Sudan University of Science and Technology
College of Graduate Studies

Effect of Different Organic, Nitrogen Fertilizer and seasonality on Growth and Yield of Two Maize (*Zea mays* L.*)* Genotypes

تأثير الأسمدة العضوية المختلفة والنيتروجينة والموسمية علي

نمو وإنتاجية صنفين من الذرة الشامية

A thesis submitted in fulfillment of the requirements for the

Degree of (Ph.D.) in Agronomy

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DEDICATION

To the soul of my father & my brother abdalgader

To my mother

To my brothers and sisters, especially Eiman

To my husband

To my friends, especially Samia and my family

With love and respect

Hind Ahmed

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ABSTRACT

Nursery experiment was conducted at the nursery of the College of Agricultural Studies; Sudan University of Sciences and Technology, Shambat, during winter season, (2015/16) to investigate the response of six open pollinated genotypes of maize seeds, Hudiba1(C_1), Hudiba2 (C_2), VAR 113(C_3), ZML 311(C_4), ZML 309 (C_5), ZML 305(C_6), to three types of bacteria strain mixtures, *Bacillus megatherium var phosphorus +Azotobacter* spp (B_1), *Bacillus megatherium var phosphorus +Azotobacter* spp *+Azospirillium* spp (B_2) and *Bacillus megatherium var phosphorus +Azotobacter* spp + *Flavobacterium spp* (B_3). Treatments were arranged in a Randomized Complete Block Design (RCBD) replicates three times. Growth parameters studied were plant height (cm), stem thickness (cm), number of leaves/plant, leaf area (cm^2) and chlorophyll content. All genotypes responded significantly (P<0. 01) to inoculation with bacteria strain mixtures, on all growth parameters compared to control, except (C_6). The results showed that (C_2) and (C_5) genotypes inoculated with bacteria strain mixtures (B_2) and (B_3) achieved the best plant growth compared to other genotypes.

Field Experiments were conducted during two consecutive summer and two consecutive winter seasons of (2016/17 and 2017/18), at the Demonstration Farm, Sudan University of Sciences and Technology, College of Agricultural Studies, Shambat, to study the effect of organic fertilizers (bacteria strains), nitrogen fertilizer (urea) and their combinations on the performance of two maize genotypes, which best responded to bacteria strains at nursery experiment , namely Hudiba2 (V_1) and ZML309 (V_2), also bacteria strains which achieved greater plant growth in nursery experiment , *(Bacillus megatherium var phosphorus +Azotobacter* spp *+Azospirillium* spp (M_1) and *Bacillus megatherium var*

phosphorus +*Azotobacter* spp + *Flavobacterium* (M_2)), were chosen. The treatments were arranged in a Randomized Complete Block Design (RCBD) with four replications, the main plots contained two maize genotypes (V_1), (V_2), sub plots contained nitrogen fertilizer in the form of urea applied at the rate of 197.6 kg/ha (N), bacteria strain mixtures M_1, M_2 and their combinations with urea (M_1+N), (M_2+N) and control (un-inoculated unfertilized). The same growth parameters in nursery experiment were studied as in the nursery experiment. Yield and yield components were studied; cob length (cm), number of cobs/plant, number of rows/cob, number of seeds/row, harvest index (%), hundred seed weight (g) , yield (t/ha), yield of fresh and dry forage (t/ha).Quality parameters included nitrogen(%), protein and fiber content. Economic evaluation included gross income (GI), net income (NI) and benefit cost ratio (BCR), and has been taken. From the result the combinations of bacteria strain mixtures with nitrogen fertilizer had highly significant effect (P=0.01) on all growth parameters, yield, yield components and quality parameters of seeds, summer and winter seasons for two years with both genotypes. Application of (M_1+N) followed by (M_2+N) achieved significant variation (P= 0.01) it recorded maximum yield (t/ha) in all seasons, on fresh forage, dry forage, and seeds quality parameters, Furthermore, the same applications were more profitable than others. Statistical analysis revealed that performance of genotype V_2 was better than genotype V_1 in growth and yield and yield components parameters for summer and winter seasons for two year, but V_1 superiority on V_2 in grain quality parameters in summer and winter seasons for two year, except for crude protein in first winter season. On the other hand economics analysis showed that during first summer seasons there were no-significant differences between the two genotypes, while in the second

season V_1 was better than V_2. However, in both winter seasons, V_2 was better than V_1.

It can be concluded that improvement in maize plant growth and yield are more prominent and significant when genotype ZML309 inoculated with *Bacillus megatherium var phosphorus+Azotobacter* spp+ *Flavobacterium* spp and supplemented with 197.6 kg / ha (N), and Hudiba2 is good quality compare with ZML309.

المســتخلص

أجريت تجربة مشتلية فى أصص بمشتل جامعة السودان للعلوم والتكنلوجيا شمبات، للموسم الشتوى (2016/15) لبحث استجابة ستة أصناف من بذور الذرة الشامية، حديبة1 (C_1)، حديبة2 (C_2)، الصنف113 (C_3)، سلالة ذرة شامية تحت التربية311 (C_4)، سلالة ذرة شامية تحت التربية 309 (C_5)، سلالة ذرة شامية تحت التربية 305 (C_6)، لثلاثة أنواع من خليط للسلالات البكتيرية، بكتريا الماغنيزيوم والفسفور العصوية + أزوتوباكتر (B_1)، بكتريا الماغنيزيوم والفسفور العصوية + أزوتوباكتر+ أزوسبيريلوم (B_2)، بكتريا الماغنيزيوم والفسفور العصوية + أزوتوباكتر+ فلافوباكتيريوم (B_3). رُتِّبَتْ المعاملات بتصميم القطاعات الكاملة العشوائية بثلاثة مكررات. معايير النمو التى تمت دراستها طول النبات (سم)، سُمْك الساق(سم)، عدد الأوراق بالنبات، مساحة الورقة (سم^2) ومحتوى الكلوروفيل. أشارت النتائج الى استجابة جميع الأصناف لكافة أنواع خليط السلالات البكتيرية وكان لها أثر معنوي ($P<0.01$) على كل معايير النمو الخضرى مقارنةً بالشاهد باستثناء الصنف (C_6). أوضحت النتائج أن الصنفين حديبة2 (C_2) وسلالة ذرة شامية تحت التربية 309 (C_5) التى تم تلقيحها بخليط السلالات البكتيرية B_2 وB_3 حققت أفضل نمو خضري مقارنة ببقية الأصناف. أجريت تجارب حقلية خلال الموسمين المتعاقبين (2017/16 و2018/17) صيفي وشتوي بالحقل الإيضاحي لكلية الدراسات الزِّراعية جامعة السودان للعلوم والتكنولوجيا لمقارنة الأسمدة العضوية (السلالات البكتيرية)، والاسمدة المعدنية النيتروجينية (اليوريا) والخليط بينهما فى أداء صنفي الذرة الشامية الّذان سجلا أفضل استجابة لخليط السلالات البكتيرية في التجربة المشتلية حديبة2 (V_1) وسلالة ذرة شامية تحت التربية 309 (V_2) وأيضا اختير خليط السلالات البكتيرية التى حققت أعلى نمو للنبات، بكتريا الماغنيزيوم والفسفور العصوية + أزوتوباكتر + أزوسبيريلوم (M_1) وبكتريا الماغنيزيوم والفسفور العصوية + أزوتوباكتر+ فلافوباكتيريوم (M_2) للتجربة الحقلية. رُتِّبَتْ المعاملات بتصميم القطاعات الكاملة العشوائية بأربعة مكررات، إحتوت القطع الرئيسة على صنفي الذرة الشامية (V_1) و(V_2) والقطع الفرعية احتوت على: السماد النيتروجينى في شكل يوريا بمعدل 197 كجم/هكتار(N) ، خليط السلالات البكتيرية (M_1) و(M_2) والمزج بينهما واليوريا (M_1+N)،(M_2+N) بالاضافة للشاهد. تم أخذ نفس معايير النمو الخضري التي تمت دراستها

في التجربة المشتلية بجانب مقاييس الإنتاجية ومكوناتها، أخُذ وزن الجذور (جم/م^2)، طول الكوز (سم)، عدد الكيزان/نبات، عدد الصفوف/الكوز، عدد الحبوب/الصف، دليل الحصاد%، وزن المائة حبة (جم)، الانتاجية (طن/هكتار)، انتاجية العلف رطب وجاف (طن/هكتار)، إلى جانب معايير الجودة التي شملت نسبة البروتين الخام، محتوى النيتروجين والألياف الخام. شمل التحليل الاقتصادي إجمالي الدخل، صافي الدخل ونسبة فائدة التكلفة. كان الإتجاه العام هو أن مَزْج سلالات البكتيريا مع الأسمدة النيتروجينية لها أثر معنوي ($P< 0.01$) مع جميع معايير النمو الخضري والإنتاجية ومكوناتها للبذور والأعلاف بالإضافة لمعايير الجودة للبذور في الموسمين الصيفيين والشتويين مع الصنفين. أظهر تطبيق (M_2+N) متبوعاً بـ (M_1+N) تبايناً ملحوظاً ($P<0.01$) حيث سجلوا أعلى إنتاجية للموسمين صيفاً وشتاءً. العلف الرطب والجاف ومعايير جودة البذور سلكوا نفس الإتجاه سابق الذكر، وكذلك أعطى التطبيقان أفضل ربحية مقارنةً بالتطبيقات الأخرى. أوضح التحليل الإحصائي أن أداء الصنف V_1 أفضل من الصنف V_2 في النمو الخضري والانتاجية ومكوناتها للموسمين الصيفيين والشتويين ولكن V_2 سبق V_1 فى معايير جودة البذور للموسميين الصيفيين والشتويين باستثناء البروتين الخام في الموسم الشتوي الأول. من ناحية أخرى أظهر التحليل الإقتصادي عدم وجود اختلاف معنوي بين الصنفين خلال الموسم الصيفي الأول بينما كان V_1 الموسم الثانى أفضل من V_2، أما في الموسمين الشتويين فكان V_2 أفضل من V_1.

خلصت الدراسة إلى أن استخدام خليط بكتريا الماغنيزيوم والفسفور العصوية + أزوتوباكتر+ فلافوباكتيريوم مضاف إليه السماد النيتروجينى في شكل يوريا N أدى الى تحسين نمو وانتاجية الذرة الشامية، وكانت حديبة 2 أفضل جودة مقارنة بسلالة ذرة شامية تحت التربية 309.

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CHAPTER ONE

INTRODUCTION

Maize or corn (*Zea mays* L.) belongs to the family Poaceae. The origin of Maize remains uncertain although is generally agreed that its evolution into modern forms took place in Mexico. It is called "King of cereals" because of its productivity potential compared to any other cereal crop and its remarkable adaptability in a wide range of climates, (Farnia and Meysam, 2015). In the world production, maize is ranked as the third major cereal crop after wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) (Zamir *et al.*, 2013). Maize is cultivated throughout the world and greater amounts of maize are produced each year than any other grain (El Toum, 2016). It is cultivated globally as being one of the most important cereal crops worldwide, superior position of maize is due to its very wide spread and various utilization. During centuries maize plant was known for its multifariously use, it provides food for human, feed for animals and poultry, and fodder for livestock (ABPSD, 2008). United States of America is the top country in maize production in the world. As of 2018, maize production in the USA was $366{,}287 \times 10^3$ tonnes that accounts for 34.53% of the world's maize production. The top other 5 countries are (China, Brazil, Argentina, and Ukraine) account for 76.49%. The world's total maize production was estimated at 1.06×10^3 million tonnes in 2018 (FAO, 2019).

It is a rich source of raw materials for industry, it's main by-products starch, syrup, glucose, gluten and oil are used in diversified industries like, alcohol production, textile, paper, pharmaceuticals, cosmetic industry, edible oil industry, poultry feed and many chemical industries (Zeeshan *el al.*, 2013). Also, maize is an important source of calories and protein in human diet in many countries of the

world and is the main staple food in Africa particularly in eastern Africa (Krivanek *el al.,* 2007). Maize protein "Zien" has significant quantities of vitamin A, nicotinic acid, riboflavin, vitamin E and phosphorus. Moreover maize oil obtained from germ of kernel is rich in polyunsaturated fatty acids and also contains high level of natural anti-oxidants; hence maize oil is ideal for heart patients (Zeeshan *el al.,* 2013).

Maize is recently adopted in Sudan and may have been introduced during the Turkish colonial period in the nineteenth century (Mukhtar, 2006). It is a promising cereal crop in Sudan with the potential usefulness for both human beings and livestock (Salih *et al.,* 2008). In Sudan, maize is consumed as green maize, or is boiled, or roasted. The grain can also be dried, ground and boiled into porridge. It's grown as a minor crop in rain-fed areas in the Western States of Sudan (Kordofan and Darfur) also as irrigated crop in small irrigated schemes in the Northern and Mid-States of Sudan, (AOAD. 2008).

Maize can occupy an important position in the economy of the country due to the possibility of blending maize with wheat for bread- making. There is increase in the demand of maize for poultry feed and for forage as well as its great potential for export (to provide new source of hard currency). According to the statistics of the Federal Ministry of Agriculture, the area cropped with maize in 2014 was above 120 thousand feddan. This area is expected to increase considerably since the crop is receiving more attention from the private sector as both forage and grain feed (Mohammed *et al.,* 2015). This needs research for increasing maize production and productivity in the Sudan. Maize production constraints in Sudan include drought, diseases and pests, poor adaptation of some varieties, socio-economic factors such as limited access to external inputs, especially seed of improved varieties and fertilizers.

Application of biofertilizers highly considered to limit the use of mineral fertilizers and decreasing agricultural costs, maximizing crop yield by providing the available nutritive elements and growth promoting substances, (Metin *et al*., 2010). One of the environmentally sound approaches for nutrient management and ecosystem function is the use of soil microorganisms which can either fix atmospheric nitrogen, solubilize phosphate, synthesizing growth promoting substance or by enhancing the decomposition of plant residues to release vital nutrients and increase humid content of soil (Wu *et al*., 2005).

Therefore, this study is proposed to achieve the following objectives:

1. Measure the growth of two maize genotypes effective by organic, nitrogen fertilizer and seasonality.
2. Measure the productivity of two maize genotypes effective by organic, nitrogen fertilizer and seasonality.
3. Measure the productivity of fodder of two maize genotypes effective by organic, nitrogen fertilizer and seasonality.
4. Measure the quality of two maize genotypes effective by organic, nitrogen fertilizer and seasonality
5. Economic evaluation of organic and nitrogen fertilizer used.

CHAPTER TWO

LITERATURE REVIEW

2.1. History of maize:

Modern corn or maize was likely domesticated from a Mexican wild grass somewhere around 7,000 to 10,000 years ago. The Mexican wild grass has been identified as Balsa teosinte, *Zea mays* spp. The Balsa teosinte was native to the Balsa River Valley of Mexico. Domestication happened as ancient farmers noticed that not all plants were the same. They would save seeds from the best plants and use them for seed the next year. This selection process was essentially the beginning of plant breeding, (Pruitt, 2016). Up to this point, teosinte seeds would have been difficult to consume and yielded little nutritive value to humans.

Over time the Mesoamerican natives managed to improve the crop, by systematically selecting certain varieties for their desired traits. This process led to the gradual transformation of teosinte to its present day form known as maize, a name which is a likely derivative of "mahis", meaning" source of life" for Tanio people (Pretty and Smith, 2004). Shortly after maize domestication, it spread throughout North and South America, likely spreading was along trade networks. As it moved, early maize growers utilized the genetic variation to adapt maize to new environments. By the time Europeans arrived, there were about 300 distinct races of corn in the Americas, spanning from Chile to Southern Canada. Later European traders took maize to Asia and Africa (Alexandratos and Bruinsma, 2012). Races of maize are characterized by morphological characteristics and ecogeographic adaptations. Even within these races there can still be a distinct amount of variation. Maize originated in a tropical climate, but over thousands of

years, genetic diversity was harnessed to provide a staple crop that was a high producer in a wide variety of environments (Vollbrecht and Sigmon, 2005).

2.2. Maize types and their usage:

A number of maize types can be discerned on the basis of endosperm and kernel composition (Paliwal *el al*,. 2000; Darrah *el al*,. 2003)

- Flint maize kernels are characterized by their high percentage of hard endosperm around a small soft center. Flint maize is grown predominantly in Latin America and Europe for food use.
- Dent maize is the most commonly grown for grain and silage, and is the predominant type grown in the USA. Hard endosperm is present on the sides and base of the kernel. The remainder of the kernel is filled with soft starch; when the grain starts drying the soft starch at the top of the kernel contracts, producing the depression for which it is named.
- Floury maize is being grown predominantly in the Andean region. Its endosperm is mainly composed of soft starch, making it easy to grind and process into food.
- Waxy maize kernels contain almost entirely amylopectins their starch (rather than the normal 70% amylopectin and 30% amylase). Waxy maize is preferred for food in some parts of East Asia and for some industrial uses; it produces starch similar to tapioca.
- Pop maize kernels are characterized by a high proportion of hard endosperm, which is much higher than in any other maize kernel. Pop maize is grown on small scale compared to other types but popped kernels are consumed world-wide as a snack food.

- Sweet maize is grown for green ears (sweet corn). The ears are harvested at approximately 18-20 days post pollination when kernel moisture is approximately 70%. The developing grain of sweet maize is higher in sugar content due to one or more recessive mutations blocking conversion of sugar to starch.

2.3. Maize as forage:

Maize is the World's primary source for animal feed. It is the only crop amongst non-leguminous combining high quantity of biomass along with better nutritional quality. Forage maize has become a major constituent of ruminant rations in recent years, where its inclusion in dairy cow diets improves forage intake and animal performance; crop has good reputation to increase milk production when fed as green forage (Mohammed and Mohammed, 2019).

In Sudan the major grass forage crops include, Absabien (*Sorghum bicolor*), Sudangrass (*Sorghum sudanense*), Sorghum-Sudangrass hybrids and recently maize. Compared to others, maize performed very well in winter, so production of forage maize in winter solves the problem of livestock feed shortage during the cool season (Eltelib *et al*., 2006).

Maize fodders contain relatively high concentration of soluble carbohydrates and yield a high quality biomass within a short period, making it attractive as hay and silage crops for tropical areas (Zubair *et al.*, 2015).

2.4. Taxonomy of maize:

Maize belongs to the tribe Maydeae of the grass family Poaceae. "Zea" (zela) was derived from an old Greek name for a food grass. The genus Zea consists of four

species of which *(Zea mays* L), is economically important (USDA 2005). The number of chromosomes in *Zea mays* is 2 n = 20. Tribe Maydeae comprises seven genera which are recognized as namely old and New World groups. Old World comprises Coix (2n = 10/20), Chionachne (2n = 20), Sclerachne (2n = 20), Trilobachne (2n = 20) and Polytoca (2n = 20), and New World group has Zea and Tripsacum (Bhupender *et al.,* 2012). It is generally agreed that maize phytogeny was largely determined by the American genera Zea and Tripsacum. However it is accepted that the genus Coix contributed to the phylogenetic development of the species *Zea mays* (James, 2001).

2.5. Morphology of maize:

Maize root system development has been divided into two stages that correspond to embryonic and post-embryonic growth (Jiang *et al.,* 2003). Embryonic root development begins approximately 1 week after the primary and seminal roots emerge, as branching of the embryonic roots produces lateral roots that can continue to branch. Lateral roots together with root hairs, play an important role in the absorption of nutrients and water by increasing the root surface area (Gaudin *et al*. 2011). Approximately 2 weeks after germination the post-embryonic root system becomes prominent, as the coleoptilar node begins giving rise to the crown roots, a type of shoot-borne root that develops from nodes below the soil surface. Brace roots, the second type of shoot-borne roots, develop from nodes above the soil surface several weeks later as the plant matures (Hochholdinger *et al.* 2004).

The maize stem varies in height from less than 0.6 m in some genotypes to more than 5.0 m (in extreme cases) in others. The stem is cylindrical, solid and is clearly divided into nodes and internodes. It may have eight to 21 internodes. The internodes directly below the first four leaves do not lengthen, whereas those

below the sixth, seventh and eighth leaves lengthen to approximately 25.50 and 90 mm, respectively (Farnham *et al.*, 2003). Tillers may develop from nodes below the soil surface. The lateral shoot bearing the main ear develops more or less from the bud on the eighth node above the soil surface. The five or six buds directly below the bud gives rise to rudimentary lateral shoots of which one or two develop to produce ears (Plessis, 2003).

The eight to 20 leaves that may form are arranged spirally on the stem, and they occur alternately in two opposite rows on the stem. The maize leaf is a typical grass leaf and consists of a sheath, ligules, auricles and a blade. The leaf blade is long, narrow, undulating and tapers twoards the tip and is glabrous to hairy. The leaf is supported by a prominent mid-rib along its entire length (Plessis, 2003). Stomata occur in rows along the entire of the leaf surface. More stomata occur on the underside of the leaf than on the upper surface. On the upper surface motor cells are present. These large, wedge-shaped cells occur in rows, parallel to and between the rows of stomata (Taiz *et al.*, 2015). During moist conditions, these cells rapidly absorb water, become turgid and unfold the leaf. During warm, dry weather, the cells quickly lose their turgor with the result that leaves curl inwards exposing a smaller leaf surface to evaporation.

Male and female flowers are borne on the same plant as separate inflorescences. Male flowers are borne in the tassel and female flowers on the ear. The maize ear (the female inflorescence) terminates one or more lateral branches, usually halfway up the stem. Bracts enclose the ear. The silk of the flowers at the bottom appear first and thereafter those on the upper part of the ear. It remains receptive to pollen for approximately three weeks but after the tenth day, receptivity decreases (Plessis, 2003). The tassels, the terminal flowers, ordinarily develop only male spikelets which grow in pairs with one being sessile, having no stalk, and the other

pedicellate, and a single blossom on a lean stalk. Each tassel contains some twenty-five million pollen seeds (Sleper and Poehlman, 2006) .

The lateral organ or female inflorescence is the ear. Each ear of corn contains upwards of one thousand potential kernels. Like the male tassels, the ears also bear spikelet, once again with only one of the flowers developing. Each of these flowers has one ovary "terminated by a long style known as the silk. Fine hairs cover the end of the silks to catch the pollen that is blowing in the wind. The pollen seeds, that the silk catch, are about 1/250th of an inch in diameter and barely visible to the naked eye. Due to their size and their lightweight, the pollen seeds can easily be carried by the wind for long distances (Ben-Asher *et al.,* 2008).

One main difference between corn and other cereals is that it bears seed heads, ears, that are larger than any other grass. The maize grain consists of an endosperm, embryo, a pericarp and tip cap. The endosperm contains the main carbohydrates. The embryo contains the parts that give rise to the next generation, while the pericarp and tip cap enclose the entire grain. The endosperm contains approximately 80 % of the carbohydrates, 20 % of the fat and 25 % of the minerals, while the embryo contains about 80 % of the fat, 75 % of the minerals and 20 % of the protein found in the grain (Plessis, 2003). Also corn has a higher yield of food per unit than any other grain. This productivity is one of the main contributing factors of corn's appeal to farmers (Juzsef *et al.,* 2014).

Maize has a high photosynthesis efficiency which is made possible by the specialized anatomical and biochemical features that enable a so-called C4 photosynthesis (Giorgi *et al.,* 2001). This trait is shared by only a few other crops, including sorghum and sugarcane. Legumes and most other grass crops have what is known as C3 photosynthesis, which renders them less responsive to high light

and temperature and, hence, lower-yielding. C4 photosynthesis also confers high water use efficiency: maize can produce one kg of dry weight using only about 40 kg of water, compared to water use ratios of 60 kg or more in most C3 crops (De Carvalho *et al.*, 2011).

2.6. Ecology and Growth Requirements:

Plants, in general, depend on the environment for growth, where better conditions favor better growth and productivity, thereby providing more food for the continuously increasing population of humans. Productivity is greatly reduced under poor or unfavorable environmental conditions (Torgbor, 2017). Maize is no exception and suffers in the face of several environmental factors even though it is a C4 plant with better stress tolerance mechanisms as compared to C3 plants (De Carvalho *et al*., 2011). Stress imposed on plants results in numerous physiological and biochemical changes leading to the adoption of various mechanisms to avoid or tolerate the stress to survive. While some changes include the synthesis and expression of compatible solutes (for example, proline and glycine betaine), carbohydrates and protective proteins, others affect the photosynthetic parameters upon exposure to stress (Liu *et al*., 2015).

2.6.1. Temperature:

Maize is a crop of subtropical origin and, though it has been altered by selection for adaptation in different environments, it always responds to higher temperatures. The threshold temperature for seed germination is about 10° C. The crop is relatively sensitive to cool temperatures, and it does not acclimatize to low temperatures as do most cool-season crops (Abendroth *et al.*, 2011). Temperatures of 5° to 7° C may be followed by photo-inhibited physiological damage that may

reduce photosynthetic rates for several days thereafter. High temperatures are a serious problem for maize. In fact, temperatures up to 40° C usually cause little or no injury if soil moisture is adequate. Extended periods of hot, dry winds can cause tassel "blasting" (desiccation) and loss of pollen viability (Taiz *et al.,* 2015).

Pollen shed usually takes place in the cooler hours of the morning, and is often finished before the high afternoon temperatures. There is evidence that hybrids vary in their sensitivity to both heat and drought, though genetic drought tolerance may mean some loss in yield potential. As a result, such hybrids may not be good choices for regions that usually have good growing conditions (Torgbor, 2017). Heat stress has been shown to lengthen the time gap between anthesis and silking. Heat stress prior or during this period can reduce yield (Carcova and Otegui, 2001).

As a C4 plant, maize responds well to both high temperatures and intense sunlight (Taiz *et al.*, 2015). Well-watered maize plants reach maximum leaf photosynthesis rates at midday temperatures of 32° to 35° C. Photosynthetic rates of sun-adapted maize do not saturate until light intensity approaches full sunlight. Because photosynthetic capture of sunlight energy is the primary driving force for maize growth and yield, excessive cloudiness and short days tend to lower maize yields (Torgbor, 2017).

2.6.2. Water Requirements:

Water availability is a major limitation of grain yield (Milander, 2015). Though maize is water-efficient, the objective to obtain high yields requires a considerable amount of water. Maize can successfully be grown in areas receiving an annual rainfall of 60 cm, which should be well distributed throughout its growing stages. It needs more than 50% of its total water requirements in about 30 to 35 days after

tasseling and inadequate soil moisture at grain filling stage results in a poor yield and shriveled seeds. It cannot withstand frost at any stage (Novacek *et al.*, 2013).

Under rain fed conditions, which is the most common production system, plant water is supplied by seasonal rainfall and stored as soil water. Hence, deep soils and those with high organic matter content which store much more plant-available water are considered the most suitable for maize production. Water uptake gradually increases from the germination into the vegetative growth stage. It reaches a peak by the time the crop canopy is complete, and more in particular from just before until just after the pollination period. Water shortages during this period may prevent successful flowering and fertilization, and thereby greatly reduce grain yield (Novacek *et al.*, 2013).

Maize frequently suffers from weather-related problems during the growing season, the effects of which differ with the severity and duration of the stress, and the stage of crop development. Drought is one of the major causes of crop loss worldwide, bringing about a 20-40% reduction in average yields. Maize is fairly tolerant of dry soils and moisture stress from early vegetative stages until about two weeks before pollination. Mild drought during mid-vegetative stages may even be beneficial because roots generally grow downward more strongly as surface soils are drying up (Ashraf and Harris, 2013). During two weeks before, and two weeks following pollination, maize is very sensitive to drought, and dry soils during this period can cause serious yield losses. Most of these losses are due to failure of pollination, and the most common cause is the failure of silks to emerge. When this happens, silks do not receive pollen, and, thus, the kernels are not fertilized and do not develop (Efeoglu *et al.*, 2009).

Developing kernels can also abort for several weeks after pollination. Drought later in grain-fill has a less serious effect on yield, though root function may decrease and kernels may not fill completely (Ashraf and Harris, 2013). As a major environmental stress, drought causes not only stomata closure and damage to the photosynthetic pigments, but also leads to the deterioration of the thylakoid membrane, resulting in the reduction of the chlorophyll content.

This leads to a reduction in the growth of the leaves as well as the roots of maize and wheat under stress. The decrease in the chlorophyll is mainly attributed to the accelerated rate of breakdown rather the slow rate of chlorophyll synthesis due to drought (Wahid *et al.*, 2007).

2.6.3. Soils:

Soil texture is a foremost as it controls moisture and nutrient capacity. Loam or silt loam surface soil and brown silt clay loam having fairly permeable sub soil are the ideal soil types for cultivation of maize.

Deep fertile soils rich in organic matter and well-drained soils are the most preferred ones. However maize can be grown on a variety of soils (Troyer, 2001). Soil pH in the range of 7.5 to 8.5 supports good crop growth, however, at pH beyond these extremes, problems of toxicity are found with certain elements and essential nutrients. The most suitable soil for maize is one with a good effective depth, favorable morphological properties, good internal drainage, and an optimal moisture regime, sufficient and balanced quantities of plant nutrients and chemical properties that are favorable specifically for maize production. The ability of the soil to hold few weeks of water in case of dry periods during the season is a most important determinant of the potential of such soil to produce maize. It has a relatively deep root system, reaching as much as 2 m deep in some cases, and these

roots need space to develop. For normal root development, the crop requires a minimum soil depth of 80-100 cm (Widdicombe and Thelen, 2002).

2.7 Nitrogen fertilizer in maize production:

Maize is nitro positive and needs ample quantity for high yield. Nitrogen deficiency is a key factor for limiting maize yields (Alvarez and Grigera, 2005). The reduction due to nitrogen deficiency is more than of other elements deficiency (Mohammadian *et al.,* 2010). Nitrogen (N) is generally deficient in Sudan's soils as in most other semi-arid regions. In such regions nitrogen is usually added to the soil in large quantities. Therefore, intensive farming practices that aim to producing higher yield require extensive use of nitrogen fertilization which are costly and create environmental pollutions (Baser *et al*., 2012). Maize can utilize nitrogen in both the ammonium and nitrate forms but, because of the ready conversion of ammonium to nitrate by soil microbes; most nitrogen is taken up as nitrate (Farnham *et al.,* 2003). If nitrogen is supplied via irrigation water, urea is the best source (Birch *et al.*, 2003).

The excess uses of chemical fertilizers in agriculture are costly with adverse effects on physio-chemical properties of soils. Therefore, in the recent years several organic fertilizers have been introduced that act as natural stimulators for plant growth and development (Khan *et al*., 2009). The knowledge of such natural stimulators or microbial inoculums has long history started with culture of small scale compost production and passes from generation to generation of farmers (Abdul Halim, 2009).

A specific group of this kind of fertilizers includes products based on plant growth-promoting microorganisms named bio-fertilizer or 'microbial inoculants' that are preparation containing live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulytic microorganisms. These are used for

application of seed, soil or composting areas with the objective to enhance the numbers of such microorganisms and accelerate certain microbial process to augment the extent of the availability of nutrients in a form which can assimilated by plant (Khosro and Yousef, 2012).

2.8 Bio-fertilizer:

Biofertilizers or bacteria strains which are eco-friendly play an important role for supplementing the essential plant nutrients for sustainable agriculture and economy (Fadlalla *et al.,* 2016). They are cheaper, pollution free, based on renewable energy sources and also improve soil (Saeed *et al.,* 2004). Both plant and bacterium can live separately but the association is very beneficial for them.

Moreover, microbial fertilizers can clean the environment; enhance the productive capacity of land and reduce the amount of chemical fertilizer consumption (Hossein and Farshad, 2013) and improve plant growth and health. Enhancement of cereal yields by inoculation with no symbiotic nitrogen fixing bacteria was recorded by many researchers (Fadlalla *et al.*, 2016).

2.8.1 Common bio-fertilizers

2.8.1.1 *Rhizobium*:

Rhizobium is a symbiotic bacterium forming root nodules in legume plants. These nodules act as miniature nitrogen production factories in the fields. The nodule bacteria fix more nitrogen (N2) than needed by legume plant and the bacteria. The surplus fixed nitrogen is then secreted and fertilizes the soil. *Rhizobium* is more efficient than-free living nitrogen-fixing bacteria and can fix 50-200 kgs N/ha in one crop season. It can increase yield up to 10-35%. Rhizobium population in the soil depends on the presence of legume crops in the field (Sheraz *et al.,* 2010).

The bacteria enter the roots through root hairs; interaction is progressing through several steps and it ultimately leads to nodule formation, inside the nodule many bacterial cells changing into non dividing bactericides, which produce nitrogen's enzyme which reduces atmospheric nitrogen to ammonia (Venkatashwarlu 2008).

2.8.1.2 *Azotobacter*:

Azotobacter represents the main group of heterotrophic, non-symbiotic, gram negative, free living nitrogen-fixing bacteria. They are capable of fixing an average of 20 kg N/ha/year. The genus *Azotobacter* includes 6 species, with Achroococcum most commonly inhabiting in various soils all over the world (Mahato *et al.*, 2009). *Azotobacter* species besides playing a role in nitrogen fixation, it has the capacity to synthesize and secrete considerable amounts of biological active substances like vitamins, gibberellins and auxins (Suhag, 2016).

These bacteria produce growth promoting hormones which helps in enhancing growth and yield of the plant (Doroshenko *et al.*, 2007). *Azotobacter* establishes symbiotic relationships with different parts of plants, and may develop special structures as the site of nitrogen fixation and have the capacity to produce oxidases and catalases for the protection of their nitrogen, and it also has the ability to solubilize phosphates in aquaculture systems (Gomare *et al.*, 2013). Application of *Azotobacter* give up to 20% increase in yield of crops such as wheat, barley, maize, carrot, cabbage etc.

2.8.1.3 *Azospirillium*:

Members of the genus *Azospirillium* are aerobic, free living, nitrogen fixers which live in associative symbiosis. In this type of association bacteria live on the root surface of the host plant and do not form any nodule with roots of grasses.

Azospirillium sp. have the ability to fix 20-40 kg N/ha. They result in average increase in yield of 15-30% (Venkatashwarlu 2008).

The beneficial effect of *Azospirillium* may derive both from its nitrogen fixation and stimulating effect on root development (Noshin *et al.,* 2008). It directly benefits plants by improving shoot and root development and increasing the rate of water and mineral uptake by roots. It increases crop yield and its inoculation benefits crop. They also benefit the host plants by supplying growth hormones and vitamins (Gonzalez *et al.,* 2005). Fulchieri and Frioni (1994) observed that maize inoculated with *Azospirillium* had enhanced dry weight of seed by 59%.

2.8.1.4 *Flavobacterium:*

The genus *Flavobacterium*, a member of the family *Flavobacteriaceae* within the *phylum Bacteroidetes*, are widespread in freshwater, marine, and terrestrial environments and are believed to play a significant role in the turnover of organic matter (Kolton *et al.,* 2012).

Flavobacterium is often characterized based on the presence of a yellow-orange pigment, flexirubin and gliding motility, *Flavobacterium* spp. are often highly abundant in the rhizosphere of agricultural crops and certain evidence suggests that they are associated with the stimulation of plant resistance to disease (Johansen *et al.,* 2009).

2.8.1.5 *Azolla:*

Azolla is a water fern inside which grows the nitrogen fixing blue green algae Anabaena. It contains 2-3% nitrogen when wet and also produces organic matter in the soil. The *Azolla-Anabaena* combination type bio-fertilizer is used all over the

world. This can be grown in a cooler region. But there is a need to develop a strain that can be tolerant to high temperature salinity and resistant to pests and diseases. Production technology is very easy and can be adopted by rice farmers. The application of Azolla as bio-fertilizer and all other important uses play a significant role in maintaining or improving the state of global environment (Semwal *et al*. 2016).

The only constraint in *Azolla* is that it is an aquatic plant and water becomes limiting factor in growing it particularly in summer. It is mostly used in rice fields where water is available for its growth and multiplication. It is supplemented with 8-20 kg phosphate per hectare. It improves the height of rice plants, number of tillers, seeds and straw yield. There is a 50% higher yield by using *Azolla* as bio-fertilizer (Venkatashwarlu 2008)

2.8.1.6 *Bacillus megatherium* var *phosphorus*:

Bacillus megatherium var. phosphorus is a large rod shaped Gram positive bacterium commonly called as *phosphobacterium*. Presence of *Bacillus* spp in agricultural fields reported to enhance plant growth directly and/or indirectly (Ankit *et al.*, 2011). Phosphorus, both native in soil and applied in inorganic fertilizers, becomes mostly unavailable to crops because of its less mobility and solubility. Phosphate solubilising microorganisms present in soil are *Pseudomonas, Bacillus micrococcus*, *Aspergillus*, *Fusarium* etc. They convert non-available inorganic phosphorus present in soil into an available form utilizable by crop plants. The bacteria *Bacillus, Thiobacillus* can produce iron chelating substances siderophores which chelate the iron present in the root zone. This iron becomes non-available to harmful microorganisms and crop plants are protected from them (Antoun, 2012).

Microbial solubilization applies the natural ability of a microorganism to liberate phosphorus from unavailable structures. The main mechanism recognized to be responsible for the solubilization of phosphorus is the production of different types of organic acids. They can also secrete organic acids and lower the pH in their vicinity to bring about solubilization of bound phosphates in soil. By the hydrolytic activities of these organic acids the insoluble phosphorus in rendered soluble in the soil. These organisms play a major role in the solubilization and uptake of native and applied phosphorus. It can increase crop yield up to 200-500 kg/ ha (Agnieszka *et al.* 2018).

2.9. Inoculation of bacteria strains:

Bacteria strains are generally applied to the soil, seeds or seedlings, with or without some carrier for the microorganisms, for example, peat, composts or stickers. Regardless of methods, the number of cells reaching the soil from commercial products is smaller than the existing numbers of soil or rhizosphere microorganisms; these added cells are unlikely to have a beneficial impact on the plant unless multiplication occurs (Chen, 2006).

In addition, the population of introduced microorganisms will decline and be eliminated in a very short time, often days or weeks. The formulation of inoculate, method of application and storage of the product are all critical to the success of a biological product. Short shelf life, lack of suitable carrier materials, susceptibility to high temperature, problems in transportation and storage are bio-fertilizer bottlenecks that still need to be solved in order to obtain effective inoculation (Date.2001).

2.9.1. Seed inoculation:

Seed inoculation uses a specific strain of microbe that can grow in association with plant roots; soil conditions have to be favorable for the inoculants to perform well. The seed treatment can be done with any of two or more bacteria without antagonistic effect. In the case of seed treatment with *Rhizobium, Azotobacter*, *Azospirillium*, the seeds must be coated with *Rhizobium* or *Azotobacter* or *Azospirillium.* This method will provide maximum numbers of population of each bacterium to generate better results (Fulchieri and Frioni 1994).

2.9.2. Soil inoculation:

In soil inoculation, microbes are added directly to the soil where they have to compete with microbes already living in the soil that are already adapted to local conditions and greatly outnumber the inoculate. Inoculants of mixed cultures of beneficial microorganisms have considerable potential for controlling the soil microbiological equilibrium and providing a more favorable environment for plant growth and protection. Therefore, adequate quality control and a high level of consistency in performance and benefits must be ensured (Date, 2001).

2.10. Bacteria strains and nitrogen fixation:

For optimum plant growth, nutrients must be available in sufficient and balanced quantities (Abdel Ghany *et al.,* 2013). Nitrogen biofertilizers help to correct the nitrogen levels in the soil. Nitrogen is a limiting factor for plant growth because plants need certain amount of nitrogen in the soil to thrive. Different bacteria strains have an optimum effect for different soils, so the choice of nitrogen bio-fertilizer to be used depends on the cultivated crop (Gorica and Gordana, 2007).

Following photosynthesis, nitrogen fixation is the second most important process in crop production. Photosynthesis captures sunlight and produces energy, and nitrogen fixation uses nitrogen gas to form ammonium. The process of biological nitrogen fixation is of greatest importance for plants (Cvijanovi *et al.,* 2011). Nitrogen fixation can provide for free up to 300-400 kg N/ha/yr. (Adam, 2002). Biological nitrogen fixation represents annually up to 100 million tons of N for terrestrial ecosystems, and from 30 to 300 million tons for marine ecosystems. In addition, 20 million tons result from chemical fixation due to atmospheric phenomena (Mosier, 2002).

Bactria strains can add 20-200kg N ha (by fixation), liberate growth-promoting substances and increase crop yield by 10-50%. Associative nitrogen fixing bacteria have an important place in non-leguminous plants fertilization in modern agricultural production. They can be used as a substitute or supplement to mineral fertilizers either as individual strains of certain species or strain mixture of one or more species in various forms (liquid, wet, dry).

They are most commonly applied as seed treatment (seed inoculation) immediately before planting, by irrigation through drip system or application into the soil (Gorica and Gordana, 2007). Activity of nitrogen fixing microorganisms depends greatly upon excessive amount of carbon compounds and adequately low level of combined nitrogen (Andrew *et al*., 2007).

2.11. Effect of bacteria strains on maize:

Bacteria strains play an important role for supplementing the essential plant nutrients for sustainable agriculture, economy and eco- friendly environment. Application of bacteria strains became of great necessity to get a yield of high quality and to avoid the environmental pollution. In maize, application of Bactria strains increased growth and yield in many researches, grain yields of the different maize genotypes treated with *Azospirillium* spp. Seed inoculation with *Rhizobium*,

phosphorus solubilizing bacteria, and organic amendment increased seed production of the crop (Panwar *et al.*, 2006).

Beyranvand *et al.*, (2013) suggested that effect of nitrogen and phosphate biofertilizers were evaluated positively, there was an increase in plant height, ear weight, and number of grain per cob, grain yield and biomass yield. Increasing yield was attributed to the plant growth promoting substances by root colonizing bacteria more than the biological nitrogen fixation, stating that yield increased due to promoting root growth which in turn enhancing nutrients and water uptake from the soil (Farnia and Torkaman, 2015).

Hussain *et al.*, (1987) reported that maize seeds inoculated with *Azotobacter* have increased grain yield by 19.63% compared to control. Increase in yield due to inoculation was not only due to N2 fixation but also due to production of growth promoting hormones by the bacterium.

Biari *et al.*, (2008) reported that plant growth promoting rhizobacteria (PGPR), belonging to the genera *Azospirillium* and *Azotobacter*, improved nutrient uptake of maize under field conditions, subsequently increased vegetative growth characters and grain yield. Ebrahimpour *et al.*, (2011) reported that integrated applications of biological fertilizer (Nitroxin including *Azospirillium* sp., *Pseudomonas* sp. *Azotobacter* sp. and phosphate solubilizing microbial biofertilizers, including *Bacillus caogulans*) and chemical fertilizer (urea) in maize resulted in highest grain yield, harvest index, number of rows in cob, kernel weight, number of seeds in a row.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Nursery Experiment:

A Pot experiment was conducted at the nursery of the College of Agricultural Studies Sudan University of Sciences and Technology at Shambat, in winter season (2015/16) to investigate the response of six open pollinated genotypes of maize to three types of bacteria strain mixtures, and then choose the best genotypes of maize in terms of vegetative growth for the basic experiment.

3.1.2 Materials:

3.1.2.1 Plant material:

Six open pollinated maize genotype seeds were obtained from Wad Madani Research Station, El-Gezira State

Names	Type Germplasm
Hudiba1	Improvement open pollinated variety
Hudiba2	Improvement open pollinated variety
VAR 113	local variety
ZML 311	Inbred line
ZML 309	Inbred line
ZML 305	Inbred line

3.1.2.2. Bacteria strains material and preparation:

Four bacterial strains (*Azotobacter* spp, *Azospirillium* spp, *Flavobacterium* and *Bacillus megatherium var phosphorus*) were obtained from Environment, Natural Resources and Desertification Research Institute, National Centre for Research.

A broth medium of meat peptone was prepared by adding the following constituents (g) 7.5 peptone, 5 meat extract and 5 NaCl to one liter of distilled water. Then the medium was sterilized by autoclaving at 121ºC for 15 minutes. After that the broth was inoculated by the bacterial strains each one separately. The inoculated broth was put in an incubator shaker for 48 hours. Briefly, one kilogram of sterilized charcoal (sterilized by autoclaving at 121ºC for 30 minutes) was mixed with 500 ml of the bacterial broth culture. The bacteria strains rate was 500 g to inoculate the seeds of one feddan (8kg) (Osman *et al.*, 2013).

3.1.3. Methods:

3.1.3.1. Experimental design and treatments:

The experimental design was Randomized Complete Block Design (RCBD) with three replications. The main plots contained six open pollinated genotypes of maize which are:

1. C_1 Hudiba 1
2. C_2 Hudiba 2
3. C_3 VAR 113
4. C_4 ZML 311
5. C_5 ZML 309
6. C_6 ZML 305

Sub plots were assigned for three types of bacteria strain mixtures:

1. B_0= Control (untreated)
2. B_1= *Bacillus megatherium var phosphorus +Azotobacter* spp.
3. B_2= *Bacillus megatherium var phosphorus*+ *Azotobacter* spp+ *Azospirillium* spp.
4. B_3= *Bacillus megatherium var phosphorus*+ *Azotobacter* spp+ *Flavobacterium spp.*

3.1.3.2 Cultural practices:

Bacteria strain mixtures were applied at sowing. Maize seeds were mixed carefully with sugar solution (10%) and charcoal until completely coated then the seeds were left to dry in the shade for 15 minutes before sowing.

Irrigation was immediately applied after sowing, then every seven to ten days intervals, according to temperature range and soil need. Weed control was done manually two weeks after sowing (WAS) and then when needed, throughout the growing season.

3.1.4. Data collection:

Data were collected 30, 45 and 60 days after sowing (DAS), from a sample of three plants from each pot to measure the following growth parameters:

3.1.4.1. Plant height (cm):

The height of the main stem from ground level to the tip of the plant, taken from three samples of plants to determine the mean of plant height (cm) using a measuring tape.

3.1.4. 2. Stem thickness (cm):

Stem thickness was measured from three samples of plants, at 10 cm above the ground level, using a measuring tape.

3.1.4. 3. Number of leaves/plant:

Mean number of leaves/plant was determined, by counting the number of leaves per plant.

3.1.4. 4. Leaf area:

The mean of leaf area was determined as follows:

Leaf area (LA) = length (cm) × maximum width (cm)× 0.75

3.1.4. 5. Chlorophyll content:

Chlorophyll content was estimated using chlorophyll meter for the sample of the three plants and the mean was then calculated.

3.2. Field experimental site:

Afield experiments was conducted during two consecutive summer and two consecutive winter seasons of (2016/17 and 2017/18), at the Demonstration farm of the College of Agricultural Studies - Sudan University of Science and Technology at Shambat, which is located between latitude 15^{o}- 40^{o} N and longitude 32^{o}-32^{o} E and 380 meters above sea level. Climate is tropical, usually hot and humid in summer and cold and dry in winter. The temperature reached a maximum value (45.9°C) in June and a minimum value (22°C) in January. It drops during July to October due to the incidence of the rainy season.

The soil of the experimental site is heavy clay soil. Relative humidity ranges between 31-51 % during winter (El Toum, 2016).

3.2 Materials:

3.2.1 Plant material:

Two open genotype seeds were selected (Hudiba2 and ZML309) which responded best to bacteria strain mixtures in the nursery experiment.

3.2.2 Bacteria strains material:

Two types of Bacteria strain mixtures were selected (B_2= *Bacillus megatherium var phosphorus* +*Azotobacter* spp +*Azospirillium* spp, and B_3= *Bacillus megatherium var phosphorus* +*Azotobacter* spp + *Flavobacterium* spp) are they gave the best results of vegetative growth characters in nursery experiment.

3.2.3. Nitrogen fertilizer material:

Nitrogen fertilizer in the form of urea (46% N) obtained from the market applied at the rate 197.6kg/ha.

3.3. Methods:

3.3.1. Land preparation, sowing and the layout of the experiment:

Experimental area was tilled adequately to prepare a suitable seed bed. The implements used included a desk plough (cross plow) to break and loosen the soil and a leveler (scraper) to level it for easy movement and uniform distribution of irrigation water. The field was then divided to four blocks (replications) each contained 12 equal plots of 3m ×4m size (4 ridges each three meters long). Prior to sowing and after harvesting, soil sample were collected randomly from depth 0-30 cm using an auger to estimate soil N, P, pH and EC in soil laboratory of the Department of Soil, College of Agricultural Studies, appendix(1).

Planting was done manually on the shoulder of ridges on the last week of July in summer seasons and in the second week of November in winter seasons. 3-5 seeds per hole were sown 70 cm apart and 30 cm between plants at seed rate of 37.5 kg/ha (or 45 g/plot). Re-sowing was carried out after 15 days after sowing.

3.3.2. Experimental design and treatments:

Experimental design used was Randomized Complete Block Design (RCBD), with four replications. The main plots contained two maize genotypes:

1. Hudiba2 (V_1).
2. ZML309 (V_2).

Sub plots contained six treatments:

1. M_1= *Bacillus megatherium var phosphorus* +*Azotobacter* spp + *Azospirillium* spp.
2. M_2= *Bacillus megatherium var phosphorus* +*Azotobacter* spp+ *Flavobacterium* spp.
3. N=197.6 kg/ha.
4. M_1+N.
5. M_2+N.
6. Control (un-inoculated, unfertilized).

3.3.3. Cultural practices:

3.3.3.1. Fertilizers:

Bacteria strain mixtures were added at sowing, after mixing with seeds. Nitrogen fertilizer was applied two times, one half at two (WAS) and the other at 4 (WAS).

3.3.3.2. Irrigation:

Irrigated immediately after sowing, then every seven to ten days was applied interval until harvesting, according to temperature range and soil needs.

3.3.3.3. Weed control:

Weed control was done manually two (WAS) and then after 30, 45 and 50(DAS).

3.3.3.4. Pest and diseases control:

Maize stem –borer (*Chilo partellus*) attacked the plant in early stage of growth, in the first summer season and was controlled by spraying the insecticide Ekarosine and was repeated twice after 35 and 50 (DAS). And in second summer season army worms (*Spodoptera frugiperda*) attacked the plants in early stage of growth; also it attacked them in the two winter seasons. In the first season the attack was in early stage of growth (28 DAS) and in second season at later stage (45 DAS). It was controlled by spraying Hitcel 44% EC.

3.3.4. Data collection:

3.3.4.1. Vegetative growth characters:

Data were collected 30, 45 and 60 (DAS), from a sample of five plants randomly taken from the middle two rows of each plot to measure the same vegetative growth characters which were taken in nursery experiment using similar methods.

3.3.4.2. Yield and yield components:

3.3.4.2. 1. Root weight (g):

The average root weight was determined from plants in one square meter from each plot. Root samples were air dried until the weight was constant, and then weighed in grams.

3.3.4.2.2. Number of cobs /plant:

The mean number of cobs per plant was obtained from the randomly selected sample of the five plants per plot.

3.3.4.2.3. Cob length (cm):

Cob length was determined from the randomly selected sample of the five cobs per plot, and the mean was calculated.

3.3.4.2.4. Number of rows /cob:

The mean number of rows per cob was counted from the randomly selected sample of five cobs of the five plants.

3.3.4.2.5. Number of seeds /row:

The mean number of seeds per row was counted from the randomly selected sample of five cobs of the five plants.

3.3.4.2.6. Hundred seeds weight (g) :

Hundred seeds weight was obtained after air drying the samples until a constant weight was reached and weight of 100-grains were taken randomly from each plot using a balance.

3.3.4.2.7. Fresh forage yield (tons/ha):

The average fresh weight was determined from one meter square harvested area at milk stage from each plot, sickle was used for clipping plants around five cm above the soil surface. Samples were weighed using a balance immediately in the field to get the fresh weight. Final fresh yield was calculated in tons per hectare.

3.3.4.2.8. Dry forage yield (tons/ha):

Dry weight was determined through, fresh samples were dried under the sun until a constant weight was reached and weighed to obtain the mean dry weight. Final dry yield was calculated in tons per hectare.

3.3.4.2. 9.Seeds yield (t/ha):

One meter square of each plot was harvested, the cobs were speared from the plants, dried, weighed and the total grain yield was calculated

3.3.4.2.10. Harvest index:

Seed from the harvested sample of one meter square were dried and then the harvest index was calculated using the following equation:

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.3.5. Seed quality analysis:

Seed crude protein, organic nitrogen and crude fiber contents were determined following the standard methods of the Association of Official American Analytical Chemists (AOAC, I990). The organic nitrogen content was determined using the micro Kjeldahl method, and an estimate of the crude protein content was estimated by multiplying the organic nitrogen content by a factor of 6.25 (Sosulski and Imafidon, 1990).

3.3.6. Economic analysis:

The economic returns of the treatments were calculated based on the Gross income (GI), Net income (NI), and Benefit cost ratio (BCR).

3.3.6.1. Gross income (GI):

For each treatment, the GI was calculated as follows:

$GI_t = Y_t \times GP_t$

Where:

GI_t =Gross income of treatment, t.

Y_t = grain yield from treatment, t.

GP_t = grain price per kg/f.

3.3.6.2. Net income (NI):

For each treatment, the NI was calculated as follows:

$NI_t = GI_t - TVC_t$

Where:

NI_t= net income of treatment, t.

GI_t= gross income from treatment, t.

TVC_t= total variable cost for treatment, t.

3.3.6.3. Benefit cost ratio (BCR):

For each treatment, the BCR was calculated as follows:

$$BCR_t = \frac{GI_t}{TVC_t}$$

Where:

BCR_t = Benefit cost ratio, t.

GI_t= gross income from treatment, t.

TVC_t= total variable cost for treatment, t.

3.3.7. Statistical analysis:

Data collected from pot and field experiments were statistically analyzed using statistic 8 computer programs and IBM SPSS statistical package 22. While the least significant difference (LSD) at P=0.05 was used to compare the differences among treatment means (Steel *et al.*, 1997).

CHAPTER FOUR

RESULTS

4.1 Vegetative growth parameters of nursery experiment:

Statistical analysis showed highly significant difference among treatments ($P<0.05$) on all growth parameters in the three reading 30, 45 and 60 (DAS) (appendix 2).

4.1.1 Plant height (cm):

Results declared that untreated genotypes (C_1, C_2, C_3, C_4, C_5 and C_6) at 30 (DAS), gave highly of 3.8, 6.2, 4.3, 2.7, 4.8 and 6.7 cm respectively. All treatments increased plant growth as compared to the corresponding control except C6 (Fig. 1).

Results at 45 (DAS), revealed that maize genotypes inoculated with B1, B2 and B3 sustained the highest growth as compared to control except C_6 (Fig. 2).

At 60 (DAS), in general the plant growth increased with time. Genotypes inoculated with B2 and B3 achieved the highest growth as compared to other treatments (Fig. 3).

In general C_2 and C_5 compared to other genotypes, revealed good response to all types of bacteria strain mixtures.

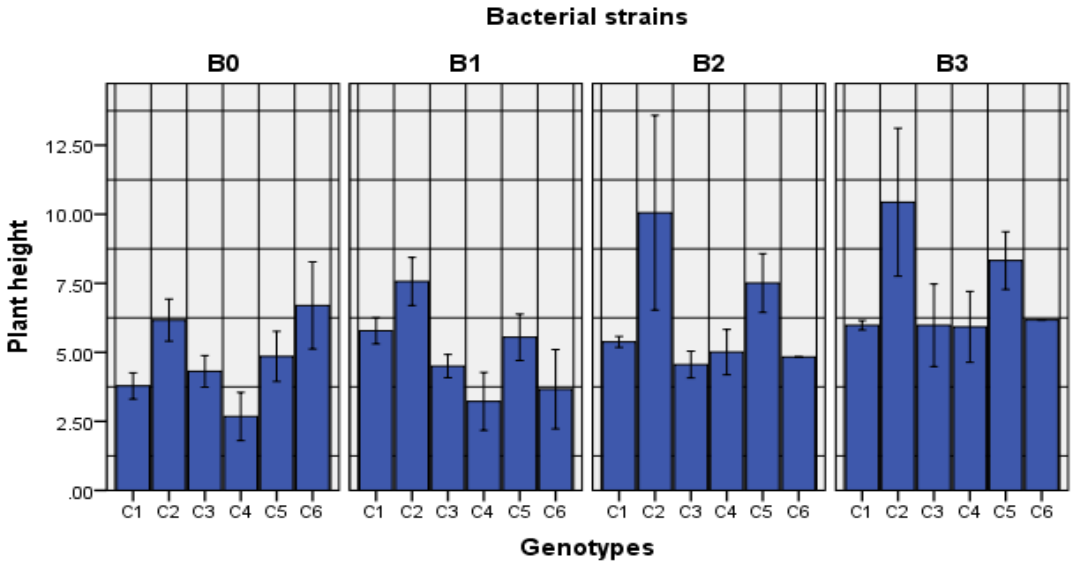

Fig. 1 : Effects of bacteria strains on plant height of maize genotypes at 30 (DAS)

Key: C1 Hudiba1, C2 Hudiba2, C3 VAR 113, C4 ZML 311, C5 ZML 309, C6 ZML 305 /Control; B0:(un-inoculated unfertilized).2.B1; Bacillus megatherium var phosphorus +Azotobacter spp B2; (Bacillus megatherium var phosphorus +Azotobacter spp +Azospirillium spp) B3; (Bacillus megatherium var phosphorus +Azotobacter spp + Flavobacterium spp)

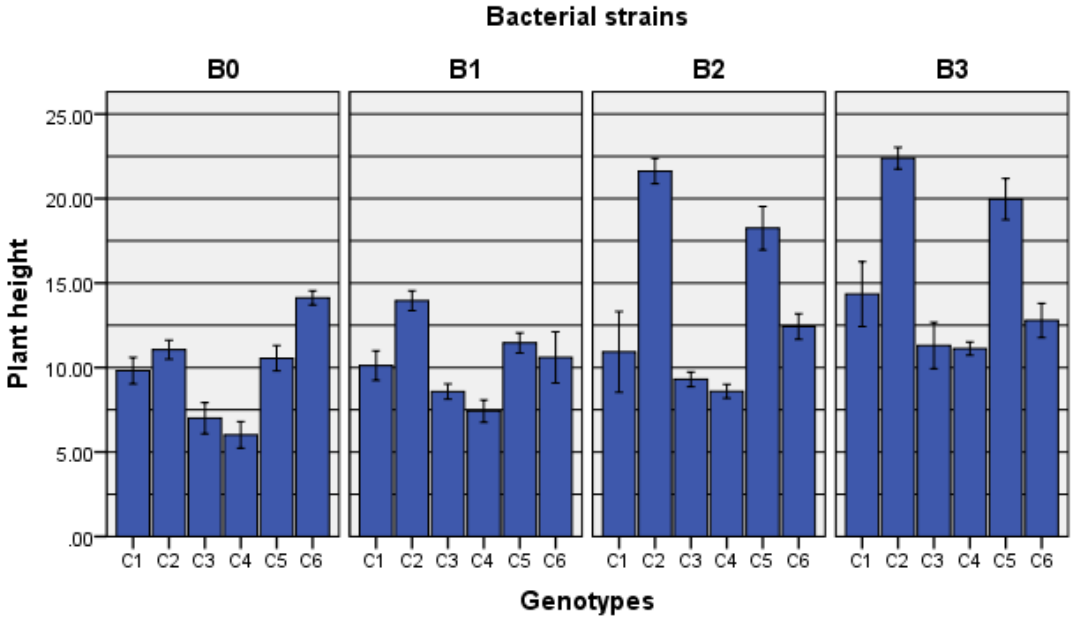

Fig.2. Effects of bacteria strains on plant height of maize genotypes at 45 (DAS)

Symbols are as shown on Fig.1

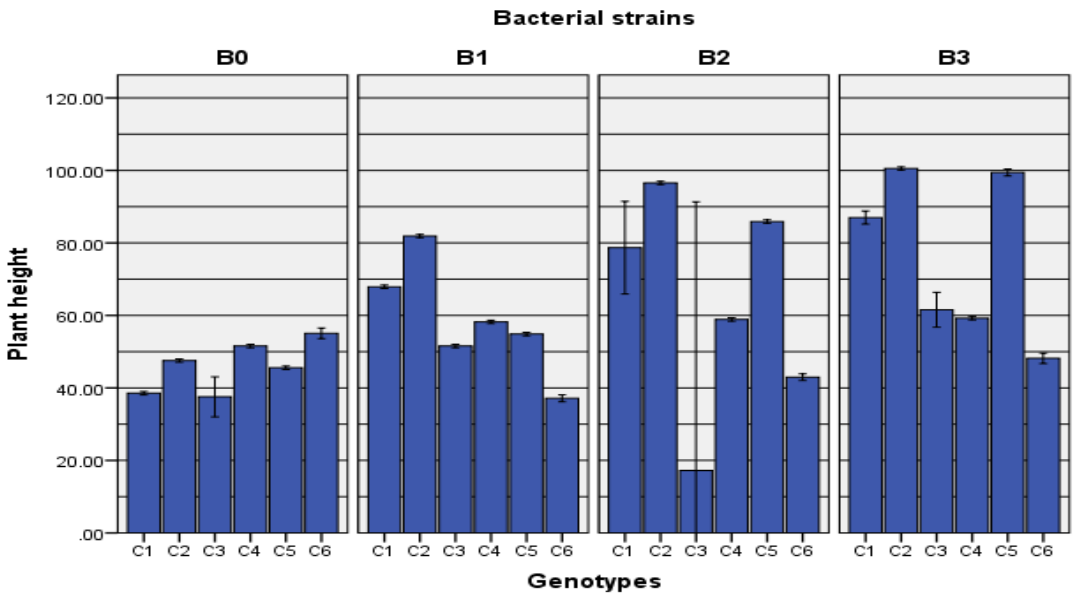

Fig.3. Effects of bacteria strains on plant height of maize genotypes at 60 (DAS)

Symbols are as shown on Fig.1

4.1.2 Stem thickness (cm):

The results in (Fig. 4), shows that at 30 (DAS) untreated genotypes (C_1, C_2, C_3, C4, C_5 and C_6) gave 1.2, 2.1, 1.7, 1.1, 2.2, and 2.3 cm stem thickness, respectively. All treatments increased stem thickness as compared to the control. Among all treatments, B_2 and B_3, irrespective to maize genotypes, sustained the highest stem thickness as compared to control.

Results revealed that maize genotypes inoculated with B_1, B_2 and B_3 at 45 (DAS), increased stem thickness as compared to control, except C_6 (Fig. 5) .

Genotypes inoculated with B_2 and B_3 at 60 (DAS), achieved the greater stem thickness as compared to other treatments except C_6 (Fig. 6).

Application of bacteria strain mixtures B_3, B_2 gained the best stem thickness with C_2 and C_5 compared to other genotypes, for all sampling dates.

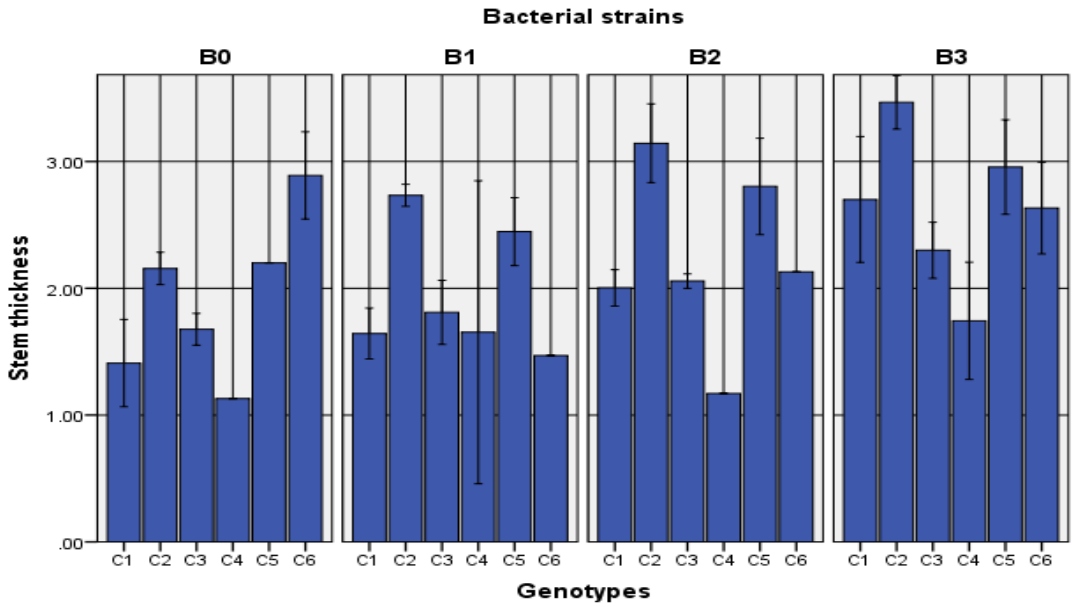

Fig.4. Effects of bacteria strains on stem thickness of maize genotypes at 30 (DAS)

Symbols are as shown on Fig.1

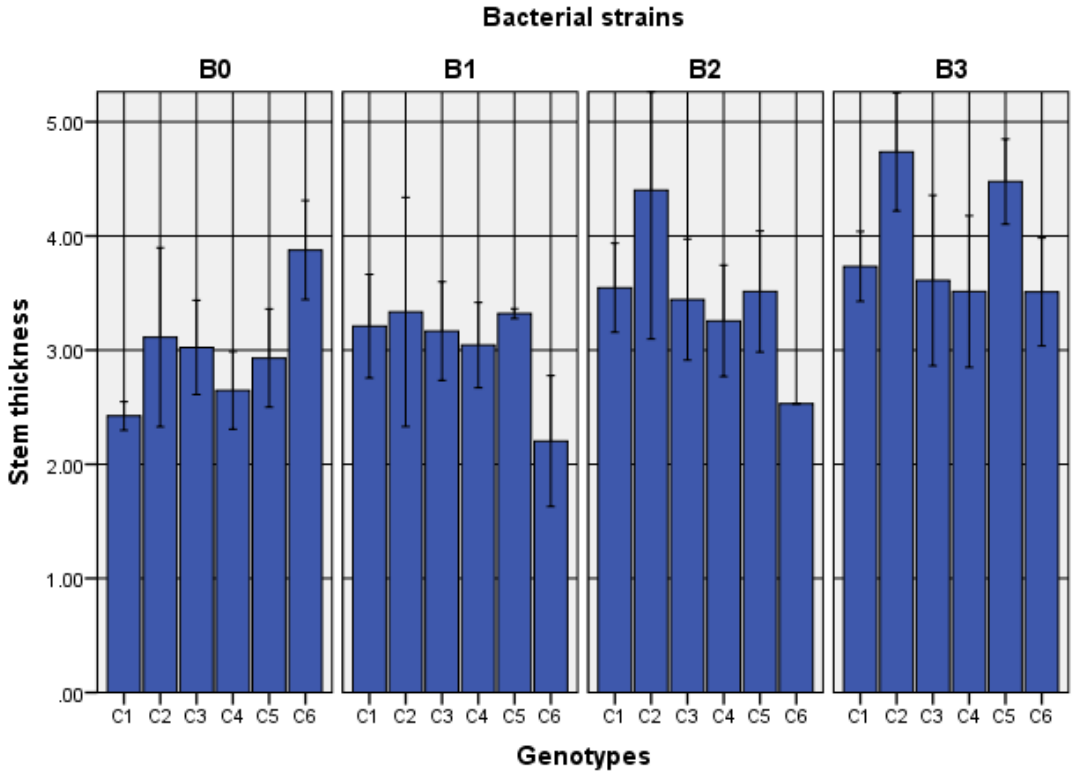

Fig.5. Effects of bacteria strains on stem thickness of maize genotypes at 45 (DAS)

Symbols are as shown on Fig.1

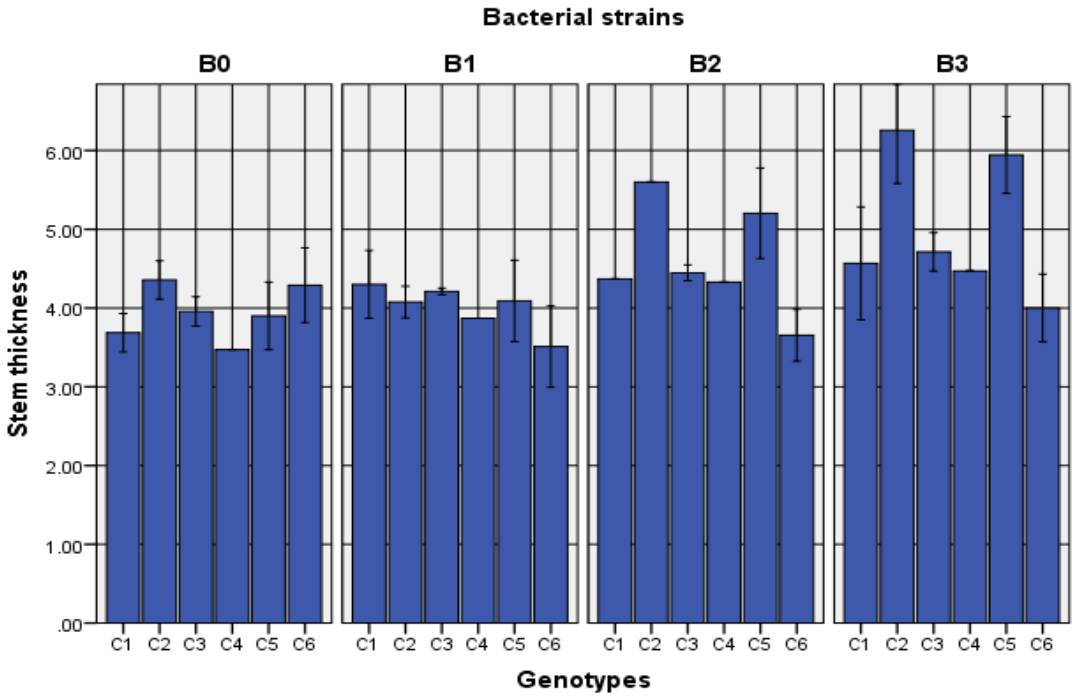

Fig.6. Effects of bacteria strains on stem thickness of maize genotypes at 60 (DAS)

Symbols are as shown on Fig.1

4.1.3 Number of leaves / plant:

The effects of microbial inoculants and maize genotypes on number of leaves/plant at 30 (DAS) were shown in (Fig.7). Maize genotypes inoculated with B_2 and B_3 had the maximum number of leaves/plant as compared to other treatments except C_6. Furthermore, maize genotypes at 45 (DAS) followed the same aforementioned trend (Fig. 8).

At 60 (DAS), in general the number of leaves/plant increased with time. Results showed that untreated genotypes (C_1, C_2, C_3, C4, C_5 and C_6) gave 7.5, 10.7, 8.2, 10.2, 9.0 and 10.1, leaves/plant, respectively. All treatments increased number of leaves/plant as compared to the control, except C_6 (Fig. 9).

In general C_2 and C_5 compared to other genotypes appeared good responded to all type of bacteria strain mixtures.

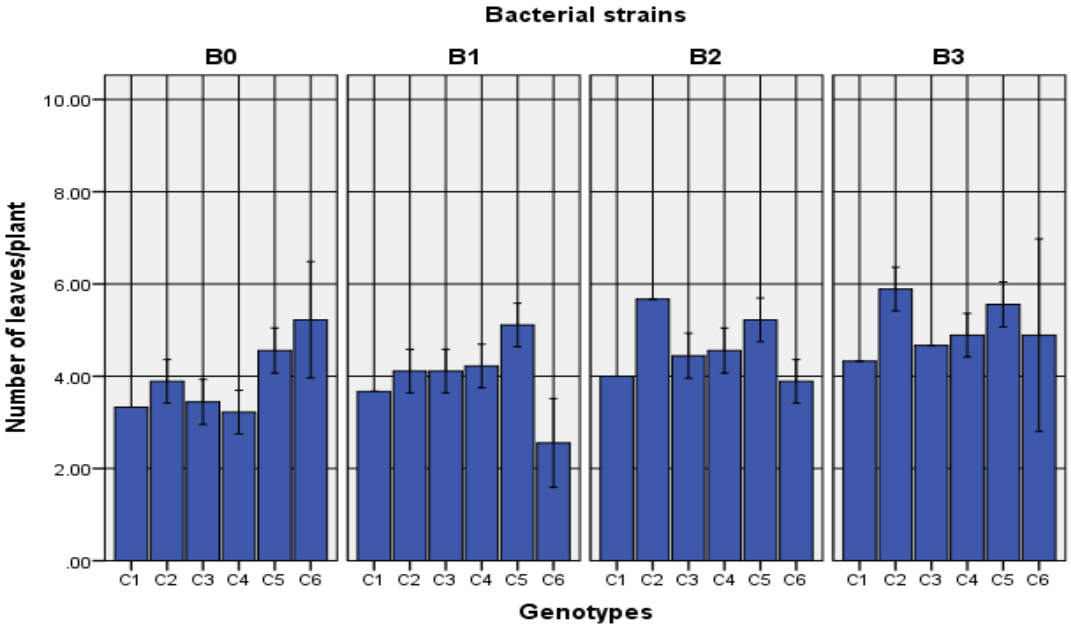

Fig.7. Effects of bacteria strains on number of leaves/plant of maize genotypes at 30 (DAS)

Symbols are as shown on Fig.1

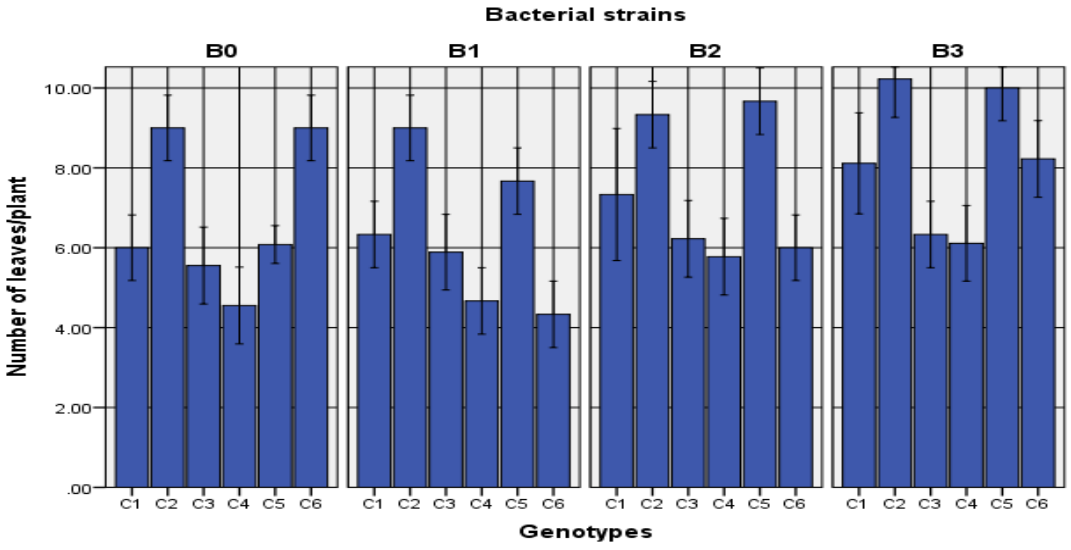

Fig.8. Effects of bacteria strains on number of leaves/plant of maize genotypes at 45 (DAS)

Symbols are as shown on Fig.1

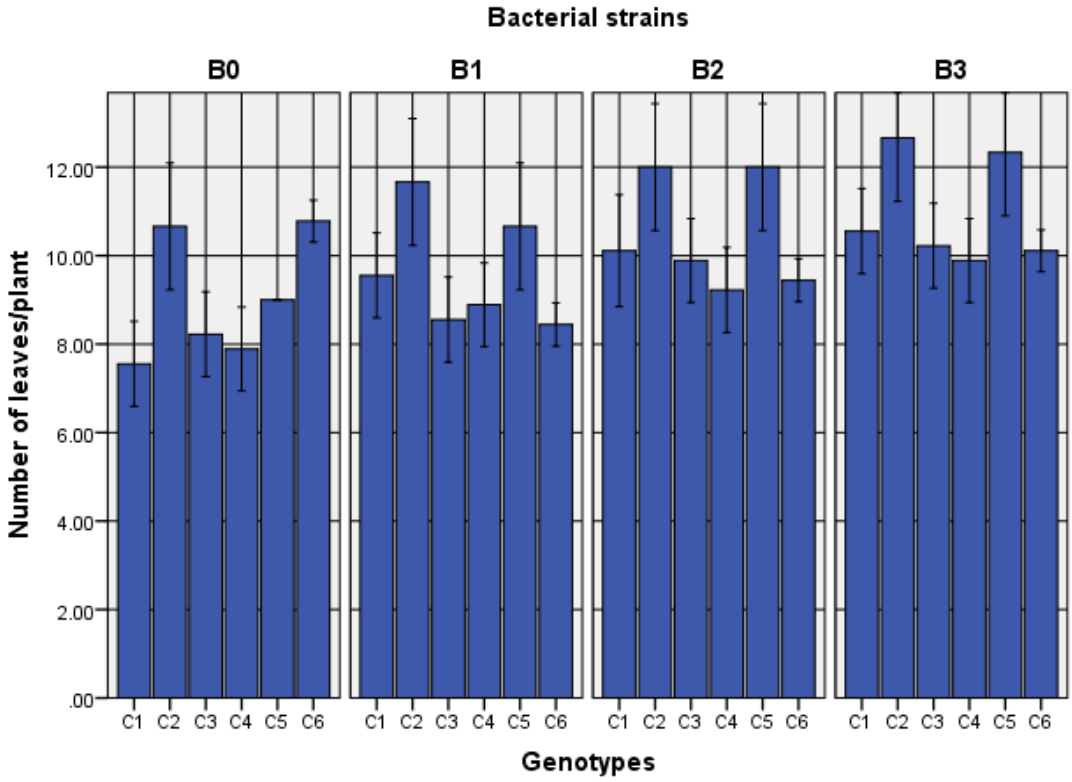

Fig.9. Effects of bacteria strains on number of leaves/plant of maize genotypes at 60 (DAS)

Symbols are as shown on Fig.1

4.1.4 Leaf area (cm^2):

Results showed that untreated genotypes (C_1, C_2, C_3, C4, C_5 and C_6) at 30 (DAS), gave leaf area of: 23.9, 34.0, 14.0, 23.3, 24.2, and 35.6, respectively. All treatments increased leaf area as compared to the control except, C_6 (Fig. 10).

Genotypes inoculated with B_2 and B_3 at 45 (DAS), gained better leaf area as compared to B_1 and control. (Fig.11).

At 60 (DAS), in general the leaf area increased with time. Genotypes inoculated with B_2 and B_3 achieved higher leaf area as compared to other treatments except, C_6 (Fig. 12).

Application of bacteria strain mixtures in general gained the best leaf area with C_2 and C_5 compared to other genotypes.

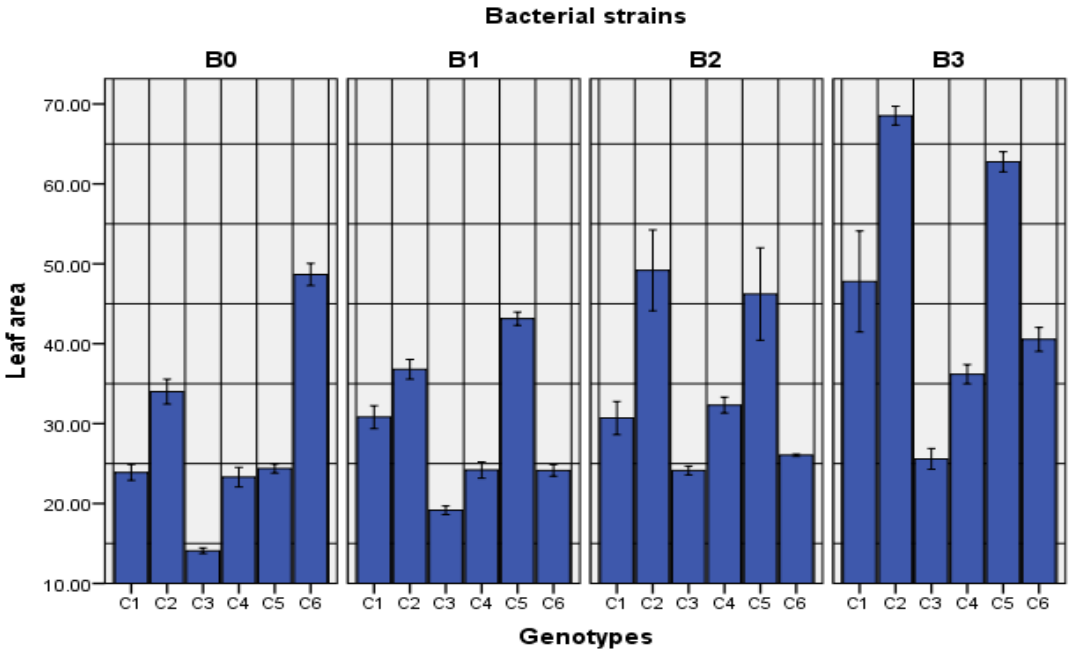

Fig.10. Effects of bacteria strains on leaf area of maize genotypes at 30 (DAS)

Symbols are as shown on Fig.1

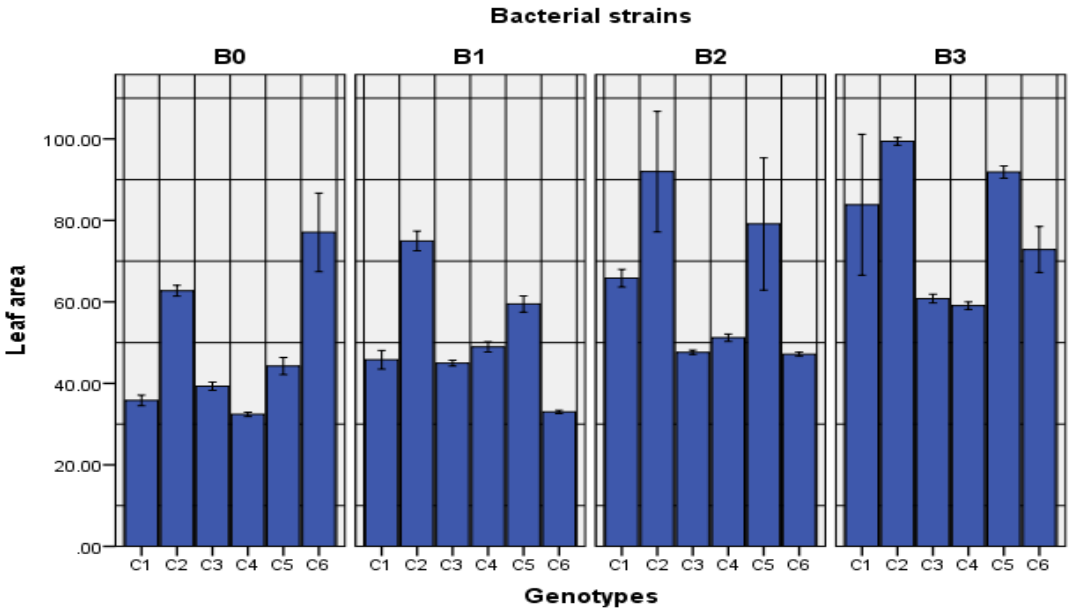

Fig.11. Effects of bacteria strains on leaf area of maize genotypes at 45 (DAS)

Symbols are as shown on Fig.1

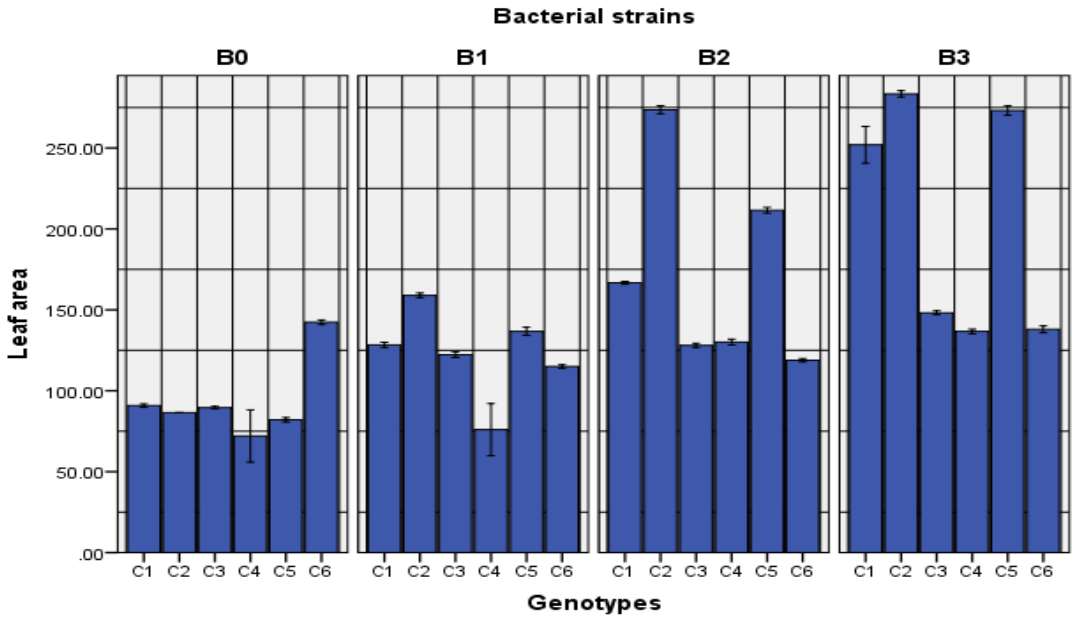

Fig.12. Effects of bacteria strains on leaf area of maize genotypes at 60 (DAS)

Symbols are as shown on Fig.1

4.1.5 Chlorophyll content

(Fig.13) showed the effects of microbial inoculants on chlorophyll content at 45 (DAS), untreated genotypes (C_1, C_2, C_3, C4, C_5 and C_6) gave 22.1%, 28.0%, 20.0%, 24.2%, 25.2% and 31.2 % of chlorophyll, respectively. All treatments increased chlorophyll content as compared to the control except C_6. Among all treatments, B_3 irrespective to maize genotypes, sustained the highest chlorophyll content as compared to the control.

At 60 (DAS), in general, the chlorophyll content reduced with time. Genotypes inoculated with B_2 and B_3 achieved greater chlorophyll content as compared to other treatments (Fig. 14).

In general C_2 and C_5 displayed good response compared to other genotypes at all types of bacteria strain mixtures.

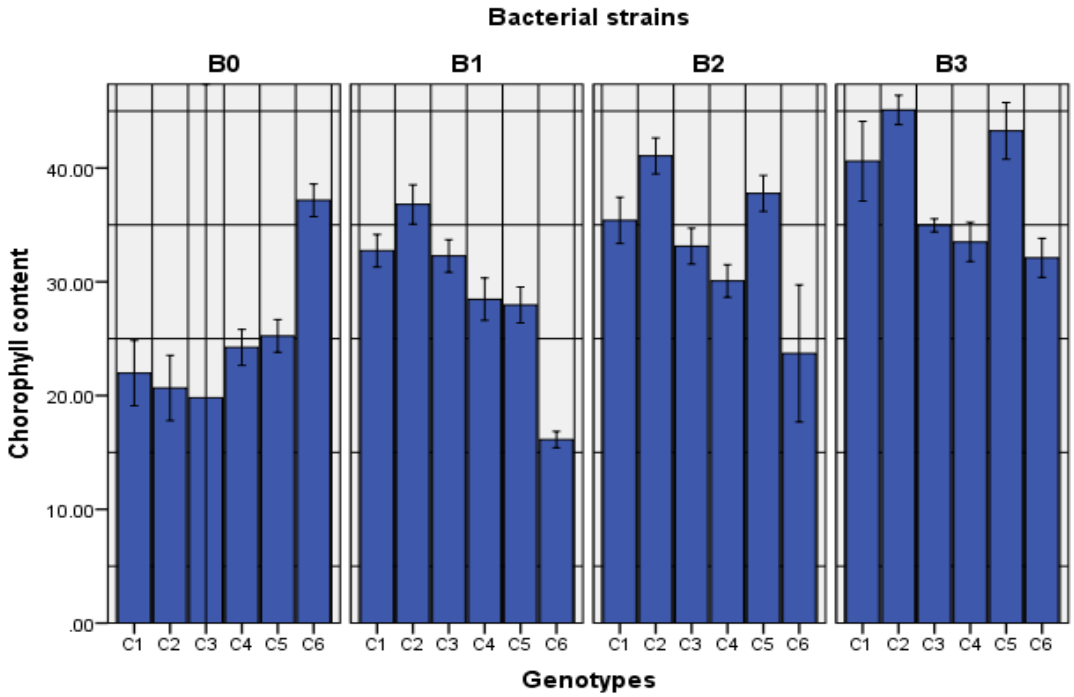

Fig.13. Effects of bacteria strains on chorophyll content of maize genotypes at 45 (DAS)

Symbols are as shown on Fig.1

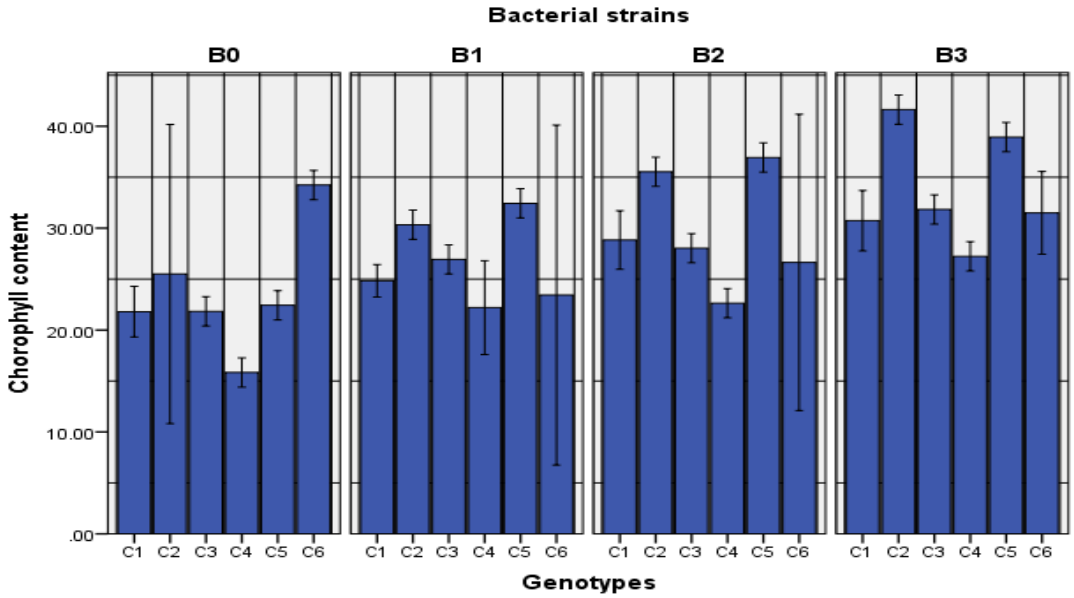

Fig.14. Effects of bacteria strains on chorophyll content of maize genotypes at 60 (DAS)

Symbols are as shown on Fig.1

4.2 Vegetative growth parameters of basic experiment:

4.2.1 Plant height (cm):

The statistical analysis revealed that treatments had highly significant difference (P=0.01) on plant height in the three sampling dates 30, 45 and 60 (DAS) in all season except genotypes at 60 (DAS) season 2017 and at 45 and 60 (DAS) season 2018 appendices (3and 4).

Summer season gave higher plant height in the three sampling dates 30, 45 and 60 (DAS) except at 60 (DAS) winter season 2018 had higher plant height (Table1&2).

In summer and winter season ZML309 gave higher plant height than Hudiba2 in the three sampling dates 30, 45 and 60 (DAS) (Table1&2).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher plant height at summer and winter season in the three sampling dates 30, 45 and 60 (DAS). On the other hand, there were no differences between the applications of (M_2+N) and (M_1+N) at 30 (DAS) season 2017(Table1&2).

The interaction of seasonality and genotypes had highly significant differences (P=0.01) in plant height in the season 2017 at 60 (DAS), and in season 2018 at 45 and 60 (DAS), while interaction of seasonality and fertilizes season 2018 had significant differences (P=0.05) at 30 and 60 (DAS), appendices (3and 4).

4.2.2 Stem thickness (cm):

The analysis of variance showed that treatments had highly significant difference (P=0.01) on stem thickness in the three sampling dates 30, 45 and 60 (DAS) in all season except genotypes at 60 (DAS) season 2018 appendices (3and 4).

Summer season gave higher stem thickness in the three sampling dates 30, 45 and 60 (DAS) season 2017 while season 2018 winter season gave higher stem thickness in the three sampling dates (Table1&2).

Genotype ZML309 gave higher stem thickness in summer and winter season. While no significant difference between ZML309 and Hudiba2 season 2018 in the three sampling dates (Table1&2).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher stem thickness at summer and winter season in the three sampling dates 30, 45 and 60 (DAS). On the other hand, there were no differences between the applications of (M_2+N) and (M_1+N) at 60 (DAS) season 2017(Table1&2).

The interaction of seasonality and fertilizes had highly significant differences (P=0.01) in stem thickness in the season 2017 at 30 and 45 (DAS). Although interaction of seasonality and genotypes all season had significant differences (P=0.05) at 45 (DAS), appendices (3and 4).

4.2.3 Number of leaves:

The statistical analysis indicated that treatments had highly significant difference (P=0.01) on number of leaves in the three sampling dates 30, 45 and 60 (DAS) in all season except genotypes at 60 (DAS) season 2018 appendices (3and 4).

Summer season gave higher number of leaves in the three sampling dates 30, 45 and 60 (DAS) season 2017 while season 2018 winter season gave higher number of leaves in the three sampling dates (Table1&2).

Genotype ZML309 gave higher number of leaves in all season (Table1&2).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher number of leaves at all season in the three sampling dates 30, 45 and 60 (DAS). On the other hand, there were no differences between the applications of (M_2+N) and (M_1+N) at 45 (DAS) season 2018(Table1&2).

The interaction of seasonality and genotypes had highly significant differences (P=0.01) in number of leaves in the season 2018 at 45 and 60 (DAS) appendices (3and 4).

4.2.4 Leaf area

The statistical analysis revealed that treatments had highly significant difference (P=0.01) on leaf area in the three sampling dates 30, 45 and 60 (DAS) in all season except genotypes at three sampling dates season 2018 appendices (3and 4).

Summer season gave higher leaf area in the three sampling dates 30, 45 and 60 (DAS) season 2017 while season 2018 winter season gave higher number of leaves in the three sampling dates (Table1&2).

Genotype ZML309 gave higher leaf area in summer and winter season, while no significant difference between ZML309 and Hudiba2 at 45 and 60 (DAS) season 2018 (Table1&2).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher leaf area at all season in the three sampling dates (Table1&2).

The interaction of seasonality and fertilizes had significant differences (P=0.05) in leaf area in the season 2017 at 45 (DAS), and in season 2018 at 30 and 45 (DAS), while interaction of seasonality and genotypes all season had highly significant differences (P=0.01) at 45 (DAS), appendices (3and 4).

4.2.5 Chlorophyll content:

The analysis of variance showed that treatments had significant difference (P=0.05) on chlorophyll content in the two sampling dates 45 and 60 (DAS) in all season except genotypes at two sampling dates (DAS) season 2018 appendices (3and 4).

Summer season gave higher chlorophyll content in the two sampling dates 45 and 60 (DAS) season 2017 while season 2018 winter season gave higher chlorophyll content in the two sampling dates (Table1&2).

Genotype ZML309 gave higher chlorophyll content in summer and winter season, while no significant difference between ZML309 and Hudiba2 at two sampling dates season 2018 (Table1&2).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher chlorophyll content at all season in the two sampling dates (Table1&2).

Treatments interactions were not affected in chlorophyll content in tall season appendices (3and 4).

Table (1): Effects of seasonality, genotypes and fertilizers on means of vegetative growth parameters of maize at 30, 45 and 60 (DAS) season 2017

Treatment	Plant height/cm			Stem thickness/cm			Number of leaves			Leaf area			Chlorophyll content	
	30	45	60	30	45	60	30	45	60	30	45	60	45	60
S	25.4a	76.5a	114.2a	5.6a	6.5a	7.0b	9.9a	12.3a	13.1b	200.4a	369.1a	421.3a	41.1b	41.5a
W	20.1b	73.6b	109.1b	5.0b	5.9b	7.4a	8.5b	10.8b	13.6a	138.7b	275.9b	395.1b	45.2a	38.5b
LSD	1.4	1.8	2.3	0.2	0.1	0.2	0.2	0.2	0.2	17.0	10.9	7.5	1.2	2.1
SE±	0.6	0.9	1.1	0.1	0.1	0.1	0.1	0.5	0.1	8.6	5.5	3.8	0.6	1.1
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
V_1	21.6b	75.1b	111.6a	5.0b	5.8b	7.0b	8.9b	11.0b	13.1b	165.5a	310.9b	399.0b	41.6b	38.2b
V_2	23.9a	77.9a	111.7a	5.5a	6.7a	7.4a	9.5a	12.1a	13.6a	173.7a	333.9a	417.3a	44.6a	41.8a
LSD	1.4	1.8	2.3	0.2	0.1	0.2	0.2	0.2	0.2	17.0	10.9	7.5	1.2	2.1
SE±	0.6	0.9	1.1	0.1	0.1	0.1	0.1	0.5	0.1	8.5	5.5	3.8	0.6	1.1
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
C	18.1c	65.3d	98.9e	4.3e	5.1e	6.6c	8.1e	10.3e	11.7e	121.0d	259.4e	347.3e	37.8e	33.8d
M_1	21.7b	73.1c	106.5d	4.8d	5.8d	6.9bc	8.5d	10.8de	12.7d	139.9cd	279.7d	374.7d	40.0d	38.2c
M_2	22.0b	78.6b	112.7c	5.6c	6.5c	7.2b	9.1c	11.8bc	13.4c	169.3bc	335.8c	414.7c	44.0bc	41.2bc
N	21.7b	76.8b	110.0cd	4.8d	5.8d	7.2b	8.7d	11.3cd	12.7d	157.3c	294.3d	375.0d	42.1cd	37.6c
M_1+N	25.4a	79.1b	116.8b	6.0b	6.9b	7.5a	10.2b	12.2b	14.4b	195.8b	359.8b	452.8b	44.9b	42.5b
M_2+N	27.4a	86.2a	124.7a	6.4a	7.4a	7.8a	10.6a	23.0a	15.2a	234.2a	405.8a	484.4a	50.2a	46.7a
LSD	2.4	3.1	4.4	0.3	0.2	0.4	0.4	0.8	0.4	29.5	18.9	13.1	2.1	3.7
SE±	1.2	1.5	2.0	0.1	0.1	0.2	0.2	0.4	0.2	14.8	9.5	6.5	1.0	1.8
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Means in the same column with same letters are not significantly different. Key: S; Summer season; W; Winter season. V_1; (Hudiba2) V_2; (ZML309). Control; (un-inoculated unfertilized) M1; (*Bacillus megatherium var phosphorus +Azotobacter* spp *+Azospirillium* spp) M2; (*Bacillus megatherium var phosphorus +Azotobacter* spp + *Flavobacterium spp*) N; (Nitrogen 197.6 kg/ha).

Table (2): Effects of seasonality, genotypes and fertilizers on means of vegetative growth parameters at 30, 45 and 60 (DAS) season 2018

Treatment	Plant height/cm			Stem thickness/cm			Number of leaves			Leaf area			Chlorophyll content	
	30	45	60	30	45	60	30	45	60	30	45	60	45	60
S	24.6a	79.0a	103.7b	4.1b	4.9b	6.4b	7.2b	10.2b	13.4a	120.2b	251.8b	355.8b	37.2b	34.9b
W	15.2b	71.8b	112.7a	5.3a	6.3b	7.1a	8.9a	11.5a	12.3b	162.4a	292.3a	407.5a	43.4a	39.7a
LSD	0.5	0.9	0.5	0.2	0.1	0.1	0.2	0.5	0.2	2.9	7.6	38.5	0.5	0.9
SE±	0.2	0.5	0.9	0.1	0.1	0.1	0.1	0.2	0.1	1.5	3.8	11.2	1.1	0.5
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9		1.9
V_1	19.4b	75.4a	108.0a	4.7a	5.2b	6.7a	7.8b	10.6b	12.8a	137.9b	268.4a	378.5a	39.9a	36.9a
V_2	20.4a	75.4 a	108.3a	4.7a	5.9a	6.8a	8.4a	11.1a	12.9a	144.7a	275.6a	384.8a	40.7a	37.6a
LSD	0.5	0.9	0.8	0.2	0.1	0.1	0.2	0.4	0.2	2.9	7.6	22.3	1.2	0.9
SE±	0.2	0.5	0.9	0.1	0.1	0.1	0.1	0.2	0.1	1.5	3.8	11.2	0.5	0.5
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
C	14.9e	63.6d	92.2f	3.6	4.4e	5.9e	6.9e	9.4d	11.2e	96.3f	205.6e	328.3c	34.4e	31.1e
M_1	19.0d	74.2c	102.3e	4.1d	4.9d	6.4d	7.3d	10.0cd	12.2d	110.9e	220.9d	352.1c	36.8d	34.8d
M_2	20.0c	76.3b	110.0c	5.1c	5.8c	6.7c	7.8c	10.9b	12.8c	140.7c	285.8c	391.1b	41.5b	37.9bc
N	19.7cd	76.4b	107.2d	4.1d	5.1d	6.8c	7.6cd	10.5bc	12.3d	121.1d	232.4	351.7c	39.3c	36.9c
M_1+N	21.6b	77.7b	115.7b	5.4b	6.4b	7.1b	9.2b	11.7a	13.9b	172.9b	321.1b	420.8ab	42.5b	39.4b
M_2+N	24.0a	84.3a	121.7a	5.9a	6.9a	7.5a	9.7a	12.5a	14.7a	205.9a	366.4a	445.9a	42.5b	43.8a
LSD	0.8	1.9	1.6	0.2	0.3	0.2	0.4	0.8	0.4	5.0	13.2	38.5	1.9	1.6
SE±	0.4	0.7	0.8	0.1	0.1	0.1	0.2	0.4	0.2	2.5	6.6	19.3	0.9	0.8
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (3): Effects of interaction between seasonality and genotypes, fertilizers on means of vegetative growth parameters of maize at 30, 45 and 60 (DAS) season 2017

Treatment		Plant height/cm			Stem thickness/cm			Number of leaves			Leaf area			Chlorophyll content	
		30	45	60	30	45	60	30	45	60	30	45	60	45	60
S	V_1	24.6a	77.5b	115.9a	5.4b	6.3b	6.8c	9.5b	11.9b	13.6b	196.8a	364.8a	415.7b	43.6b	39.0b
	V_2	26.0a	81.4a	112.4b	5.8a	6.7a	7.6a	9.5b	12.7a	14.0a	204.1a	373.3a	426.8a	46.7a	43.9a
W	V_1	18.6c	72.8c	107.2c	4.8c	5.3c	7.2b	8.2d	10.1c	13.2c	134.2b	257.1c	382.3c	39.6c	37.4b
	V_2	21.7b	74.4c	110.9b	5.3b	6.6a	7.3b	8.8c	11.6b	12.6d	143.3b	294.6b	407.8b	42.6b	39.6b
LSD		1.9	2.5	3.2	0.2	0.2	0.3	0.5	0.6	0.3	24.1	15.4	10.7	1.7	3.0
SE±		1.0	1.3	1.6	0.1	0.1	0.1	0.3	0.3	0.2	12.1	7.7	5.3	0.9	1.5
CV%		2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
S	C	22.0bcd	68.9e	102.9f	4.6e	5.4e	6.8d	8.8e	11.2cd	12.1e	146.2de	308.9de	360.4e	35.6g	35.6ef
	M1	23.2bc	73.6d	108.2de	5.3d	6.2d	6.9d	9.4d	11.6bc	13.2d	173.1cd	331.8d	392.4d	38.1fg	39.8cd
	M2	23.9b	82.1b	116.0c	5.9c	6.8bc	7.3bc	9.8cd	12.5ab	13.8c	207.2bc	384.0bc	425.5c	42.8cd	43.4abcd
	N	24.0b	79.6bc	112.7cd	5.4d	6.3d	7.4b	9.8d	12.3bc	13.2d	200.9bc	361.9c	395.4d	43.7bcd	37.5e
	M1+N	28.9a	82.7b	118.3bc	6.0bc	7.0b	7.8ab	10.6ab	12.7ab	15.1ab	222.4ab	398.2b	462.1b	43.8bcd	44.5abc
	M2+N	29.7a	89.8a	126.6a	6.4ab	7.4a	8.1a	10.9a	13.5a	15.6a	252.9a	429.4a	491.6a	49.2a	47.9a
W	C	14.0e	61.8f	94.8g	3.9f	4.7f	6.3e	7.2f	9.4g	11.3f	95.9g	210.0f	334.2f	39.9ef	32.0f
	M_1	20.0d	72.5de	104.8ef	4.4e	5.4e	6.9d	7.6f	10.0fg	12.4e	106.7fg	227.6f	356.9e	41.9de	36.4ef
	M_2	20.2cd	75.0d	109.5d	5.4d	6.1d	7.1cd	8.4e	11.2cd	13.1d	131.3ef	287.5e	403.8d	45.2bc	38.9de
	N	19.4d	74.1d	107.3de	4.2ef	5.3e	6.9d	7.7f	10.4ef	12.3e	113.6fg	226.6f	354.7e	40.5ef	37.9e
	M_1+N	22.0bcd	75.5cd	115.4c	5.9c	6.7c	7.3bc	9.8cd	11.7bc	13.8c	169.3cde	321.4d	443.5c	46.2b	40.6bc
	M_2+N	25.2ab	82.1b	122.6ab	6.4a	7.4a	7.6ab	10.3bc	12.5ab	14.8b	215.6ab	382.3bc	477.2ab	51.1a	45.4ab
LSD		3.4	4.3	5.6	0.4	0.1	0.5	0.5	1.1	0.5	41.7	26.7	18.5	2.9	5.2
SE±		1.7	2.2	2.8	0.2	0.3	0.2	0.3	0.6	0.3	20.9	13.4	9.3	1.5	2.6
CV%		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (4): Effects of interaction between seasonality and genotypes, fertilizers on means of vegetative growth parameters at 30, 45 and 60 (DAS) season 2018

Treatment		Plant height/cm			Stem thickness/cm			Number of leaves			Leaf area			Chlorophyll content	
		30	45	60	30	45	60	30	45	60	30	45	60	45	60
S	V_1	14.6d	72.6c	110.6b	4.1b	4.5d	6.5c	6.9d	10.3c	13.2b	116.3d	260.9c	360.4b	37.6	35.4c
	V_2	15.7c	70.9d	114.6a	4.1b	5.2c	6.2d	7.4c	10.1c	13.6a	124.0c	242.6d	351.3b	36.8	34.4c
W	V_1	24.2b	78.2b	105.3c	5.3a	5.9b	6.9b	8.7b	10.9b	12.4c	159.4b	275.9b	396.7a	42.4b	38.5b
	V_2	24.9a	79.8a	102.1d	5.4a	6.6a	7.4a	9.3a	12.1a	12.2c	165.4a	308.6a	418.3a	44.6a	40.9a
LSD		0.7	1.3	1.3	0.2	0.2	0.2	0.3	0.6	0.3	4.1	10.8	31.5	1.5	1.3
SE±		0.3	0.6	0.6	0.1	0.1	0.1	0.2	0.3	0.2	2.1	5.4	15.8	0.8	0.6
CV%		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
S	C	9.4h	59.9g	98.2g	3.0h	3.7h	5.9h	6.2h	8.9i	10.7f	94.7h	187.6f	312.7f	31.4f	28.4g
	M_1	13.6g	70.6e	98.3g	3.5g	3.8h	6.5fg	6.5gh	9.3hi	11.7	105.4g	200.8f	337.8ef	33.9ef	32.8f
	M_2	15.5f	73.3d	105.2e	4.5ef	5.1f	6.7ef	7.1f	10.3ef	12.4d	139.6e	264.8d	362.6de	38.5c	35.5de
	N	14.8f	72.3de	102.1f	3.6g	4.3g	6.7ef	6.7fg	9.7gh	11.7e	120.6f	224.8e	336.5ef	35.6	34.2ef
	M_1+N	17.3e	73.9d	112.0d	4.8e	5.7e	7.1cd	8.1cd	11.1cd	13.2c	168.3d	305.7c	391.9c	39.6c	36.9d
	M_2+N	20.3d	80.4b	118.4b	5.3d	6.2cd	7.4ab	8.8b	11.8bc	14.2b	198.6b	326.9b	403.3c	44.4b	41.8b
W	C	20.4d	67.2f	86.1h	4.2f	4.9f	5.9h	7.6e	10.1fg	11.8e	98.1h	223.5e	343.9ef	37.4cd	33.8ef
	M_1	24.4c	77.8c	98.3g	4.7e	5.7e	6.5fg	8.0de	10.7d	12.8cd	116.2f	241.1e	370.9cd	39.8c	36.8d
	M_2	24.4c	79.3bc	114.8c	5.7c	6.5c	6.7ef	8.7b	11.7bc	13.1c	141.8e	306.8c	419.5bc	44.5b	40.4bc
	N	24.6c	80.5b	112.3d	4.6e	5.8de	6.8de	8.6bc	11.2c	12.9cd	121.5f	224.8e	377.8cd	42.9b	39.5c
	M_1+N	25.9b	81.3b	19.3b	6.1b	6.9b	7.2bc	10.3a	12.4ab	14.5b	177.4c	336.5b	459.6ab	45.5b	41.9b
	M_2+N	27.7a	88.1a	125.0a	6.6a	7.6a	7.5a	10.7a	13.2a	15.3a	213.2a	405.8a	488.6a	50.8a	45.9a
LSD		1.2	2.2	2.2	0.3	0.4	0.3	0.5	1.1	0.5	7.1	18.7	54.5	2.7	2.2
SE±		0.6	1.1	1.1	0.2	0.2	0.2	0.3	0.6	0.3	3.6	9.4	27.4	1.3	1.1
CV%		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (5): Effects of interaction between genotypes and fertilizers on means of vegetative growth parameters of maize at 30, 45 and 60 (DAS) season 2017

Treatment		Plant height/cm			Stem thickness/cm			Number of leaves			Leaf area			Chlorophyll content	
		30	45	60	30	45	60	30	45	60	30	45	60	45	60
V_1	C	16.5g	63.4f	100.8gh	4.0f	4.7g	6.4f	7.7i	9.8g	11.4h	115.1g	250.8h	339.2g	35.6g	31.3e
	M_1	20.6ef	71.5de	106.7ef	4.6e	5.3f	6.7ef	8.2gh	10.2fg	12.5fg	136.6ef	268.9gh	365.5ef	38.1fg	36.3de
	M_2	21.3def	76.4bc	113.5cd	5.4cd	6.1e	7.0de	8.7fg	11.2de	13.2de	165.6cd	323.4de	407.1d	42.8cd	40.2cd
	N	20.2cef	75.1cd	110.1de	4.6e	5.4f	6.9de	8.3gh	10.7ef	12.5fg	155.2de	283.1fg	366.9ef	40.5ef	34.4e
	M_1+N	24.4bcd	78.4bc	116.2c	5.7c	6.4d	7.4bc	9.8cd	11.8bcd	14.2c	172.8c	347.6cd	442.1d	43.6bcd	41.9bc
	M_2+N	26.6ab	86.0a	121.9ab	6.2b	6.9c	7.6ab	10.3bc	12.5abc	14.9ab	229.8ab	362.0b	473.2b	49.2a	45.4ab
V_2	C	19.6fg	67.3ef	96.9h	4.5e	5.5f	6.8ef	8.3gh	10.8ef	11.9g	127.1fg	268.2gh	355.5fg	39.9ef	36.3de
	M_1	22.8def	74.6cd	106.3fg	5.1d	6.3de	7.2cd	8.8fg	11.4cd	13.1e	172.9cd	290.5fg	383.9e	41.9de	40.1cd
	M_2	22.8def	80.7b	111.9cd	5.8bc	6.8c	7.3bc	9.4de	12.3bc	13.7d	143.2ef	348.2cd	422.2d	45.2bc	42.2bc
	N	23.3cde	78.6bc	109.9de	5.1d	6.3de	7.4bc	9.2ef	11.9bcd	12.9ef	159.3cd	305.5ef	383.1e	43.7bcd	41.0bcd
	M_1+N	26.4abc	79.9b	117.4bc	6.2b	7.3b	7.7ab	10.6ab	12.7ab	14.7bc	200.9abc	371.9bc	463.6b	46.2b	43.2abc
	M_2+N	28.2a	86.4a	127.4a	6.7a	7.9a	8.1a	10.9a	13.5a	15.4a	238.7a	419.7a	495.7a	51.1a	47.9a
LSD		3.4	4.3	5.6	0.4	0.3	0.5	0.5	1.1	0.5	41.6	26.7	18.5	2.9	5.2
SE±		1.7	2.2	2.8	0.2	0.1	0.3	0.3	0.6	0.3	20.9	13.4	9.3	1.4	2.6
CV%		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (6): Effects of interaction between genotypes and fertilizers on means of vegetative growth parameters at 30, 45 and 60 (DAS) season 2018

Treatment		Plant height/cm			Stem thickness/cm			Number of leaves			Leaf area			Chlorophyll content	
		30	45	60	30	45	60	30	45	60	30	45	60	45	60
V_1	C	16.3e	63.6d	92.9g	3.6f	4.0f	5.9h	6.7g	9.3f	11.3e	49.7h	201.5g	326.5d	33.9h	30.8f
	M_1	20.5cde	74.2c	101.8f	4.1e	4.5e	6.4g	7.0fg	9.7ef	12.3d	105.5g	216.5ef	358.1cd	37.3ef	34.6e
	M_2	21.4cd	76.6b	109.7d	5.1cd	5.5d	6.7ef	7.4de	10.6cd	12.6cd	139.6e	290.4c	388.4bc	41.0bcd	37.8cd
	N	20.4cbe	76.2bc	106.9e	4.0e	4.8e	6.7ef	7.3ef	10.2de	12.3d	120.6	229.2de	348.2cd	38.8de	36.1de
	M_1+N	24.4abc	77.8b	114.4c	5.4bc	5.9c	7.1cd	8.9b	11.5b	13.7b	168.3d	322.4b	417.6ab	42.2bc	38.8bc
	M_2+N	24.8abc	84.1a	121.9a	5.9a	6.4b	7.4ab	9.7a	12.3ab	14.6a	198.6b	359.7a	444.3a	47.6a	43.6a
V_2	C	19.1de	63.5d	91.4g	3.6f	4.7e	5.9h	7.1efg	9.6ef	12.2d	98.1h	209.6fg	330.1d	36.4fg	31.3f
	M_1	22.8bcd	74.2c	102.8f	4.1e	5.3d	6.5fg	7.5d	10.3de	12.3d	121.5f	225.3def	358.1cd	37.3ef	34.9e
	M_2	22.0bcd	74.2bc	110.3d	5.1d	6.1c	6.8ef	8.3c	11.2bc	12.8c	141.8e	281.2c	393.6abc	41.9bc	38.0bcd
	N	22.0bcd	76.6b	107.5e	4.1e	5.4d	6.8de	7.9cd	10.7cd	12.3d	121.5e	235.5d	355.2cd	39.8cd	37.7cd
	M_1+N	26.2ab	77.5b	116.9b	5.5b	6.8b	7.2bc	9.5a	11.9ab	13.9b	177.4c	319.8b	423.9ab	42.9b	40.1b
	M_2+N	28.5a	84.3a	121.3a	6.1a	7.3a	7.5a	9.9a	12.7a	14.8a	213.2a	373.0a	447.6a	47.5a	44.0a
LSD		4.6	2.2	2.2	0.3	0.4	0.3	0.5	1.1	0.5	7.1	18.7	54.5	2.6	2.2
SE±		1.7	1.1	1.1	0.2	0.2	0.2	0.2	0.6	0.3	3.6	9.4	27.3	1.3	1.1
CV%		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (7): Effects of interaction between seasonality genotypes and fertilizers on means of vegetative growth parameters of maize at 30, 45 and 60 (DAS) season 2017

Treatment			Plant height/cm			Stem thickness/cm			Number of leaves			Leaf area			Chlorophyll content	
			30	45	60	30	45	60	30	45	60	30	45	60	45	60
S	V_1	C	21.0efg	65.8ij	108.8gh	4.4kl	5.3i	6.8fg	8.6hi	10.8fgh	11.9no	137.3ef	305.7hi	354.7lm	37.6lm	31.8ij
		M_1	22.8def	71.2hi	110.6fg	5.1hi	5.6hi	6.8fg	9.0fg	11.2ef	12.9hi	170.8bc	327.7gh	388.1ij	44.9de	37.2de
		M_2	23.4def	78.6def	119.0bc	5.7cde	6.8ef	7.2bcde	9.4ef	12.2bcd	13.7ef	204.8abc	379.4cd	422.3fg	44.8de	44.8abc
		N	22.4def	76.9ef	114.8cd	5.2gh	6.1g	7.2bcde	9.3fg	11.7bcd	13.0gh	200.3abc	357.1ef	392.2hi	42.5fg	32.1hi
		M_1+N	28.5abc	82.0cde	118.9bc	5.7cde	6.7f	7.6abcd	10.2bcd	12.4abc	14.9bc	220.6ab	393.8bc	455.1d	45.7de	44.4abc
		M_2+N	29.8a	90.3a	123.1ab	6.1bc	7.2cd	7.8abc	0.6ab	13.3ab	15.4ab	250.2a	429.3a	488.7ab	51.2ab	46.5ab
	V_2	C	23.0def	71.9h	97.2k	4.8ij	5.6hi	6.9de	9.1fg	11.2ef	12.4kl	155.1de	312.2hi	366.2	40.1ij	39.4bc
		M_1	24.2cdef	75.9fg	105.9hi	5.4fg	6.6f	7.2bcde	9.7cd	12.2bcd	13.4efgh	175.5bc	335.9fgh	396.6gh	43.2ef	42.4abc
		M_2	24.4bc	85.6abc	112.7de	6.0cd	6.9de	7.4abcd	10.3bc	12.9abcd	14.0def	209.6abc	388.7bc	428.8f	46.6cd	44.9abc
		N	25.7abcd	82.2cde	110.7fg	6.6de	6.6f	7.7abc	10.3bc	12.8abcd	13.4fg	201.6abc	366.9de	398.5g	46.0cd	42.9abc
		M_1+N	9.3ab	83.4bc	117.7bcd	6.2abc	7.2cd	7.8ab	11.1a	13.0abc	15.3ab	227.1ab	404.9ab	469.2b	47.7b	44.7abc
		M_2+N	29.7a	89.4ab	130.4a	6.6ab	7.7b	8.3a	11.3a	13.7a	15.8a	255.5a	433.5a	501.7a	51.9a	49.4a
W	V_1	C	12.0k	60.9j	92.9l	3.6n	4.0k	6.1h	6.9m	9.9hij	11.0p	92.9h	195.9m	323.7n	33.6n	30.8j
		M_1	18.3hig	71.7hi	102.9jk	4.1lm	5.4i	6.5gh	7.5ki	9.2j	12.1lm	102.5gh	210.2lm	342.8mn	36.1mn	35.3fg
		M_2	19.2ghij	74.3gh	107.6gh	5.1hi	5.4i	6.9ef	8.1ij	10.2gh	12.8ij	126.4ef	267.4jk	392.0hi	40.8hi	38.3cd
		N	18.0ij	73.3gh	105.5ij	3.9mn	4.7j	6.7fgh	7.4ki	11.8bcd	11.9mn	110.1fg	209.0lm	341.7mn	38.5kl	36.7ef
		M_1+N	20.3fgh	74.8gh	113.6cde	5.6de	6.1g	7.2bcde	9.5de	11.0ef	13.5efg	164.0cd	301.5ij	429.0ef	41.6gh	39.4bc
		M_2+N	23.6de	81.7cde	120.8b	6.2abcd	6.7f	7.4bcd	10.1bcd	11.8bcd	14.5cd	209.4abc	358.7ef	464.7bc	47.2bc	44.2abcd
	V_2	C	16.2jk	62.5j	96.7k	4.1lm	4.7j	6.6fgh	7.5ki	8.8j	11.6op	99.1gh	224.1lm	344.8mn	36.6mn	33.2gh
		M1	21.6efg	73.3gh	106.7hi	4.7ijk	6.1g	7.2bcde	7.9jk	10.8fg	12.7jk	110.9fg	245.0kl	371.1jk	39.1jk	37.7cd
		M2	21.2efg	75.8fg	111.3ef	5.6de	6.7f	7.2bcde	8.7gh	11.8bcd	13.4fg	136.2ef	307.4hi	415.6fg	43.8de	39.5bc
		N	20.8fghij	74.8gh	109.1gh	4.5jk	5.8g	7.2bcde	8.0igk	11.2de	12.6kl	117.1ef	244.2kl	367.8kl	41.5gh	39.1cd
		M1+N	23.7cdefg	76.3ef	117.2bcd	6.1bc	7.4bc	7.6bc	10.1bcd	12.5abcd	14.1de	174.5bc	341.4fg	458.0c	44.6de	41.8bc
		M2+N	26.8abcd	83.3cd	124.4ab	6.7a	8.1a	7.8abc	10.6ab	13.3ab	15.1abc	221.8abc	405.8ab	489.6ab	50.2abc	46.6ab
LSD			4.8	6.1	7.9	7.9	0.4	0.7	0.7	1.6	0.7	58.9	37.7	26.1	4.2	7.3
SE±			2.4	3.1	4.0	4.0	0.2	0.4	0.4	0.8	0.4	29.6	18.9	13.1	2.1	3.7
CV%			1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (8): Effects of interaction between seasonality genotypes and fertilizers on means of vegetative growth parameters of maize at 30, 45 and 60 (DAS) season 2018

Treatment			Plant height/cm			Stem thickness/cm			Number of leaves			Leaf area			Chlorophyll content	
			30	45	60	30	45	60	30	45	60	30	45	60	45	60
S	V_1	C	8.8k	60. 8j	88.3m	3.5g	3.5m	5.5mn	6.0j	8.9jk	10.7m	76.9n	190.7mn	318.7gh	31.7ij	28.7m
		M_1	12.7j	71.7fg	99.6kl	3.7g	3.8lm	6.2jk	6.3j	9.4ij	11.8jk	86.9mn	205.8kl	341.6fg	34.3hi	33.2kl
		M_2	14.9i	74.8def	106.8gh	4.5ef	4.8ij	6.6ghi	6.6ij	10.4fg	12.5ghi	126.0ij	275.6fg	368.0ef	38.8efg	36.8gh
		N	14.5i	72.9ef	100.6jk	3.4gh	3.9lm	6.4ij	6.2j	9.8hi	13.4e	108.8l	232.2hij	340.6fg	35.9fg	34.6hi
		M_1+N	17.0h	74.8de	112.6de	4.8e	5.2hi	6.9def	8.0ef	11.2c	13.3ef	143.3fg	321.9d	385.0de	39.9de	37.3fgh
		M_2+N	19..5fg	81.1b	120.9b	5.4d	5.8fg	7.3bcd	8.8cd	11.9b	14.3bc	156.1e	339.5cd	408.4bc	44.7bc	42.1bc
	V_2	C	9.9k	59.1j	84.0n	4.2f	4.1kl	5.2n	6.3j	8.8k	10.6m	79.5n	184.5n	306.8h	31.0j	28.0m
		M_1	14.5i	69.5gh	97.0l	4.4ef	4.6jk	6.2kl	6.7hi	9.3ij	11.6l	123.9ijk	195.7lm	334.0fg	33.5hi	32.5l
		M_2	16.1hi	72.6efg	103.7ij	5.7cd	5.4gh	6.3jk	7.5fg	10.2gh	12.3hij	125.5ij	254.1gh	357.1ef	38.1efg	34.3ij
		N	15.2i	71.7fg	100.6gk	3.7g	4.7ij	6.2kl	6.7hi	9.6hi	11.5l	114.8kl	217.5jk	332.6fg	35.2gh	33.9jk
		M_1+N	17.6h	73.1ef	111.5def	4.8e	6.1ef	6.6gh	8.2de	11.0def	13.3ef	148.9ef	289.5ef	378.9dfe	39.2ef	36.6gh
		M_2+N	21.1ef	79.8bc	115.9c	5.3d	6.6de	7.1cde	8.8cd	11.7bc	14.1d	179.4d	314.4de	398.2cd	44.0bc	41.4cd
W	V_1	C	19.4g	66.3i	97.7kl	4.2f	4.5jk	6.2jk	7.4fgh	9.6hi	11.6l	96.3m	212.3jkl	334.4fg	36.1fg	32.9l
		M_1	23.5d	68.1hi	104.1hi	4.8e	5.2hi	6.6gh	7.7efg	10.1gh	12.6fgh	112.5l	227.3ij	350.5fg	38.1efg	36.2ghi
		M_2	24.3cd	78.8bc	112.7de	5.7cd	6.2ef	6.8ef	8.2de	10.8def	12.8efg	153.1ef	286.8f	408.8bc	43.2bcd	38.9ef
		N	24.7bcd	79.4bc	110.1ef	4.6ef	5.7fgh	7.0de	8.3de	10.5efg	12.8efgh	132.4hi	226.3j	355.8ef	41.6cd	37.6fg
		M_1+N	25.6bc	80.7b	116.3c	5.9bc	6.6de	7.2cde	9.8b	11.9bc	14.2cd	193.4c	322.9d	466.2abc	44.4bc	40.3de
		M_2+N	27.8a	87.3a	123.0b	6.4ab	7.1bc	7.5abc	10.6a	12.6abc	15.0ab	241.1a	379.9b	480.2ab	50.6a	45.1ab
	V_2	C	21.4e	66.4hi	98.8kl	4.2f	5.4gh	6.6hi	7.9ef	11.0de	12.1ij	116.6jk	234.7hi	353.4ef	38.7efg	34.7hi
		M_1	25.3bc	69.5gh	108.5fg	4.7e	6.1ef	7.1cde	8.3de	11.3bcd	12.9efg	136.4gh	254.9gh	382.2def	41.2cd	37.4fg
		M_2	24.6cd	79.7bc	116.9c	5.7cd	6.7cd	7.2cd	9.1bc	12.3abcd	13.1efg	158.0e	326.7cd	360.9abc	45.7b	41.8cd
		N	24.5cd	81.6b	114.4cd	4.6ef	5.9f	7.4abc	8.8cd	11.9bc	13.1efg	28.3hi	253.6ghi	377.7def	44.3bc	41.5cd
		M_1+N	26.4ab	81.9b	122.3b	6.2b	7.4b	7.7ab	10.7a	12.9ab	14.8abc	205.9b	350.1c	469.0abc	46.6b	43.6abc
		M_2+N	27.6a	88.9a	127.0a	6.8a	8.1a	7.9a	10.9a	13.7a	15.6a	247.1a	431.7a	497.1a	51.1a	46.7a
LSD			1.7	1.6	3.1	0.5	0.5	0.4	0.7	1.6	0.7	10.1	26.4	77.1	3.7	3.1
SE±			0.9	3.1	1.6	0.2	0.3	0.2	0.4	0.8	0.4	5.1	13.3	38.7	1.9	1.6
CV%			1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

4.3 Yield and Yield Components:

4.3.1 Weight of root (g) /m^2:

The analysis of variance indicated that treatments had highly significant difference (P=0.01) all season except genotypes season 2017 had significant difference (P=0.05) appendices (5and 6).

Summer season gave higher weight of root season 2017 while season 2018 winter season gave higher weight of root (Table 9&10). Genotype ZML309 gave higher weight of root in all season, (Table9&10).

Illustrated data in (Table 9&10) pointed out that application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher weight of root all season. Application of (M_2+N) gave 87 and 99% greater weight of root over control in the 2017 and 2018 season, respectively.

Treatment interactions were not affected in weight of root in all season except interaction between seasonality and fertilizes had significant differences (P=0.05) season 2018 appendices (3and 4). On the other hand, there were no significant differences between interactions winter season with genotypes two season (Table11&12).

4.3.2 Number of cobs/plant:

The statistical analysis revealed that seasonality and fertilizes season 2017 and fertilizes season 2018 had highly significant difference (P=0.01) on number of cobs/plant appendices (5and 6). There were no significant differences between summer and winter season 2017in number of cobs/plant, while season 2018 winter season gave higher number of cobs/plant (Table 9&10).

There were no significant differences between Genotype ZML309 and Hudiba2 all season in number of cobs/plant, (Table9&10). Application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher number of cobs/plant at all season, it gave 50 and 36% greater number of cobs/plant over control in the 2017 and 2018 season, respectively (Table 9&10). Treatments interactions were not affected in number of cobs/plant in all season appendices (3and 4).

4.3.3 Cobs Length (cm):

The analysis of variance showed that treatments had highly significant difference (P=0.01) in cobs length in all season except genotypes season 2017 had significant difference (P=0.05) appendices (5and 6). Summer season gave higher cobs length season 2017 while season 2018 winter season gave higher cobs length (Table9&10). Genotype ZML309 gave higher cobs length season 2017, while Hudiba2 gave higher cobs length season 2018 (Table 9&10).

Data presented in (Table 9&10) showed that combination bacteria strains and nitrogen fertilizer (B_3+N) gave higher cobs length at all season, it gave 25 and 26% greater cobs length over control in the 2017 and 2018 season, respectively (Table 9&10). The interaction of treatments had significant differences (P=0.05) in cobs length in all season, except interaction between seasonality, genotypes and fertilizes appendices (5and 6).

4.3.4 Number of rows /cob:

The analysis showed highly significant difference (P=0.01) among all treatments, on number of rows /cob in all season, except genotypes season 2018 appendices (5and 6).

Summer season gave higher number of rows/cob season 2017 while season 2018 winter season gave higher number of rows /cob (Table 9&10). Genotype ZML309 gave higher number of rows/cob in summer and winter season, while no significant difference between ZML309 and Hudiba2 season 2018 (Table9&10).

Data in (Table 9&10) showed that combination bacteria strains and nitrogen fertilizer (B_3+N) gave higher number of rows/cob at all season, it gave 37 and 35% greater number of rows/cob over control in the 2017 and 2018 season, respectively (Table 9&10). Treatments interactions were not affected in number of rows/cob in all season appendices (3and 4).

4.3.5 Number of seeds /row:

The analysis of variance indicated that treatments had highly significant difference (P=0.01) on number of seeds /row in all season except genotypes season 2018 appendices (5and 6).

Summer season gave higher number of seeds /row season 2017 while season 2018 winter season gave higher number of seeds /row (Table 9&10). Genotype ZML309 gave higher number of seeds/row season 2017, while Hudiba2 gave higher number of seeds /row season 2018 (Table9&10).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher number of seeds /row at all season, it gave 34 and 36% greater number of seeds /row over control in the 2017 and 2018 season, respectively (Table 9&10).

There were no significant differences between treatments interactions in number of seeds /row in all season except interactions between seasonality and genotypes appendices (3and 4).

4.3.6 Hundred seeds weight (g):

The statistical analysis indicated that treatments had highly significant difference (P=0.01) on hundred seeds weight all season appendices (5and 6).

Summer season gave higher hundred seeds weight season 2017 while season 2018 winter season gave higher hundred seeds weight (Table 9&10). Genotype ZML309 gave higher hundred seeds weight all season (Table9&10).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher hundred seeds weight at all season, it gave 31 and 23% greater hundred seeds weight over control in the 2017 and 2018 season, respectively (Table 9&10).

Treatments interactions were not affected in hundred seeds weight in all season except interactions between seasonality and genotypes season 2018 appendices (5and 6).

4.3.7 Harvest index %:

The analysis of variance showed that treatments had highly significant difference (P=0.01) in harvest index in all season except seasonality season 2017 appendices (5and 6).

Summer season gave higher harvest index season 2017 while season 2018 winter season gave higher harvest index (Table 9&10). Genotype ZML309 gave harvest index all season (Table9&10).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher harvest index at all season, it gave 28 and 39% greater harvest index over control in the 2017 and 2018 season, respectively (Table 9&10).

The interaction of treatments had significant differences (P=0.05) in harvest index in all season, except interaction between seasonality, genotypes and fertilizes appendices (5and 6).

4.3.8 Yield (t/ha):

The analysis showed highly significant difference (P=0.01) among all treatments, on yield (t/ha) in all season appendices (5and 6). Summer season gave higher yield (t/ha) all season (Table 9&10).

Genotype ZML309 gave higher yield (t/ha) all season (Table 9&10). Application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher yield (t/ha) at all season, it gave 121 and 181% greater yield (t/ha) over control in the 2017 and 2018 season, respectively (Table 9&10).

Treatments interactions were not affected in yield (t/ha) in season 2017 when interaction of treatments had significant differences (P=0.05) in yield (t/ha) in season 2018 appendices (5and 6).

Table (9): Effects of seasonality, genotypes and fertilizers on means of yield and yield components parameters of maize season 2017

Treatment	Weight of root (g) /m2	Number of cobs/Plant	Cob Length (cm)	Number of rows /cob	No of seeds /row	100 seeds weight/gm	Harvest index %	Yield (t/ha)
S	77.8a	1.3a	15.8a	12.8a	22.9a	16.6a	24.8a	3.6a
W	54.7b	1.2a	13.5b	12.2b	21.9b	13.6b	24.3b	2.3b
LSD	2.5	0.1	0.2	0.2	0.3	0.4	0.5	0.1
SE±	1.3	0.0	0.1	0.1	0.1	0.2	0.3	0.0
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
V_1	64.5B	1.3a	14.2b	12.2b	23.2a	14.6b	23.9b	2.9b
V_2	68.0A	1.3a	15.1a	12.8a	21.7b	15.6a	25.2a	3.1a
LSD	2.5	0.1	0.2	0.2	0.3	0.4	0.5	0.1
SE±	1.3	0.0	0.1	0.1	0.2	0.2	0.3	0.0
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
C	47.3e	1.0d	13.0f	10.4f	19.7e	12.9e	21.5e	1.9f
M_1	55.9d	1.2c	14.5d	12.4d	21.2d	14.3d	23.2d	2.3e
M_2	65.6c	1.4b	14.9c	12.5	21.8c	15.3c	24.6c	3.1c
N	59.8d	1.0d	13.4e	11.6e	20.7e	15.1c	23.8cd	2.6d
M_1+N	80.1b	1.4b	15.6b	13.4b	24.9b	16.1b	26.5b	3.8b
M_2+N	88.8a	1.5a	16.3a	14.2a	26.4a	16.9a	27.6a	4.2a
LSD	4.4	0.1	0.3	0.3	0.6	0.6	0.8	0.2
SE±	2.2	0.1	0.2	0.1	0.3	0.3	0.4	0.1
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (10): Effects of seasonality, genotypes and fertilizers on means of yield and yield components parameters of maize season 2018

Treatment	Weight of root (g) /m2	Number of cobs/Plant	Cob Length (cm)	Number of rows /cob	No of seeds /row	100 seeds weight/gm	Harvest index %	Yield (t/ha)
S	48.9b	1.2b	11.5b	11.3b	21.0b	10.9b	19.7b	2.5a
W	63.2a	1.3a	14.9a	12.9a	22.4a	16.1a	25.5a	1.9b
LSD	1.2	0.1	0.2	0.2	0.2	0.2	0.5	0.0
SE±	0.6	0.0	0.1	0.1	0.1	0.1	0.2	0.0
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
V_1	54.8b	1.3a	13.4a	12.2a	21.6b	13.4b	22.0b	2.1b
V_2	57.3a	1.3a	13.1b	12.0a	21.8a	13.6a	23.2a	2.2a
LSD	1.2	0.1	0.2	0.2	0.2	0.2	0.5	0.0
SE±	0.6	0.0	0.1	0.1	0.1	0.1	0.2	0.0
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
C	36.8f	1.1c	11.7f	10.2e	18.8	11.9e	18.8f	1.1f
M_1	48.1e	1.2c	12.5e	11.6d	20.3	13.1d	21.6d	1.6e
M_2	57.5c	1.3b	13.4c	12.3c	20.9c	13.6c	20.6e	2.2c
N	55.5d	1.2c	12.5e	11.7d	20.7c	13.5c	23.2c	2.1d
M_1+N	64.9b	1.3b	14.0b	13.1b	23.9b	14.2b	25.2b	2.9b
M_2+N	73.4a	1.5a	14.7a	13.8a	25.5a	14.6a	26.1a	3.1a
LSD	2.1	0.1	0.3	0.3	0.4	0.3	0.8	0.1
SE±	1.1	0.1	0.1	1.2	0.2	0.2	0.4	0.0
CV%	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (11): Effects of interaction between seasonality and genotypes, fertilizers on means of yield and yield components parameters of maize season 2017

Treatment		Weight of root (g) /m2	Number of cobs/Plant	Cob Length (cm)	Number of rows /cob	No of seeds /row	100 seeds weight/gm	Harvest index %	Yield (t/ha)
S	V_1	75.2b	1.26a	15.4b	12.4b	22.1c	16.0b	25.3b	3.5a
	V_2	80.4a	1.27a	16.2a	13.2a	23.8a	17.2a	24.3c	3.7a
W	V_1	53.7c	1.24a	12.9d	11.9c	21.3d	13.3d	22.4d	2.2c
	V_2	55.7c	125a	14.0c	12.4b	22.6b	13.9c	26.1a	2.5b
LSD		3.6	0.1	0.3	0.2	0.5	0.5	0.7	0.1
SE±		1.8	0.0	0.1	0.1	0.2	0.3	0.4	0.1
CV%		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
S	C	59.6de	1.1c	13.9gh	10.5g	21.0de	14.0fg	21.8gh	2.5f
	M_1	66.8c	1.2c	15.5d	12.9c	21.7d	15.4d	22.9efg	2.8e
	M_2	75.9b	1.4b	16.2c	13.3c	22.6c	16.9bc	25.6cd	3.6c
	N	66.4c	1.1c	14.5ef	11.9e	21.3de	16.7c	25.2d	3.2d
	M_1+N	96.1a	1.4b	16.9b	13.7b	25.2b	17.7b	26.3bcd	4.6b
	M_2+N	102.1a	1.5a	17.8a	14.7a	26.7a	18.9a	26.9b	5.0a
W	C	34.9h	1.1c	12.2i	10.3g	20.1f	11.9h	21.2h	1.2i
	M_1	45.1g	1.2c	13.5h	12.0e	20.6ef	13.2g	23.5ef	1.8h
	M_2	55.3ef	1.4b	13.7gh	12.4d	19.3g	13.7fg	23.6e	2.5ef
	N	53.3f	1.1c	12.4i	11.4f	20.2f	13.4fg	22.3fgh	2.0g
	M_1+N	64.1cd	1.4b	14.2fg	13.1c	24.6b	14.3ef	26.6bc	3.1d
	M_2+N	75.4b	1.4ab	14.9e	13.7b	26.3a	15.0de	28.4a	3.4c
LSD		6.1	0.1	0.4	0.4	0.8	0.9	1.2	0.2
SE±		3.1	0.1	0.2	0.2	0.4	0.5	0.6	0.1
CV%		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (12): Effects of interaction between seasonality and genotypes, fertilizers on means of yield and yield components parameters of maize season 2018

Treatment		Weight of root (g) /m2	Number of cobs/Plant	Cob Length (cm)	Number of rows /cob	No of seeds /row	100 seeds weight/gm	Harvest index %	Yield (t/ha)
S	V_1	46.9c	1.2b	12.1c	11.7c	20.7d	11.6c	20.4c	1.9c
	V_2	50.9b	1.2b	19.9d	11.0d	20.6d	10.2d	18.9d	1.8d
W	V_1	62.6a	1.4ab	14.6b	12.7b	21.8b	17.0a	23.6b	2.3b
	V_2	63.6a	1.3a	15.3a	13.1a	23.0a	15.1b	27.4a	2.7a
LSD		1.7	0.1	0.2	0.2	0.3	0.3	0.7	0.0
SE±		0.9	0.0	0.1	0.1	0.2	0.1	0.3	0.0
CV%		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
S	C	30.6g	1.0f	10.2j	9.5g	18.1g	9.5i	13.8	0.8j
	M_1	41.3f	1.2de	11.1i	10.8f	19.7f	10.6h	17.9g	1.3i
	M_2	51.7e	1.3bc	11.7h	11.7e	20.5e	11.1g	18.3g	1.9f
	N	49.5e	1.0f	11.0i	10.9f	20.4e	10.9gh	21.9f	1.9g
	M_1+N	57.5d	1.3b	12.2g	12.2d	22.9c	11.6f	22.6ef	2.5d
	M_2+N	63.2c	1.4ab	12.8f	13.1b	24.6b	11.8f	23.6cde	2.7c
W	C	43.1f	1.1ef	13.2e	11.0f	19.6f	14.5e	23.1de	1.5h
	M_1	54.9d	1.2cd	14.8c	12.5cd	20.9de	15.6d	25.3b	1.9f
	M_2	63.5c	1.3bc	15.1c	12.9bc	21.4d	16.2c	23.8cd	2.5d
	N	61.5c	1.2c	13.9d	12.4d	21.2d	16.1cd	24.4bc	2.4e
	M_1+N	72.3	1..3b	15.9b	14.0a	24.9b	16.8b	27.7a	3.3b
	M_2+N	83.6a	1.6a	16.7a	14.4a	26.5a	17.3a	28.6a	3.4a
LSD		2.9	0.2	0.4	0.4	0.6	0.5	1.2	0.1
SE±		1.5	0.1	0.2	0.2	0.3	0.2	0.6	0.0
CV%		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (13): Effects of interaction between genotypes and fertilizers on means of yield and yield components parameters of maize season 2017

Treatment		Weight of root (g) /m2	Number of cobs/Plant	Cob Length (cm)	Number of rows /cob	No of seeds /row	100 seeds weight/gm	Harvest index %	Yield (t/ha)
V_1	C	45.3n	1.1d	12.3h	10.1j	20.3gh	12.7h	20.4	1.8i
	M_1	53.3fg	1.2cd	14.1e	12.2fg	20.3gh	13.9f	22.2e	2.1gh
	M_2	63.9de	1.4b	14.7d	12.5ef	20.8fg	14.9def	24.3d	2.9d
	N	59.5e	1.1d	12.9g	11.9g	20.3gh	14.5f	22.8e	2.5f
	M_1+N	78.5c	1.4b	15.0cd	13.2cd	24.3c	15.6cde	25.9bc	3.7c
	M_2+N	86.1ab	1.4b	15.8b	13.8b	25.9b	16.3bc	27.4a	4.1b
V_2	C	49.2gh	1.1d	13.6f	10.7i	20.4gh	13.9fg	22.6e	2.0hi
	M_1	58.6ef	1.2cd	14.9cd	12.8de	21.9de	14.6ef	24.1d	2.4fg
	M_2	67.2d	1.4b	15.2c	13.2c	22.7d	15.8bcd	24.9cd	3.2d
	N	60.2e	1.1d	13.9ef	11.3h	21.5ef	15.6bcd	24.8cd	2.7e
	M_1+N	81.7bc	1.3bc	16.1b	13.7b	25.4b	16.5b	26.9ab	3.9b
	M_2+N	91.4a	1.6a	16.8a	14.6a	27.1a	17.7a	27.7a	4.3a
LSD		6.2	0.1	o.4	0.4	0.8	0.9	1.2	0.2
SE±		3.1	0.1	0.2	0.2	0.4	0.5	0.6	0.1
CV%		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (14): Effects of interaction between genotypes and fertilizers on means of yield and yield components parameters of maize season 2018

Treatment		Weight of root (g) /m2	Number of cobs/Plant	Cob Length (cm)	Number of rows /cob	No of seeds /row	100 seeds weight/gm	Harvest index %	Yield (t/ha)
V_1	C	35.5h	1.09e	11.9hi	10.2e	18.8f	11.8g	17.9f	1.1i
	M_1	47.9g	1.18de	13.4de	11.7d	20.2e	12.9f	21.2cd	1.6g
	M_2	56.6ef	1.3bc	13.7cd	12.4c	20.9cd	13.4de	20.6de	2.2de
	N	54.4f	1.15e	12.1gh	11.6d	20.6cde	13.4de	21.6cd	2.1f
	M_1+N	63.3d	1.3bc	14.1b	13.2b	23.6b	14.1bc	25.0b	2.9c
	M_2+N	71.3b	1.4ab	14.8a	13.8a	25.5a	14.4ab	25.7ab	3.0b
V_2	C	38.2h	1.09e	11.5i	10.3e	18.9f	12.2g	19.6e	1.2h
	M_1	48.4g	1.2cd	12.4g	11.6d	20.2e	13.2ef	22.0c	1.7g
	M_2	58.6e	1.4bc	13.2ef	12.2c	20.4de	13.7cd	20.8d	2.2d
	N	56.6ef	1.15e	12.9f	11.7d	20.9cd	13.5de	24.7b	2.2ef
	M_1+N	66.6c	1.4bc	13.9bc	12.9b	24.2b	14.3b	25.3ab	2.8c
	M_2+N	75.5a	1.5a	14.6a	13.7a	25.5a	14.7a	26.5a	3.2a
LSD		3.0	0.2	0.4	0.4	0.6	0.5	1.2	0.1
SE±		1.5	0.1	0.2	0.2	0.3	0.2	0.6	0.0
CV%		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (15): Effects of interaction between seasonality genotypes and fertilizers on means of yield and yield components parameters of maize at season 2017

Treatment			Weight of root (g) /m2	Number of cobs/Plant	Cob Length (cm)	Number of rows /cob	No of seeds /row	100 seeds weight/gm	Harvest index %	Yield (t/ha)
S	V_1	C	56.8ghij	1.1d	13.3lm	10.20	19.3kl	13.9ijk	22.5ghij	2.4ij
		M_1	62.5fghi	1.2cd	15.1fg	12.6gh	20.8ghi	15.2fghi	22.9ghi	2.7hi
		M_2	73.5cde	1.3bc	16.1cde	12.8ef	21.3fgh	16.3def	26.4cde	3.5de
		N	66.8def	1.1d	14.1jk	11.5lm	20.4hij	15.9efg	24.8ef	3.1fg
		M_1+N	93.9b	1.4ab	16.5c	13.4cd	24.7cd	16.9cde	27.1bcd	4.5c
		M_2+N	97.8ab	1.4ab	17.4b	14.1b	26.2ab	17.9bc	28.1bc	4.9ab
	V_2	C	62.5fghi	1.1d	14.5hij	10.8n	20.9ghi	14.1hi	21.2jk	2.6hi
		M_1	71.1cdef	1.2cd	15.9de	13.3de	22.8e	12.8lm	22.8ghij	2.8gh
		M_2	78.2c	1.3bc	16.3cd	13.7bcd	23.9d	13.4jk	24.9ef	3.7d
		N	66.1def	1.1d	14.8gh	12.3hi	22.2ef	13.2kl	25.6def	3.2ef
		M_1+N	98.2ab	1.3bc	17.4b	14.1b	25.6bc	18.3b	25.6def	4.7bc
		M_2+N	106.4a	1.6a	18.1a	15.3a	27.1a	19.9a	25.7de	5.0a
W	V_1	C	33.9n	1.1d	11.5n	10.1o	18.7l	11.4n	18.4l	1.4m
		M_1	44.1lm	1.2cd	12.8m	11.7jk	19.9ij	12.7lm	21.5ij	1.6lm
		M_2	54.3ijk	1.3bc	13.3lm	12.2ij	20.3hi	14.1hij	22.2hi	2.4ij
		N	52.3jkl	1.1d	11.7n	11.1mn	19.5jk	13.7jk	20.7k	1.9kl
		M_1+N	63.1fgh	1.3bc	13.5kl	12.9fg	23.9d	14.6gh	23.9fgh	2.8gh
		M_2+N	74.4cd	1.4bc	14.3hij	13.4cd	25.7bc	14.7gh	26.8bcd	3.2f
	V_2	C	35.9mn	1.1d	12.7m	10.5no	19.9ij	12.4mn	23.9fg	1.1n
		M_1	46.1kl	1.2cd	13.9jk	12.3hi	21.2fgh	13.6jk	25.4def	1.9kl
		M_2	56.3hij	1.3bc	14.2ij	12.6gh	21.6fg	14.1hi	24.9ef	2.7hi
		N	54.3ijk	1.1d	12.9lm	11.6kl	20.8ghi	13.7jkl	24.8ef	2.2jk
		M_1+N	65.1efg	1.3bc	14.7ghi	13.4cde	25.2bc	14.2hi	28.3ab	3.3ef
		M_2+N	76.4c	1.5ab	15.5ef	13.9bc	26.9a	15.4fgh	29.9a	3.6d
LSD			8.7	0.2	0.6	0.6	1.1	1.3	1.7	0.3
SE±			4.4	0.1	0.3	0.3	0.6	0.7	0.9	0.2
CV%			1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (16): Effects of interaction between seasonality genotypes and fertilizers on means of yield and yield components parameters of maize season 2018

Treatment			Weight of root (g) /m2	Number of cobs/Plant	Cob Length (cm)	Number of rows /cob	No of seeds /row	100 seeds weight/gm	Harvest index %	Yield (t/ha)
W	V_1	C	28.7l	1.0e	10.9l	9.6l	18.7h	10.2o	14.9j	0.9f
		M_1	39.9k	1.2cd	11.9ij	11.2hij	20.2g	11.3lm	18.8h	1.4n
		M_2	50.5ij	1.3bc	12.4hi	12.1fg	20.7fg	11.7kl	18.9h	2.0ij
		N	48.1j	1.0e	11/0l	11.2hij	20.6fg	11.6kl	21.6g	1.9jk
		M_1+N	54.9gh	1.3bc	12.9gh	12.6def	23.1d	12.2jk	23.4def	2.6ef
		M_2+N	59.7ef	1.3bc	13.4f	13.5bc	25.2b	12.5j	24.8d	2.8d
	V_2	C	32.5l	1.0e	9.5n	9.3l	17.5i	8.8p	12.6k	0.7q
		M_1	42.7k	1.2cd	10.1m	10.3k	19.3h	9.8p	17.0i	1.3o
		M_2	52.9ghi	1.3bc	11.1kl	11.4hi	20.4fg	10.3no	17.7hi	1.9kl
		N	50.8hi	1.0e	11.0l	10.7jk	20.3fg	10.2no	22.3efg	1.8l
		M_1+N	60.0e	1.3cd	11.6jk	11.8gh	22.6d	10.8mn	21.8fg	2.4g
		M_2+N	66.7c	1.5ab	12.1ij	12.7de	24.0c	11.1lm	22.3efg	2.6e
S	V_1	C	42.3k	1.0e	12.9fg	10.8ijk	18.9h	13.4i	20.9g	1.3o
		M_1	54.1ghi	1.1cd	14.8de	12.8de	20.3fg	14.7h	23.6de	1.8l
		M_2	62.7cde	1.3bc	15.0cde	12.8de	21.1ef	15.2gh	22.2efg	2.4g
		N	60.7de	1.3bc	13.2fg	12.3efg	20.6fg	15.2gh	21.7g	2.3h
		M_1+N	71.5b	1.2cd	15.4c	13.9b	24.1c	15.9ef	26.6c	3.1c
		M_2+N	82.9a	1.5ab	16.2b	14.1b	25.9b	16.3de	26.6c	3.2c
	V_2	C	43.9k	1.1cd	13.5f	11.2hij	20.3fg	15.6fg	23.9d	1.6m
		M1	54.1ghi	1.2cd	14.7de	12.8de	21.7e	16.5cde	27.1c	2.1i
		M2	64.2cd	1.3bc	15.3cd	13.0cd	21.8e	17.1bc	26.6c	2.6e
		N	62.3de	1.2cd	14.7e	12.6def	21.7e	16.9cd	27.2c	2.5fg
		M_1+N	73.1b	1.3bc	16.3b	14.1b	25.8b	17.7b	28.9b	3.4b
		M_2+N	84.4a	1.7a	17.2a	14.7a	27.1a	18.4a	30.6a	3.7a
LSD			4.2	0.2	0.5	0.6	0.8	0.7	1.6	0.1
SE±			2.1	0.1	0.3	0.3	0.4	0.3	0.8	0.1
CV%			1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

4.4 Forage yield (tons/ha):

4.4.1 Fresh forage yield (tons/ha):

The statistical analysis revealed that treatments had highly significant difference (P=0.01) on fresh forage yield in all season appendices (7).

Summer season gave higher fresh forage yield season 2017 while season 2018 winter season gave higher fresh forage yield (Table 17). Genotype ZML309 gave higher fresh forage yield season 2017, while Hudiba2 gave higher fresh forage yield season 2018 (Table 17).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M2+N) gave higher fresh forage yield at all season, it gave 141 and 189 % greater fresh forage yield over control in the 2017 and 2018 season, respectively (Table 17).

There were no significant differences between treatments interactions in fresh forage yield in all season except interactions between seasonality, genotypes and fertilizes season 2018 it had significant differences (P=0.05) appendices (7).

4.4.2 Dry forage yield (tons/ha):

The analysis of variance showed that treatments had highly significant difference (P=0.01) in dry forage yield in all season except genotypes season 2017 appendices (7).

Summer season gave higher harvest index season 2017 while season 2018 winter season gave higher harvest index (Table 9&10). Genotype ZML309 gave higher dry forage yield all season, on the other hand, there were no significant difference between ZML309 and Hudiba2 season 2018 (Table 17).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M2+N) gave higher dry forage yield at all season, it gave 176 and 194% greater dry forage yield over control in the 2017 and 2018 season, respectively (Table 17).

Treatments interactions were not affected in dry forage yield in all season except interactions between seasonality and genotypes season 2018 appendices (7).

4.5 Seeds quality analysis:

4.5.1 Crude protein:

The statistical analysis indicated that treatments had highly significant difference (P=0.01) on crude protein all season appendices (8).

Winter season gave higher crude protein all season (Table21). Hudiba2 Genotype gave higher crude protein all season (Table 21).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M2+N) gave higher crude protein at all season, it gave 21 and 14% greater crude protein over control in the 2017 and 2018 season, respectively (Table 21).

Treatments interactions were not affected in crude protein in all season appendices (8).

4.5.2 Nitrogen%:

The statistical analysis cleared that treatments had highly significant difference (P=0.05) on nitrogen all season except genotypes season 2017 appendices (8).

Winter season gave higher nitrogen all season (Table21). Hudiba2 Genotype gave higher nitrogen all season (Table 21).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M_2+N) gave higher nitrogen at all season, it gave 21 and 14% greater nitrogen over control in the 2017 and 2018 season, respectively, there were no significant differences between application (M_2+N) and (M_1+N) season 2018 (Table 21).

There were no significant differences between treatments interactions in nitrogen all season appendices (8).

4.5.3 Crude fiber:

The statistical analysis revealed that treatments had highly significant difference (P=0.01) on crude fiber in all season appendices (8).

Winter season gave higher crude fiber all season (Table21). Hudiba2 Genotype gave higher crude fiber all season (Table 21).

Application of combination bacteria strain mixtures and nitrogen fertilizer (M2+N) gave higher crude fiber at all season, it gave 29 and 36% greater crude fiber over control in the 2017 and 2018 season, respectively, (Table 21).

There were no significant differences between treatments interactions in crude fiber in all season appendices (8).

Table (17): Effects of seasonality, genotypes and fertilizers on means of forage yield of maize

Treatment	Fresh forage yield (t/ha)		Dray forage yield (t/ha)	
	Season 2017	Season 2018	Season 2017	Season 2018
S	30.9a	22.8b	15.5a	10.4b
W	26.8b	33.9a	13.5b	15.4a
LSD	1.4	0.9	1.1	0.6
SE±	0.7	0.5	0.5	0.3
CV%	1.9	1.9	1.9	1.9
V_1	26.2b	29.1a	12.8b	12.9a
V_2	31.5a	27.3b	16.2a	12.9a
LSD	1.4	0.9	1.1	0.6
SE±	0.7	0.5	0.5	0.3
CV%	1.9	1.9	1.9	1.9
C	15.8d	12.9e	7.2d	5.9d
M_1	25.9c	25.3d	13.5c	12.5c
M_2	31.6b	29.7c	14.3c	12.8c
N	28.1c	30.6c	14.5c	13.3c
M_1+N	33.6b	33.4b	17.5b	15.6b
M_2+N	38.1a	37.4a	19.9a	17.4a
LSD	2.4	1.7	1.8	1.1
SE±	1.2	0.8	1.0	0.5
CV%	1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (18): Effects of interaction between seasonality and genotypes, fertilizers on means of forage yield of maize

Treatment		Fresh forage yield (t/ha)		Dray forage yield (t/ha)	
		Season 2017	Season 2018	Season 2017	Season 2018
S	V_1	27.4b	24.6b	13.5bc	11.7c
	V_2	34.3a	20.6c	17.5a	9.2d
W	V_1	25.1c	33.7a	12.2c	14.2b
	V_2	28.6b	34.1a	14.8b	16.6a
LSD		1.9	1.4	1.5	0.9
SE±		1.0	0.7	0.7	0.4
CV%		1.9	1.9	1.9	1.9
S	C	19.1h	6.9h	8.2e	3.7g
	M_1	27.4fg	19.8g	13.8	9.9e
	M_2	32.9bcd	23.5f	15.1cd	10.3e
	N	29.1ef	24.6f	15.1cd	10.7e
	M_1+N	35.6b	28.0e	18.8b	13.0d
	M_2+N	41.1a	32.7d	21.8a	14.9c
W	C	12.5i	19.1g	6.2e	8.1f
	M_1	24.6g	30.9	13.2d	15.0c
	M_2	30.3def	35.9c	13.5d	15.3c
	N	27.1fg	36.6bc	13.9cd	15.8c
	M_1+N	31.6cde	38.7b	16.2bc	18.1b
	M_2+N	34.9bc	42.1a	18.1b	19.9a
LSD		3.4	2.4	2.6	1.5
SE±		1.7	1.2	1.3	0.8
CV%		1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (19): Effects of interaction between genotypes and fertilizers on means of forage yield of maize

Treatment		Fresh forage yield (t/ha)		Dray forage yield (t/ha)	
		Season 2017	Season 2018	Season 2017	Season 2018
V_1	C	11.3h	12.9h	5.3h	5.6d
	M_1	23.3fg	26.6f	11.1fg	12.6c
	M_2	29.3de	30.5cde	13.7def	12.9c
	N	25.9ef	31.6cd	13.2ef	13.4c
	M_1+N	31.5cd	34.6b	15.5cde	15.6b
	M_2+N	36.1b	38.6a	17.9bc	17.5a
V_2	C	20.3g	13.0h	9.1g	6.2d
	M_1	28.7de	24.1g	15.8cd	12.4c
	M_2	33.9bc	28.9ef	14.9de	12.7c
	N	30.3d	29.5de	15.8cd	13.2c
	M_1+N	35.6b	32.2c	19.5ab	15.5b
	M_2+N	39.9a	36.2b	21.9a	17.4a
LSD		3.4	2.4	2.6	1.5
SE±		1.7	1.2	1.3	0.8
CV%		1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (20): Effects of interaction between seasonality genotypes and fertilizers on means of forage yield

Treatment			Fresh forage yield (t/ha)		Dray forage yield (t/ha)	
			Season 2017	Season 2018	Season 2017	Season 2018
S	V_1	C	13.6lm	9.9m	6.7klm	5.2m
		M_1	23.0k	22.1j	11.3ijk	12.1ghi
		M_2	30.3ef	26.1i	14.9ef	11.3hij
		N	26.2hi	25.6i	12.8ghi	11.1hij
		M_1+N	33.2cd	29.8h	16.3cdefg	14.4def
		M_2+N	38.2b	33.9efg	18.7bcd	15.8cde
	V_2	C	24.6ij	3.9n	9.8kl	2.2n
		M_1	31.8def	17.5kl	16.3cdefg	7.8kl
		M_2	35.6bcd	20.8jk	15.2def	9.2jk
		N	32.2def	23.5ij	17.6cde	10.4ij
		M_1+N	37.9bc	26.2i	21.3ab	11.6hi
		M_2+N	43.9a	31.5fgh	24.9a	13.9efg
W	V_1	C	15.9l	15.9l	3.9n	5.9lm
		M_1	23.6jk	31.0gh	11.0jk	13.0fgh
		M_2	28.3gh	34.8def	12.4hi	14.4def
		N	25.6hi	37.7bcd	13.6fg	14.6cde
		M_1+N	29.8ef	39.4bc	14.8efg	16.8c
		M_2+N	33.9bcde	43.3a	17.2cdef	19.2ab
	V_2	C	9.0m	22.2j	9.8lm	10.2ij
		M_1	25.6hi	30.7gh	15.3def	17.1bc
		M_2	32.2def	37.1cde	14.6sfgh	16.3cd
		N	28.6fg	35.5de	14.3efgh	15.9cde
		M_1+N	33.3cd	38.2bcd	17.6cde	19.4a
		M_2+N	35.6bcd	40.8ab	19.1bc	20.8a
LSD			4.8	3.4	3.6	2.2
SE±			2.4	1.7	1.8	1.1
CV%			1.9	1.9	1.9	1.9

Symbols are as shown on table (1)

Table (21): Effects of seasonality, genotypes and fertilizers on means of biochemical characters of maize

Treatment	Crude protein%		Nitrogen %		Crude fiber%	
	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
S	9.1b	9.4b	1.7a	1.5b	3.6b	3.6b
W	10.7a	10.1a	1.5b	1.6a	3.9a	3.7a
LSD	0.3	0.1	0.04	0.02	0.04	0.1
SE±	0.1	0.1	0.02	0.01	0.02	0.02
CV%	2.1	2.1	2.1	2.1	2.1	2.1
V_1	10.1a	9.9a	1.6a	1.6a	3.8a	3.9a
V_2	9.7b	9.6b	1.5b	1.5b	3.5b	3.6b
LSD	0.3	0.1	0.04	0.02	0.04	0.1
SE±	0.1	0.1	0.02	0.01	0.02	0.02
CV%	2.1	2.1	2.1	2.1	2.1	2.1
C	8.6d	10.7a	1.3d	1.3d	3.1e	3.0d
M_1	9.7c	9.4d	1.55c	1.5c	3.6d	3.7c
M_2	9.9c	9.8c	1.58bc	1.6b	3.7c	3.7c
N	10.1bc	9.8c	1.60bc	1.6b	3.7c	3.7c
M_1+N	10.5ab	10.5b	1.66b	1.7a	3.8b	3.9b
M_2+N	10.8a	10.7a	1.7a	1.7a	4.0a	4.1a
LSD	0.5	0.2	0.08	0.04	0.07	0.1
SE±	0.2	0.1	0.04	0.02	0.03	0.04
CV%	2.1	2.1	2.1	2.1	2.1	2.1

Symbols are as shown on table (1)

Table (22): Effects of interaction between seasonality and genotypes, fertilizers on means of biochemical characters of maize

Treatment		Crude protein%		Nitrogen %		Crude fiber%	
		Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
S	V_1	9.4b	9.6c	1.5b	1.5b	3.7b	3.7b
	V_2	8.9b	9.2b	1.4c	1.4c	3.5d	3.5d
W	V_1	10.8a	10.2a	1.7a	1.6a	3.9a	3.8a
	V_2	10.6c	10.1a	1.7a	1.6a	3.6c	3.6
LSD		0.4	0.2	0.06	0.03	0.06	0.1
SE±		0.2	0.1	0.03	0.01	0.02	0.03
CV%		2.1	2.1	2.1	2.1	2.1	2.1
S	C	7.5h	7.9g	1.2h	1.3h	2.9h	3.0f
	M_1	8.9g	9.1e	1.4g	1.46f	3.5f	3.6e
	M_2	9.3fg	9.8cd	1.4fg	1.56de	3.6e	3.7de
	N	9.3fg	9.2e	1.4fg	1.48f	3.6e	3.6e
	M_1+N	9.7ef	10.1bc	1.5ef	1.61bcd	3.8c	3.8cd
	M_2+N	10.1de	10.3b	1.6cde	1.65b	3.9b	4.0b
W	C	9.7ef	8.7f	1.5ef	1.39g	3.3g	3.1f
	M_1	10.4cd	9.1e	1.6bcd	1.5e	3.6de	3.6e
	M_2	10.4cd	9.9cd	1.6bcd	1.5cde	3.8c	3.7de
	N	10.8bc	10.3b	1.7bc	1.64bc	3.7cd	3.8cd
	M_1+N	11.2ab	10.8a	1.8ab	1.7a	3.9b	3.9bc
	M_2+N	11.5a	11.1a	1.9a	1.8a	4.1a	4.2a
LSD		0.6	0.3	0.11	0.05	0.1	0.1
SE±		0.3	0.2	0.05	0.03	0.04	0.1
CV%		2.1	2.1	2.1	2.1	2.1	2.1

Symbols are as shown on table (1)

Table (23): Effects of interaction between genotypes and fertilizers on means of biochemical characters of maize

Treatment		Crude protein%		Nitrogen %		Crude fiber%	
		Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
V_1	C	8.6d	8.3h	1.4e	1.33h	3.3g	3.0f
	M_1	9.8bc	9.4g	1.5cd	1.51g	3.7e	3.7cd
	M_2	10.1bc	10.2de	1.62bcd	1.63de	3.8c	3.8c
	N	10.4ab	9.9ef	1.66abc	1.58ef	3.8cd	3.8c
	M_1+N	10.7a	10.6ab	1.72ab	1.70ab	3.9b	3.9b
	M_2+N	10.9a	10.9a	1.74a	1.73a	4.2a	4.4a
V_2	C	8.5d	8.3h	1.4e	1.32h	2.9h	2.0g
	M_1	9.6c	9.3g	1.5cd	1.49g	3.5f	3.6de
	M_2	9.7c	9.6fg	1.5cd	1.53fg	3.6e	3.6de
	N	9.7c	9.6fg	1.4cd	1.54fg	3.6e	3.6de
	M_1+N	10.1bc	10.3cd	1.5cd	1.64cd	3.7de	3.7cd
	M_2+N	10.8a	10.5bc	1.78a	1.67bc	3.9c	4.0b
LSD		0.6	0.3	0.12	0.05	0.1	0.1
SE±		0.3	0.2	0.1	0.03	0.04	0.1
CV%		2.1	2.1	2.1	2.1	2.1	2.1

Symbols are as shown on table (1)

Table (24): Effects of interaction between seasonality genotypes and fertilizers on means of biochemical characters

Treatment			Crude protein%		Nitrogen %		Crude fiber%	
			Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
S	V_1	C	7.6lm	8.0m	1.2jk	1.29l	3.0l	3.1l
		M_1	9.2hij	9.3ijk	1.47fgh	1.49ij	3.6fg	3.75fghi
		M_2	9.6fgh	10.2def	1.54defgh	1.64def	3.7fg	3.8def
		N	9.7efgh	9.5hi	1.56defgh	1.52hi	3.7fg	3.74fghi
		M_1+N	9.9defgh	10.2def	1.59defg	1.64def	3.9d	3.9cde
		M_2+N	10.2cdef	10.4cde	1.63cdef	1.67cde	4.1b	4.1ab
	V_2	C	7.3m	7.7m	1.1k	1.24l	2.8m	3.1l
		M_1	8.5kl	8.8jkl	1.36ij	1.42jk	3.4jk	3.5j
		M_2	8.9ijk	9.3ij	1.43gh	1.49ij	3.5ijk	3.67ghij
		N	8.8jk	8.9jkl	1.4hi	1.52hi	3.5ijk	2.9m
		M1+N	9.4ghi	9.9efgh	1.5efg	1.59efg	3.6fgh	3.5j
		M2+N	10.1defg	10.2def	1.62cde	1.63defg	3.8def	3.9de
W	V_1	C	9.8efg	8.6l	1.56defgh	1.38k	3.7efg	3.73fghi
		M_1	10.4cdef	9.5hi	166cde	1.52hi	3.4jk	3.76efgh
		M_2	10.6bcde	10.1efg	1.69bcd	1.62efg	3.9d	2.9m
		N	11.1abc	10.2def	1.77abc	1.64def	3.8de	3.9de
		M1+N	11.6a	11.1ab	1.8ab	1.77ab	4.0bc	4.0bc
		M2+N	11.6a	11.4a	1.8ab	1.82a	4.2a	4.3a
	V_2	C	9.7fgh	8.7kl	1.57defgh	1.41k	3.1l	3.3k
		M_1	10.6bcde	9.7ghi	1.70bcd	1.56ghi	3.5hi	3.6ij
		M_2	10.4cdef	9.8fgh	1.66cde	1.57fgh	3.7fgh	3.67ghij
		N	10.6bcde	10.3de	1.67cd	1.64de	3.7efg	3.8efg
		M1+N	10.9abcd	10.6bcd	1.68cd	1.70bcd	3.7efg	3.8efg
		M2+N	11.4ab	10.8bc	1.9a	1.73bc	3.9cd	4.0bc
LSD			0.9	0.5	0.2	0.1	0.1	0.2
SE±			0.4	0.2	0.1	0.04	0.1	0.1
CV%			2.1	2.1	2.1	2.1	2.1	2.1

Symbols are as shown on table

4.6 Economics analysis:

4.6.2 Gross income (GI):

Data presented in (Fig.15) relived that application of combination bacteria strains plus nitrogen fertilizer (M_2+N) becomes more profitable than control and another application, it gave higher gross income at all seasons. Statistical analysis cleared that no significant different between two genotypes at summer season 2017, while in summer season 2018 Hudiba2 is better than ZML309. While ZML309 is better than Hudiba2 both winter seasons.

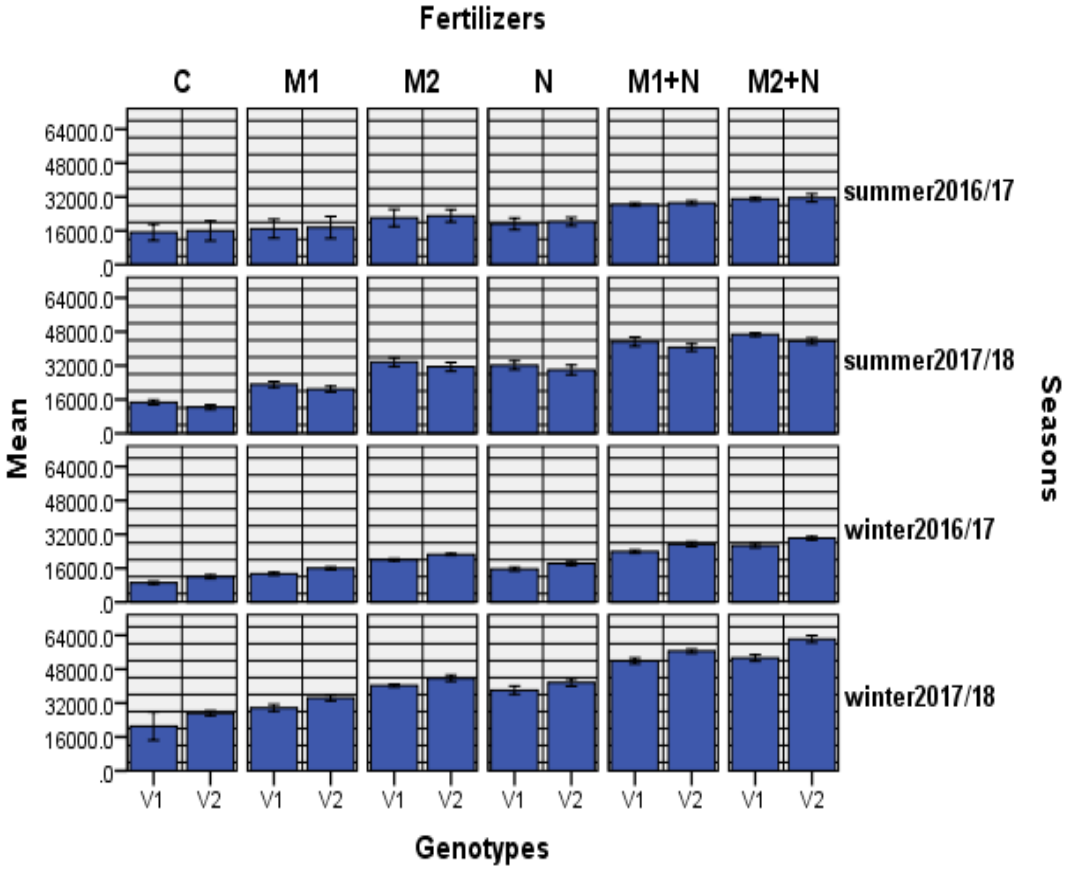

Fig 15. Effects of seasonality, genotypes and fertilizers on gross income (GI) of maize

Key: V1; (Hudiba2) V2; (ZML309). Control; (un-inoculated unfertilized) M1; (Bacillus megatherium var phosphorus +Azotobacter spp +Azospirillium spp) M2; (Bacillus megatherium var phosphorus +Azotobacter spp + Flavobacterium spp) N; (Nitrogen 197.6 kg/ha). Error bars: 95% CI

4.6.2 Net income (NI):

Data presented in (Fig.16), showed that the application (M_2+N) had maximum net income all seasons. Statistical analysis displayed no significant different between two genotypes summer season 2017, while summer season 2018 Hudiba2 is better than ZML309, while both winter seasons ZML309 is better than Hudiba2. All treatment showed economic feasibility except control with ZML309 summer season 2018 it's loosed 805 (SDG/fed) and control with Hudiba2 at winter season 2017, loosed 1.641 (SDG/feddan).

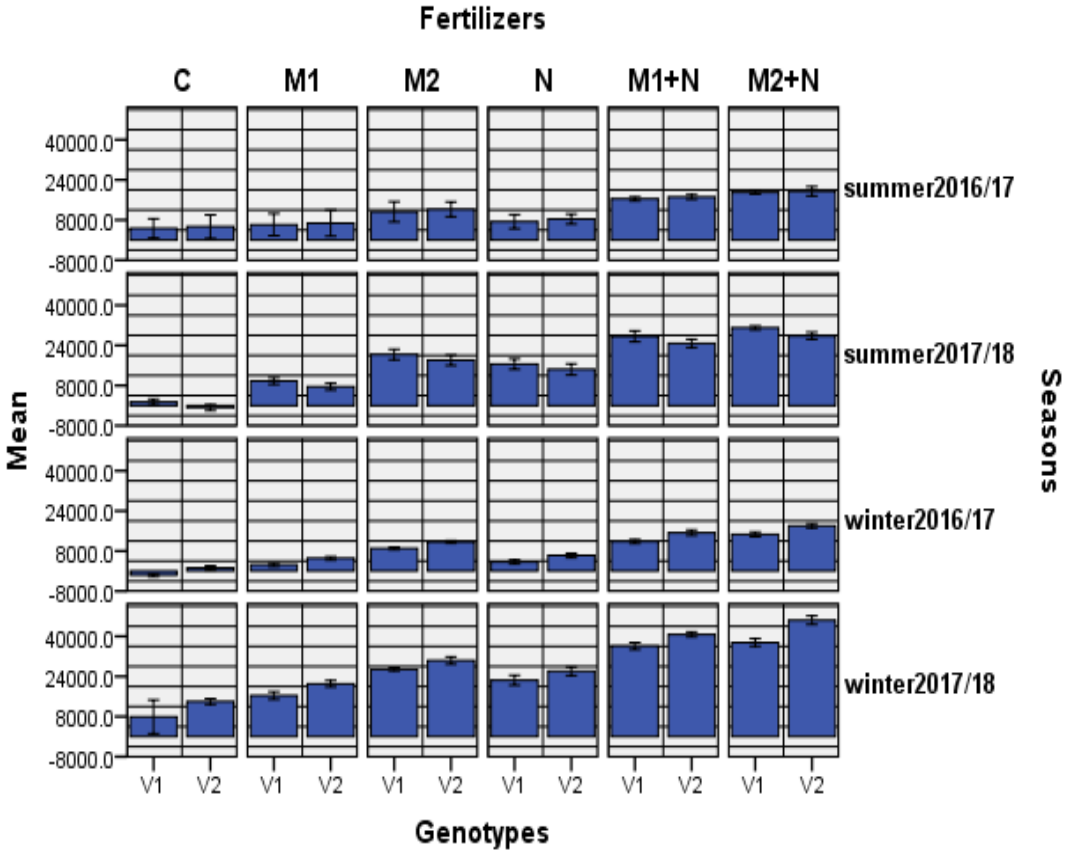

Fig 16. Effects of seasonality, genotypes and fertilizers on net income (NI) of maize

Symbols are as shown on Fig (15)

4.6.3 Benefit cost ratio (BCR):

Illustrated data in (Fig.17) pointed out that application of combination bacteria strains plus nitrogen fertilizer (M_2+N) had maximum benefit cost ratio at all seasons. While no significant different between (M_2+N) and (M_1+N) summer season 2017.

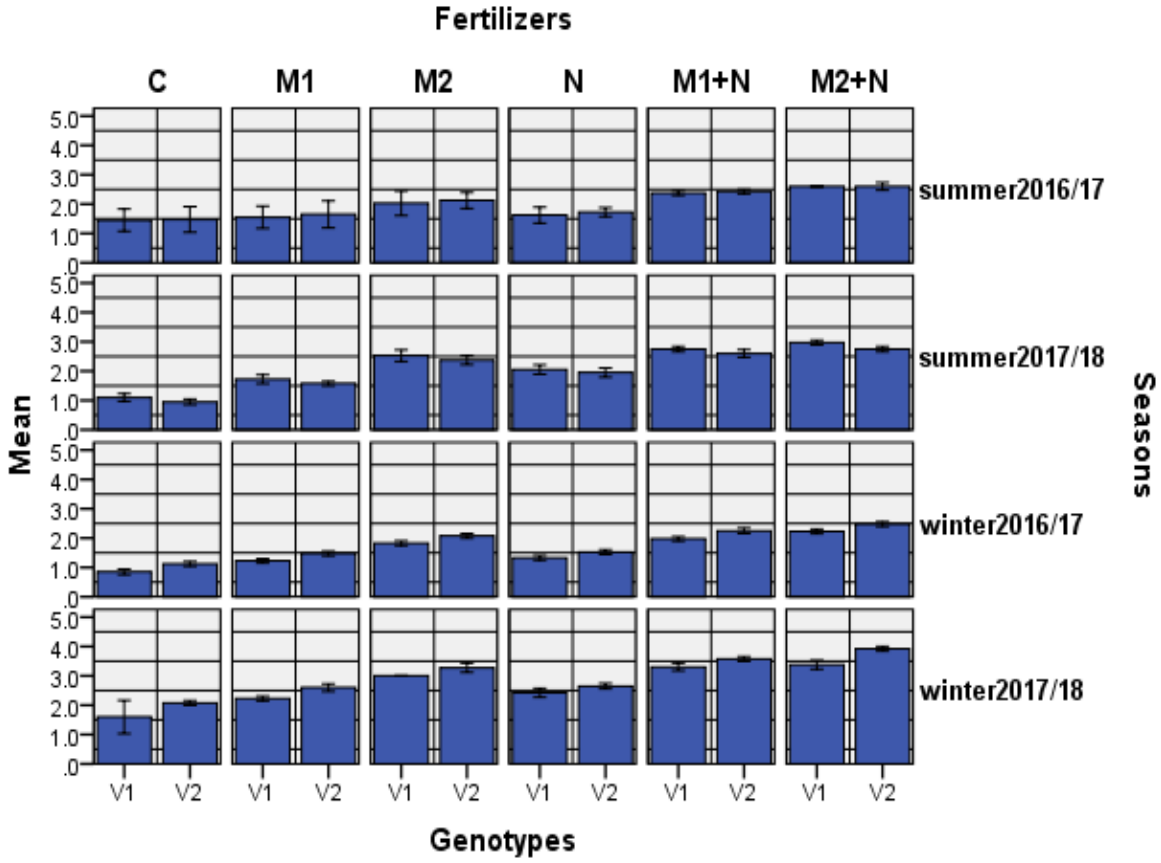

Fig 17. Effects of seasonality, genotypes and fertilizers on benefit cost ratio (BCR) of maize

Symbols are as shown on Fig (15)

CHAPTER FIVE

DISCUSSION

5.1 Vegetative growth parameters of nursery experiment:

Most of the vegetative growth parameters of the six genotypes of maize studied showed significant response to application of bacteria strain mixtures at 30, 45 and 60 (DAS). Application of microbial inoculants as revealed by Akladious and Abbas (2012) caused increase in all measured growth parameters of maize plant. Similar observation and conclusions were also reported by Alori *et al.,* (2019).

Bacteria strains increased nutrients uptake by plant and also increased available nutrients, in general. Plant height was influenced by water and nutrients availability through increasing number of nodes and middle nodes length. Shaalan (2005) also indicated that inoculating nigella (*Nigella sativa* L.) seed with biological fertilizers, such as *Azospirillium* and *Azotobacter,* caused improved plant growth attributes such as plant height. In addition, bacteria strain mixtures increased leaf number, stem thickness and leaf area, especially in cereal crops by producing growth promoting nutrients. On the other hand, plant development attribute were influenced by growth hormones, especially auxin, which has important role in increasing growth (Hoshang *et al.,* 2011).

El-Zieny *et al.*, (2001) indicated that bacteria strains, such as *Azotobacter* inoculants improve plant growth, leaf number, leaf area and vegetative growth through increased root length, root surface area, number of root tips and volume (Vacheron *et al.,* 2013). Similar results were reported by Kandil *et al.,* (2004) in a study of beet sugar (*Beta Vulgaris* L.), also Asghar *et al.* (2004) indicated that bacteria strains such as

Flavobacterium spp inoculants have been able to produce auxin hormone that led to increased plant growth regulators. The most common best characterized and physiologically most active auxin in plant is indole-3-acetic acid (IAA), it is known to stimulate both a rapid response (e.g. increased cell elongation) and a long-term response (e.g. cell division and differentiation) in plants (Ahmad *et al.,* 2005).

The results obtained of leaf chlorophyll content may be attributed to the microorganisms effect on nutrients release in soil in available forms, leading to increased nitrogen content in the plants; this, in turn, led to increasing the chlorophyll content, (Shanthi *et al.,* 2012 and Mahato and Neupane 2017).

In general, the growth of all genotypes increased by application of bacteria strain mixtures, it is attributed to the fact that bacteria strains increases or promotes the supply of important nutrients crucial for the overall productivity of the soil (Karthick *et al.,* 2014, Farnia and Kazemi 2015), the favorable effect of bacteria strains on growth parameters might be referred to its important role in fixing atmospheric N as well as increasing the secretion of natural hormones, namely IAA, GA3 and cytokinins, antibiotics and possibly raising the availability of various nutrients. Similar results were reported by (Zahir *et al.,* 1998 and Azab and Dewiny 2018).

Also, Obid *et al.,* (2016) reported that microorganisms are able to increase absorption of food elements, by dissolving insoluble phosphates through reactions in the rhizosphere, and the absorption of elements became available and therefore resulted in the increase of growth characters.

The positive effect of bacteria strains on enhancing plant growth was studied by many authors, such as Ahmed *et al.*, (2010) on chickpea (*Cicer arietinum*. L) plants, Hassan (2005) on guar (*Cyamopsis tetragonoloba*.L*)* and fenugreek (*Trigonella foenum-graecum*.L) plants and Hassan *et al.*, (2009) on black cumin (*Nigella sativa* .L) plant.

The different response of genotypes to bacteria strains could be mainly due to genetic variations between the genotypes, as well as phenotypic differences as reported by Shaharoona *et al* ., (2006). However, there have been very few reports on the impact of plant genotypes on the growth promoting potential of bacterial strains.

5.2 Vegetative growth parameters of field experiment:

Vegetative growth parameters of maize in field experiment work were influenced significantly by application of bacteria strain mixtures with nitrogen, (M_2+N) and (M_1+N) in summer and winter for two seasons in three durations 30, 45 and 60 (DAS). Increased the plant height, stem thickness and leaf area of maize due to combined of bacterial strain mixtures plus nitrogen fertilizer M_2+N and M_1+N can be explained by the fact that application of bacterial strains with nitrogen fertilizer not only increased the nutritious elements which the plant needed, but also increased N in the root zone and the synergistic effect of these microorganisms on the physiological and metabolic activities of the plant. This enhancing effect may induce exudates of some hormonal substances like cytokinins and auxins, which encourage plant height, stem thickness and leaf area. This also may be attributed to more atmospheric nitrogen fixed in the soil, which was probably due to mobilization of bacteria, providing favorable conditions and discharge of antibiotics that leads to the development of root systems of maize through changes in root system

morphology, lateral rhizomes number and root length and also number and length of root hairs and their branches, thus increasing, roots uptake level, increased water and nutrients uptake by plant, subsequently increased vegetative growth. These results agreed with (Leoni *et al.*, 2002; Alnoaim and Hamad 2004; Garg, *et al.*, 2005; Akbari *et al.*, 2009; Bakhet *el al.*, 2006 and Azab and Dewiny 2018).

Previous studies have shown positive growth responses in maize when inoculated with plant growth-promoting bacteria (PGPB) (Widawati and Suliasih, 2018). Molina *et al.* (2017) reported that 22% improvement of maize plant height was obtained when inoculated with bacteria. Similarly, Arruda *et al.* (2013) revealed that the maize inoculation with different bacteria strains significantly promoted root (50-68 %) and shoot (25-54 %) growth.

Number of leaves per plant was significantly increased by combining with bacteria strain mixtures, in addition to nitrogen in summer and winter for two seasons where the application of M_2+N and M_1+N increased number of leaves per plant over control. These increments could be attributed to the fact that nitrogen rates often increase plant growth and plant height and this resulted in more nodes and internodes and subsequently more production of leaves. Similar results were indicated by many researchers, (El Toum, 2016; Ayub *et al.*, 2003 and Nadeem *et al.*, 2009).

Chlorophyll content was significantly increased by combination of bacteria strain mixtures plus nitrogen, M_2+N and M_1+N in summer and winter for two seasons. The results obtained for chlorophyll content may be attributed to the micro-organisms effect on nutrients release in soil in available from, leading to the increase of nitrogen content in the plants

plus N-fertilizers, also the increase in trace elements in the soil caused by the organic acids produced by microorganisms led to a decrease in the pH of the soil, which in turn led to the increase of chlorophyll content, as reported by (Ashour 1998; Subb-Roa, 1981 and Baser, *et al.,* 2012). N-fertilizers and bacterial strain mixtures supplied the high amount of nitrogen for tissue growth, thus, increased chlorophyll content, (Shanthi *et al.,* 2012 and Mahato and Neupane 2017).

The positive interactions between the applied N-fertilizers and bacteria strain mixtures on plant vegetative growth may be due to the promoting effects of both N-elements and bacterial strains together on the established plant roots and nutrient uptake. Similar results were indicated by (Bakhet *el al.,* 2006 and Nadeem *el al.,* 2009).

5.3 Yield and yield components:

Application of bacteria strains with nitrogen (M_2+N) and (M_1+N), in summer and winter for two seasons caused an increase in root weight, this significant increase in root values may be related to increases in the availability of nutrients due to bacterial strains combined with nitrogen fertilizer that may lead to an increased photosynthesizing surface. Thus, increase in accumulation of simple sugars and starch in roots occurred and resulted in enhancement of roots. This result is in line with El-Gamal (1996) on potato tubers (*Solanum tuberosum.* L).

The longer period of ripening of maize due to inoculation by bacteria strain mixtures is possible to transform more photosynthetic matter from source to seeds and as a result increasing yield, which induced the uptake ability of the roots to nutrients and positive increase in the yield parameters because of the improved root system as a source-sink relationship to the reproductive part (shoot), this agreed with

(Mohammed *et al.,* 2001; Naseri *et al,.* 2013). This result may be due to promotion growth hormones which caused growth of aerial organs that reason improved yield and grains (Fadlalla *et al,.* 2016).

Also increasing yield parameters is due to the improvement of female inflorescence development and pollination, in addition to increasing the assimilatory materials and translocation to the seeds. Dakhly *et al.*, (2004) on squash (*Cucurbita pepo*) showed that both N application and bacterial strains increased sex ratio, which reflects the importance of equilibrium between male and female flowers that caused good pollination and high fruit setting percentage.

The improvement in yield components could be attributed to the energy source provided to the microbes with nitrogen fertilizer, enhancing biological activities and availability of nitrogen. Similar observations and conclusions were also reported by Abdullahi *et al.*, (2014). Furthermore this result is in agreement with El Shafie *et al.*, (2010) Ebrahimpour *et al.*, (2011), Meena *et al.*, (2012), and Fadlalla *et al.*, (2016) who mentioned that application of chemical and bacterial strains increased the biological and grain yield of corn plants.

Ghannoum *et al.,* (2011) reported that C4 photosynthesis path way allows a very efficient conversion of CO2 into carbohydrates and final seed yield, especially under improved root system through the application of bacterial strains combined with nitrogen fertilizer (Naserirad *et al,*.2011 and Rizwan *et al.,* 2008).

5.4 Forage yield:

Both fresh and dry forage yields were significantly influenced by the application of combination of bacteria strain mixtures with nitrogen, M2+N and M1+N, summer and winter for two seasons. Fresh and dry

forage yields were mainly due to affected plant height, number of leaves per plant, stem thickness, leaf area and chlorophyll content, also increase in plant fresh and dry weight may be due to the increase of N in the root zone as a result of nitrogen application and fixed N by bacteria, besides the solubilization of mineral nutrient synthesis of vitamins, amino acids and gibberellins, which stimulate growth and yield. Thus, production of more dry matter as a result of improved photosynthetic activity at higher level of N was obtained (Ayub *et al.,* 2009; Tariq *et al.,* 2011). These results are in agreement with other reports of (Ayub *et al.,* 2007, and Mahfouz *et al.,* 2015).

In conclusion the increment in plant fresh and dry weight may be attributed to a greater increase of root biomass due to higher absorption of nutrients and water from the soil, leading to production of higher vegetative biomass (Ahmed *et al.,* 2013).

5.5 Seed quality:

The highest percentage of protein content was recorded under the application of bacteria strain mixtures with nitrogen, M_2+N and M_1+N, in summer and winter for two seasons. Such superior effect was achieved due to increase of nitrogen supply by bacteria strains and nitrogen fertilizer which has paramount effect on the synthesis of protein (Anees *et al.,* 2016). Protein increment may be due to its promotion of free living nitrogen fixing bacteria and enhancing nitrogen fixation, and then supplying of different nutrients, like nitrogen (Cakmakci *et al.,* 2006). This result was supported by Saber and Sharaf (2013) who reported that protein was increased due to the application of biofertilizers in wheat cultivar. Also, Helmy (2014) found that using the bio-fertilizer with urea increased protein content in barley (*Hordeum vulgare.* L).

Hellal *et al.,* (2011) on dill (*Anethum graveolens L.*) plant indicated that applying bacteria strains treatment alone or in combination with chemical N fertilizer increased the chemical constituents of dill plant compared to the untreated control. These results are in harmony with those obtained by, Badawi *et al.,* (2005) on sweet fennel (*Foeniculum vulgare* L.), Wange, (1995) on garlic (*Allium sativum.* L), Swaefy *et al.,* (2007) on peppermint (*Mentha pamiroalaic.* L.) plants and Umar *et al.,* (2009) on strawberry *(Fragaria L.*).

5.6 Economics analysis

Economic feasibility in financial terms of any innovation or technique has primary importance in deciding its wider adoption among farming community (Khan *et al.,* 2012). Economic analysis was carried out at the end of the study to evaluate the best, economical treatments that gave best grain yield.

Data regarding economic analysis for treatments revealed that the highest gross income, net income and benefit cost ratio were earned with, bacteria strains combined with chemical fertilizers (M_2+N), followed by (M_1+N) at summer and winter for two seasons, where grain yield increase was reported with the bacteria strain mixtures supplemented with nitrogen application which account for important benefit, cause decreasing in the inputs of production because of economizing much money to chemical fertilizers and increase in yield. These results are in harmony with those obtained by (Azimi *et al.,* 2013; Shanwad *et al.,* 2010 and Sujata *et al.,* 2008).

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

The results obtained for the nursery experiment showed that application of bacterial strains significantly increased all growth parameter assessed (plant height (cm), stem thickness (cm), number of leaves/plant, leaf area (cm2), chlorophyll content) except C6.

The result obtained for the field experiment showed that vegetative growth, yield and yield components, fresh and dry fodder, and quality parameters of maize genotypes, were enhanced by combination of bacteria strain mixtures in addition to nitrogen fertilizer, in summer and winter for all seasons. Those treatments were more profitable.

Performance of genotype ZML309 is better than genotype Hudiba2 in all growth and yield parameters in summer and winter for all seasons, where Hudiba2 was superior to ZML309 in grain quality parameters. Feasibility study explained that in winter seasons ZML309 is better than Hudiba2, while in summer seasons in general Hudiba2 is better than ZML309.

Recommendations

- Application of bacteria strain mixtures combination with urea (M_1+N) and (M_2+N), reduces the amount of applied mineral fertilizers, supports plant growth under less polluted conditions and recorded higher crop yield and best seed quality.
- From the economic point of view, such application also reduces the agricultural costs as a result of decreasing the amounts of expensive inorganic N-fertilizers and increasing the yield of crops due to providing them with available nutrient source and growth promoting substances.

- The genotype ZML309 performed better in most of yield and yield components than Hudiba2.
- To get the best profitability you must cultivate genotype ZML309 with fertilizers (M_1+N) winter season.
- Further long term field experiments are recommended to be conducted on diverse crops so as to ascertain the benefits of combination between bacteria strain mixtures and urea. It is suggested these data can be used in further investigations as the potential agents of new bacterial strain for improved maize production and other crops.

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APPENDIXES

Table 1. PH, EC, N and P content in the soil of the experiment site before sowing and after sowing in summer and winter seasons (2016/17)

Treatment	Summer								Winter							
	before				After				before				After			
	PH	EC (ds/m)	N%	P (ppm)	PH	EC (ds/m)	N%	P (ppm)	PH	EC (ds/m)	N%	P (ppm)	PH	EC (ds/m)	N%	P (ppm)
C	7.7	1.9	0.01	4	7.8	1.1	0.01	2	7.5	2.0	0.02	3	7.7	1.9	0.03	2
N	7.8	2.2	0.01	3	7.9	1.6	0.03	4	7.7	2.3	0.03	4	7.9	2.4	0.04	3
B1	7.7	2.0	0.02	2	7.8	1.2	0.02	3	7.6	1.9	0.03	5	7.7	2.0	0.03	4
B2	7.9	2.1	0.02	2	8.0	1.9	0.03	4	7.7	2.2	0.03	3	7.9	2.5	0.04	3
B1+N	7.8	2.3	0.03	3	7.9	1.8	0.05	5	7.8	2.4	0.03	4	8.1	2.4	0.04	4
B2+N	8.0	2.4	0.02	4	8.1	2.2	0.04	6	7.9	2.4	0.04	4	8.2	2.5	0.05	3

(0-30cm) depth

Table (2): Square means of the vegetative growth parameters at 30, 45 and 60 (DAS) for the treatment and interactions for nursery experiment

Treatment	DF	Plant height/cm			Stem thickness/cm			Number of leaves/plant			Leaf area/cm^2			chlorophyll content	
		DAS													
		30	45	60	30	45	60	30	45	60	30	45	60	45	60
F	3	87.5**	65.9**	153.1**	739.2**	207.0**	512.6**	71.7**	74.1**	927.8**	89.3**	85.3**	48.9**	73.4**	61.42**
G	5	117.2**	24.3**	133.2**	849.9**	116.2**	326.4**	74.1**	42.1**	336.8**	161.6**	195.2**	17.3**	80.6**	39.3**
G * F	15	12.7**	13.1**	285.9**	95.2**	29.5**	69.2**	18.5**	16.9**	999.0**	20.0**	25.2**	16.7**	9.7**	7.78**
Error	48														
C.V		8.63	6.72	2.65	3.36	3.36	4.18	10.19	6.00	1.47	6.49	5.24	8.46	4.26	8.17

Key: DAS = Days After Sowing. F: Fertilizer, G: Genotypes

*= Significant at 5% level (Significant)

**= Significant at 1% level (Highly Significant)

NS = not significantly different at P = 0.05

Table (3): Square means of the vegetative growth parameters at 30, 45 and 60 (DAS) for the treatment and their interactions season 2017

Treatment	Plant height/cm			Stem thickness/cm			Number of leaves			Leaf area			Chlorophyll content	
	30	45	60	30	45	60	30	45	60	30	45	60	45	60
S	55.9^{**}	43.7^{**}	19.7^{**}	42.3^{**}	77.2^{**}	13.2^{**}	165.2^{**}	40.1^{**}	69.2^{**}	52.2^{**}	290.9^{**}	47.9^{**}	44.4^{*}	7.6^{*}
F	14.8^{**}	40.7^{**}	39.4^{**}	59.1^{**}	67.6^{**}	12.2^{**}	59.5^{**}	11.9^{**}	92.7^{**}	15.1^{**}	67.5^{**}	128.6^{**}	33.7^{*}	11.7^{*}
G	10.6^{**}	9.7^{**}	0.0^{NS}	30.5^{**}	99.9^{**}	14.1^{**}	39.8^{**}	23.8^{**}	22.5^{**}	0.91^{*}	17.8^{*}	23.5^{**}	25.1^{*}	11.2^{*}
S× F	1.0^{NS}	1.3^{NS}	0.5^{NS}	5.1^{**}	7.4^{**}	0.7^{NS}	4.5^{NS}	0.5^{NS}	0.5^{NS}	0.8^{NS}	4.8^{*}	1.19^{NS}	0.4^{NS}	0.45^{NS}
S×G	1.7^{NS}	1.9^{NS}	9.6^{**}	0.6^{NS}	44.9^{*}.	0.3^{NS}	0.7^{NS}	2.4^{NS}	0.7^{NS}	0.0^{NS}	7.1^{**}	3.6^{NS}	1.0^{NS}	1.7^{NS}
G×F	0.2^{NS}	0.5^{NS}	1.3^{NS}	0.0^{NS}	0.7^{NS}	0.1^{NS}	0.1^{NS}	0.1^{NS}	0.0^{NS}	0.0^{NS}	0.0^{NS}	0.1^{NS}	0.4^{NS}	0.6^{NS}
S×G×F	0.1^{NS}	0.5^{NS}	1.3^{NS}	0.0^{NS}	0.7^{NS}	0.1^{NS}	0.1^{NS}	0.0^{NS}	0.0^{NS}	0.0^{NS}	0.0^{NS}	0.1^{NS}	0.4^{SN}	0.5^{NS}
CV%	15.0	5.7	5.0	7.9	4.5	6.9	5.8	9.8	4.0	24.7	8.3	4.5	6.9	13.0

Key: S: Seasons: F: Fertilizer, G: Genotypes

*= Significant at 5% level (Significant)

**= Significant at 1% level (Highly Significant)

NS = not significantly different at P = 0.05

Table (4): Square means of the vegetative growth parameters at 30, 45 and 60 (DAS) for the treatment and their interactions season 2018

Treatment	Plant height/cm			Stem thickness/cm			Number of leaves			Leaf area			Chlorophyll content	
	30	45	60	30	45	60	30	45	60	30	45	60	45	60
S	149.9**	259.9**	394.4**	326.2**	334.3**	146.1**	299.5**	35.1**	99.4**	84.2**	79.1**	21.4**	98.5*	100.9*
F	101.1**	148.6**	351.1**	126.4**	106.5**	47.3**	83.2**	16.5**	85.4**	531.7**	89.1**	11.1**	48.6*	60.3*
G	15.5**	0.0^{NS}	0.9^{NS}	0.5^{NS}	96.5**	2.4^{NS}	26.7**	5.2**	1.9^{NS}	21.9^{NS}	3.5^{NS}	0.3^{NS}	1.8^{NS}	2.6^{NS}
S× F	5.3*	0.5^{NS}	3.5*	0.3^{NS}	0.5^{NS}	2.6^{NS}	1.1^{NS}	0.1^{NS}	0.8^{NS}	32.1*	5.1*	0.9^{NS}	0.2^{NS}	0.3^{NS}
S×G	0.6^{NS}	12.8**	63.1**	0.9^{NS}	36.7*	0.0^{NS}	0.7^{NS}	8.6**	9.6**	0.3^{NS}	44.4**	1.9^{NS}	7.4^{NS}	14.4^{NS}
G×F	0.9^{NS}	0.1^{NS}	1.5^{NS}	0.3^{NS}	0.5^{NS}	0.0^{NS}	0.9^{NS}	0.0^{NS}	0.1^{NS}	2.4^{NS}	0.3^{NS}	0.0^{NS}	0.1^{NS}	0.4^{NS}
S×G×F	0.6^{NS}	0.1^{NS}	0.3^{NS}	0.7^{NS}	0.7^{NS}	0.1^{NS}	0.5^{NS}	0.0^{NS}	0.1^{NS}	1.9^{NS}	0.9^{NS}	0.0^{NS}	0.1^{NS}	0.4^{NS}
CV	6.1	2.9	2.0	6.9	6.6	4.6	6.1	10.2	4.1	5.1	6.9	14.3	6.6	5.9

Symbols are as shown on table (3)

Table (5): Square means of the yield and yield components parameters for the treatment and their interactions season 2017

Treatment	Weight of root (g) /m2	Number of cobs/Plant	Cob Length (cm)	Number of rows /cob	No of seeds /row	100 seeds weight/gm	Harvest index %	Yield (t/ha)
S	335.4^{**}	0.5^{NS}	660.4^{**}	68.7^{**}	34.2^{**}	247.4^{**}	4.9^{NS}	700.9^{**}
G	8.1^{*}	0.1^{NS}	108.9^{**}	64.5^{**}	81.5^{**}	24.5^{**}	28.5^{**}	24.4^{**}
F	100.8^{**}	25.1^{**}	130.4^{**}	178.9^{**}	179.1^{**}	34.4^{**}	52.9^{**}	242.3^{**}
S× G	1.6^{NS}	0.0^{NS}	4.5^{*}	3.7^{NS}	1.5^{NS}	1.9^{NS}	88.2^{**}	5.9^{NS}
S× F	4.2^{NS}	0.2^{NS}	4.3^{*}	2.3^{NS}	1.3^{NS}	2.1^{NS}	7.3^{**}	4.5^{NS}
G×F	0.3^{NS}	1.3^{NS}	1.4^{*}	0.3^{NS}	0.7^{NS}	0.4^{NS}	1.5^{**}	0.0^{NS}
S×G×F	0.3^{NS}	0.0^{NS}	0.4^{NS}	11.5^{NS}	0.7^{NS}	0.9^{NS}	1.5^{NS}	0.1^{NS}
CV	9.4	11.3	3.0	3.2	3.5	6.3	5.0	7.8

Symbols are as shown on table (3)

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Table (6): Square means of the yield and yield components parameters for the treatment and their interactions season 2018

Treatment	Weight of root (g) /m2	Number of cobs/Plant	Cob Length (cm)	Number of rows /cob	No of seeds /row	100 seeds weight/gm	Harvest index %	Yield (t/ha)
S	542.1**	5.9**	187.0**	290.7**	129.8**	288.1**	601.9**	163.5**
G	16.6**	0.7^{NS}	10.3*	3.11^{NS}	4.1^{NS}	7.0**	24.0**	27.6**
F	292.2**	16.2**	124.2**	130.5**	281.7**	59.8**	91.2**	146.6**
S× G	5.6^{NS}	0.2^{NS}	134.5*	35.9^{NS}	66.0**	295.4**	123.8**	215.2**
S× F	4.8**	0.9^{NS}	3.9*	1.4^{NS}	3.2^{NS}	0.6^{NS}	19.6**	5.5*
G×F	0.7^{NS}	0.7^{NS}	8.4*	0.4^{NS}	0.5^{NS}	0.2^{NS}	3.3**	1.8*
S×G×F	0.4^{NS}	0.1^{NS}	0.6^{NS}	0.7^{NS}	1.1^{NS}	0.2^{NS}	2.6^{NS}	3.3*
CV	5.3	12.3	2.9	3.6	2.7	3.5	5.1	3.6

Symbols are as shown on table (3)

Table (7): Square means of the forage yield for the treatment and their interactions

Treatment	Dray forage yield (t/ha)		Fresh forage yield (t/ha)	
	Season 2017	Season 2018	Season 2017	Season 2018
S	13.6^{**}	246.8^{**}	34.1^{**}	531.6^{**}
G	41.2^{**}	0.0^{NS}	56.8^{**}	13.6^{**}
F	44.7^{**}	103.2^{**}	81.2^{**}	199.1^{**}
S×G	1.6^{NS}	60.3^{**}	5.9^{NS}	20.1^{NS}
S×F	0.7^{NS}	0.1^{NS}	1.3^{NS}	0.9^{NS}
G×F	0.9^{NS}	0.1^{NS}	1.2^{NS}	0.7^{NS}
S×G×F	1.0^{NS}	3.0^{NS}	0.4^{NS}	3.9^{*}
CV	17.8	11.9	11.8	8.5

Symbols are as shown on table (3)

Table (8): Square means of biochemical characters for the treatment and their interactions

Treatment	Crude protein%		Nitrogen %		Crude fiber%	
	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
S	154.6^{**}	109.9^{**}	120.4^{*}	111.6^{*}	78.2^{**}	15.2^{**}
G	9.4^{**}	19.3^{**}	6.6^{NS}	19.4^{*}	146.2^{**}	75.6^{**}
F	24.2^{**}	112.0^{**}	18.0^{*}	115.4^{*}	159.9^{**}	130.0^{**}
S× G	1.3^{NS}	5.9^{NS}	0.9^{NS}	5.4^{NS}	0.8^{NS}	0.0^{NS}
S× F	1.4^{NS}	3.4^{NS}	1.2^{NS}	3.4^{NS}	2.9^{NS}	1.4^{NS}
G×F	0.6^{NS}	1.5^{NS}	0.9^{NS}	1.6^{NS}	1.1^{NS}	1.2^{NS}
S×G×F	0.4^{NS}	2.0^{NS}	0.4^{NS}	1.9^{NS}	1.6^{NS}	1.2^{NS}
CV	4.5	2.3	5.1	2.3	1.8	2.3

Symbols are as shown on table (3)