0.2158ns	8.679*	1356ns	69.7*	1524ns	9.292*	6.556ns
R*V*S	8	2.5031ns	1.377ns	76.67***	10.8519n s	6.207ns	0.1299**	2.567ns	1192**	29.9ns	2044*	3.236ns	13.11ns
Error ©	56	2.4630ns	2.377ns	17.142ns	2.7284ns	5.345ns	0.1299ns	2.783ns	6850ns	21.6ns	7977ns	3,445ns	2.33ns
Total	80												
G mean		63.247	59.296	26.617	18.630	16.210	4.7444	14.46	433.57	30.096	1635.0	17.565	9.2185
CV a		2.30	1.89	19.16	4.50	13.86	5.40	10.54	8.26	9.03	17.16	9.77	16.60
CV b		2.58	2.82	16.36	11.46	12.78	10.02	8.40	15.21	15.37	16.94	8.66	10.83
CV c		2.48	2.60	16.16	8.87	14.26	7.60	11,54	19.09	15.43	17.28	10.57	16.56

M=Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. R*V interaction between ridge and variety, V*S interaction between Varieties and spacing, P*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Appendix (10): Mean squares of interaction between all treatments for growth components of 2016:

	Mean squares									
Varibles	Df	Plant pop/ m^2	Plant Height (cm)	Ear Height (cm)	Leaf number/ Plant	Leaf width (cm)	Leaf length (cm)	Leaf Area Index	Stem Diameter (cm)	Harvest Index
Rep	2	237.9ns	9436.1ns	1003.ns	4.427ns	16.791ns	55.852ns	0.1177ns	0.5773ns	20.79ns
Ridge R	2	1100ns	20560.6*	758.7ns	0.66704ns	0.2342ns	10.503ns	0.035ns	0.0185ns	37.11ns
Error (a)	4	318.3ns	3891.8ns	971.6ns	0.7807ns	1.2099ns	41.22ns	0.0791ns	0.1066ns	31.67ns
Variety V	2	9.05ns	47.1ns	44.35ns	0.1378ns	0.2764ns	64.8483*	0.0472ns	0.0156ns	60.828*
R*V	4	236.ns	176.2ns	15.20ns	0.1254ns	0.5129ns	6.6218ns	0.0120ns	0.0015ns	16.13ns
Error (b)	4	179.ns	475.6ns	86.64ns	0.5251ns	0.3776ns	18.047ns	0.0133ns	0.086ns	19.61ns
Spacing S	2	169ns	70.4ns	10.32ns	2.6915*	0.0075ns	33.587ns	6.096**	0.0665ns	26.33ns
R*S	4	28.79ns	430.7*	26.65ns	0.7207ns	0.2035ns	5.5431ns	0.02305n	0.0530ns	95.65*
V*S	4	11.90ns	83.6ns	56.49*	0.4865ns	0.1173ns	10.019ns	0.0353ns	0.0712ns	110.8**
R*V*S	6	151.28*	146.0ns	47.04*	1.0691ns	0.5852*	23.371ns	0.0298ns	0.0129ns	63.948*
Error ©		72.90ns	196.5ns	24.02	0.6399ns	0.0075	24.880ns	0.0349ns	0.0598ns	25.01ns
Total	80									
G mean		42.395	157.09	57.500	11.904	7.9309	65.194	1.3814	2.2273	15.404
CV a		42.09	39.71	54.21	7.42	13.87	9.85	20.36	14.66	36.53
CV b		31.60	13.88	16.19	6.09	7.75	6.52	8.33	13.17	28.75
CV c		20.14	8.92	8.52	6.72	6.43	7.65	13.54	10.98	32.47

M=Sowing methods (=M1=Ridge,M2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant difference, Means with the same letters are not significantly different from each other at 0.05 level of significance.

Appendix (11): Mean squares of interaction between all treatments for yield and yield components for 2016:

	Mean squares MS												
Varibles	Df	50% Tasselling	50%Silk	No. of Ear/plot	Ear length (cm)	EEL(cm)	Ear Diameter (cm)	rows/Ear	Number of seeds /row	Seeds/ Ear	Seed Yield Kg/ha	100 Kernels weight	Hay Y T/h
Replic	2	186.ns	22.1ns	14.90ns	42.8ns	6.273ns	6.643ns	3.442ns	324.ns	5709.8	2806ns	84.31ns	46.8ns
Ridge	2	36.4ns	22.07*	7.024ns	13.7ns	3.901ns	13.44ns	4.407ns	172.ns	2915ns	23174ns	10.72ns	96.6ns
Error (a)	4	38.0ns	2.9238	26.76ns	118.ns	5.049ns	10.49ns	10.66ns	99.1ns	15587	7876ns	24.76ns	44.9ns
Variety	2	4.81ns	0.98ns	10.20ns	65.7ns	25.64*	7.24ns	0.71ns	30.0ns	2063*	9676*	38.43ns	39.3ns
R*V	4	21.8ns	7.52ns	16.22ns	24.96*	2.031ns	6.74ns	1.53ns	63.4ns	2115*	7673ns	11.76ns	28.3ns
Error (b)	4	16.0ns	5.00ns	7.11ns	21.8ns	4.29ns	7.73ns	2.53ns	28.3ns	4683.7	48597ns	15.19ns	42.6ns
Spacing	2	1.1ns	0.74ns	20.246*	5.72ns	20.83*	7.188ns	3.60ns	47.5ns	2118*	48598ns	21.20ns	32.2ns
R*S	4	2.58ns	1.81ns	11.092*	43.0ns	17.61*	5.21ns	5.61ns	40.3ns	2387.3ns	35108ns	15.56ns	33.31ns
V*S	4	6.76ns	2.09ns	2.118ns	31.5ns	2.956ns	5.55ns	1.63ns	79.63*	8644ns	15236ns	44.21*	64.15ns
R*V*S	6	6.93ns	4.67ns	6.539ns	12.1ns	6.206ns	6.46ns	3.04ns	11.8ns	5003ns	20435ns	10.12ns	45.1ns
Error ©		10.04ns	4.88ns	4.702ns	35.3ns	5.345ns	6.86ns	2.87ns	33.5ns	4759ns	7978ns	13.36ns	45.0ns
Total	80												
G mean		42.380	56.90	13.543	68.7ns	16.210	2.5590	12.986	21.808	293.08	1635.0	17.725	9.9375
CV a		14.43	3.01	38.20	15.8ns	13.86	126.57	25.14	45.64	42.60	17.16	28.89	67.41
CV b		9.44	3.93	19.69	6.80n	12.78	108.62	12.25	24.38	23.35	16.94	22.63	65.65
CV c		7.48	3.88	16.01	8.66	14.26	102.35	13.04	26.54	23.54	17.28	21.22	67.48

M=Sowing methods (=M1=Ridge,2=Flat, M3=Farmer's practice), V=Variety (V1=Hudiaba1, V2=Hudiaba2, V3=vari.113), S=Spacing cm (S1=20,S2=30and S3=40) between plants. M*V interaction between ridge and variety, V*S interaction between Varieties and spacing, M*V*S interaction between sowing methods, spacing's and varieties LSD 0.05 least significant, Means with the same letters are not significantly different from each other at 0.05 level of significance