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Influence of Nitrogen Fertilization, Its Time of Application and Intra - Row Spacing on the Yield of Extra Early Maize in the Sudan Savanna, Nigeria

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Abstract: *Field experiments were conducted during the 2016 and 2017 dry seasons at Institute for Agricultural Research Farm Kadawa and Zobe Irrigation Fields in Kano and Dutsinma respectively to study the influence of intra-row spacing, nitrogen fertilizer and time of its application on the yield of Extra Early maize. The treatments tested consisted of factorial combinations of three levels of nitrogen (0, 60, and 120 kg/ha), three intra row spacings (15 cm, 25 cm, and 35 cm) and three different times of fertilizer application (at planting+4WAS, 2WAS+4WAS and 2WAS+4WAS+6WAS). The treatments were laid in a split-plot design in four replications with the combination of nitrogen levels and its times of application assigned to the main plot, while intra row spacing assigned to sub-plot. The results of the investigation showed that 25 cm and 35 cm intra row spacing produced the tallest plants, higher number of leaves per plant and number of grains per row at Dutsinma. At Kadawa most of the parameters showed no significant effect on intra row spacing. Nitrogen fertilizer at 120 kg/ha resulted in higher values of yield parameters at both locations, with a grain yield of 1700.50 kg/ha and 1234 kg/ha at Dutsinma for 2016 and 2017 seasons respectively, while at Kadawa N rate of 120 kg/ha produced grain yield of 6155.60 kg/ha and 1800 kg/ha in 2016 and 2017 growing seasons respectively. Time of fertilizer application affected the yield of the test crop at both locations.*

Keywords: *Maize, Intra-row spacing, Nitrogen, Fertilizer, Kadawa, Zobe*

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INTRODUCTION

Maize (Zea mays L.) is an important cereal crop in the world as it is ranked first in production and productivity (FAOSTAT, 2013). It is regarded as a strategic food and feed crop that provides great energy for humans and livestock. It is important in industrial production of ethanol. Much of world maize production is utilized for animal feed, but human consumption in many developing and developed countries is on the increase (Lakew et al, 2016).

Maize is a major staple food crop in Nigeria and across Africa. There is high demand for maize in industries for flour mills, breweries, confectionaries as well as for both human and animal consumption (Sabo et al., 2016). Despite high production rate of maize in Nigeria, average yields of 1.8 MT/ha (FAOSTAT, 2014) are still considered low as yields could be increased without increasing the area currently used for its cultivation. This low yield issue can be addressed especially through the use of optimum intra row spacing, optimum fertilizer rates applied at the right times and use of high yielding varieties (Sahel, 2017). Nitrogen rates and time of application are among the major abiotic factors limiting the productivity of the crop (Abebe and Feyisa, 2017).

Therefore the main objectives of this study are;

a) To determine the effect of different levels of nitrogen fertilizer on the yield of extra early maize.
b) To assess the response of extra early maize to different times of nitrogen fertilizer application.
c) To determine the influence of intra- row spacing on the yield of extra early maize.
d) To evaluate the combined effects of nitrogen fertilizer, times of nitrogen fertilizer application and intra row spacing on the yield of extra early maize in the Sudan Savanna, Nigeria.

MATERIALS AND METHODS

A. Experimental Location and Treatments

The experiment was conducted for two seasons (2016 and 2017 dry seasons) under irrigation at the Irrigation Research Station of the Institute for Agricultural Research (IAR) Kadawa: (ll°39'N, 08º20ˈE and 500 m above sea level), and Zobe irrigation fields at Dutsinma. (12027'N, 07°29'E and 542 m above sea level) both in the Sudan Savanna ecological zone of Nigeria. An extra early maturing maize (zea mays L.) variety SAMMAZ 12 (previously known as 95-TZEE-W) was used in the study. The treatments consisted of factorial combinations of three levels of Nitrogen (0 ,60 ,and 120 kgha-1) , three intra row spacings [15 cm, 25 cm and 35 cm] and three different times of fertilizer applications as follows; At planting+4WAS, 2WAS+4WAS and 2WAS+4WAS+6WAS. These treatments were laid out in a split plot design with nitrogen levels and its times of application assigned to main plot and intra-row spacing assigned to sub plot and replicated four times.

The areas for the gross and net plots of each sub plot were 15 m^2 (3 m x 5 m) and 7.5 m^2 (1.5 m x 5 m). There were four ridges in the gross plot and two ridges in the net plot of each sub plot. The seeds were sown by hand at the rate of two seeds per hole as per the intra-row spacing of 15, 25 and 35 cm respectively, keeping the inter row spacing of 75 cm-constant. Seedlings were thinned to one plant per stand at two weeks after sowing (WAS).

B. Observation and Data Collection

Five maize plants from each sub plot were randomly tagged for observations at harvest. The following observations were measured.

1- Number of ears per plant
2- Number of grains per row
3- 100-grains weight
4- Grain yield (kg/ha)

Statistical Analysis

General linear model procedure (GLM) of the Statistical Analysis System (SAS) package (SAS: 1990] was used for statistical analysis of all the data collected and differences between the treatments means were compared using Duncan's Multiple Range Test as described by Duncan (1955).

RESULTS AND DISCUSSION

Yield and Yield Components

The results of number of ears per plant, number of grains per row, 100-grains weight and grain yield (kg/ha) of extra early maize as influenced by intra row spacing, nitrogen fertilizer levels and time of fertilizer application at Dutsinma and Kadawa during 2016 and 2017 cropping season were presented in Tables 1 and 2.

Number of ears per plant

In both years at Dutsinma, 35 cm spacing produced more ears per plant followed by 25 cm and the lowest number was produced by 15 cm spacing. This could be as a result of less competition due to optimum plant population. While at Kadawa in both years 35 cm still recorded the highest number of ears per plant than the remaining spacing which were similar. Application of 60 and 120 kg/ha produced higher ears than the control at Dutsinma in 2016, while in 2017 in Dutsinma, nitrogen application of 120 kgN/ha recorded highest number of ears per plant followed by 60kg N/ha and the least number of ears per plant was from control, the same trend was recorded at both years at Kadawa. Time of fertilizer application was statistically significant where at planting+4WAS produced highest number of ears per plant than the other times of fertilizer application which were similar at Dutsinma in both years. This could be due to the fact that fertilizer was applied at the vegetative and reproductive stages, thus made the nutrient available for plant use. However, at Kadawa in both years at planting+4WAS and 2WAS+4WAS+6WAS gave more number of ears than 2WAS+4WAS, Adzemi et al., (2017) reported a similar result which was obtained in their work on sweet corn.

Number of grains per row

The number of grains per row is a genetically controlled factor but environmental and nutritional level may also influence it (Abdallah et al., 2016). Grain yield is directly related to number of grains per row. The more number of grains per row results in more grain yield. At Dutsinma in 2016, 35 cm and 25 cm spacing produced more number of grains per row than 15 cm which produced the least. In 2017, 35 cm recorded higher number of grains per row followed by 25 cm then 15 cm spacing which gave the lowest. At Kadawa in 2016, 25 cm and 35 cm intra row spacing produced similar number of grains but higher than 15 cm spacing which was at par with 35cm. There was no significant influence of spacing on number of grains per row at Kadawa 2017. Application of 120 kg and 60 kgN/ha at both locations in 2016 recorded similar number of grains per row but higher than the control. Nitrogen level had no significant influence on number of grains per row in both locations in 2017. Time of application of fertilizer at planting+4WAS and 2WAS+4WAS was higher than 2WAS+4WAS+6WAS at Dutsinma in 2017, Kadawa in 2016 and 2017. There was no significant effect of time of fertilizer application on number of grains per row at Dutsinma in 2016.

100-grain weight

100-grain weight is an important factor directly contributing to final grain yield of crop. There was no significant influence of intra row spacing on 100 grain weight in both locations and years except at Dutsinma in 2016 where 35 cm and 25 cm spacing recorded similar and heavier 100 grain weight of maize than 15 cm spacing. This result confirmed the report made by Ahmed et al., (2016) that 1000 grain weight declined with increased plant population. Nitrogen fertilizer application did not have impact on 100 grains weight at Dutsinma while application of 120kgN/ha and 60kgN/ha produced similar and heavier 100 grain weight than the control in both years at Kadawa. Time of application of fertilizer had no influence on 100 grain weight in both years at Dutsinma and in 2017 at Kadawa, but application of fertilizer at 2WAS, 4WAS and 6WAS gave heavier 100grain weight than the remaining times of fertilizer application which were similar at Kadawa in 2016.

Grain yield

Grain yield of a crop is the ultimate objective of all the research of grain crops. It is a factor which is related with many other factors such as plant density, number of cob per plant, number of row per cob, number of grains per row and 1000-grain weight etc. So an increase or decrease in any of the above factors may influence the crop yield.

In both locations and years, intra row spacing had no influence on grain yield except at Dutsinma in 2017 where 35 cm and 25 cm spacings recorded similar grain yield but higher than 15 cm. However, the higher grain yield obtained at closer intra-row spacing (25 cm), could be attributed to higher number of plants and harvestable cobs at optimum spacing. This result was in conformity with the findings of Namakka et al., (2009) who obtained highest grain yield from closest intra-row spacing of 25cm.

Nitrogen application had no significant effect on grain yield in both years at Dutsinma and Kadawa in 2017, while at Kadawa in 2016 control treatment produced the higher grain yield than the remaining fertilizer levels which recorded similar grain yield. At Dutsinma in 2017 application of fertilizer at planting and 2WAS + 4WAS, gave similar grain yield but higher than 2WAS, 4WAS and 6WAS which was comparable with 2WAS+4WAS and at Kadawa in 2017 at planting and 4WAS and 2WAS+4WAS recorded similar grain yield but higher than 2WAS, 4WAS and 6WAS. Zerihun and Hailu, (2017) reported that the purpose of timely application of nitrogen fertilizer was to synchronize plant requirement of the element in the soil throughout the growing season, with the availability of nutrient throughout the growing season, the fear of deficiency and consequently low yield of maize can be eliminated, similar result was reported by Haruna et al., (2018).

CONCLUSION

Higher growth, yield and yield components of maize, observed in Dutsinma at both years compared with Kadawa. These could be attributed to the favorable agro-climatic conditions particularly solar radiation and temperature. It can be concluded that extra early maize variety if grown with 120 kgN/ha and intra-row spacing of 25 cm fertilizer applied throughout the growing period will result in increased yield and yield component parameters at Dutsinma and Kadawa under dry season.

Table 1: Yield parameters of extra early Maize as influenced by intra-row spacing, Nitrogen fertilizer levels and time of fertilizer application at Dutinma during 2016 and 2017 cropping seasons.

Treatments	2016				2017			
	NoE/Plant	NoG/Row	100gw	GY (kg/ha)	NoE/Plant	NoG/Row	100gw	GY (kg/ha)
Spacings (cm)								
15	1.06c	22.7b	23.9b	1798.0	1.12c	22.2c	30.8	1086.9b
25	1.18b	24.6a	24.8a	1769.7	1.25b	23.7b	31.81	1277.3a
35	1.32a	24.9a	25.3a	1611.5	1.39a	25.1a	30.1	1289.7a
SE±	0.3	0.47	0.41	128.4	0.2	0.41	1.0	54.7
N-Level (kg/ha)								
0	1.09b	22.5b	24.1	1700.8	1.05c	23.4	30.4	1207.0
60	1.22a	25.1a	25.0	1292.3	1.26b	23.6	31.9	1212.8
120	1.25a	24.6a	24.8	1686.2	1.45a	24.0	30.4	1234.0
SE±	0.3	0.47	0.41	128.4	0.2	0.41	1.0	54.7
ToFA								
At P+4WAS	1.30a	24.4	24.6	1824.7	1.35a	24.2a	30.8	1305.0a
2WAS+4WAS	1.12b	24.3	25.1	1579.9	1.19b	24.0a	31.2	1250.9ab
2WAS+4WAS+6WAS	1.14b	23.5	24.3	1774.6	1.22b	22.8b	30.7	1097.9b
SE±	0.3	0.47	0.41	128.4	0.2	0.41	1.0	54.7
Interactions								
ST	ns	ns	ns	ns	**	*	ns	ns
SN	ns	ns	ns	ns	**	ns	ns	ns
NT	ns	ns	**	**	ns	ns	ns	ns
SNT	ns	ns	ns	ns	ns	ns	ns	ns

Means within the same column followed by the same letter(s) are not significantly different at 5% level of probability according to Duncan's Multiple Range test (DMRT).
ns=not significant, NoE=Number of ears, NoG=Number of grains, gw=grain weight, GY=Grain yield, ToFA=Time of fertilizer application, SE=Standard error.

Table 2: Yield parameters of extra early Maize as influenced by intra-row spacing, Nitrogen fertilizer levels and time of fertilizer application at Kadawa during 2016 and 2017 cropping seasons.

Treatments	2016				2017			
	NoE/Plant	NoG/Row	100gw	GY (kg/ha)	NoE/Plant	NoG/Row	100gw	GY (kg/ha)
Spacings (cm)								
15	1.14b	22.0b	24.9	5372.2	1.17b	21.8	24.2	1733.3
25	1.17bb	22.8a	25.1	5227.8	1.19b	22.0	24.7	1750.0
35	1.41a	22.4ab	25.6	4811.1	1.25a	20.9	24.3	1627.8
SE±	0.1	0.22	0.35	350.7	0.1	0.40	0.75	130.7
N-Level (kg/ha)								
0	1.04c	21.3b	24.6b	6155.6a	1.03c	21.5	22.5b	1650.0
60	1.13b	22.7a	25.1ab	4405.6b	1.10b	21.4	25.5a.9	1661.1
120	1.41a	23.2a	25.8a	4850.0b	1.48a	21.7	25.2a	1800.0
SE±	0.1	0.22	0.35	350.7	0.1	0.40	0.75	130.7
ToFA								
At P+4WAS	1.22a	23.0	24.8b	4916.7	1.21a	22.2a	25.0	1861.1a
2WAS+4WAS	1.14b	22.6	24.7b	5450.0	1.14b	21.7ab	23.1	1911.1a
2WAS+4WAS+6WAS	1.23a	21.6	26.1a	5044.4	1.25a	20.8b	25.2	1338.9b
SE±	0.1	0.22	0.35	350.7	0.1	0.40	0.75	130.7
Interactions								
ST	ns	ns	ns	ns	**	ns	ns	ns
SN	ns	ns	ns	ns	ns	ns	ns	ns
NT	ns	ns	ns	ns	ns	ns	ns	ns
SNT	ns	ns	ns	ns	ns	ns	ns	ns

Means within the same column followed by the same letter(s) are not significantly different at 5% level of probability according to Duncan's Multiple Range test (DMRT).
ns=not significant, NoE=Number of ears, NoG=Number of grains, gw=grain weight, GY=Grain yield, ToFA=Time of fertilizer application, SE=Standard error

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