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Effects of different fertilizers on growth and yield components of *Maize* (*Zea mays L.*)

تأثير الأسمدة المختلفة على نمو ومؤشرات إنتاجية محصول الذره الشامية

A Thesis submitted in partial fulfillment of the requirements for the degree of M.Sc. in Agronomy

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بسم الله الرحمن الرحيم

((وَآيَةٌ لَّهُمُ الْأَرْضُ الْمَيْتَةُ أَحْيَيْنَاهَا وَأَخْرَجْنَا مِنْهَا حَبًّا فَمِنْهُ يَأْكُلُونَ))

صدق الله العظيم

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I want thanks my family, friends

I would not forget anyone help me.

Conferment

To my parents, Brothers

To my husband, son &daughter

To who supports me

ABSTRACT

A field experiment was conducted at the Demonstration Farm- College of Agricultural Studies, Sudan University of Science and Technology, Shambat during the Winter Season 2018\2019, to investigate the effect of foliar, DAP and their combination on growth and yield of maize (Zea mays).The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replication .The maize variety used was (Hudeiba2) .The treatments consist of three type of fertilizers: Di-ammonium phosphate (DAP) 120.Kg\ha, foliar (Micro nutrients') 240ml\ha, DAP with foliar, untreated control was used as comparison between treatments , parameters studied included : (plant height(cm), number of leaves per plant, leave area(cm^2), stem diameter(cm), Dry weight(g), yield components (cob length(cm) cob diameter(cm) number of rows per cob, number of kernels per raw, number of kernels per cob, hundred grain weight(g), weight\plant(g). The results showed that foliar combination with DAP had significant effect on all parameters studied as compared to the control, it increases plant height by 31%,number of leaves 9%,leaf area 36%,stem diameter 44%, dry weight 207%, cob length 40%, cob diameter 14% number of kernels per row 51%, number of kernels per cob57%,weight plant 99%, except hundred grain weight effected by DAP it increases 28%, there were no significant different among fertilizers treatments on number of rows per cob.

الخلاصة

أجريت تجربة حقليه بالحقل التجريبي لكلية الدراسات الزراعية، جامعة السودان للعلوم والتكنولوجيا بشمبات خلال الموسم الشتوي 2018 \ 2019 لدراسه أثر أستخدام أسمدة مختلفة على نمو ومؤشرات إنتاجية محصول الذرة الشامية، تم تنفيذ التجربة باستخدام تصميم القطاعات العشوائيه الكاملة على أربع مكررات الصنف المزروع (حديبه2) والأسمدة هي: سماد فوسفات الامونيوم الثنائي120 كجم\هكتار) والسماد الورقي (عناصر صغرى 240مل\هكتار)
تمت دراسة تأثير الأسمدة المختلفه على معايير النمو الخضري والأنتاجية وهي: طول النبات(سم)، عددالأوراق، مساحة الورقة(سم^2) ، سمك الساق(سم) ، الوزن الجاف(جم)، طول الكوز (سم)، سمك الكوز(سم)، عددالصفوف،عددالحبوب في الصف، عدد الحبوب في الكوز، وزن المائة حبة(جم)، وزن النبات (جم) أظهرت النتائج أن للسماد الورقي مع فوسفات الأمونيوم الثنائي ذات أثر معنوي علي كل الصفات حين قورنت مع الشاهد حيث كانت الزياده لطول النبات 31%,عدد الأوراق 9%, مساحه الورقه 36%, سمك الساق44%, الوزن الجاف 207%, طول الكوز 40%, سمك الكوز 14%, عدد الحبوب في الصف 51%, عدد الحبوب في الكوز57%,في ماعدا وزن المائة حبة وأظهرت النتائج عدم وجود فروقات معنوية بين المعاملات على عدد الصفوف في الكوز.

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CHAPTER ONE

Introduction

Maize (*Zea mays L.*) ,also known as corn, a member of the grass family poaceae , is one of the worlds leading cereal grains along with rice and wheat .Is first domesticated by indigenous people in southern Mexico about 10,000 year ago (Doebleyj,2004). However, not all of this maize is consumed directly by human; a considerable amount of maize production is used for corn ethanol, animal feed and other maize products (Wikipedia, 2017).

Maize has the highest average yield per/ ha , and remains third after wheat and rice in total area and production in the world (FAO ,2012).Due to high productivity ,maize called as the Queen of cereal (Panda,2010).

Among the maize growing countries USA, has the highest area followed by Brazil, China, Mexico and India, Russia, Indonesia and Philippines (Panda,2010).

The world area of maize production was 176 million /ha during 2012.

The global total area sown to maize has increased by about 40% and production has doubled global cereal demand is under way, and by 2020 is estimated at 2.1 billion MT (Sabo et. al ,2016).

Maize can be grown in wide range of environments (Fornham et .al,2003) this ability is reflected in the high diversity of its morphological and physiological traits (Dowsnell et. al,1996).

Maize can be used at any stage of growth so it is called contingent crop (Panda,2010) is growing primarily for grain, secondarily for fodder, raw material for industrial process and diversified product , the based industrial products are corn oil, starch, and alcohol , sweet corn, corn cob, maize occupies a significant position in our diet as corn flour and corn flak too(Panda,2010) there has been more interest for silage making during the last few year (Graham,1985) in the developed world , maize is mostly used for animal feed (70%) and only small percentage (50%) is consumed by human (FAO 2012),Every part of maize has economic value , maize is rich in starch (carbohydrates) with an average of about 70% but low in protein about 9.5%, the oil concentrated mainly in the germ with an average 4% , of the kernel are 1.4% sugars , 2.3% fiber and 1.4% ash (Ali,1996)

In 2014 , total world production was 1,04 billion tons (Chaudhary et. al,2012) Based on the Lesotho Bureau of statistics agricultural assessment maize production , estimated at 200000 tones in 2017.

Maize is the only crop among non leguminous crops fodder that combine better nutritional quality , which is far much better than sorghum and millet which possesses toxic materials such oxalate, as reported by (Chaudhary et. al ,2012Gahmaraden et. al, 2009).

Maize was introduced into Africa in the 1500s and has since become one of Africans dominant food crops (Nour and lazim,1997-2000).

In the Sudan, maize is considered as a minor crop, was grown under rain-fed agriculture in Kordofan, Darfur and in small irrigated areas in the Northern states. Recently, more attention is beginning paid to the crop and expansion was noticed under Gezira scheme- Blue Nile scheme – White Nile scheme,The increasing demand for maize for poultry feed or intermediary product for human nutrition have let to greater interest in this crop, Generally environmental condition in the Sudan favorable for maize production(Ahmed,2011).

Research on maize has started since early sixties of the last century at Hudeiba Research Station.

The work at that time, however, focused more on breading aspects rather than crop management (Baybordi, 2006).

In Sudan area cropped to maize amount 126 thousand acre (121,500 Fed)Which amount 82%of that of 2013(Food security annual Report2015)

The area is expected to increase due to the fact that more attention put to maize by policy makers, by the importance of maize as grain and fodder feed (Mohammad et. al,2015).

Maize is well known for its high demand for nutrients and other production inputs. Thereby, among factors those enhance maize productivity such as nitrogen levels, foliar and soil fertilization as well as the application time.

The increase in agricultural production and the purity of industrial fertilizers have resulted in depletion of soil and reduction of micronutrients there- fore, the application of fertilizers have become an important to increase mineral content, especially in cereal grains, that are relatively poor sources of mineral nutrients . However, studies about mineral fertilization have been focused The increase of maize yield adds up to the satisfaction of the grown demand of the increasing livestock and poultry industry. Hence there is a need to evolve best nutrition to enhance the yield of maize and foliar application of nutrients to correct the nutritional deficiencies in plant and soil.

The objectives of this study are:

-To improve the production and productivity of maize in Sudan.

- Study the effect of foliar ,DAP and their combination fertilizer on growth and yield components of maize.

CHAPTER TWO

Literature Review

2-1 Background:

Maize one of the main important cereal crop (Drinic et. al, 2009) it has high grain yield and great adaptation. Internationally 67% of maize is used for livestock feed 25% for human and the rest for manufacturing purpose, Morphologically maize exhibits larger diversity of phenotype than any other grain crop (Rajesh et. al ,2013).

2-2 Taxonomy:

Maize belong to the tribe of the grass family poaceae zea (zeal) was derived from old Greek name for food grass (Doeblayj, 1990).

2-3 Origin and History:

The origin of maize is still uncertain though some workers mention it to be high land of Peru, Bolivia or while other say it to be southern Mexico and Central America. The first mention of the crop on the records when Columbus reached the American main land and his scout brought to him the maize samples from the Island of Cuba and the maize excavation in the new world show that maize was grown as an important food crop about 2500 year Columbus landed there .(Panda, 2010).

Maize spread to the rest of the world because of its ability to grow in diver's climates. It was cultivated in Spain just a few decades after Columbus and then spread Italy, West Africa and else where.

2-4 Economic important:

Maize is an important crop from which more many products are generated such as human food, bio fuel and livestock feed .As the second most widely consumed cereal in the world (Merrill, 2009).

World maize production has increased steadily over the past few decades according to the statistics of food and Agriculture 2012, maize kernels are the major edible part of human diet and livestock feed. The nutritional composition and content of maize kernels, contain four main vitamins including Niacin, Vitamin\B6, Thiamin and Riboflavin, maize is increasingly used as a feed stock and bio fuels in the period from September 2011to August 2012.

46% of maize grain produced in USA were used for bio ethanol production it is estimated will reach about 5.9 $\times 10^9$ gallon by 2020(Martin et. al, 2014).

2-5 Botanical description:

Maize is a tall, robust annul, usually with a single dominant stem Although there may be few basal branches (tillers) in some genotype and environments. It leaves are distinguishes two ranks of single leaves born in alternate position.

Maize was one of the first species shown to possess the C_4 dicarboxylic Acid pathway of photosynthesis (Hatch and Slack, 1970).

Maize is amonoecious plant, it produces its staminate flowers in a terminal inflorescence (tassel) and its pistillate flower on lateral shoot (ears), maize produces its economic yield grain on lateral shoot.

Maize is protandorous, is primarily a cross- pollinated species. Pollen production is excessive and there are estimate that 25.000 to 50.000 pollen grains are produced for each potential kernel (Mangels drof, 1974).

2-6 Vegetative grows stages:

These grows stage occur about 1 week after the plant emerges, at the stage 1 to 2 leaves are visible on the stem, the seedling root system has stopped growing; root hairs are present on nodal root, small tassel is initiated of the growing point and the root system is well distributed in the soil and extends about 45cm deep and 69cm wide.

The fourth whorl of nodal root is elongating, the maize plant rapidly accumulates nutrients and dry matter.

The potential number of kernel and the potential number ovules is established, the maize plant is only 12/15 day away from the start of reproductive growth, this vegetative stage is the most critical period of kernel yield determination, the vegetative plant is reaching full size. (Jan.2009)

2-7 Reproductive growth stages:

Silk stage when silks emerge from ear to receive pollen and begin the fertilization process, the pollination typically occurs in relatively short (5-8day) after fertilization silk detach from the ovule and dry and turn down.

Blister stage the ear, lateral shoot and bracts are fully developed and starch begins to accumulate in the endosperm.

Milk stage occurs about 20 day after silk stage as kernels develop a buttery yellow color and are full of milky white fluid.

Dough stage about 30 day after silk stage, when kernels gain consistency and size, kernels become more yellow, and many will actually develop a dent in kernel.

Dent stage occurs about 40 day after silk stage, when kernels are fully dented and hard starch, kernels crown turns the bright, shiny, dark yellow of mature kernels and obtain the starch development.

Physiological maturity when kernels development is finished, occur about 20 day after dent stage, grain weight accumulation is complete at this stage.

Biological maturity although grains have reached physiological maturity, they must dry out before reached biological maturity, under favorable condition drying take place approximately 5% per week up to 20 % level after which there is a slow down (Erick, 2018).

2-8 Maize type:

Dent corn this is the most common type growing in SA. The top of the kernels yellow or white color.

Flint corn it is widely grown and cultivated in India, endosperm of kernel is soft and starchy in the center and completely enclosed by very hard outer layer.

pop corn it possess exceptional qualities, size of kernel is small but the endosperm is hard, when they are heated, the pressure build up with in the kernels suddenly results in an explosion and the grain is turn out.

Flour corn it possesses a soft endosperm, all color red corns are grown but white, blue are the most common.

Sweet corn the sugar and starch makes the major component of the endosperm, the cobs are picked up green for table purpose.

Pod corn each kernel is enclosed in pod, it is primitive type of corn and hence of no important.

Waxy corn the endosperm of the kernel when cut or broken gives waxy appearance; it produces the starch similar to tapioca starch for making adhesive for articles (Vinod, 2012).

2-9 Environmental requirements:

2-9-1 Temperature: Maize is a warm weather crop, the minimum temperature for germination 10°c the critical temperature affecting yield 32°c.

2-9-2 Rainfall: Maize is grown mostly in regions having annul rainfall between 60/m to110/m but is grown in areas having rainfall of about 40m.

2-9-3 Soil: Maize grows in a wide range of soil, but the best suitable soil for maize is deep, rich soils of the sub- tropics where there is abundant nitrogen (Jean, 2003).

2-10 Maize in Sudan:

Maize is a promising cereal crop in Sudan with the potential usefulness for both human beings and livestock (Salih et. al ,2008).

Introduction of maize to Sudan is not known however, it might have come through west Africa where it was introduced by Portuguese or through Egypt (Tothill, 1948).There fore, the crop is grown in the Sudan for along time and is characterized by high genetic variability, which can be exploited in improving the crop.

Corn is the fourth cereal crop in Sudan after sorghum, wheat and millet, it is cultivated on small scales as subsistent rain fed crop around villages in Nuba mountains and the Blue Nile, the crop is also grown under irrigation in central eastern and northern Sudan (Elhassan, 2004) Reported that, corn is the one of the promising crop in Sudan for export especially to the arb world, further more the establishment of starch and glucose factories that take place in the country (Nour and lazim ,1997).State that, maize has a high potential in northern Sudan, being grown during both summer and winter seasons for grain and forage yields ranging from 2-5 t/h can be obtained under optimum condition. Recently there has been increasing interest in maize production in Sudan (Nour et .al ,1998).

Maize is among the substitute crop to replace wheat in the agriculture schemes, especially in Gezira scheme, it can occupy an important position in the economy of the country due to the possibility of mixing it with wheat for bread making (Mohamedein ,2006).

Maize research in Sudan is very limited it was only confined to forage maize (Imam, 1971) reported that summer planting of maize resulted in very poor yields compared to winter planting, (Kambal, 1984)

Agriculture Research corporation (ARC) released three open pollinated varieties of maize Hudeiba-1, Hudeiba-2 and vari113. ARC also conducted a lot of work regarding maize various aspects addressing different maize traits even in most of ARC research station in the different Sudanese environments and different irrigation systems.

In the rain fed farming was assigned to Gadarif, Kassala, Kadogli, Elobied, ElFashir, Ginana , Nyala, Damazeen research station, in which genotype and varieties testing, nitrogen fertilization, population density, inter cropping, stem borer and some breeding traits were conducted in these station.

In the irrigated sector was assigned to Gezira, Rahad, New Halfa, Shandi, Hudeiba and soba saline sodic soil research station.

The approved ARC maize breeding program comprises of breeding for different aspect including, evaluation and assessment of genotype , improvement of grain yield and quality, breeding for stem borer resistant, breeding for Striga resistance and breading for drought tolerance and other different a biotic stress.

2-11 Fertilization:

Maize will tolerate a relatively low PH but if the PH falls below 5.5 an application of time should be several month before sowing, nitrogen is the most important plant food for maize, and under average condition, the crop should receive a complete fertilizer supplying about 200-250 unit of N, 100-120 units of P_2O_5 and 100-120 units of K_2O per hectare and this should be worked into seed bed before sowing(park et. al, 1978).

2-11-1 Important of fertilizer:

Fertilizer is any organic or inorganic material of natural or synthetic origin that is added to a soil to supply one or more plant nutrients essential to the growth of plant. Conservative estimates report 30 to 50% of crop yields are attributed to natural or synthetic commercial fertilizer (Wikipedia ,2013).

2-11-1-1 Nitrogen(N): is the essential plant element that is the most frequently limits irrigated crop production, commercial nitrogen fertilizers are a cost- effective means of supplementing soil supplied nitrogen are necessary for grows and sustaining high crop yield (Ramniwas, 2006).

2-11-1-2 Phosphorus (P): Is an essential plant nutrient required for optimum crop production, plant need Phosphorus for growth utilization of sugar and starch, photosynthesis, nucleus formation and cell division, Phosphorus compounds are involved in the transfer and storage of energy within plants, energy from photosynthesis and the metabolism of carbohydrates is started in phosphate compounds for later use in growth and reproduction ,phosphorus is readily trans located within plant, moving from older to younger tissues as the plant forms cell and develops roots, stems and leaves.

Adequate P result in rapid growth and early maturity, which is important in areas where frost is a concern.

Frequently, P will enhance the quality of vegetative crop growth; an adequate supply of available P in soil is associated with increased root growth, which means roots can explore more soil for nutrients and moisture.

Phosphorus occurs in most plant in concentration between 0.1 and 0.4 percent, an a dry weight basis A deficiency of P will slow over all plant growth delay crop maturity (Ross and Allan, 2013) .

2-11-1-3 Di-ammonium phosphate (DAP): Di-ammonium phosphate (DAP) {(NH_4) HPO_4} 18% N and 46% P_2O_5 is the most world wide fertilizer, it is produced in around 20 countries and consumed in every developed agricultural market (FAO, 2012).

It is made from two common constituents in the fertilizer industry, Nitrogen (N) and Phosphorus (P), moreover it is relatively high in nutrient content and its excellent physical properties make it a popular choice in farming and other industries.

DAP are water soluble and thus dissolves quickly in soil to release plant available. , the ammonium present in DAP is an excellent N source and will be gradually converted to nitrate by soil bacteria, resulting in a subsequent drop in PH,DAP fertilizer is has many properties such as optimal fertilizer for winter cereals, ensures good root system growth, high yield, high quality plant products ,DAP can be applied pre or to sowing mixed with soil at the depth of 20cm under the ground,nitrogen content in DAP support the photosynthesis process and improve roots grows and development (IPNI, 2012).

2-11-2 Foliar fertilization: foliar fertilization by spraying crop has recently been adopted for some crop, with the aim of providing balanced nutrition (Salih et. al, 2010).

Foliar fertilization enhances overall nutrient level in the plant and sugar production during time of stress and it also increases bio chemical activities in the leaf by increasing chlorophyll a, b which presumably the photosynthesis (Asghar et. al ,2011).

The foliar fertilization in agriculture has been a popular practice with farmers since 1950s when it was learnt that foliar fertilization effective, where used to show that foliar applied fertilizers passed through the leaf cuticle and into the cell (Brasher et. al ,1953).

The mechanistic processes by which foliar applied nutrients taken up are through leaf stomata (Eichert and Burkhard, 1999).

Foliar application increases nutrition absorption in comparison from soil (shah et. al ,2007).

2-11-3 Effect of foliar fertilization on growth and yield of maize:

Foliar spraying with $ZnSO_4$ at the rate of 0.30 % significantly increased growth, yield and its components as well as grain quality of maize.

(Adhikary et. al,2010) recorded that highest grain yield (5.99 t/ha) was recorded with the crop which was supplied with all micronutrients (B, Zn, S, Mn and Mo) applied in combination with NPK fertilizers at 120:60 :40 kg /ha which produced almost 171 % higher grain yield than those with control plot (2.21 t/ha) and 1.48 t/ha of additional grains over NPK treated crop(Ghaffari et. al, 2011).

indicated that micronutrient foliar application significant effect on plant height, leaf length, grain and biological yield, however the effect of micronutrient foliar application on width of leaf, diameter of stem, number of rows per ear, number of grain per ear and weight of grain was not significant(Salem and E Gizawy, 2012) indicated that foliar spraying by micronutrients gave the highest values of ears/plant, grains/ear, 100-grain weight and grain yield.

Foliar application of zinc was observed to increase dry matter of corn, wheat and sunflower while zinc deficiency reduced total dry matter of corn from 74% to 26.6% depending on cultivar (Trehan, Sharma 2000).

(Mahmoud ,2001) at National Research Centre, Dokki, Cairo, Egypt (clay soil).Reported that the foliar application of trace elements solution (5.2%-Mn, 0.65%-Zn and 0.65%-Cu) 4 ml , on maize and wheat recorded significantly higher plant height (288.7 cm), ear weight (248.3 g), grain weight (218.2 g ear-1), 100 grain weight (46.8 g), grain yield (13.92 - Maize and 4.57 - wheat, grain yield t ha, respectively). and it was at par with foliar fertilization of 2 ml .

(Parasuraman ,2008) at Tamil Nadu Regional Research Station, Paiyur (sandy clay loam soil) noticed that the foliar fertilization of multi-nutrients on maize (1% DAP + 1% MOP +0.5% $ZnSO_4$ + 0.2% B + 1% Fe_2SO_4) with 100 per cent soil applied fertilizers was gave the higher maize grain yield (3443 kg ha), Stover yield (6.8 t ha), net income (25507 ` ha), and higher macronutrients uptake (131.3, 25.7 and 122.4 kg).

Dorneanu et al. (2011) from Central Research Station for Plants Growing on sand soils, Dabuleni-Dolj reported that the foliar application of complete water soluble fertilizers (macro + micronutrients) 5 per cent (500 l ha) on maize with basal fertilizer under sandy soil
was significantly increased the maize grain yield (5185 kg ha) and higher grain production(10.22 kg per kg fertilizer use) over the control (2100 Kg ha)

2-11-4 Trace Element:

Zinc (Zn) : being essential nutrient plays a significant role in Stomata regulation and reducing the tensions of less Water by creating ionic balance in plants system (Baybordi, 2006). and is involved in various physiological Processes such as synthesis of protein and carbohydrates
(Yadavi et. al, 2014).

Boron(B) : application improves growth, and enhances stress tolerance inplants and improves grain production (Hussain et. al, 2012).

Both Zn and B play an important role in the basic plant functions like photosynthesis, protein and chlorophyll synthesis (Cakmak, 2008).

(Zn and B) are also involved in root growth, synthesis of proteins and carbohydrates, increase flower setting (Moeinian et. al, 2011) and reduce kernel abortion especially (Wahid et. al, 2011).

Iron (I): is essential for crop growth and food production, iron is a component of many enzymes associate with energy transfer nitrogen reduction and fixation and lignin formation.

Manganese (Mn): primarily as part of enzyme systems in plant, it activates several important metabolic reaction and plays a direct role in photosynthesis. Manganese accelerates maturity while increasing the availability of phosphorus and calcium.

Molybdenum (Mo): is a trace element found in the soil and required for the synthesis and activity of the enzyme nitrate reductive.

Copper (Cu): activates enzymes and catalyzes reaction in several plant growth processes the presence of copper is closely linked to vitamin A production and it helps ensure successful protein synthesis.
(IPNI).

CHAPTER THREE

Materials and Methods

3-1 Experimental site:

The experiment was conducted at the experimental Farm College of Agricultural Studies, Sudan University of Science and Technology during the Winter Season, 2018-2019.

Shambat is located between latitudes 15.40 North and longitude 32.32 East and altitude of 380 meters above sea level.

The climate is characterized by semi – desert tropic with a low percentage of humidity and average rain fall of 158mm per annum and temperature of 20.30ºc-36.1ºc (Khairy, 2010). the soil at Shambat site is heavy clay, pH 7.5-8 as described by Abdelgader,(2010)

3-2 Layout of the experiment :

The experiment was arranged in Randomized Complete Block Design (RCBD) with four replications to study the effect of different fertilizers on growth and yield of maize crop, untreated control was used as comparison between treatments.

3-3 Land Preparation:

The land was prepared by disc plough, disc harrowed, and leveled ridging up from North to South, and the spacing between ridges was 70\cm and between holes was 20/cm.

The size of the plot was 4×4 m^2 consisting of four ridges.

Sowing was done manually on the shoulder of the ridges at 4-5 cm depth in the November 2018.

3-4 Plant materials:

Maize seed were obtained from Hudeiba Research Station, variety Hudeiba/2.

3-5 Fertilization treatments:

The treatments consist of:

a- Di- ammonium phosphate (DAP) 120kg/ha

b- Foliar (Micro nutrients') 240ml/ha (Iron, Zink, Manganese, Boron, Copper, Molybdenum)

c- DAP with foliar.

The Di-ammonium fertilizer was applied broadcasted on the ridges before sowing, while foliar fertilizer by spraying before flowering and after cobs composition.

3-6 Data Collection:

3-6-1 Plant height (Cm):

Plant height was measured from ground level up to the end of tassel for the five plant sample then averaged to get the mean plant height.

3-6-2 Number of leaves /Plant:

The leaves number were counted for the five plant sample th the mean number of leaf/ Plant was calculated and registered.

3-6-3 Leaf Area (cm^2):

The leaf per plant of five sample was measured, The leaf length multiplied by the maximum width and then multiplied by 0.75 (Sticker, 1961).

3-6-4 Stem diameter (cm):

Stem diameter measured using the vernea for the five plant sample to get the average stem diameter.

3-5-5 Dry weight (g):

The plants of each plot was harvested and subsequently dried in oven then weight was recorded.

3-5-6 Cob length (Cm):

The cob length was measured obtained from five plant sample, and the average was recorded.

3-5-7 Cob diameter (cm):

Cob diameter was measured using the vernea for the five plant sample to get the average cob diameter.

3-5-8 Number of rows per cob:

The number of rows\ cob five plant samples, were recorded.

3-5-9 Number of kernels per row:

The number of kernels, obtained from five plant samples, were recorded .

3-5-10 Number of kernels per cob:

The number of kernels\cob were recorded ,   multiply of the number of kernels in the row by the number of rows per cob.

3-5-11 100 grain weight(g):

This character was recorded by taking a random sample of 100grain from the total cobs weight and then weighed using sensitive balance.

3-5-12 Weight/plant (g):

After cobs dried and threshed, the weight of one cob was taken.

3-6 Analysis:

The collected data for growth and yield characters was subjected to analysis of variance used for a Randomized Complete Block Design (RCBD) arrangement by using Statistix (8) software program.

CHAPTER FOUR

Results and Discussion

4-1 Growth Characters

4-1-1 Plant height (cm):

The analysis of variance showed that there were significant differences among treatments for plant height table (1) the highest value (184.70\cm) was given by the mixture of foliar with DAP while the lowest value was obtained by control (140.30\cm) it increases plant height by 31% as compared to control among other treatments there are not significantly different at 5% level of least significant difference. Significant variation in the plant height might be due to time availability of the needed nutrients to the plant at the important growth stages and foliar application of micronutrient has led to resulting in increased plant height a similar result was reported by many researcher (Cakmak *et al,* 1989) (Ghazvineh and Yousefi, (2012).

Further, this result was also in-line with the results of Afifi *et al,(* 2011), where the foliar fertilization of maize plants with urea and micronutrients recorded the higher plant height (229.45 cm).

4-1-2 Number of leaves:

Different type of fertilizers showed significant differences on number of leaves per plant table (1) foliar with DAP treatment gave the highest number of leaves, among other treatments there are not significantly different at 5% level of least significant difference.

4-1-3 Leaf area (cm^2):

Leaf area showed significant differences , maize treated by the mixture of foliar with DAP fertilizers obtained the highest mean (330.68cm^2) as compared to control (241.65cm^2) it increasing leaf area by 36% as compare to control among other treatments there are not significantly different at 5% level of least significant difference.

The leaf area greatly influenced by the foliar application foliar nutrition improved the vegetative growth and increased leaf area the micronutrients alone or in combination significantly increased leaf area, this result was also accordance with (. Safyan *et al*,2012).

4-1-4 Stem diameter (cm)

The effect of fertilizer treatments on stem diameter of maize presented on table (1) analysis of variance showed significant differences among treatmenst, foliar with DAP recorded the largest stem diameter (2.43cm) table (1) while control the lowest mean of stem diameter (1.68cm), among other treatments there are significantly different at 5% level of least significant difference.

4-1-5Dry Weight (g):

From the statistical analysis of variance it was clear that there were significant differences among the fertilizer treatments on plant dry weight of maize table (2) the largest plant weight (523.5g) was obtained by mixture of foliar with DAP fertilizer as compared to control (252.50g) it increase the plant dry weight by 207% as compared to control, among other treatments there are not significantly different at 5% level of least significant difference.

4-2 Yield Components:

4-2-1Cob Length (cm):

Cob length showed significant differences as shown in table (2) maize treated by mixture of foliar with DAP fertilizer obtained the highest means(16.98cm) as compared to control(12.08cm) , it increases cob length by 40 % compared to control , among other treatments there are not significantly different at 5% level of least significant difference.

control resulted in shorter cobs compared to treatments probably due to reduced supply and availability of plant nutrients, this result was also inline with (selvaraju and Iruthayara,j1994) the increase in length of cobs and number of grains per cob with increased foliar fertilizer application it could be attributed to adequate nutrient supply which in turn improved all growth and yield influencing characters.

4-2-2 Cob Diameter (cm):

The effect of fertilizer treatments on cob diameter of maize presented on table (2) analysis of variance showed significant difference among treatment , foliar with DAP recorded the largest value (4.07cm) the lowest value (3.55cm) was given by control, among other treatments there are not significantly different at 5% level of least significant difference.

4-2-3 Number of rows per cob:

From the statistical analysis of variance it was clear that there were not significant difference among fertilizer treatments on number of rows per cob, also there are no significant differences among the means at 5% level of least significant difference,number of rows was not effected by fertilizers treatments a similar result also obtained by (Salem and El-Gizawy, 2012).

4-2-4 Number of kernels per row:

The effect of different fertilizer treatments on number of kernels per row presented in table (3) Analysis of variance showed significant differences among treatments , the highest number of kernels per row(34.85) recorded by mixture of foliar with DAP , among other treatments there are not significantly different at 5% level of least significant difference.

4-2-5 Number of kernels per Cob:

Significant differences were showed among fertilizer treatments on number of kernels per cob table (3) the largest number was (511.50) recorded by mixture of foliar with DAP fertilizer as compare to control (324.80) increases number of seed per cob by 57% as compared to control , among other treatments there are not significantly different at 5% level of least significant difference.

4-2-6 100 grain Weight(g):-

The effect of fertilizers on (100) grain weight of maize is displayed to table (3) the analysis of variance showed significant differences between treatments, the highest mean of (100) grain weight was (13.83g) recorded by DAP fertilizer while the lowest mean was (10.73g) recorded by control, among other treatments there are not significantly different at 5% level of least significant difference, foliar nutrition of wheat showed significant response on weight of 100 grain reported by (Aljuthery et. al) (Salm and Egizawy) indicated that foliar spraying by micro nutrients gave the highest 100 grain weight, this result is in disagreement with this study observed that weight of 100 grain effected by DAP application.

4-2-7 Weight/ plant(g):-

From the statistical analysis of variance there were significant differences among treatments table (3) the highest mean recorded by mixture of foliar with DAP treatment while the lowest was (34.80) recorded by control , among other treatments there are not significantly different at 5% level of least significant difference, however the effect of micronutrient foliar application on width of leaf, diameter of stem, , number of grain per ear and weight of grain was not significant reported by (Salem and E Gizawy 2012) This result is in disagreements with this study.

In the present study the foliar application resulted in the increase of weight plant this agree with that obtained by many researcher (Rafeal dasilva et. al) and (Salem and El-Gizawy) (Ghffari et. al) (Parasuraman) (Dornanu et. al).

It can be concluded that all attributes were an indication of increased productivity and foliar, DAP combination gave more grain yield than control under agro climatic condition of central Sudan.

Table (1) Effect of different fertilizers on plant height, number of leaves, leaf area and stem diameter for maize during 2018\2019 Winter Season)

Treatment	Plant height (cm)	Number of leaves	Leaf area (cm^2)	stem diameter (cm)
Control	140.30^{c}	11.40^{b}	241.65^{c}	1.68^{d}
DAP	159.10^{b}	12.20^{a}	276.94^{bc}	1.96^{c}
Foliar	169.80^{b}	12.30^{a}	294.56^{ab}	2.18^{b}
Foliar &DAP	184.70^{a}	12.45^{a}	330.68^{a}	2.43^{a}
Means	163.48	12.08	285.96	2.06
SE	3.354	0.1294	12.055	0.0452
LSD	10.732	0.414	38.567	0.146

Means followed by the same letter for each column are not significantly different at 5% level of L.S.D .

Table (2) effect of different fertilizers on dry weight, cob length and cob diameter, number of rows per cob for maize during 2018\2019 Winter Season.

Treatment	Dry weight (g)	Cob length (cm)	Cob diameter (cm)	Number of rows \cob
Control	252.50^{c}	12.08^{c}	3.55^{c}	14
DAP	321.25^{c}	14.60^{b}	3.77^{b}	14
Foliar	431.25^{b}	15.18^{b}	3.91^{ab}	15
Foliar& DAP	523.75^{a}	16.98^{a}	4.07^{a}	14
Means	382.19	14.71	3.84	14
SE	23.133	0.4155	0.6082	0.4206
LSD	74.01	1.33	1.95	1.34

Means followed by the same letter for each column are not significantly different at 5% level of LSD

Table (3) Effect of different fertilizers on number of kernels per raw, number of kernels per cob, Hundred grain weight and Weight per Plant for maize during 2018\2019 Winter Season.

Treatment	Number of kernels / raw	Number of kernels/ cob	Hundred Seed Weight(g)	Weight/plant (g)
Control	22.95^{c}	324.80^{c}	10.73^{b}	34.80^{b}
DAP	29.70^{b}	428.05^{b}	13.83^{a}	59.12^{a}
Foliar	29.70^{b}	448.55^{ab}	12.68^{ab}	57.02^{a}
Foliar& DAP	34.85^{a}	511.50^{a}	13.55^{a}	69.41^{a}
Means	29.30	428.22	12.69	55.09
SE	1.2463	24.240	0.7833	5.2662
LSD	3.99	77.55	2.51	16.85

Means followed by the same letter for each column are not significantly different at 5% level of L.S.D

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Randomized Complete Block ANOVA Table for plant height

Source	DF	MS	F
Rep	3	125.56	
Tre	3	1395.64	31.01
Error	9	45.01	
Total	15		

Grand Mean 163.48   CV 4.10

Randomized Complete Block ANOVA Table for number of leave

Source	DF	MS	F
Rep	3	0.16917	
Tre	3	0.88250	13.18
Error	9	0.06694	
Total	15		

Grand Mean 12.088   CV 2.14

Randomized Complete Block ANOVA Table for Leaf area

Source	DF	MS	F
Rep	3	494.36	
Tre	3	5491.20	9.45
Error	9	581.31	
Total	15		

Grand Mean 285.96   CV 8.43

Randomized Complete Block ANOVA Table for stem diameter

Source	DF	MS	F
Rep	3	0.00492	
Tre	3	0.39665	47.35
Error	9	0.00838	
Total	15		

Grand Mean 2.0625   CV 4.44

Randomized Complete Block ANOVA Table for Fresh weight

Source	DF	MS	F
Rep	3	25167	
Tre	3	134736	12.16
Error	9	11079	
Total	15		

Grand Mean 742.00   CV 14.19

Randomized Complete Block ANOVA Table for Dry weight

Source	DF	MS	F
Rep	3	7989.1	
Tre	3	57305.7	26.77
Error	9	2140.5	
Total	15		

Grand Mean 382.19   CV 12.11

Randomized Complete Block ANOVA Table for Cob length

Source	DF	MS	F
Rep	3	0.8956	
Tre	3	16.4023	23.75
Error	9	0.6906	
Total	15		

Grand Mean 14.706   CV 5.65

Randomized Complete Block ANOVA Table for Cob diameter

Source	DF	MS	F
Rep	3	2.7234	
Tre	3	19.6546	13.28
Error	9	1.4797	
Total	15		

Grand Mean 38.315   CV 3.17

Randomized Complete Block ANOVA Table for Number of rows

Source	DF	MS	F
Rep	3	1.17667	
Tre	3	0.83000	1.17
Error	9	0.70778	
Total	15		

Grand Mean 14.575   CV 5.77

Randomized Complete Block AOV Table for Number of Kernels per row

Source	DF	MS	F
Rep	3	10.0467	
Tre	3	95.2600	15.33
Error	9	6.2133	
Total	15		

Grand Mean 29.300   CV 8.51

Randomized Complete Block ANOVA Table for Number of Kernels per Cob

Source	DF	MS	F
Rep	3	2334.8	
Tre	3	24059.5	10.24
Error	9	2350.3	
Total	15		

Grand Mean 428.22   CV 11.32

Randomized Complete Block AOV Table for Hundred Seed Weight

Source	DF	MS	F
Rep	3	0.39563	
Tre	3	7.85229	3.20
Error	9	2.45396	
Total	15		

Grand Mean 12.694   CV 12.34

Randomized Complete Block ANOVA Table for Weight /Plant

Source	DF	MS	F
Rep	3	21.774	
Tre	3	848.867	7.65
Error	9	110.932	
Total	15		

Grand Mean 55.085   CV 19.12