SUDANUNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF GRADUATE STUDIES

Effect of Diammonium Phosphate Fertilization on Growth and Yield of Irrigated Forage Maize *(Zea mays L.)*

أثر سماد ثنائي امونيوم الفوسفات على نمو وإنتاج الذرة الشامية العلفية

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Thesis Submitted in Partial Fulfillment for the Degree of M.Sc.

(AGRONOMY)

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2014

الآية

قال تعالي:

بسم الله الرحمن الرحيم

(وَهُوَ الَّذِي أَنشَأَ جَنَّاتٍ مَّعْرُوشَاتٍ وَغَيْرَ مَعْرُوشَاتٍ
وَالنَّخْلَ وَالزَّرْعَ مُخْتَلِفًا أُكُلُهُ وَالزَّيْتُونَ وَالرُّمَّانَ مُتَشَابِهًا
وَغَيْرَ مُتَشَابِهٍ كُلُوا مِن ثَمَرِهِ إِذَا أَثْمَرَ وَآتُوا حَقَّهُ يَوْمَ
حَصَادِهِ وَلَا تُسْرِفُوا إِنَّهُ لَا يُحِبُّ الْمُسْرِفِينَ)

صدق الله العظيم

سورة فصلت الآية (141)

DEDICATION

To my parent

To my wife

To my brothers

To my sons

To my teachers

And to my friends with respect

Thank you very much

Abdel Elrahim

ACKNOWLEDGMENT

Above all I render my thanks to the merciful ALLAH who offers me all things to accomplish this study.

Thanks are due to Dr.Sami Ali Mohamed Hamid.

Thanks are extended to the Shambat at Research Center, Sudanese Arab Seeds Company-Khartoum for their help.

Thanks also for staff of College of Agricultural Studies, Shambat.My thanks are also due to my family .Finally thanks are to my friends and staff of Department of Agronomy at the College of Agricultural Studies for their help.

Last, but not least, I wish to thank all those who contributed directly or indirectly in this work, but not mention here.

Abdel Elrahim

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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 of 2012/13, to investigate the effect of diammonium phosphate (DAP)fertilizer (18%N, 46% P_2O_5) on growth and yield of irrigated forage maize(*Zea mays* L.) only one season.

The experiment was laid out in a randomized complete block design (RCBD), with three replications. Two maize genotypes hybrids was used Eden and Boon (C1 and C2), the fertilizers treatment consisted of five levels of diammonium phosphate (DAP) fertilizer: 50kg DAP/ha (D2), 100kg DAP/ha (D3), 150kg DAP/ha (D4), 200kg DAP/ha (D5) and control zero kgDAP/ha (D1).

Characters studied included: relative growth rate, plant height, leaf area, stem diameter and fresh forage yield tons/ha.

The results showed that diammonium phosphate (DAP) fertilizers treatments had a significant effect on growth of the two maize genotypes (Eden and Boon), leaf area and plant height, while no significant differences were obtained in the relative growth rate, stem diameter, and yield .

الخلاصة

أجريت تجربة حقلية بالحقل التجريبي لكلية الدراسات الزراعية جامعة السودان للعلوم والتكنولوجيا(شمبات) خلال موسم شتوى واحد ٢٠١٢-٢٠١٣م ،لدراسة أثر سماد ثنائ امونيوم الفوسفات(داب).على نمو وانتاج الذرة الشامية العلفيه والصنفين المستخدمين هما Hybrid(Eden and Boon) تحت ظروف الري الصناعي. وكان التصميم الإحصائى المستعمل لهذه التجربة هوالتصميم العشوائي ذو القطاعات الكاملة بثلاثة مكررات. وقد كانت المعدلات المستعملة لسماد(الداب)٥٠ كجم /هكتار،١٠٠كجم /هكتار،١٥٠كجم /هكتار ،٢٠٠ كجم /هكتار والشاهد(بدون تسميد).

تمت دراسة تاثير سماد الداب على معاييرالنمو الخضري والإنتاجية وهى:-

معدل النموالعشبى – طول النبات – مساحة الورقة – محيط الساق –انتاجية العلف الاخضر طن/هكتار .

أوضحت النتائج ان سماد (الداب) كان له تأثيرا معنوي على الصنفين المستخدمين من الذرة الشامية(hybrid Eden وhybrid Boon) و كان التاثيرمعنويا على زيادة مساحة الورقة وطول النبات ،بينما لم تكن هناك فروقات واضحة في معدل النموالعشبى ومحيط الساق و الإنتاج.

CHAPTER ONE

INTRODUCTION

Maize (corn) *Zea mays L.* is an annual herbaceous plant which belongs to the family *Poaceae*. Maize is believed to be originated in Mexico. Maize is characterized by very wide genetic diversity. The species *mays* is known to have about seven sub-species. The crop; accordingly, is regarded as a multi-purpose crop. Among these seven, the dent corn is used mainly for forage production.

Sudan is one of the richest countries in animal wealth. Thus animal production represents one of the major economic sectors of the country. It is natural that forage production should receive much attention, especially in areas of the country which are densely populated as Khartoum State. This is to meet the ever increasing demand for animal products.

In Khartoum State; according to the State Ministry of Agriculture, irrigated forage crops occupy about 52% of the total cultivated area. However, there is a production gap estimated by 37%.This gap hinders the export rates of live sheep and cattle, and forage mainly to Gulf States. Large numbers of animals are transported from western Sudan through Khartoum to export ports, where they stay for fattening period. This increases the demand for forage, which is originally high. The production gap was attributed mainly to the traditional cultural practices practiced by the producers. The main Forage crop produced is mainly sorghum cultivars like Abu 70. A numbers forage crop is recommended to fill this gap, especially in winter where the yield of the sorghum cultivars is very low. Forage maize is regarded; accordingly, as a promising alternative as a winter forage crop.

One of the most important cultural practices that contributes very much to increase in the forage yield is fertilizer application. Fertilizers containing nitrogen and phosphorous contribute much to this increase in forage yield, because most of our soils are deficient in nitrogen and available phosphorous.

The traditional practice is applying nitrogen as urea, and phosphorous as triple super phosphate. Recently, diammonium phosphate (18%N and 46% P_2O_5) was released after encouraging results with different crops grown within the Central Clay Plains of the Sudan according to the National Crop Husbandry Committee.

The objective of this study is to evaluate:

1. The performance of two maize forage hybrids; namely, Eden and Boon under the environmental conditions prevailing at Shambat.
2. The effect of applying diammonium phosphate on the forage yield of these two maize hybrids, and the any possible genotype/fertilizer interaction.

CHAPTER TWO

REVIEW OF LITRATURE

2.1 .Botany

Maize *Zea mays L.,* Known also as corn, is a member of grass family *Poaceae*.It is believed to be originated in South America, most probably in Mexico, Guatemala, or Honduras (Mangelsdorf, 1947). *Zea mays* is classified into seven sub-species according to the grain structure (Sharma, 1972; Rabeh, 2007):

1-Flint corn *Zea Mays indurata*, with hard, horny rounded or short flat kernels used for food and feed purposes.

2-Dent corn *Zea mays indentata*, the kernel contains soft and hard starch, and becomes indented at maturity .It is a major crop used to make food, animal feed and industrial products.

3- Sweet corn or green corn *Zea mays saccharata*.It is often eaten fresh, it contains a high percentage of sugar in the milk stage, used in livestock feeds and other industrial purposes as in the case of glucose and starch production.

4. Waxy corn *Zea mays ceratina* the grain has waxy appearance when cut, it's a source of starch.

5. Pop corn: *Zea mays everta*: with small ears and small pointed rounded kernels. It has very hard endosperm when exposed to dry heat, grains are popped or averted by expulsion of the contained moisture and form a white starchy mass many times the size of the original kernel.

6. Flour corn also known as soft or squaw corn:_*Zea mays amylacea* it has kernels shaped like those of flint corn or composed almost entirely of soft starch.

7. Indian or Pod corn: *Zea mays L*. It is grown by Indians, it has white red brown or multicolor kernels, used in mixture with wheat flour to make bread, this corn can make the greatest quantity of biomass than other types, so it can be used for fodder.

2.2. Economic Importance

Maize ranks number three among the important cereals in the world following wheat and rice (Nour et al, 2005). It is a multipurpose crop with a variety of food and feed uses. It has also various industrial uses, because of its wide genetic variability and broad global distribution (Aoad, 2006; and Rabeh, (2007).In Sudan maize immature cobs are eaten after boiling or roasting. The green matter is used as fodder, especially in winter (Zahir et al, 2007).

In Khartoum State, the livestock size is estimated to be around 800000 units according to the statistics of the State Ministry of Agriculture in 2010. And the production of irrigated fodders represents 84.5% of the total State production. However, the gap between the production and the consumption is estimated by 39.1%. This gap was attributed mainly to 1500000 animal units which passes across the State to the export ports, and stay for fattening period in the State. Accordingly, maize is considered as one of several alternatives to fill the gap especially in winter to face the seasonal low productivity of other grass fodder e.g. Abu70.

2.3. Ecology

2.3.1. Climate

Sys et al (1993) reported that maize can grow within a temperature range of 14-40c°, with optimum temperatures of 18-21c°.The same authors added that the crop germination is reduced by 13c°, and fails at 10c°.They showed that maize grows in regions that receive 500-5000 mm/annum of rainfall.

An optimal water supply can be secured in regions that have precipitation of 500-120mm/annum. The crop is sensitive to moisture stress from the beginning of flowering until the end of the grain formation i.e. 50-100 days after sowing.

2.3.2. Soil

Maize can grow on wide range of soils, on conditions that they are deep, well aerated, and well drained. Optimum growth rates are expected on loams and silty loams with adequate organic matter. The pH range is 5.2-8.5, and the optimum pH 5.8-7.8(Sys et al, 1993).

2.4. Cultural Practices

2.4.1 Sowing

The recommended optimum sowing date of forage maize is during the winter season in Khartoum and River Nile States (Khair, 1999). The same author pointed that for optimum yield, forage maize should be sown on ridges when grown on clay soils. He added that the optimum plant population is 46000-61000 plants per hectare.

2.4.2. Irrigation

Abu Swar (2004) reported that the optimum irrigation interval for forage maize is 10-15 days.

2.5. Fertilizers

Most of the soils in the Sudan are regarded as moderately fertile or poor soils, (Dawelbeit et al, 2007) They showed that this is due to the low content of organic matter (< 1.0%), low nitrogen (< 0.1%), and low available phosphorous less than 10 ppm .Thus, applying fertilizers containing nitrogen and phosphorous are expected to increase the yield of all irrigated crops. Nour et al (2005) reported that the application of nitrogen at the rate of 86kg/ha as urea increased the maize yield significantly. The application of phosphorous as triple super phosphate up to 86kg P_2O_5/ha did not affect the maize yield significantly. In a supportive report Salih et al (2007) recommended the application of 86kg N/ha as urea for maize .This recommendation was made after studying the nitrogen use efficiency following the application of 43 and 86 kg N/ha as urea, ammonium sulphate, ammonium sulphate nitrate, and NPK: (23-23-0) on two maize cultivars.Salih et al (2007) in another report; however, pointed out the response of maize cultivars to the application of phosphorous as triple super phosphate at the rate of 43kg P_2O_5 /ha.Osman et al(2008) recommended the application of 43kg N/ha as urea to maize grown under moisture stress conditions, while under normal conditions they recommend sulpher containing fertilizers i.e. ammonium sulphate and ammonium sulphate nitrate

2.6. Diammonium phosphate

In the last of decade, diammonium phosphate (DAP: 18% N and 46% P_2O_5) was released by the National Crop Husbandry Committee. It was tested on several irrigated crops grown in the Central Clay Plains of Sudan. The tests resulted in good results compared with nitrogenous fertilizer such as urea and phosphorous as triple super phosphate.Ali et al (2006) reported that the application of diammonium phosphate in combination with urea or ammonium sulphate which gave good results in seed cotton yield data and net returns with long stable cotton cultivar Barakat90 grown under Gezira conditions. In another report Ali et al (2006) showed that wheat grown under Gezira conditions responded well to the application of diammonium phosphate. Cane and sugar yields statistical and economical analyses supported the recommendation of applying diammonium phosphate in combination with urea to the second ratoon of sugarcane grown in Elguneid Scheme as reported by Elhag et al (2007).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experiment site

A filed experiment was carried out in the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat. Shambat is located at latitude 15°31' N and longitude 32º 35 ' E, in the semi-desert region (Adam, 2003; Appendix1). The experiment was sown in the winter season of 2012-2013, on loamy soil with pH 8.2 as described by Abdelgadir (2010) (Appendix2).

3.2. Materials

3.2.1. Plant material

Seeds of two maize *Zea mays* L. hybrid lines, namely Eden and Boon were kindly supplied by the Sudanese Arab Seeds Company-Khartoum.

3.2.2. Fertilizer

The fertilizer used was Diammonium Phosphate (DAP) 18% N, 46% P_2O_5), obtained from the local markets.

3.3. Methods

3.3.1. Land preparation

The land was ploughed, harrowed, and ridged 70cm apart, and then divided in to plots with four ridges, 3.5meters wide and 3meters long.

3.3.2. Experimental design

A factorial arrangement in a randomize complete block design (RCBD) with three replicates was used.

3.3.3. Sowing

Sowing was carried out on December 15th 2012. 2-3 seeds of were sown on the tops, an intra-row spacing of 20cm.

3.3.4. Treatments

For the two lines: Eden (C1) and Boon (C2) the fertilizer was applied in 5 doses as follows:

1. Control 0kg DAP/ha (D1)
2. 50kg DAP/ha (D2)
3. 100kg DAP/ha (D3)
4. 150kg DAP/ha (D4)
5. 200kg DAP/ha (D5)

3.4. Data collection and analysis

3.4.1. Relative growth rate ($g.m^2.day^1$)

Plants in 0.5 meter length from one of the middle ridges were cut above the soil 10 days after sowing. The oven dry weight,(dw1)and(dw2) for the two periods, respectively were recorded, The samples in paper pag were oven, dried for 48 hours at 70c°.

From the above mentioned samples the relative growth rate was calculated, after Radoford, (1967), as follows:

$$RGR=\frac{D_2 - D_1}{T_2 - T_1}$$

3.4.2. Plant height (cm)

The apparent plant height (cm) was measured from five plants randomly take from the middle of each plot one month after sowing. The mean plant height (cm) was recorded for each treatment.

3.4.3. Leaf area (cm²)

Five plants were take randomly from the middle of the plot. Their maximum length (cm), and maximum width (cm) were take, the leaf area was calculated flowing Stickler (1961) as follows:

Leaf area (cm^2) = maximum length (cm) × maximum width (cm) × 0.75.The mean leaf area (cm^2) was recorded for each treatment.

3.4.4. Stem diameter (cm)

A vernier was used to measure the stem diameter at node number four from the stem base, from five randomly take plants from the middle of each plot. The stem diameter was recorded for each treatment.

3.4.5. Fresh forage weight (t/ha)

Fresh forage was harvested 80days after sowing, from 2meter on middle of two internal ridge, the yield area is $0.7\times2m^2$ by cutting the rest plants just above the soil surface. The yield was calculated in ton/hectare.

3.4.6. Statistical analysis

Analysis of variance (ANOVA) was carried out on the data. Duncan Multiple Range Test (DMRT) was used to separate the means (Little and Hill, 1978).

CHAPTER FOUR

RESULTS

4.1. Relative Growth Rate (g. m². day¹.)

Hybrid Eden exceeded hybrid Boon in the relative growth rate .However, the difference between both genotypes was not statistically significant. The growth rates of both genotypes showed erratic insignificant response to the fertilizer treatment applied (table4.1).

Table 4. 1 Effect of diammonium phosphate (DAP) fertilizer on relative growth rate (g.m² .dy¹) of two maize genotypes:

TREATMENTS	(C1)	(C2)	MEAN
(D1)	11.13	10.50	10.81 (a)
(D2)	13.07	11.67	12.37 (a)
(D3)	12.03	11.03	11.53 (a)
(D4)	8.37	11.83	10.09 (a)
(D5)	11.40	13.30	12.35 (a)
Mean	11.20	11.67	ns
SE±	1.2023		
CV%	28.34		

The means followed by same letter(s) within colums are not significantly different at 0.05 probability level according to Duncan Multiple Range Test (DMRT).

4.2. Plant height (cm)

Hybrid Eden produced taller plants compared to hybrid Boon. Both genotypes exhibited erratic response to diammonium phosphate as far as plant height is concerned. All differences (between genotypes, as well as fertilize rate) were statistically significant (table 4.2.).

Table 4. 2. Effect of diammonium phosphate (DAP) fertilizer on plant height (cm) of two maize genotypes:

TREATMENT	(C1)	(C2)	MEAN
(D1)	100.9	113.7	107.3 (b)
(D2)	105.8	106.2	106.0 (b)
(D3)	108.1	113.5	110.8 (b)
(D4)	141.0	108.7	124.9 (a)
(D5)	134.9	111.6	123.3 (a)
Mean	118.1	110.7	(*)
SE±	8.4276		
CV%	21.23		

The means followed by the same letter(s) within colums are not significantly different at 0.05 probability level according to Duncan Multiple Range Test (DMRT).

4.3 Leaf area (cm^2)

Table 4.3. Indicates that the leaf area (cm^2) was increased significantly with increase in rate of application of diammonium phosphate (DAP).Hybrid Eden significantly exceeded hybrid Boon in leaf area at 0.01 probability level.

Table 4.3. Effect of diammonium phosphate (DAP) fertilizers on leaf area (cm^2) of tow Maize genotypes:

TREATMENT	(C1)	(D2)	MEAN
(D1)	317.1	336.7	326.9 (b)
(D2)	392.1	327.1	354.6 (b)
(D3)	372.7	397.7	385.2 (b)
(D4)	463.4	382.8	423.1 (a)
(D5)	500.1	359.2	429.9 (a)
Mean	409.0	358.7	(*)
SE±	34.87		
CV%	9.85		

The means followed by the same letter(s) within colums are not significantly different at 0.01 probability level from each other according to Duncan Multiple Range Test (DMRT).

4.4. Stem diameter (cm)

Both genotypes exhibited slight insignificant increase in stem diameter with increasing rate of diammonium phosphate (DAP). Also this respect slight non significant difference between both genotypes was evidenced in (table 4.4.).

Table 4. 4.Effect of diammonium phosphate (DAP) fertilizer on stem diameter (cm) of two Maize genotypes:

TREATMENT	(C1)	(C2)	MEAN
(D1)	5.5	5.2	5.4 (a)
(D2)	5.5	5.4	5.5 (a)
(D3)	5.3	6.1	5.7 (a)
(D4)	6.2	5.9	6.1 (a)
(D5)	6.8	5.8	6.3(a)
Mean	5.9	5.7	(ns)
ES±	0.2814		
CV%	10.73		

The means followed by same letter(s) within colums are not significantly different at 0.05 probability level according to Duncan Multiple Range Test (DMRT).

4.5. Fodder Forage weight (t/ha)

The response of the two maize genotype (Eden and Boon) to the only slight difference was produced by genotype hybrid Eden over genotype hybrid Boon. (Table 4.5).

Diammonium phosphate (DAP) was erratic. The differences in fresh weight (t/ha) resulting for fertilizer application were not statistically significant, mean statistical differences in the fresh weight of were resulted due to the fertilize application.

Table 4. 5.Effect of diammonium phosphate (DAP) fertilizer on fresh forage weight tons/hectare of two Maize genotypes:

TREATENT	(C1)	(C2)	MEAN
(D1)	10.37	11.33	10.85 (a)
(D2)	9.0	8.8	8.9 (a)
(D3)	8.67	9.06	8.87 (a)
(D4)	9.87	10.83	10.35 (a)
(D5)	12.2	11.9	12.05 (a)
Mean	10.02	10.39	(ns)
ES±	0.9561		
CV%	22.16		

The means followed by the same letter(s) within colums are not significantly different at 0.05 probability level according to Duncan Multiple Range Test (DMRT).

CAPTER FIVE

DISCUSSION

Application of diammonium phosphate at the rates of 50, 100, 150, and 200kg/ha produced no statistically significant increases in the relative growth rate, stem diameter and the fresh weight of both maize genotype Eden and Boon over the control.Dawelbeit et al (2007) reported that vertisoils of the Central Sudan are deficiency in nitrogen (less than 0.1%) and available phosphorous (less than 10ppm).They added that the relatively high cation exchange capacity (CEC) and base saturation of such soils indicate their ability to retain added nutrients especially nitrogen and phosphorous. Since the soil of the experimental site at Shambat resemble, what has been mentioned above (Abdelgadir, (2010), however, this study revealed no increases in these evaluated characters as were expected. This could be attributed to the low nitrogen content of diammonium phosphate. That the highest rate of 200kg/ha contains only 36kg N/ha.While Nour et al, (2005) reported an increase in maize yield with the application of 86kgN/ha as urea.

Genotype Eden produced significantly taller plant than Boon due to the application of diammonium phosphate at the rate of 150 and 200kg/ha, compared to other treatment, without statistically significant differences between these two fertilizer treatments. However hybrid Boon showed no significant difference in plant heights among the treatments.

On the other hand, the genetic factor was clear in the leaf area, genotype Eden produced significantly greater leaf area compared with genotype Boon. Both genotypes responded positively to the application of diammonium phosphate at the rates of 100 and 150kg but the response decreased at 200kg for genotype Boon. Hybrid Eden showed steady significant increase in leaf area with the increase in the application rates of DAP.

Saha et al (1994) reported that maize, as other cereals, requires good supply of nitrogen and phosphorous so as to give high yield. Several other reports attributed the low yield of maize grown traditionally in Sudan due to the low soil fertility mainly nitrogen and phosphorous contents (FAO, 1971; Smaling, 1993; and Mokwunye, 1996).Nour et al (2005) concluded that maize grain yield was increased significantly with the application of up to 86kgN\ha.However, that showed that the crop did not respond to the application of phosphorous as triple super phosphate at the rate of up to 86kg P_2O_5\ha.However, Salih et al (2008) recommended that for maize production in irrigated central Gezira 43kg P_2O_5/ha as triple super phosphate coupled with 86kg N\ha as urea.

CHAPTER SIX

SUMMARY AND CONCLUSIOS

6.1. Summary

A field experiment was carried out in the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat in the winter season of 2012-2013.The main objective was to study the effect of different rates (0, 50, 100, 150, and 200kg) of diammonium phosphate (DAP) on growth and yield of Eden and Boon genotypes of forage maize. The results showed no significant differences in the relative growth rate, stem diameter, and the fresh forage weight characters, while the treatments resulted in significant differences in leaf area and plant height characters.

6.2. Conclusion

From the results obtained the following could be concluded:

1. For such experiment, diammonium phosphate should be supplemented with nitrogen source, it should be applied beyond the rate of 100kg/ha.
2. Genotypes Eden and Boon should be compared with released forage maize cultivars for further growth and yield evaluation.
3. The experiment should be repeated for another season to confirm the results.

REFERENCES

Abdelgadir, M.A.M.2010.Effect of Nitrogen Fertilizer on Irrigated Pearl Millet Pennisetum americanum (L.K.- Scham).Forage Yield .M.sc.Thesis.Sudan University of Science and Technology.pp83.

Abu Sawar, A.O.2004.Forage Crops Production in the Sudan (in Arabic).Khartoum University press.pp.198.

Adam, H.S.2002.Agricultural Climate. Second Edition(in Arabic).Gezira University Press.pp 119.

Ali, N.A.; A.F.Abu Sarra; E.A.Babiker; Elamin, A.E.M; M.S.Ali; and O.A.Dahab.2006.Response of long stable cotton to phosphorous in form of diammonium phosphate (DAP) under Gezira conditions .The National Crop Husbandry Committee .Wad Medani –Sudan.

Ali, N.A; M.M.Omer; M.S.Ali, A.F.AbuSarra; .E.M.Elamin; and O.A.Dahab.Response of wheat to nitrogen and phosphorous in form of diammonium phosphate under Gezira conditions .National Crop Husbandry Committee Wad Medani-Sudan.

Aoad,M.2006.Primary Feasibility Study for Corn Production at Gezira Province(inArabic)Arab Organization to Agricultural Development.

Dawelbeit, S.A; F.M.Salih; O.A.Dahab; and S.E.H.Ahmed, 2007.Current Research in Fertilizer Use in Irrigated Agriculture in Sudan.13th AFA International Annual Fertilizers Forum and Exhibition.Sharm Elseikh.Egypt.

Elhag, A.N.A.Ali; S.A. Mukhtar; A.E.Elamin; and O. A. Dahab. 2007. Response of Sugarcane ratoon crop to phosphorous in form of diammonium phosphate (DAP) under Guneid conditions. The 42 and Meeting of the National Crop Husbandry Committee.Wad Medani-Sudan.

FAO.1971.Improving SoilFertility.FAO Soil Bulletin 14.FAO.UN.Rome,Italy

Khair, M.A.M.1999.Principles of Forage Production (in Arabic).Agricultural Research Corporation.Wad-Medani-Sudan.pp.220.

Little, A.M.and F.J.Hill. (1978).Agricultural Experimentation: design and Analysis. John Wille and Sons, Inc.New York, USA.pp35.

Mangelsdorf, P.C. (1947).The origin and evolution of maize. Advances in Genetic, 1,161-207.

Ministry of Agriculture Khartoum State2010.

Mokwunye,A.D;Jager,D;and E.M.A.Smaling,1996.Restoring and maintaining the productivity of West Africa Soils.IFDC-Africa.Lome,Togo.

Nour, A.M.; M.E.Lazim; A.A.Hashim.2005.Effect of nitrogen and phosphorous on growth and yield of maize. Proceedings of 37th and 38th Meetings of the National Crop Husbandry Committee.1-5.Wad Medani-Sudan.

Osman, A.A.M.; E.A.Ali; A.E.Mohamed; A.I.Adam; and M. E. Hamad. 2008. Response of water stressed maize (Zea mays L.) to selected N-fertilizers. The 44th National Crop Husbandry Committee Meeting –Wad Medani-Sudan.

Rabeh, Y.M.M, (2007). The Effect of Different Phosphorus Levels on Growth and Yield of to Maize Cultivars (Zea mays L.) Under Rain-Condition. Msc. Thesis. University of Khartoum.pp3-4.

Radoford, P.J. (1967).Growth analysis formula their use and abuse. Crop 7:17-175.

Saha,H.M.,E.N.Gasheru;G.M.Kamau;M.K.ONeil;and J.K.Ranson.1994.Effect of nitrogen and plant density on the performance of Pwani Hybrid Maize.

Salih, M.A., E.S.Ali; E.A.Babiker; N.A.Ali, and A.E.Elamin. 2007. Response of two maize (Zea mays L.) varieties to different sources and rates of phosphorous.Th43th National Crop Husbandry Committee Meeting. Wad Medani-Sudan.

Sharma, R.K, (1972).Component of yield in sweet and pop corn.Madaras Agricultural Journal 61(8):381-385.

Stickler, F.C., S.Wearden and A, Wpouli, (1961) Leaf area determination grain, Agronomy Journal, 53:187-189.

Sys.C.; E.V.Ranst, J.Debaveye; and F.Beernaert.1993.Land Evalution.Part 3Crop Requirements.Brussels-Belgium-pp.201.

Zahir, Z.A.M., M.I.Navced, H.S.Zafar, M.Rehman, Arashad And M, Khalid, 2007.A.Evalution Of Compost Organic Waste Enriched With Nitrogen And L.Tryptophan For Improving Growth And Yield Of Maize.

Appendices

Appendix 1: The semi-desert climate

Sun-shine duration	3650 hour/year
Solar radiation	22.7MJ/m²/day
Maximum temperature	42ºc (May)
Minimum temperature	12ºc (January)
Temperature range	32 ºc
Rainfall	100-250mm/annum
Evaporation	2400mm/annum

Appendix 2: Chemical and Physical properties of the field soil.

PH	8.2
ECC ds/m	0.5
SAR	4.6
Soluble cation (meg/I)	
Ca +Mg	0.9
Na	3.1
K	0.3
CL meg/L	10.3
Na%	0.04
Pp.p.m	3.1
$CaCo^{3}$%	2.00
Sand%	15
Silt%	23
Clay%	62

ANOVA TABLE SUMMARY APPENDIX 3:

Sources of variation	Degree of freedom	Relative Growth Rate	Plant height	Leaves area	Stem diameter	Fresh forage weight t/ha
Replication	2	0.4280	2.0396	0.1267	1.0309	0.0530
Factor (A) fertilizer	4	0.4014 NS	0.6785*	0.9576*	1.2670 NS	1.2036 NS
Factor (B) genotype	1	0.1343 NS	0.6910*	13.3902**	0.6929 NS	0.1973 NS
Factor(A×B) interaction	4	0.6584 NS	0.9567*	5.3355*	1.7224 NS	0.1091 NS
Error	10	-	-	-	-	-
SE±	-	1.2023	8.4276	34.8701	0.2814	0.9561
CV%	-	28.36	21.23	9.85	10.73	22.16

*Significant different.

** High significant different.

(NS) Nun significant different.

Appendix 3.1. Relative growth rate (RGR)

Source	Degree of freedom	Sum of square	Mean square	F value
Replication	2	12.373	6.186	0.4280
Factor A fertilizer	4	23.210	5.803	0.4014
Error	8	115.634	144.54	-
Factor B genotype	1	1.408	1.408	0.1343
A×B interaction	4	27.617	6.904	0.6584
Error	10	104.860	10.486	-
Total	29	285.102		

Appendix 3.2.Plant height

Source of variance	Degree of freedom	Sum of square	Mean square	F value
Replication	2	2897.155	1448.577	2.0396
Factor A fertilizer	4	1927.555	481.889	0.6985
Error	8	5681.925	710.241	-
Factor B genotype	1	407.745	407.745	0.6985
A×B interaction	4	2258.275	564.569	0.9567
Error	10	5901.000	590.100	-
Total	29	19073.655		

Appendix 3.3.Leaves area

Source	Degree of freedom	Sum of square	Mean square	F value
Replication	2	3080.522	1540.261	0.1267
Factor A fertilizer	4	46574.759	11643.690	0.9576
Error	8	97273.962	12159.245	-
Factor B genotype	1	19121.828	19121.828	13.3902
A×B interaction	4	30477.624	7619.406	5.3355
Error	10	14280.516	1428.052	-
Total	29	210809.212		

Appendix 3.4. Stem diameter

Source	Degree of freedom	Sum of square	Mean square	F value
Replication	2	1.633	0.816	1.0309
Factor A fertilizer	4	4.013	1.003	1.2670
Error	8	6.334	0.792	-
Factor B genotype	1	0.265	0.265	0.6929
A×B interaction	4	2.636	0.659	1.7224
Error	10	3.825	0.383	-
Total	29	18.706		

Appendix 3.5. Fresh forage weight ton/ha

Source	Degree of freedom	Sum of square	Mean square	F value
Replication	2	0.969	0.484	0.0530
Factor A fertilizer	4	44.011	11.003	1.2036
Error	8	73.135	9.142	-
Factor B genotype	1	1.008	1.008	0.1973
A×B interaction	4	2.230	0.558	0.1091
Error	10	51.117	5.112	-
Total	29	172.470		