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Research Article
Response of Maize (*Zea mays* L.) Varieties to Nitrogen Application in the Guinea Savanna Agro-Ecology of Ghana

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Abstract
Background and Objective: Maize is one of the oldest cultivated crops and, globally, it is the third most important cereal after wheat and rice in the area and total production. Compared to all other cereals, maize has the highest average yield per unit area. The objective of the research was to evaluate maize varietal response to different nitrogen fertilizer rates. **Materials and Methods:** The treatment consisted of 2 factors, namely, 6 varieties of maize and 4 levels of nitrogen application rates. These were arranged in 6×4 factorial combinations and laid out using Randomized Complete Block Design (RCBD) with 3 replications. Data collected were subjected to combined analysis for variation in factorial experiments in RCBD using Genstat statistical package edition 18. Means were separated using Duncan's multiple range test at a 5% probability level. **Results:** The study revealed that varieties such as IWD-C3-SYN-F2 and OBATAMPA produced the highest grain yield and growth parameters (agronomic traits) relative to other varieties. Maximum grain yield and biomass production also occurred at nitrogen application rates of 90 and 120 kg N ha^{-1}. **Conclusion:** Varieties such as IWD-C3-SYN-F2 and OBATAMPA and N rate of 90 kg N ha^{-1} are therefore, recommended to be used for maize production by the resource-poor farmers in the Guinea Savanna Agro-Ecology of Ghana.

Key words: Nitrogen rates, pistillate flowers, growth parameters, yield components, Guinea Savanna, agroecology, resource-poor farmers

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Maize (*Zea mays* L.) belongs to the tribe *Maydeae* of the grass family Gramineae (Poaceae). It is a native of Southern Mexico[1]. Maize is a versatile crop grown over a range of agro-climatic zones[2]. The genus Zea (zela) is derived from a Greek name for food grass. The genus Zea consists of 4 species of which *Zea mays* L. is economically important. The other *Zea* species, referred to as teosintes are largely wild grasses native to Mexico and Central America[1]. The number of chromosomes in *Zea mays* is 2n = 20. Maize is a tall, determinate and monoecious plant. The plant has separate staminate and pistillate flowers on the same plant. It is an annual C_4 plant varying in height from 1-4 m[2]. Maize is generally a protandrous plant, that is, the maize flower matures earlier than the female. Maize was introduced into Ghana by the Portuguese traders at the beginning of the 16th century and has become ultimately, the major essential cereal crop cultivated in the country. Maize ranks 3rd globally in the area and total production, after wheat and rice[1]. Maize remains an essential cereal crop and is a polyvalent seed. The large percentage of maize produced in Africa is utilized for household consumption even though it is progressively used for feeding animals[3]. In Northern Ghana, maize stovers are used as fuelwood and for several decades, maize has been used as an industrial raw material from which products such as cornflakes, oil, jam, alcohol and paper are produced[4].

The area planted to maize in Ghana is approximately 1 million ha. The per capita consumption of maize is also estimated at 44 kg per person per year and the national demand is projected to grow at about 1.83% per annum[5]. Maize is an important cereal cultivated in all the 5 agro-ecological zones of Ghana. These include forest, Guinea Savanna, coastal savanna, transitional zone and Sudan savanna[7]. The Guinea and Sudan savannas however have the highest potential for increased maize production and productivity due to high solar radiation and low incidence of diseases[6]. Maize is one of the country's major food security crops. Furthermore, it also remains Ghana's most consumed cereal crop, with surging production since 1965[7]. Maize is largely the utmost prudent cereal crop in Ghana and it is cultivated largely by rural and peri-urban farm families and the resource-poor smallholder farmers[8]. It is extensively eaten nationwide and is Ghana's second most essential staple food after cassava[9]. The maize crop, however, has a minimum stress-tolerant among the three main cereal crops[10].

The maize crop plays an important role in improving the nutrition and livelihoods of the people of Ghana and the world at large. Maize is the principal staple crop that is produced and consumed by most farm households in Ghana. It is produced predominantly by smallholder resource-poor under rain-fed conditions. The crop is adapted and grows well in most of the ecological zones of Ghana including the Northern savanna. It is a major source of calories in Ghana. It has nearly replaced traditional staple crops like sorghum and pearl millet in Northern Ghana. Maize production in Ghana is, however, bedevilled with problems of soil degradation, low soil nutrient levels (particularly nitrogen and phosphorus), inappropriate fertilizer application, leaching of soil minerals as well as bush burning. This has been the major cause of the low yield of maize in the Guinea Savanna agro-ecology of Ghana[11]. The average maize grain yield in Ghana is about 1.7 t ha^{-1} as against an estimated achievable yield of about 6.0 t ha^{-1} [12] as a result of low nitrogen and phosphorus levels in the soil, inappropriate fertilizer application, drought and *Striga* infestation[13]. Nitrogen is an essential part of chlorophyll[14] and also forms a significant unit of many enzymes, nucleic acid and proteins. Therefore, deficiency or over-application of nitrogen affects maize yields negatively[15]. An optimal nitrogen application enhances the protein content aside from the resultant significant increase in the yield of maize crops[16]. Nitrogen deficiency stems from low crop development which reduces crop yield, leaf area, leaf number and photosynthetic rate. To boost the productivity of the maize crop, various nitrogen fertilizer application regimes need to be critically examined to determine the optimum N application rate for increased maize grain production.

The objective of the study was to examine the varietal response of maize to different nitrogen fertilizer application rates.

MATERIALS AND METHODS

Experimental area: The study was conducted at Nyankpala in the Northern Region of Ghana. This research project was conducted from 2016-2017. The experimental site is located in the Guinea Savanna agro-ecological zone of Ghana. The Guinea Savanna zone covers an area of 147,900 km^2, which is over one-third of the entire land area of Ghana[17]. The area is characterized by high temperature and low humidity during most parts of the year. The rainfall pattern is monomodal and erratic with an annual mean of 1100 mm which mostly begins in April-May and ends in October. The area is also characterized by a long dry season (4-6 months) which normally takes place from November to April. Intermittent dry spells often lasting up to 2-4 weeks occur during the growing season[17]. The rainfall, evaporation and temperature patterns monitored at Nyankpala from January-December during 2012, 2013 and 2014 cropping seasons are presented in Table 1.

Table 1: Rainfall, evaporation and temperature variations at the experimental location from January-December during 2012, 2013 and 2014 cropping seasons

	Total rain fall (mm)			Total evaporation (mm)			Mean temperature (°C)		
Months	2012	2013	2014	2012	2013	2014	2012	2013	2014
January	0.0	0.0	0.0	195.9	230.9	185.0	26.6	27.3	28.4
February	41.7	2.4	2.4	209.4	223.2	202.2	30.2	34.6	29.9
March	1.7	89.6	25.7	245.0	194.8	223.3	32.7	44.1	31.9
April	108.9	66.8	50.7	163.6	167.1	176.5	30.6	37.8	31.5
May	88.1	30.0	45.6	147.1	168.2	174.2	29.0	29.8	31.2
June	148.9	161.9	166.5	114.9	110.4	117.1	27.6	31.3	29.4
July	198.8	203.8	122.9	92.3	116.6	97.2	26.1	26.7	27.9
August	77.0	217.4	240.0	80.1	85.6	78.0	25.6	26.0	26.9
September	209.1	164.1	195.6	74.4	77.6	80.5	26.5	26.4	26.8
October	151.3	119.7	153.1	98.9	93.7	98.2	27.6	27.6	28.1
November	0.0	23.3	0.0	138.7	127.4	139.0	29.1	29.0	30.0
December	4.8	0.0	0.0	118.3	163.2	174.8	27.6	27.5	28.4

Source: SARI annual reports for 2012, 2013 and 2014

Table 2: Physico-chemical characteristic of the soil at horizon 0-15 cm at Nyankpala

Parameters	Value	Remarks
Texture	Sandy loam	
pH	6.50	Mod. acidic
Organic matter (OC)	1.9	Low
Total phosphorus (P) (mg kg^{-1})	1.80	Very low
Organic carbon (g kg^{-1})	1.58	Very low
Total nitrogen (N) (g kg^{-1})	0.65	Very low
Exchangeable potassium (K) (cmol. kg^{-1})	0.65	Low

Source: Field experiment, 2016

Soil analysis: Before planting, soil samples were randomly collected from four different cores at 0-15 cm for the determination of soil physical and chemical properties using a soil auger. Results from soil analysis indicated that soils at the experimental site were largely Sandy loam and classified as Ferric Acrisol, equivalent to Typic Haplustult in the USDA soil classification system. The soil pH was 6.5 with very low nitrogen and organic matter content. The result of the initial soil analysis is presented in Table 2.

Land preparation and experimental design: The experiments were conducted at the experimental field of the CSIR-Savanna Agricultural Research Institute (SARI) at Nyankpala in the Northern Region of Ghana. In each of the experimental years, the land was prepared by ploughing, after which all debris was removed. Land demarcation was done using lining and pegs. The prepared land was levelled using a hoe before seeds of the genotypes were planted. Six maize varieties obtained from the Savanna Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR) were screened under 4 nitrogen fertilizer application rates for improved grain yield, yield components and other growth/agronomic characteristics during the 2016 and 2017 cropping seasons under field experimental conditions. The treatment consisted of 2 factors, namely, 6 varieties of maize and 4 levels of nitrogen application rates. The 6 varieties used for the study were: TZE-W-DT-STR-C4, IWD-C3-SYN-F2, GH120 DYF/D POP, OBATAMPA, DT-STR-W-C2 and COMP 1 SYN. The four nitrogen rates used for the study were: 0, 60, 90 and 120 kg N ha^{-1}. These were arranged in 6×4 factorial combinations and laid out using Randomized Complete Block Design (RCBD) with three replications. The control plants (0 kg N ha^{-1}) did not receive nitrogen fertilizer. The furrows between blocks/replications were 1.5 m whiles 1 m space was left in between plots. A plot size of 6×4 m was used with a planting distance of 75×40 cm. Planting was done in July, 2016 and 2017. Three seeds per hill were planted and later thinned out to two per hill after germination. The plant population for all plots were 66,666 plants ha^{-1}.

Cultural practices: Four nitrogen fertilizer regimes were applied (0, 60, 90 and 120 kg N ha^{-1}). The side placement method of fertilizer application was employed in a split application. Basal fertilizer (NPK 15-15-15) was applied at 2 weeks after planting at the rate of 0 and 45 kg N PK ha^{-1}. Plants were top-dressed with additional N using urea at the rate of 0, 15, 45 and 75 kg N ha^{-1} at 4 weeks after planting. Pre-emergence chemical weed application was carried out. Application of a combination of Pendimethalin [N-(1-ethyl propyl)-3, 4-dimethyl-2, 6-dinitrobenzenamine] and Gesaprim [2-chloro-4-(ethylamino)-6-(isopropylamino)-5-triazine] at a rate of 1.5 L and 1.0 L ha^{-1} were used at planting. Where there was heavy weed growth before planting, an additional application of Paraquat (1, 1-dimethyl-4, 4-bipyridinium ion) was also carried out at 1.0 L ha^{-1}. Hand weeding was also carried out to keep the experimental field free of weeds 4 weeks after planting.

Data collection and analysis: During the 2016 and 2017 cropping seasons, data on chlorophyll content, number of leaves, plant height, days to 50% tasselling, days to 50% silking, days to 50% physiological maturity, hundred seeds weight, total biomass production, number of grains per cob and total grain yield were recorded and subjected to combined analysis for variation in factorial experiments in RCBD using Genstat statistical package edition 18. Means were separated using Duncan's multiple range test at a 5% probability level.

RESULTS

Effect of variety on growth parameters

Leaf, shoot and biomass production: Two seasons were combined and analyzed and the results indicated that the variety GH120 DYF/D POP produced the lowest number of 11 leaves, while OBATAMPA produced the highest number of 14 leaves (Table 3). There were significant differences ($p<0.05$) between OBATAMPA and GH120 DYF/D POP to leave production (Table 4). COMP 1 SYN recorded the highest plant height of 181 cm whilst TZE-W-DT-STR-C4 recorded the least plant height of 121 cm. There was a significant difference ($p<0.05$) between COMP 1 SYN and TZE-W-DT-STR-C4 for shoot production.

Total biomass production was highest among OBATAMPA (13500 kg ha^{-1}) but this was not significantly different ($p>0.05$) from that of COMP 1 SYN which recorded biomass of 13000 kg ha^{-1}.

Silk production and physiological maturity: The variety COMP 1 SYN took a maximum of 68 days for silk production whilst DT-STR-W-C2 took a minimum of 59 days to produce silk (Table 3). There was a significant difference ($p<0.05$) in terms of the number of days for silk production between the varieties COMP 1 SYN and DT-STR-W-C2 (Table 4). COMP 1 SYN took a maximum of 93 days to attain physiological maturity and this was significantly different from all the other five varieties to days to physiological maturity.

Effect of variety on grain yield and 100-grain weight: OBATAMPA recorded the highest grain yield of 3.6 t ha^{-1} under all N application rates (Table 3). The yield was however not significantly different ($p>0.05$) from that of IWD-C3-SYN-F2 (3.5 t ha^{-1}) (Table 4). The variety GH120 DYF/D POP produced the lowest grain yield of 2.5 t ha^{-1}. For grain weight, OBATAMPA recorded the highest of 45 g but this was not significantly different ($p>0.05$) from that of IWD-C3-SYN-F2 (39 g) and TZE-W-DT-STR-C4 (39 g).

Effect of nitrogen rate on growth parameters

Leaf, shoot and biomass production: All the varieties applied with 90 kg N ha^{-1} recorded an average of 13 leaves, whilst the varieties applied with 0 kg N ha^{-1} recorded the lowest of 10 leaves (Fig. 1). They were no significant differences

Table 3: Effect of variety on yield and growth parameters measured during the 2016 and 2017 cropping seasons

	Growth and yield parameters						
Varieties	Number of leaves	Plant height (cm)	Days to 50% silking	Days to 50% physiological maturity	Total biomass (in 1000 kg ha^{-1})	100-grain weight (g)	Grain yield (t ha^{-1})
TZE-W-DT-STR-C4	13^{ab}	121^{d}	60^{cd}	83^{d}	11^{ab}	39^{ab}	2.8^{ab}
IWD-C3-SYN-F2	12^{abc}	131^{c}	65^{b}	90^{b}	13.5^{a}	39^{ab}	3.5^{a}
GH120 DYF/D POP	11^{c}	161^{b}	60^{cd}	83^{d}	8^{b}	31^{c}	2.5^{b}
OBATAMPA	14^{a}	158^{b}	66^{ab}	88^{c}	13.5^{a}	45^{a}	3.6^{a}
DT-STR-W-C2	12^{abc}	130^{c}	59^{d}	83^{d}	11^{ab}	36^{bc}	2.7^{ab}
COMP 1 SYN	12^{abc}	181^{a}	68^{a}	93^{a}	13^{a}	38^{b}	2.9^{ab}
Mean	12.1	147	62.9	86.1	11.7	38	2.9
SEM	1	2	2	2	1	1	1

SEM: Standard error of the mean

Table 4: Analysis of variance for yield and yield components as influenced by varietal, N rates and interaction effects in 2016 and 2017 cropping seasons

		F probability (0.05)						
Source of variations	DF	Number of leaves	Plant height (cm)	Days to 50% silking	Days to 50% physiological maturity	Total biomass (in 1000 kg ha^{-1})	100-grain weight (g)	Grain yield (t ha^{-1})
Fertilizer rate (N)	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Variety (V)	5	0.042	0.000	0.000	0.000	0.002	0.000	0.009
N×V	23	0.253	0.240	0.348	0.224	0.360	0.439	0.472
Residual	40							
Total	71							
SE		1	2	2	2	1	1	1
CV (%)		14.13	15.20	45.60	33.51	6.22	10.12	28.84

DF: Degree of freedom, CV: Coefficient of variation and SE: Standard error

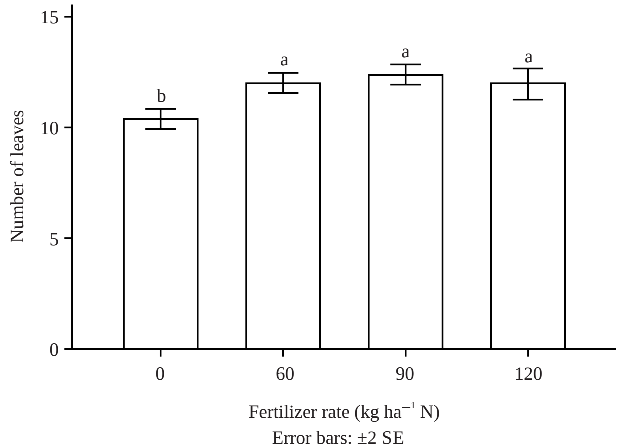

Fig. 1: Effect of N rate on the number of leaves of maize grown under four fertilizer rates
Bars represent the standard error of the mean

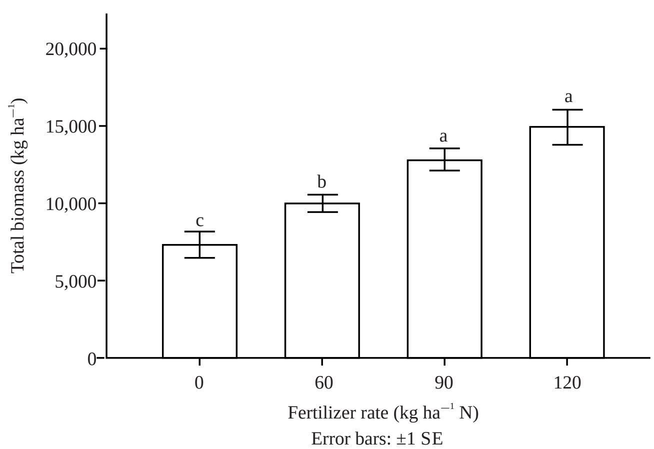

Fig. 2: Effect of N rate on biomass production of maize grown under four fertilizer rates
Bars represent the standard error of the mean

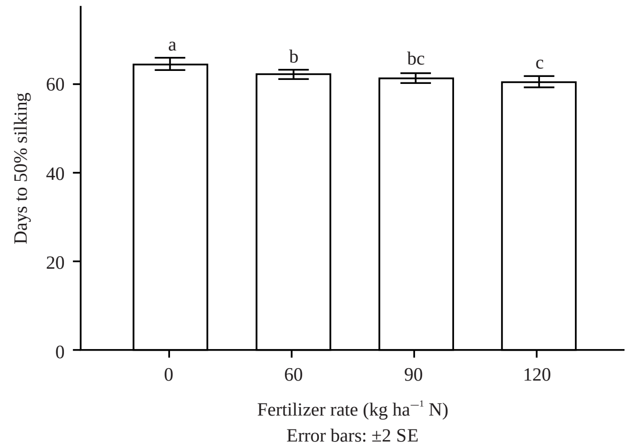

Fig. 3: Effect of N rate on days to 50% silking of maize grown under four fertilizer rates
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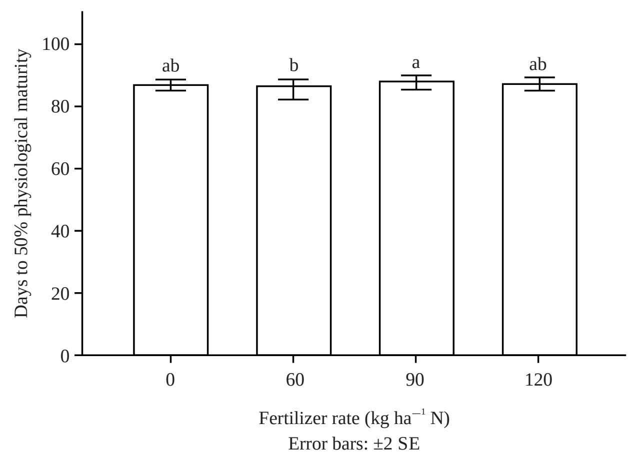

Fig. 4: Effect of N rate on days to 50% physiological maturity of maize grown under four fertilizer rates
Bars represent the standard error of the mean

($p>0.05$) between the 90 kg N ha^{-1} application rate and the other application rates (60 and 120 kg N ha^{-1}) to leaf production (Table 4).

The control plants applied with 0 kg N ha^{-1} recorded the lowest biomass yield of 7500 kg ha^{-1}, whilst the varieties applied with 120 kg N ha^{-1} recorded the highest biomass yield (15000 kg ha^{-1}) (Fig. 2). They were significant differences ($p<0.05$) between the plants applied with 120 kg N ha^{-1} rate and 0 and 60 kg N ha^{-1} rate (Table 4) to biomass production. However, biomass production was significantly similar among plants applied with 120 and 90 kg N ha^{-1}.

Silk production and physiological maturity: The control plants applied with 0 kg N ha^{-1} recorded the highest number of 65 days for 50% silking, whilst the varieties applied with 120 kg N ha^{-1} recorded the lowest of 58 days for silking (Fig. 3). They were a significant difference ($p<0.05$) between the 120 kg N ha^{-1} application rate and that of 0, 60 and 90 kg N ha^{-1} application rates to days to silk production (Table 4). The varieties applied with 90 kg N ha^{-1} took a maximum of 85 days to attain physiological maturity. However, this was not significantly different ($p>0.05$) from the days taken to attain physiological maturity by plants applied with N rates of 0 and 120 kg ha^{-1} (Fig. 4).

Effect of nitrogen rate on yield and yield components

Grain production per cob: All the varieties applied with 120 kg N ha^{-1} recorded a maximum of 500 grains per cob,

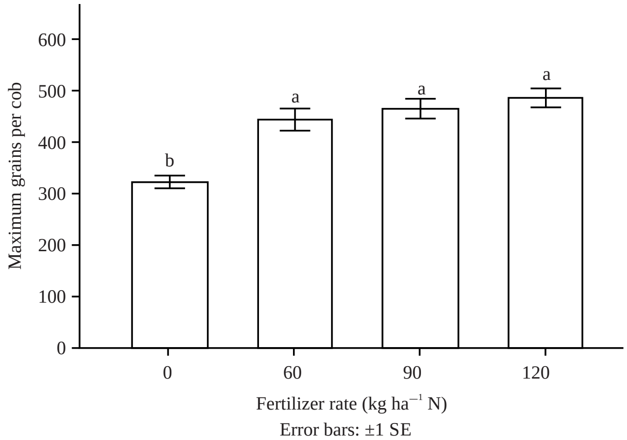

Fig. 5: Effect of N rate on maximum grain production per cob of maize varieties grown under four fertilizer rates
Bars represent the standard error of the mean

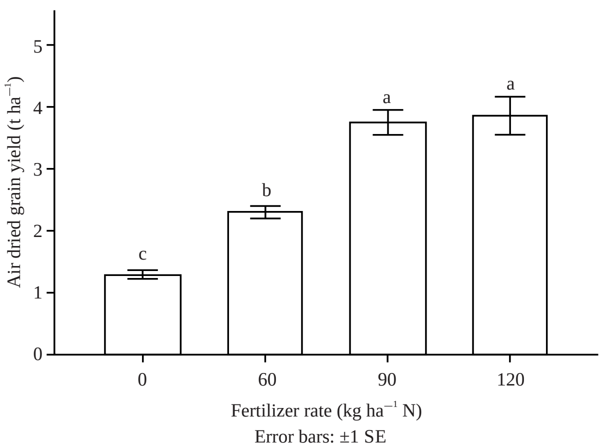

Fig. 6: Effect of N rate on grain yield of maize grown under four fertilizer rates
Bars represent the standard error of the mean

whilst the varieties applied with 0 kg N ha^{-1} recorded a minimum of 310 grains per cob (Fig. 5). They were no significant differences (p>0.05) between the 120 kg N ha^{-1} application rate and the other application rates of 60 and 90 kg N ha^{-1} to grain production per cob (Table 4).

Grain yield: Plants applied with 120 kg N ha^{-1} recorded the highest grain yield of 4 t ha^{-1}, whilst the control plants applied with 0 kg N ha^{-1} recorded the lowest grain yield of 1.3 t ha^{-1} (Fig. 6). They were, however, no significant differences (p>0.05) between the 120 and 90 kg N ha^{-1} application rates to grain production (Table 4).

DISCUSSION

From the study, varieties applied with 90 kg N ha^{-1} was not significantly different from 0 and 120 kg ha^{-1} to days taken to attain physiological maturity and this might occur as a result of non-effective utilization of nitrogen by plants that received 120 kg N ha^{-1}. Erratic rainfall distribution and the amount could have considerably influenced the response of maize to nitrogen application. This is because the rain might have caused runoff and leaching of applied nitrogen.

Nitrogen utilization efficiency in maize production is estimated at 33%, due to loss of N fertilizer from leaching below the root zone, denitrification and soil- and plant-derived volatilization[18]. The inherent genetic factors could have also caused the uniformity of days to attaining physiological maturity among the maize varieties. This observation confirms the findings of researchers[19], who reported that maize varieties have a specific growth cycle. Genetic variability in growth and development exists among different maize cultivars[20] and this might have contributed to the differences in the observed number of days to 50% physiological maturity.

Silking and physiological maturity were earlier among DT-STR-W-C2, TZE-W-DT-STR-C4 and GH120 DYF/D POP but delayed among COMP 1 SYN and OBATAMPA for all nitrogen application rates. Possibly the different varieties DT-STR-W-C2, TZE-W-DT-STR-C4 and GH120 DYF/D POP had a relatively high nitrogen use efficiency relative to the other varieties resulting in an earlier production of silk. This result is supported by the previous studies[21]. It is also revealed that maize cultivars had significant differences in days to 50% silking and physiological maturity[22]. The variation in maturity periods could be a result of both genetic and environmental factors. The studies of different authors[23,24] revealed that the growth, development and maturity of maize are directly related to the number of nutrients that are made available to plant during their growth period. Air-dried grain yield was highest among OBATAMPA and IWD-C3-SYN-F2 but lowest among GH120 DYF/D POP. The observed increase in yield with increasing N rates is in agreement with the finding of researchers[25], who observed that moderate absorption of nitrogen by maize plants tends to increase its net returns. The differences in yield of different varieties may be attributed to the existence of differences in cultivars in terms of their reactions to external factors and utilization of soil and water resources, which also have a significant effect on yield and other agro-morphological parameters[26].

There have been genetic variability in growth and development among different cultivars of maize[27]. The highest number of leaves was recorded by OBATAMPA but that was not significantly different from TZE-W-DT-STR-C4. This may be attributed to the inherent ability of these varieties to generate more leaves. However, GH120 DYF/D POP produced the least number of leaves. The variation in leaf production could have been due to differences in response to different rates of N application. The variation in leaf appearance could also be a result of the crop's inherent ability to efficiently utilize soil resources. Increasing nitrogen fertilizer rate from 0 up to 250 kg N ha^{-1} significantly increases leaf production among maize plants[28]. IWD-C3-SYN-F2 and OBATAMPA produced the highest biomass but this was not statistically different ($p>0.05$) from COMP 1 SYN. The lowest biomass production was recorded by GH120 DYF/D POP. A significant disparity has been observed in genotypes to biomass production[29]. The insignificant differences in the maximum grains per cob of the varieties are in contrast to the findings of previous studies[30,29], who observed significant differences in varieties to yield and other agro-morphological traits. Generally, all treatments at N>0 kg ha^{-1} significantly produced more grains per cob than the control. The findings are partly in agreement with that of researchers[31,32], who observed that the number of grains per cob varied with different varieties.

In general, it was observed from the field data that grain yield and yield components produced are related to the variation in N rates. All the varieties applied with 120 kg N ha^{-1} recorded relatively higher grain yield and several grains per cob as compared to yields produced at 0, 60 and 90 kg N ha^{-1}. Increasing N levels significantly increase grain yield, days to 50% silk emergence, percent grain moisture content at harvest and 1000-seed weight but negatively impacted ear acceptability rating and percent total lodging[33]. Nitrogen is a vital nutrient and a major yield-determining factor required for maize production[34]. Nitrogen fertilizer levels are significant for grain yield, days to mid-silking, days to mid-anthesis, anthesis-silking interval, plant height, ear height, open tip, cob aspects, dry stover weight, cob length and grain depth at nitrogen levels of 0, 45 and 90 kg N ha^{-1}[35]. This may be due to adequate nitrogen in combination with P and K which greatly influenced the vegetative growth of the plant. The observed trend in cob weight confirms the results of the previous study[26], who observed significant differences in cob weight among different genotypes and at different N rates. Differences arise as a result of the difference in the genetic composition of the cultivars which also influence their responses to the external environment. On the contrary, no significant differences have been observed in cob weight for different varieties[30]. Different N levels also produced significant differences in empty cob weight. The results are supported by the findings of researchers[22], who reported that grains per cob increased with increasing levels of NPK fertilizers. The highest number of grains per cob was recorded at 120 kg N ha^{-1} across all the 6 genotypes used in the study.

Varieties such as OBATAMPA and IWD-C3-SYN-F2 and nitrogen application rates of 90 kg N ha^{-1} are the recommended varieties and N application rates, respectively, for farmers in the Guinea Savannah agroecology of Ghana.

CONCLUSION

The study was conducted to examine the varietal response of maize to different nitrogen fertilizer application rates. The varieties OBATAMPA and IWD-C3-SYN-F2 produced the best results regarding grain yield, total biomass, leaf and shoot production. All the varieties applied with 120 and 90 kg N ha^{-1} recorded relatively higher grain yield and growth parameters as compared to 0 and 60 kg N ha^{-1}. The cultivation of OBATAMPA and IWD-C3-SYN-F2 will result in increased grain yield. The application of 90 kg ha^{-1} N will also result in increased grain production.

SIGNIFICANCE STATEMENT

This study discovered that the type of maize variety and nitrogen fertilizer rate used by farmers for production influences maize grain yield in the Savannah Agroecology of Ghana. The use of low yielding varieties, coupled with an inappropriate nitrogen application rate is the major cause of the continuous low yield of maize in northern Ghana. Through this study, the researcher had discovered that the use of varieties such OBATAMPA and IWD-C3-SYN-F2 and the application of 90 kg ha^{-1} N will result in increased maize productivity in Northern Ghana.

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