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GRAIN YIELD RESPONSE OF TWO MAIZE (*ZEA MAYS L.*) VARIETIES TO OPTIMAL NITROGEN RATES IN DADIN-KOWA, GOMBE STATE, NIGERIA

YOHANNA H.[1,3], IVOKE, M.A.[2], BARNABAS, B.[1, 3], ABUBAKAR I.A.[1, 3], ABBA-AJI, A.A.[1, 3], AND MUHAMMED A.B [1, 3]

[1]TETFund Centre of Excellence for Integrated Farming Systems, Federal Polytechnic Bauchi, Bauchi, Nigeria. [2]Dept. of Horticultural Technology, Federal College of Horticulture, Dadin-Kowa, Gombe State. [3]Dept. of Agricultural Technology, Federal Polytechnics, Bauchi, Bauchi State.

Corresponding Author: ivokemichael@gmail.com

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Abstract

A field trial was conducted at the Teaching and Research Farm of the Federal College of Horticulture, Dadin-Kowa, Gombe State in the Northern Guinea Savanna belt of Nigeria to determine grain yield response of two maize (zea mays l.) varieties to optimal nitrogen rates in dadin-kowa. Two maize varieties (SAMAZ-15 and SAMAZ-18) and four nitrogen rates were used to form a two-factors Split-plot-experiment comprised of eight treatments laid in a Randomized Complete Block Design (RCBD) with three replications. The Nitrogen rates were: 0 kg ha-1, 50 kg ha-1, 100 kg ha-1 and 150 kg ha-1 applied in two split dozes; first doze at two weeks after sowing and second dose at five weeks after sowing, while Phosphorus (P) and Potassium (K) were applied once at two weeks after sowing at a constant rate of 50 kg ha-1 respectively. The results showed that nitrogen application significantly affected all growth and yield parameters measured except for number of days to tasseling and 50% tasseling. Both varieties responded positively to

Keywords: Nitrogen fertilizer, Maize variety, Growth, Grain yield, Response

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increased nitrogen up 100 kg N ha-1, beyond which no significant increase was observed. Grain yield gave higher performance values (5.29 tonha-1) at 150kg N ha-1 than 4.91 tonha-1 at 100kg N ha-1, but with no significant difference. The interaction between varieties and nitrogen showed no significant difference. Base on the results of this study, application of 100 kg N ha-1 is optimal for maximum grain yield of maize under Dadinkowa conditions. We therefore recommend 100 kg N ha-1 for maximum productivity.

Introduction

Maize (Zea mays L.) is one of the most important cereal crops globally, providing food, feed, and industrial raw materials (FAO, 2022). It is a staple food for millions of people, especially in developing countries, and a crucial source of calories, proteins, vitamins, and minerals (Shiferaw et al., 2011). Maize provide over 20% of total calories to human diets in 21 countries and over 30% in 12 countries that are home to a total of more than 310 million's people (Shiferaw et al 2011), but forecast indicate that by the year 2050, the demand for maize in developing countries will double owing to the rapid growth in poultry industries, the biggest driver of growth in maize production. (Rosegrant et al., 2009; Prasanna, 2014). In 2018, about 10.2 million tons of maize was produced from 4.8 million hectares, making Nigeria the highest producer in Africa (FAO, 2018).

Yield decrease in the tropical areas, relative to the yield in the temperate area, is largely due to low nutrient status of tropical soils especially nitrogen, phosphorus and potassium as a result of wrong agricultural practices including slash and burn farming system associated with bush fallow in addition to excessive leaching of the soil nutrients occasioned by high rainfall (Adediran and Banjoko, 2003). It was generally observed that maize fail to produce good grain in plots without adequate nutrients (Adediran and Banjoko, 2003). Inorganic fertilizers exert strong influence on plant growth, development and yield (Stefano et al., 2004). The availability of sufficient growth nutrients from inorganic fertilizers lead to improved cell activities, enhanced cells multiplication and enlargement and luxuriant growth (Fashina et al., 2002). The majority of savanna soils have been so depleted that growing most crops without fertilizer is nearly impossible (Kamara et al., 2020). Decline in soil fertility in savanna regions, attributed to population pressure and low fertilizer use has rendered the soil unable to adequately support maize yields without proper fertilization (Kamara et al., 2020). Soils deficient in both macronutrients, such as N, P, and K, as well as other key micronutrients such as copper and zinc cannot support maize yields adequately without proper fertilization (Kamara et al., 2020). Nitrogen application rate of 100kgha-1 is required for maize in the Northern part

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of Nigeria (Kamara et al., 2020). Maize yields below 1tonha-1 can occur without fertilizer use on poorly fertile soil (Kamara et al., 2020). This study, therefore, seeks to determine the effect of nitrogen application on the growth and yield of maize and also to identify the optimal application rate that promotes resource efficiency to guide farmers in applying the right amount for maximum yield. Identifying this effective nitrogen rate will not only boosts agricultural productivity but also minimizes resource wastage and foster sustainable farming practices.

Experimental location

The experiment was conducted at the Teaching and Research Farm of Federal College of Horticulture Dadinkowa, located at latitude 1103. N, longitude 1002. E and altitude of 240m above sea level. Average annual rainfall in the study area is 1021.80mm, mostly distributed between the months of May and October, while the mean daily temperature ranges from 220C to 350C (UBRBDA, 2015).

Experimental Materials and Sources

Two maize varieties were used for the experiment, SAMMAZ-15 and SAMMAZ-18 and were sourced from the Institute for Agricultural Research (IAR) Zara, Kaduna State.
Nitrogen (N) sourced from urea [(NH2)2CO)] – 46%, Phosphorous (P) sourced from single super phosphate (P_2O_5) – 20% and Potasium (K) sourced from muriate of potash (K_2O) – 60% were purchased from Dadinkowa market.

Treatments and Experimental Design

The treatments used were four levels of nitrogen: 0kg N ha^{-1} (control), 50 kg N ha^{-1}, 100 kg N ha^{-1} and 150 kg N ha^{-1} and two varieties of maize: SAMAZ 15 and SAMAZ 18, forming a two-factor Split-plot of eight treatments laid in a Randomized Complete Block Design (RCBD). The field was divided into three Blocks each of which was divided into two Main plots. Each Main plot was further divided into four subplots. Each treatment was replicated three times, giving a total of twenty-four (24) experimental units/ plots. Each plot contained 48 stands of 1 plant per stand. The entire experimental field had a plant population of 1152 plants. The field was kept pest free throughout the trial period.

Treatments (Fertilizer) Application

The nitrogen was applied in two split applications. The first dose at two weeks after sowing and the second at five weeks after sowing. Phosphorus and potassium were applied together. With the nitrogen at the rate of 50kg ha^{-1} respectively. The application

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was by dollop method 5 cm away from the plant and at the depth of 5 cm. All application was done when the soil was moist.

Data collection

Observations were made on bi-weekly basis on the following growth and yield characters:

Plant Height (cm): The height of the plant was measured using tape rule on five randomly selected plants at 2, 4, 6 and 8 weeks after sowing, and recorded.

Leaf Number: The number of leaves produced by the five (5) randomly selected plants were counted and recorded at 2, 4, 6 and 8 weeks after sowing.

Stem Gird (mm): The stem gird of the five (5) randomly selected plants were measured using digital Vernier Caliper at 2, 4, 6 and 8 weeks after sowing, and recorded.

Leaf Area: Leaf area of the five (5) random selected plants were taken by measuring the length and the width, and the Area was calculated as thus:

Area (cm^2) = Length (Y_{cm}) x width (Z_{cm}).

Number of Days to Tasseling: This was measured by counting the number of days from the date of sowing to the date of first plant tasseling from each plot.

Number of Days to Fifty percent (50%) Tasseling: This was measured by counting the number of days from the date of sowing to the date when 50% (half) of the plant population from each plot have produced tassels.

Number of Cobs per Plot: This was taken after harvest by counting the number of cobs per plot.

Fresh Cob Yield (kg): This was recorded by weighing the fresh cobs per plot in kg $plot^{-1}$ and converted to ton ha^{-1} using the formula:

Weight per plot (kg) / Plot size ($6m^2$) X $10,000m^2$ (hectare size) / 1000

Grain Yield (kg): This was recorded per plot after shelling (removing the seeds from the cobs) and weighed using a digital hanging scale, and converted to $tonha^{-1}$ using the formula:

Weight per plot (kg) / Plot size ($6m^2$) X $10,000m^2$ (hectare size) / 1000

1000-kernel weight (g): The thousand-grain yield was measured by counting 1,000 grains per plot and weighed using a digital hanging scale, and converted to kg ha^{-1} using the formula:

Weight per plot (kg) / Plot size ($6m^2$) X $10,000m^2$ (hectare size) / 1000

All data collected were subjected to analysis of variance (ANOVA) using Genstat Release 10.3 Discovery Edition 4.0 software (GENSTAT, 2011). Treatment means were separated using Fishers' Least Significant Difference at 5% level of probability.

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RESULTS AND DISCUSSION

The effect of nitrogen rates and varieties on maize plant height and number of leaves at 4, 6 and 8WAS is presented in Table 1.

The results obtained showed that nitrogen significantly influenced the maize plant height and number of leaves. All the three rates of the nitrogen gave a significant effect across the observation periods (4, 6 and 8 WAS) respectively as compared to control (0kg N ha^{-1}). At 8WAS, 150 kg N ha^{-1} produced the highest mean scores (233.30 cm) of plant height, while 100 kg N ha^{-1} produced a higher mean score (16.458) of number of leaves, but with no significant difference, statistically, between them, but they both significantly performed better than 50 kg N ha^{-1}. The two varieties (SAMAZ-15 and SAMAZ-18) showed no significant difference between them. The result is in agreement with the reports from Stefano *et al*., (2004) who stated that inorganic fertilizers exert strong influence on plant growth, development and yield. They also found that fertilizer application resulted in luxuriant growth with excessive leaves and higher number of leaves which contribute to a better canopy cover that result in weeds suppression. Fashina *et al*., (2002 and Saeed et al., (2001) reported that height of plant is an important growth character directly linked with the productive potential of plants in terms of grains; noting that the availability of sufficient growth nutrients from inorganic fertilizers lead to improved cell activities, enhanced cells multiplication and enlargement and luxuriant growth.

The effect of nitrogen rates and varieties on maize stem girth and leaf area at 4, 6 and 8 WAS is presented in Table 2.

The results revealed that there was significant effect of nitrogen on the maize stem diameter and leaf area growth performance compared to the control (0kg N ha^{-1}). At 8 WAS, 150 kg N ha^{-1} showed no significant difference from 100 kg N ha^{-1}. The highest mean diameter scores were recorded at 6 WAS as there was decline in the mean stem diameter at 8 WAS, suggesting the transition from the growth phase to the reproductive phase, thus transferring greater part of the energy to the grain formation and development. The two varieties recorded no significant difference between them. The results supported the claim from (Stefano *et al*., 2004) who earlier from their findings reported that fertilizer application resulted in luxuriant growth with excessive leaves and higher number of leaves which contribute to a better canopy cover that result in weeds suppression.

The effect of nitrogen rates and varieties on maize yield parameters are presented in Table 3.

The results showed a significant yield improvement as recorded (Table 3). The yield increased with increased rate of nitrogen up to 100 kg N ha^{-1}, beyond which no significant

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increase was observed. Fresh cob yield of 10.81 tons ha^{-1} and 11.86 tons ha^{-1} were recorded for 100 kg N ha^{-1} and 150 kg N ha^{-1}, respectively (Table 3). This is consistent with the report by Adediran and Banjoko (2003) who earlier reported that the use of inorganic fertilizers on crops increased yield. They also observed in their experiment that there was substantial depletion of nutrients with the yields where no nitrogen was applied, similarly observed in the Table 3. They also noted that maize fail to produce good grain in plots without adequate nutrients (as observed in Table 3). This position was equally reported by Uyovbisere *et al*., (2000) who reported that there was substantial depletion of nutrients when no fertilizer was applied and nitrates and available phosphorus were substantially reduced with cropping in humid zone of Southwestern Nigeria. Kolawole and Joyce (2009) reported that nitrogen fertilizer increased significantly fresh cob yield and have a profound effect on the overall performance of maize. According to the findings of Babatola (2006), they reported that increasing level of fertilizer application increased growth and yield of crops. According to Kamara *et al*. (2020), they recommended that 100 kg N ha^{-1} is required for maize in the Northern part of Nigeria. Their report was confirmed by the result of this study which showed that there was no significant difference between 100 kg N ha^{-1} and 150 kg N ha^{-1}, even though 150 kg N ha^{-1}gave higher grain yield (5.29 tons ha^{-1}) than 100 kg N ha^{-1} (4.91 tons ha^{-1}) (Table 3).

CONCLUSION

The study showed that maize yield was positively influenced by the application of Nitrogen, which increased with the increasing rates of the nitrogen up to 100 kg N ha^{-1}, beyond which no significant increase was observed, even at 150 kg N ha^{-1} despite having higher mean yield value. The result of this study is consistent with the report by Kamara *et al*. (2020) which recommended 100 kg N ha^{-1} for maize in the Northern part of Nigeria. We, therefore, recommend 100kg N ha^{-1} to the farmers in Dadinkowa while also maintain the standard of other agronomic practices to promote resource efficiency and maximum yield.

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Table 1: Effect of Nitrogen rates and Varieties on Plant Height and Number of Leaves at 4, 6 and 8 WAS

Treatments	Plant Height (cm)			Number of Leaves		
Varieties	4WAS	6WAS	8WAS	4WAS	6WAS	8WAS
SAMAZ-15	75.08	159.30	220.30	6.812	7.833	16.042
SAMAZ-18	77.08	158.90	220.10	6.771	7.604	16.042
L.S	NS	NS	NS	NS	NS	NS
L.S.D. (<0.05)	5.320	11.95	18.74	0.766	1.186	1.763
Nitrogen Rates						
0kg ha^{-1}	63.08	142.90	204.20	6.083	6.833	15.357
50kg ha^{-1}	76.93	157.60	213.30	6.625	7.625	15.917
100kg ha^{-1}	80.29	163.90	229.90	7.042	8.165	16.458
150kg ha^{-1}	84.03	171.90	233.30	7.417	8.250	16.417
L.S	*	*	*	*	*	*
L.S.D. (<0.05)	6.019	13.19	9.68	0.543	0.562	0.446
Interaction (Variety X Fertilizer)						
L.S	*	*	*	*	*	*
L.S.D. (<0.05)	7.730	16.99	15.68	0.766	0.960	1.379

Key: WAS = Weeks after Sowing; LS = Level of Significance; LSD = Least Significant Difference; NS = Not Significant; * = significant.

Table 2: Effect of Nitrogen rates and variety on Stem Diameter and Leaf Area at 4, 6 and 8 WAS

Treatments	Stem Diameter (cm)			Leaf Area (cm^2)		
Varieties	4WAS	6WAS	8WAS	4WAS	6WAS	8WAS
SAMAZ-15	22.81	24.30	22.96	531.70	802.80	847.80
SAMAZ-18	23.63	25.13	23.61	558.10	833.40	885.20
L.S	NS	NS	NS	NS	NS	NS
L.S.D. (<0.05)	3.162	2.904	2.471	183.01	57.02	82.52
Nitrogen Rates						

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Treatments	Stem Diameter (cm)			Leaf Area (cm²)		
0kg ha^{-1}	19.94	22.05	20.96	459.10	728.80	772.70
50kg ha^{-1}	23.77	24.55	22.71	538.00	804.70	848.10
100kg ha^{-1}	24.15	25.28	24.69	562.70	836.40	906.60
150kg ha^{-1}	25.01	26.97	24.79	619.70	902.50	938.80
L.S	*	*	*	*	*	*
L.S.D. (<0.05)	1.689	1.233	1.407	57.57	55.15	53.50
Interaction (Variety X Fertilizer)						
L.S	*	*	*	*	*	*
L.S.D. (<0.05)	2.685	2.280	2.164	139.85	72.31	77.77

Key: WAS = Weeks after Sowing; LS = Level of Significance; LSD = Least Significant Difference; NS = Not Significant; * = significant.

Table 3: Effect of Nitrogen Rates and Variety on Number of Days to Tasseling, 50% Tasseling, Number of Cobs Plot^{-1}, Fresh Cob Yield, Grain Yield and Thousand Grain Yield of Maize.

Treatments	NDT	NDT 50%	Number of Cobs Plot^{-1}	FCY (tons/Ha)	Grain Yield (ton/Ha)	TGY (ton/Ha)
Varieties						
SAMAZ-15	44.67	49.17	25.58	9.05	4.05	0.442
SAMAZ-18	45.50	49.33	26.92	9.95	4.05	0.426
L.S.	NS	NS	NS	NS	NS	NS
L.S.D. (< 0.05)	3.187	0.949	4.041	1.237	0.767	0.075
Nitrogen Rates						
0kg ha^{-1}	46.50	49.67	23.33	6.98	3.07	0.406
50kg ha^{-1}	45.00	49.17	25.33	8.36	3.83	0.420
100kg ha^{-1}	44.67	49.00	27.67	10.81	4.91	0.450
150kg ha^{-1}	44.17	49.17	28.67	11.86	5.29	0.460
L.S.	*	*	*	*	*	*
L.S.D. (< 0.05)	1.519	0.593	2.730	1.066	0.687	0.014
INTERACTION (Variety X Fertilizer)						
L.S.	*	*	*	*	*	*
L.S.D. (< 0.05)	2.586	0.875	3.909	1.427	0.913	0.062

Key: LS = Level of Significance; LSD = Least Significant Difference; NS = Not Significant; NDT = Number of Days to Tasseling; NDT 50% = Number of Days to 50% Tasseling; FCY = Fresh Cob Yield; TGY = Thousand Grain Yield; * = significant.

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