PERFORMANCE OF EXTRA-EARLY MAIZE (*Zea mays* L.) VARIETIES AS INFLUENCED BY RATE OF NITROGEN AND INTRA-ROW SPACING

By

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OCTOBER, 2014

DECLARATION

I declared that the work in this thesis entitled PERFORMANCE OF EXTRA-EARLY MAIZE (*Zea mays* L.) VARIETIES AS INFLUENCED BY RATE OF NITROGEN AND INTRA-ROW SPACING has been written by me and that it is a record of my research work in the Department of Agronomy under the supervision of Profs. U. F. Chiezey, J. A.Y. Shebayan and Dr. (Mrs.) A. A. Mukhtar.

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CERTIFICATION

This thesis titled PERFORMANCE OF EXTRA-EARLY MAIZE (*Zea mays* L.) VARIETIES AS INFLUENCED BY RATE OF NITROGEN AND INTRA-ROW SPACING meets the regulations governing the award of the degree of M.Sc. Agronomy of Ahmadu Bello University, Zaria and is approved for its contribution to acknowledge and literary presentation.

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Dedication

This work is dedicated to my parents, brothers and sisters.

ACKNOWLEDGEMENTS

In the name of Allah, the most Beneficent, the most Merciful. All thanks and praises are due to Allah Lord of the worlds.

I wish to express my profound and sincere gratitude to my major supervisor, Prof. U. F. Chiezey for his valuable suggestions, objective criticism and constant supervision throughout the course of this study. The same sincere appreciation is also extended to Prof. J. A.Y. Shebayan and Dr. (Mrs.) A. A. Mukhtar who co-supervised the work and made significant contributions towards executing the work and final preparation of the thesis.Sincere appreciation is also extended to Head of Department of Agronomy, Dr. B. A. Babaji for his contribution. I am highly grateful to Prof. Abdullahi Mahadi and Dr. Musa A. Mahadi for their financial support. My gratitude goes to the entire staff of Agronomy Department for their contributions in one way or the other in seeing this work through, and to all my friends, classmates and colleagues I thank you all for your good company during the whole study programme.

ABSTRACT

Two field trials were conducted one during 2012 wet season and another in 2012/2013 dry season, at the Institute for Agricultural Research (IAR) Farm, Samaru, in the northern Guinea savannah ecological zone of Nigeria to assess the performance of two extra-early maize varieties (SAMMAZ-28 and SAMMAZ-29) as influenced by rate of nitrogen and intra-row spacing. Treatments were laid out in a Randomized Complete Block Design (RCBD) replicated three times. Application of 90 kg N ha^{-1} gave significantly higher leaf area index, dry matter, net assimilation rate, flag leaf area, cob length, cob diameter, number of grains per cob and yield ha^{-1} than other levels (0, 45 and 135 kg N ha^{-1}). Control treatment took statistically more number of days to attain 50% tasseling and silking than other levels. Spacing of 20 cm produced significantly higher yield, 100-grain weight, cob weight plant^{-1}, ear leaf area, plant height, relative growth rate, crop growth rate and stand count than other spacing; the closest spacing (15 cm) produced significantly higher percent emergence, number of days to 50% tasseling and number of days to 50% silking, than the widest spacing. Varying spacing had no significant effect on plant height, flag leaf area, cob length, cob diameter, number of grains per cob, net assimilation rate and dry matter. There was positive and highly significant correlation between grain yield and dry matter, plant height, cob weight plant^{-1}, cob length plant^{-1}, cob diameter and 100-grain weight in both seasons. Regression analysis showed the optimum yield for SAMMAZ-28 to be 3437.6 kg ha^{-1} at 120 kg N ha^{-1} and 3989.4 kg ha^{-1} at 111 kg N ha^{-1} for wet and dry seasons, respectively; while for SAMMAZ-29 the optimum yield was 3521 k g ha^{-1} at 114 k g N ha^{-1} and 3385.56 kg ha^{-1} at 94 kg N ha^{-1} for wet and dry seasons, respectively. In conclusion, it could be suggested that SAMMAZ-28 with 111 kg N ha^{-1} in dry season and SAMMAZ-29 with 114 kg N ha^{-1} in wet season, each sown at 20 cm intra-row spacing could be used by farmers in the northern Guinea savannah ecological zone of Nigeria.

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CHAPTER ONE

1.0 INTRODUCTION

Maize (*Zea mays* L.) was relatively a minor food crop in Africa by 1900 (Manyong *et al.,* 2003), but over the years, its widespread uses in human diet and animal feeds popularized it in Africa, especially in Nigeria. Maize was the most widely adapted and the most important cereal in the world in 2009 has production of 822.7 million metric tonnes followed by rice and wheat with 782.3million metric tonnes and 680.2 million metric tonnes respectively (FAO, 2012). United States of America is the largest producer accounting for 37.2% of the world's total, followed by China and Brazil that accounted for 20.1% and 7.1% respectively (FAO, 2012). Africa produced 6.7% of the world's total from 29.3 million hectares. Nigeria is the second largest producer in Africa with 9.41 million metric tonnes which represented 0.9% of the world's figure (FAO 2012).

1.1 Soil and Climatic Requirements

Maize is grown between latitude 58° north and 40° south of the equator. Varying altitude affects the number of days to flowering and maturity; this is as a result of high temperature at lower altitude which accelerates growth. Conversely, the lower prevailing temperature at high altitude retards growth and extends time taken to reach maturity.

Maize requires annual rainfall of 600–900mm (IITA, 2006); sandy loam and silt loam soils containing adequate organic matter and tolerates soil pH from 5.5 to 8.0 but the optimum range is 5.5–7.0.For good growth, maize requires a lot of sunshine and warmth. Ideal temperature for its growth ranges between 21-27°C. (Wolkowski, 2001).

1.2 Uses and Economic Importance of Maize

Maize has lots of uses, both domestically and industrially**:** the fresh immature grain is roasted or cooked and eaten directly (Delorit*et al.,* 1974), the dried grain is used for the preparation of porridge after milling and boiling, it is also used for the production of livestock feeds and in industries, for the production of alcohol and non-alcoholic beverages, corn starch and production of bio-fuel (Fajemisin, 1991).

1.3 Justification and Objectives

Nitrogen is the most important constraint to increased maize production in the northern Guinea savannah of Nigeria (Singh *et al.,* 2001). The use of chemical fertilizer as nitrogen source is appreciated by farmers but its high cost, poor distribution, and inadequate credit facilities have made the commodity unavailable to resource-poor farmer, such that the rate of application of nitrogen by peasant farmers in Nigeria is as low as 5.5 kg fertilizer per hectare (Camara and Heinemann, 2006). The commonly grown maize varieties in Nigeria are medium maturing (120 days) which are sown at the recommended spacing of 25 cm x 75 cm of one plant per stand or 50 cm x 75 cm of two plants per stand, and recommended fertilizer rate of 120:60:60 of N, P_2O_5 and K_2O (I.A.R Recommended Agronomic Practices for some wet season field crop, 2012). These recommendations may not hold for the new extra-early maturing (85 days) varieties with much smaller statures. It therefore becomes necessary to evaluate these new extra-early maturing varieties under different intra-row spacing and nitrogen levels. Extra-early maize varieties have been bred for marginal areas where rainfall pattern cannot support the medium and late maturing maize varieties. The ability of extra-early maize varieties to produce fresh consumable cobs in 75 days and dry grains in about 85 days offer unique opportunities for the inhabitants of the Sudan and northern Guinea savannah ecological zones of Nigeria (Ado *et al.,* 1999)

1.4 The Objectives of the Study are;

1) To determine the response of extra-early maize varieties to rate of nitrogen.

2) To determine the response of extra early maize varieties to varying intra-row spacing.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Varietal Difference

Modern agriculture is geared towards increased yield and nutritional quality of crops but environmental factors such as improper spacing, pest and diseases, inadequate soil fertility and unsuitable crop varieties may not favor the production potential of varieties (Derby *et al.*, 2004). It is a known fact that varieties differ in their adaptation to new ecologies, yield potential, maturity period and canopy architecture (Dowsell *et al.*, 1996). It has also been established that varieties differ in physical and chemical properties of the grain, which affect their various end uses (Kling, 1991). Efforts should not be spared to find out which variety would be best suited for any given cropping system.

A study conducted in Nigeria's savannah by Hassan (1999) using two maize varieties (GH 110–28 and SAMMAZ-14) revealed that GH 110–28 produced significantly more leaves per plant, longer days to 50% tasseling and silking, higher grain yield, heavier 100–grain weight and cob weight than SAMMAZ-14. This was attributed to the fact that GH 110-28 was more responsive to fertilizer. SAMMAZ-14 expressed its superiority over GH 110-28 on plant height, leaf area index and dry matter per plant. The Researcher asserted that these characters were genetically controlled and could also be influenced by environment to a certain extent. Sharifai (2004) reported that significant increase in plant height, total dry matter, relative growth and grain yields exhibited by varieties TZPZ-SR and TZE COMP-3G over variety TZE-W could be attributed to more responsiveness to fertilizer.

2.2 Effect of Nitrogen on Growth, Yield and Yield Components of Maize

Nitrogen is the most important constraint to increased maize production in the Guinea Savannah of Nigeria (Singh *et al.,* 2001). Nitrogen is the most common deficient nutrient in most soils (Leonard, 1986). Among all the essential nutrients, nitrogen appears to have the most pronounced effect on plant growth and development (Lombin, 1988). It is a component of protein and nucleic acids and when nitrogen is sub-optimal, growth is reduced (Haque *et al.,* 2001). When nitrogen is in short supply, plants tend to be stunted and to develop restricted root system; the leaves turn yellowish-green and may drop off (Lombin, 1988).

Ayub*et al. (*2002) observed that growth characters like plant height, number of leaves per plant, stem diameter, leaf area per plant; green fodder yield and dry matter yield were increased by the application of nitrogen up to 120 kg N ha^{-1}. Wajid *et al.* (2007) evaluated the effect of three nitrogen levels on three maize cultivars, and reported increases in the following parameters: plant height, 1000-grain weight, grain yield and harvest index. Ologunde and Ogunlela (1984) reported that application of 120 kg N ha^{-1} gave highest grain yield of maize in southern Guinea savanna of Nigeria. Tanimu (1999) reported that grain yield and yield related parameters of maize significantly responded to N fertilizer up to 120 kg N ha^{-1} in two experiments conducted in Samaru. However, Buah *et al.*(2009) observed that increase in N rate beyond 90 kg N ha^{-1} did not result in corresponding increase in yield nor net benefit to merit the extra cost that may be incurred. (Namakka, 2002) reported that nitrogen application increased grain yield which was attributed to positive effect of nitrogen on number of leaves, leaf size, dry matter production, cob length and number of ear, grain weight per cob and number grains per cob.

2.3 Response to Spacing

Response to spacing varied with ecological zones of Nigeria, for instance significant response of 30cm intra-row by 75cm inter-row spacing has been recorded in the southern Guinea savannah (Mokwa). Koli (1971) and Brown *et al.* (1972) reported spacing in popcorn (*Zea mays var. averta*L.) between 33 cm intra-row and 40 cm inter-row spacing and between 19 cm intra-row and 41 cm inter-row spacing gave highest grain yield and largest weight per ear, Sukwaska (1990) reported that decrease in intra-row spacing decrease light intensity at the soil surface, soil moisture content, prolongs growing period especially the reproductive phase, increase stem and ear height, decreases assimilatory area of leaves above the ear, increase leaf area index (LAI) and lodging and decreases ear length and diameter. Intra-row spacing for maximum economic grain yield varies from 18 cm to 40 cm, depending on maturity period and planting date. There is no single recommendation for all environmental factors for all conditions because intra-row spacing varies depending on nearly all environmental factors as well as on controlled factors, such as soil fertility, hybrid selection, planting pattern, among others (Olson and Sanders, 1988). Esechie (1992) observed a decrease in ear weight and length, number of grains per ear when intra-row spacing increases from 18 to 40 cm. Maize is the most sensitive to plant population stress, of all members of the poaecae family. For each production system, there is a population that maximizes grain yield (Luis, 2001). Owueme and Sinha (1991) reported that increasing intra-row spacing beyond 40 cm increases productivity per plant, due to less competition for light, water and nutrient among the crop, as well as decrease in shading. Hassan (1999) observed that intra-row spacing of 25 cm produced significantly taller plants and high Stover dry weight. Inuwa (2001) reported an increased in LAI at 25 cm intra-row spacing. Rasheed *et al*. (2003) reported that maize grown at higher intra-row spacing (30 to 40 cm) produced significantly higher LAI, dry matter per plant, crop growth rate (CGR) and net assimilatory rate (NAR) than closer (18 to 20 cm) intra-row spacing. Choudary (1981) observed no significant difference in yield of maize with intra-row spacing of (45, 60 and 90 cm).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location

A field trial was conducted during the wet season of 2012 and repeated during the dry season of 2012/2013 at the Research Farm of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Samaru (11°11́N; 7°38′ E, and 686m above the sea level) in the northern Guinea savannah ecological zone of Nigeria.

3.2 Soil Analysis

Soil samples were randomly collected from the depth of 0-30cm across the experimental sites prior to planting and analyzed for physico-chemical properties of the soil using standard a procedure as reported by IITA (1975).The result is as shown in Appendix 1.1.

3.3 Treatments and Experimental Design

The treatments consisted of four levels of nitrogen (0, 45, 90, and 135 kg N ha^{-1}) and three intra–row spacing (15, 20 and 25 cm) using two extra–early maize varieties (SAMMAZ-28 and SAMMAZ-29) in all factorial combinations. The treatments were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The gross and net plots were 20.25m^{2}consist of six ridges (4.5 m x 4.5 m) and 13.5m^{2}consist of four ridges (4.5 m x 3 m) respectively.

3.4 Varietal Description

The   following varieties of extra-early maize were used:

3.4.1 SAMMAZ-28(99 TZEE-Y-STR): It is extra-early maturing variety (50 days to mid-silking and 80-85 days to physiological maturity). It has a height of 170 cm, yellow-seeded kernels and a potential yield of 4.0t ha^{-1}for northern Guinea savannah ecological zone of Nigeria. It's tolerant to *Striga hermonthica* and maize streak virus.

3.4.2SAMMAZ-29(2000 TZEE-W-STR): It is extra-early maturing and takes 57 days to mid-silking under uninfested with (*Striga hermonthica)* conditions. The height is 170 cm. It is white-seeded and has a potential yield of 4.0t ha^{-1} for northern Guinea savannah ecological zone of Nigeria. It is tolerant to *Striga hermonthica*, maize streak virus and drought tolerant.

3.5 Cultural Practices

3.5.1 Land preparation

Each field was ploughed and harrowed to a fine tilt, ridged 75cm apart and then marked into plots and replications. Space of 0.5m between the plots and 1.5m between replicates were used as borders.

3.5.2 Sowing

The seeds were sown manually on 20th July, 2012 wet season and on 4th March, 2012/2013 dry season at the rate of 2 seeds per hole at intra-row spacing of 15, 20 and 25 cm according to treatment and later thinned down to one plant per stand at two weeks after sowing (2WAS).

3.5.3 Fertilizer application

Four levels of nitrogen, using urea (46%), at the rate of 0, 45, 90 and 135 kg N ha^{-1} were applied in two equal split doses. The first dose was applied at 2WAS, while the second dose was applied 6WAS, as side spot placement as per treatment. A basal application of P and K in the form of single superphosphate and muriate of potash at 26.4 kg P ha^{-1} and 49.8 kg K ha^{-1} respectively was made to meet phosphorous and potassium requirements of the crop.

3.5.4 Pest and disease control

There was no incidence of Pests and diseases during the two trials.

3.5.5 Weed control

Primextra Gold (Atrazine+ s-metolachlor) was applied pre-emergence at the rate of 2.5kga.i./ha and supplemented with hoe weeding at 6 WAS.

3.5.6 Harvesting

Harvesting was done on 13th November, 2012 for wet season crop and on 27th July, 2012/2013 for dry season by removing the cobs manually when the plant reached maturity as the cobs turn yellowish-brown. The cobs were threshed and winnowed to obtain the grain.

3.6 Crop Parameter

3.6.1 Leaf area index (LAI)

Measurements were taken at 4, 8 and 12 WAS. The length and the breadth from the widest point of a functional leaf were measured with a metre rule. The product of the length and the breadth was multiplied by a factor (0.75) to calculate the leaf area (Watson, 1958). To find the LAI, the leaf areas obtained from the individual leaves were added and the average per plant was computed and divided by the land area covered by the plant (Duncan and Hasketh, 1968) as follows:

$$LAI=LA/P$$

Where: LA= leaf area (cm^2), P=ground area (cm^2)

3.6.2 Number of days to 50% tasseling

The number of days from the date of sowing to the time when about 50% of the plants per plot tasseled was counted and recorded.

3.6.3 Number of days to 50% silking

The number of days from date of sowing to the time when about 50% of the plants per plot silked was counted and recorded.

3.6.4 Flag leaf area per plant

This was determined at maturity. The length and the breadth of flag leaf (a leaf just below Tassel) from five plants per net plot from the widest point of a functional leaf were measured and the product was multiplied by a factor (0.75).

3.6.5 Ear leaf area per plant

This was determined at maturity. The length and the breadth of the ear leaf (a leaf just bellow cob) from five plants per net plot from the widest point of a functional leaf were measured and the product was multiplied by a factor (0.75).

3.6.6 Total dry matter per plant

Total dry matter per plant was determined by sampling five plants per plot and oven drying at 70˚C to a constant weight and the mean weight recorded. This was done at 4, 8 and 12 weeks after sowing.

3.6.7 Net assimilation rate (NAR)

This was also determined at 4, 8 and 12WAS. The LA (length x breath) of each sampled plant was calculated, in which the products of length and breadth was multiplied with a factor (0.75) (Watson, 1947). Net assimilation rate was calculated using the formula by (Gregory, 1926)

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} x \frac{Log_e L_2 - Log_e L_1}{L_2 - L_1} g/m^2/wk$$

Where: W_1= dry weight at a sampling period

W_2= dry weight at the next sampling period

A_1= leaf area at a sampling periods

A_2= leaf area at next sampling period

3.6.8 Plant height

Plant height (cm) was measured from the five tagged plants using a graduated meter rule from the ground to the tip at anthesis and at harvest and recorded.

3.6.9 Crop growth rate

This was determined by sampling five plants from the net plot at 4, 8 and 12WAS and oven dried to a constant weight. The following formula was used (Watson, 1958)

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}\ g/m^2/wk$$

Where:W_1= dry weight at a sampling period

W_2= dry weight at the next sampling period

t_1= time at which W_1 was taken

t_2= time at which W_2 was taken

3.6.10 Relative growth rate

This was calculated at 4, 8, and 12 WAS. It was determined after oven drying the plant to a constant weight using the formula by Fischer (1921).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}\ g/g/wk$$

Where: $LogW_1$ and $LogW_{2,}$ referred to total dry matter of plant at t_1 and t_2 respectively

3.6.11 Nitrogen content of ear leaves at tasselling

Ear leaves from five plants in each net plot were collected at 50% tasseling, oven dried and grounded into powder using grinder. The powder was then sieved and later used to analyze for nitrogen content in Laboratory, using one gram each, of the sample. The: One gram sieved sample was digested using suphuric acid and perchloric acid with copper and sodium sulphates acting as catalysts. The digest was later used to determine nitrogen content of the leaves (Bremmer, 1965; IITA, 1975).

3.6.12 Number of plants with cobs

The number of plants with cobs per plot was counted and recorded.

3.6.13 Number of cobs per plant

Number of mature cobs was counted from five randomly tagged plants in each net plot and the mean determined and recorded.

3.6.14 Mean weight of cob

Five cobs were randomly selected per plot and weighed and the mean determined and recorded.

3.6.15 Cob weight per plot

All cobs from each net plot were harvested air-dried and weighed.

3.6.16 Cob length

Five cobs were randomly selected from each plot, the length of each cob was measured using meter rule and the mean length was taken.

3.6.17 Cob diameter

The diameters of the five randomly selected cobs from each net plot were measured using a venier caliper. The mean diameter was calculated and recorded.

3.6.18 Number of grains per cob

The number of grains from five cobs was counted and the total number of grains was divided by the total number of cobs to give the mean number of grains per cob.

3.6.19 100-grain weight

From each plot 100 dried grains were randomly selected and weighed using a metlar-balance and the value recorded.

3.6.20 Grain yield per hectare

The harvested cobs from each net plot (13.5 m^2) were threshed and cleaned; the grains were weighed for each treatment plot and expressed in kilogram per hectare by extrapolation.

3.7 Data Analysis

Data collected were subjected to analysis of variance as described by Snedecor and Cochran (1967). The treatment means were compared using Duncan Multiple Range Test (Duncan, 1955). Simple correlation among the parameters were worked out using the procedure described by Dewey and Lu (1959) and Little and Hills (1978) to assess the type and magnitude of relationships between grain yield and growth parameters, yield and yield components. The polynomial responses of the grain yield to the factors tested were determined through regression analysis as suggested by Steel and Torrie (1984).

CHAPTER FOUR

4.0 RESULTS

4.1 Emergence Count

Table 4.1 shows varietal difference, effect of nitrogen rate and spacing on the emergence count of two maize varieties at Samaru in both seasons. The two varieties differed in their emergence count: SAMMAZ-28 produced higher emergence count than SAMMAZ-29 in both seasons.

Variation in nitrogen had no significant effect on emergence count of maize in both seasons, however, varying intra-row spacing caused significant differences in emergence of two maize varieties in both seasons. In 2012 wet season, increasing spacing from 15 to 20cm did not significantly affect percent emergence count, but a further increase to 25 cm significantly reduced emergence count when compared with 15 cm spacing. In 2012/2013 dry season, 15 cm and 20 cm intra-row spacing gave statistically similar percent emergence count but, each was significantly lower than that at 25 cm intra-row spacing.

There were no significant interactions among varieties, nitrogen rates and intra-row spacing on emergence count in both seasons.

Table 4. 1: Emergence count of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

Treatments	Emergence count (%)	
	2012 wet season	2012/2013 dry season
Variety(V)		
SAMMAZ-28	99.56a	95.06a
SAMMAZ-29	98.83b	94.12b
SE±	0.123	0.779
Nitrogen (N) rate ($kgha^{-1}$)		
0	99.44	95.05
45	99.28	94.28
90	99.09	93.74
135	98.95	95.28
SE ±	0.174	1.103
Intra-row spacing(R)		
15 cm	99.38a	92.60b
20 cm	99.30ab	93.86b
25 cm	98.89b	97.31a
SE ±	0.151	0.954
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	NS	NS
N x V x R	NS	NS

Means followed by the same letter(s) within same column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS=not significant

4.2 Stand Count at Harvest

Varietal difference, effect of nitrogen rate and spacing on stand count at harvest of two maize varieties at Samaru during 2012 wet season and 2012/2013 dry season are shown on Table 4.2. Significant differences in stand count at harvest among the maize varieties were observed in 2012 wet season only. SAMMAZ-28 had the higher percent stand count than SAMMAZ-29.While variation in N rate caused no significant differences in percent stand count of two maize varieties at Samaru in both seasons, varying intra-row spacing had significant effect on stand count in both seasons. In 2012 and 2012/2013 seasons, stand count at 15 to 20 cm spacing was statistically similar but each had high stand count at 25 cm.

There were no significant interactions among varieties, nitrogen rates and intra-row spacing on the stand count in both seasons.

4.3 Leaf Area Index

Table 4.3 shows the varietal difference, effect of nitrogen rate and spacing on leaf area Index (LAI) of two maize varieties in both seasons. Varietal differences did not result in significant differences in LAI in both seasons. Variation in N rate caused significant differences in LAI at 8 and 12WAS in 2012 and 12WAS in 2013; LAI with 135 kg N ha^{-1}was highest but statistically similar to that at 45 and 90 kg N ha^{-1}in all sampling periods. However, LAI at 45 and 90 kg N ha^{-1} was comparable, but was statistically similar to the untreated control only at 12WAS in both seasons. Varying spacing caused significant differences in LAI, with each increase in spacing significantly increasing LAI at each sampling period in both seasons. There were no significant interactions on LAI in both seasons.

Table 4. 2: Stand count at harvest of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Stand count (%)	
Treatments	2012 Wet season	2012/2013 dry season
Variety (V)		
SAMMAZ-28	99.05a	94.97
SAMMAZ-29	98.73b	94.34
SE±	0.162	0.687
Nitrogen (N) rate (kgha^{-1})		
0	98.84	94.54
45	99.00	94.09
90	98.90	94.05
135	99.12	95.94
SE ±	0.229	0.972
Intra-row spacing (R)		
15 cm	99.05b	93.13b
20 cm	99.00b	93.50b
25 cm	99.42a	97.33a
SE ±	0.198	0.842
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	NS	NS
N×V×R	NS	NS

Means followed by the same letter(s) within same column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

Table 4. 3: Leaf area index of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Leaf area index					
Treatments	2012 wet season			2012/2013 dry season		
	4WAS	8WAS	12WAS	4WAS	8WAS	12WAS
Variety (V)						
SAMMAZ-28	0.204	0.338	0.362	0.207	1.194	0.793
SAMMAZ-29	0.192	0.344	0.375	0.216	1.128	0.838
SE ±	0.0074	0.0104	0.0162	0.003	0.008	0.005
Nitrogen (N) rate (kgha-^{1})						
0	0.188	0.300b	0.313b	0.171	1.190	0.736b
45	0.212	0.348a	0.365ab	0.238	1.156	0.816ab
90	0.199	0.345a	0.381ab	0.212	1.090	0.818ab
135	0.195	0.372a	0.415a	0.225	1.210	0.892a
SE ±	0.0105	0.0147	0.0230	0.006	0.017	0.010
Intra-row spacing (R)						
15 cm	0.148c	0.261c	0.285c	0.146c	0.965c	0.658c
20 cm	0.186b	0.329b	0.344b	0.213b	1.150b	0.805b
25 cm	0.261a	0.434a	0.477a	0.276a	1.368a	0.983a
SE ±	0.0091	0.0127	0.0199	0.004	0.012	0.007
Interaction						
N x R	NS	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
V x R	NS	NS	NS	NS	NS	NS
N x R x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within same column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

4.4 Dry Matter

Table 4.4 shows the effect of varietal differences, nitrogen rate and spacing on dry matter of two maize varieties at Samaru in both seasons. There was no significant difference in dry matter per plant between the two varieties in both seasons. Varying nitrogen rate significantly affected dry matter of maize at 12WAS in both seasons. .At 12WAS in 2012, 135 kg N ha-^{1} produced the highest dry matter but was not different statistically from 45 and 90 kg N ha^{-1}, but was better than the untreated Control. Maize in the untreated control had comparable dry matter with maize treated with 45 and 90 kg N ha^{-1}.At 12WAS in 2012/2013 dry season, maize in the untreated and that in 45 kg N ha^{-1} had comparable dry matter, but each further increase in N significantly increased dry matter per plant. Varying Spacing had significant effect on dry matter of maize in both the seasons; Increase in spacing from 15 to 20 cm significantly increased dry matter, but further increase to 25 cm did not significantly increase this parameter.

There were no significant interactions among all the treatments on dry matter in both seasons.

4.5 Crop Growth Rate

Table 4.5 shows varietal differences, effect of nitrogen rate and spacing on the crop growth rate (CGR) of the two maize varieties at Samaru in both seasons. The two varieties differed in their CGR only at 12WAS in both seasons; SAMMAZ-28 produced higher CGR than SAMMAZ-29 in the wet season, while the reverse was the case in dry season. Varying nitrogen rate significantly affected CGR at 12WAS in 2012 and all sampling periods in 2012/2013dry season. At 12WAS in 2012 and 8WAS in 2012/2013, increase in N rate from 0 to 45kgNha^{-1} caused significant increase in CGR, and no further increase caused a significant change in the CGR. At 4WAS and 12WAS in 2012/2013 season 90 kg N ha^{-1} gave the highest CGR but statistically, it was not different from 135 kg N ha^{-1}, but each was significantly higher than the control and 45 kg N ha^{-1}.Varying spacing significantly affected

CGR at 12WAS in both seasons. Increasing spacing from 15 to 20 cm significantly increased CGR, but a further increase to 25 cm did not result in a significant increase in CGR.

There were no significant interactions among all the treatments on CGR in both seasons.

Table 4. 4: Dry matter per plant at 12WAS of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Dry matter(g) per plant	
Treatments	2012 wet season	2012/2013 dry season
	12WAS	12WAS
Variety (V)		
SAMMAZ-28	88.39	203.30
SAMMAZ-29	86.03	210.30
SE±	6.458	5.738
Nitrogen (N) rate (kgha^{-1})		
0	61.65b	156.28c
45	83.89ab	170.87c
90	96.09ab	228.67b
135	107.21a	271.57a
SE±	9.134	8.115
Intra-row spacing (R)		
15 cm	82.46b	195.70b
20 cm	96.01a	209.50a
25 cm	83.17a	215.20a
SE±	7.909	7.028
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	NS	NS
N x R x V	NS	NS

Means followed by the same letter(s) within same column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test(DMRT)

NS=not significant

Table 4. 5: Crop growth rate of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Crop growth rate (g/m^2/wk)					
Treatments	2012 wet season			2012/2013 dry season		
	4WAS	8WAS	12WAS	4WAS	8WAS	12WAS
Variety (V)						
SAMMAZ-28	1.31	6.05	14.52a	0.71	14.52	32.53b
SAMMAZ-29	1.24	7.97	11.69b	0.66	14.41	36.46a
SE ±	0.622	0.756	1.587	0.046	0.614	1.041
Nitrogen (N) rate (kgha^{-1})						
0	1.31	4.23	10.54b	0.53c	11.23b	29.17c
45	1.26	6.27	14.56a	0.62bc	14.58a	32.87bc
90	1.31	8.73	13.99a	0.82a	16.05a	39.29a
135	1.23	8.84	13.32a	0.77ab	15.97a	36.65ab
SE ±	0.088	0.1.070	2.244	0.066	0.066	1.473
Intra-row spacing (R)						
15 cm	1.29	13.95	5.67b	0.68	13.31	30.04b
20 cm	1.25	11.57	12.40a	0.68	15.09	39.82a
25 cm	1.28	13.78	12.98a	0.70	15.01	33.62a
SE ±	0.075	0.926	1.944	0.057	0.057	1.275
Interaction						
N x R	NS	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
V x R	NS	NS	NS	NS	NS	NS
N x R x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within same column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

4.6 Relative Growth Rate

Varietal difference, effect of nitrogen rate and spacing on relative growth rate (RGR) of two maize varieties at Samaru during 2012 wet season and 2012/2013 dry season are as shown in Table 4.6.

Varietal differences had no significant effect on the RGR of the two maize varieties in both seasons; however, varying rate of nitrogen had significant effect on RGR of maize at 12WAS in 2012 and at all sampling periods in 2012/2013 dry season. At 12WAS in 2012 and at 8WAS in 2013, application of 135 kg N ha^{-1} produced the highest RGR which were statistically similar to that of maize with 45 and 90 kg N ha^{-1}. At 4WAS in 2013 application of 135 kg N ha^{-1} significantly produced the highest RGR, which was statistically similar to 90 kg N ha^{-1}applied; at 12WAS increase in nitrogen rate from 0 to 45 kg N ha^{-1} significantly increased RGR, but no further increase in nitrogen caused a significant change in RGR. Varying intra-row spacing significantly influenced RGR of maize each at 12WAS in both seasons. Intra-row spacing of 20 cm gave the highest RGR but was comparable to 15 cm spacing. However, intra-row spacing of 15 cm and 25 cm had statistically similar RGR. There were no significant interactions among the treatments on RGR in both seasons.

Table 4. 6 : Relative growth rate of two maize varieties as influenced by rate of nitrogen and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Relative growth rate($gg^{-1}wk^{-1}$)					
Treatments	2012 wet season			2012/2013 dry season		
	4WAS	8WAS	12WAS	4WAS	8WAS	12WAS
Variety (V)						
SAMMAZ-28	0.40	0.62	0.09	0.23	0.77	0.31
SAMMAZ-29	0.39	0.58	0.09	0.23	0.74	0.33
SE±	0.012	0.016	0.021	0.016	0.026	0.009
Nitrogen (N) rate ($kgha^{-1}$)						
0	0.40	0.56	0.048b	0.17c	0.67b	0.25b
45	0.39	0.62	0.057ab	0.216bc	0.73ab	0.35a
90	0.41	0.62	0.097ab	0.251ab	0.75ab	0.29a
135	0.38	0.61	0.141a	0.237a	0.83a	0.37a
SE ±	0.017	0.023	0.029	0.023	0.038	0.013
Intra-row spacing (R)						
15 cm	0.40	0.61	0.08ab	0.23	0.75	0.32ab
20 cm	0.40	0.58	0.24a	0.23	0.76	0.35a
25 cm	0.39	0.61	0.15b	0.023	0.74	0.29b
SE ±	0.015	0.020	0.025	0.020	0.033	0.011
Interaction						
N x R	NS	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
V x R	NS	NS	NS	NS	NS	NS
N x R x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within same column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS=not significant

4.7 Net Assimilation Rate

Varietal differences, effect of nitrogen rate and spacing on net assimilation rate (NAR) of two maize varieties in both seasons are shown in Table 4.7. At 8WAS in both seasons, SAMMAZ-28 had the highest NAR than SAMMAZ-29. Varying rate of nitrogen had significant effect on NAR at 4 and 8WAS in 2012 wet season and at 4WAS only in 2012/2013 dry season. At 8WAS in 2012 wet seasons and 4WAS in 2012/2013 dry season, 90 kg N ha^{-1} gave significantly higher NAR than the untreated control, but was comparable to maize in 45 and 135 kg N ha^{-1}. However, at 4WAS in 2012, 135 kg N ha^{-1} gave the highest NAR than all other N rates applied. There were no significant differences in NAR due to variations in intra-row spacing and it's interactions with nitrogen rate in both seasons.

4.8 Number of Days to 50% Tasseling

Table 4.8 shows the varietal differences, effect of nitrogen rate and intra-row spacing on number of days to 50% tasselling of two maize varieties at Samaru in both seasons. There were significant differences between two varieties on number of days to 50% tasseling in both seasons. SAMMAZ-29 required longer period to reach 50% tasseling than SAMMAZ-28 in both seasons. Variation in N rate caused significant differences in number of days to 50% tasseling in both seasons. In 2012 wet season, only application of 135 kg N ha^{-1} caused a significant increase in days to 50% tasseling; in 2012/2013 dry season, 135 kg N ha^{-1}still gave highest number of days to 50% tasseling, it was statistically similar to all other treatments except the untreated control. Intra-row spacing of 25 cm resulted in significant increase in number of days to 50% tasselling than the other spacing, these other spacing had similar days to 50% tasseling. There were no significant interactions on number of days to 50% tasseling of maize in both seasons.

Table 4.7: Net assimilation rate of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Net assimilation rate($gm^{-1}wk^{-1}$)					
Treatments	2012 wet season			2012/2013 dry season		
	4WAS	8WAS	12WAS	4WAS	8WAS	12WAS
Variety (V)						
SAMMAZ-28	0.06	0.28a	0.92	0.01	2.16a	1.70
SAMMAZ-29	0.03	0.23b	0.89	0.02	0.61b	0.47
SE ±	0.006	0.017	3.133	0.001	0.486	5.557
Nitrogen (N) rate (kgha-^{1})						
0	0.04b	0.02b	0.86	0.01b	0.55	2.56
45	0.04b	0.27ab	8.32	0.02ab	1.92	7.76
90	0.04b	0.30a	0.58	0.03a	2.07	5.75
135	0.069a	0.251ab	0.03	0.02ab	0.99	6.61
SE ±	0.009	0.025	0.025	0.001	0.687	7.860
Intra-row spacing (R)						
15 cm	0.05	0.28	0.77	0.01	1.79	4.40
20 cm	0.04	0.25	7.15	0.02	1.33	0.89
25 cm	0.047	0.28	-0.34	0.02	1.04	2.03
SE ±	0.008	0.021	0.021	0.001	0.593	6.807
Interactions						
N x R	NS	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
V x R	NS	NS	NS	NS	NS	NS
N x R x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within same columnand treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

Table 4.8: Number of days to 50% tasselling of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

Number of days to 50% tasseling		
Treatments	2012 wet season	2012/2013 dry season
Variety (V)		
SAMMAZ-28	54.94b	50.55b
SAMMAZ-29	58.00a	53.19a
SE ±	0.282	0.436
Nitrogen (N) rate (kgha^{-1})		
0	55.88b	53.44b
45	55.44b	55.27ab
90	56.50b	55.94a
135	58.05a	54.93a
SE ±	0.399	0.617
Intra-row spacing (R)		
15 cm	55.75b	54.33b
20 cm	56.12b	54.79b
25 cm	57.54a	55.50a
SE ±	0.345	0.534
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	NS	NS
N x V x R	NS	NS

Means followed by the same letter(s) within same column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

4.9 Number of Days to 50% Silking

Table 4.9 shows varietal differences, effect of nitrogen rate and spacing on number of days to 50% silking of two maize varieties at Samaru in both seasons. The two maize varieties differed significantly in their number of days to 50% silking. SAMMAZ-29 reached 50% silking later than SAMMAZ-28 in both seasons. Nitrogen rates significantly affected the number of days to 50% silking only in 2012. Increase in nitrogen rate from 0 up to 90 kg N ha-^{1} did not resulted in significant delay in number of days to 50% silking, but further increase in nitrogen rate from 90 to 135 kg N ha^{-1} significantly delayed attainment of 50% silking. Varying spacing had significant effect on number of days to 50% silking in both seasons. When spacing was increased from 15 to 20 cm no change in the number of days to 50% silking was observed, but a further increase to 25 cm significantly increased the days to 50% silking in both seasons. There were no significant interactions among all the treatments on number of days to 50% silking in both seasons.

4.10 Plant Height

The two maize varieties used differed in their plant height in 2012/2013 only (Table 4.10) with SAMMAZ-29 being taller than SAMMAZ-28.Variation in N rate caused significant differences in plant height only in 2012 wet season; 135 kg N ha^{-1}produced significantly taller plants than the control, but was comparable in height to 45 and 90 kg N ha^{-1}. Varying spacing significantly affected plant height only in 2012/2013 dry season. Increased spacing from 15 to 20 cm significantly increased plant height, but further increased to 25 cm did not significantly affect this parameter. There were no significant interactions on plant height in both seasons.

Table 4.9: Number of days to 50% silking of two maize varieties as influenced by Nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Days to 50% silking	
Treatments	2012 wet season	2012/2013 dry season
Variety (V)		
SAMMAZ-28	58.97b	56.72b
SAMMAZ-29	65.66a	63.89a
SE ±	0.245	0.426
Nitrogen (N) rate (kgha^{-1})		
0	61.11b	60.27
45	62.05bc	59.77
90	62.05bc	61.05
135	63.61a	59.94
SE ±	0.346	0.603
Intra-row spacing (R)		
15 cm	61.83b	59.59b
20 cm	61.66b	59.00b
25 cm	63.45a	62.00a
SE ±	0.300	0.523
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	NS	NS
N x V x R	NS	NS

Means followed by the same letter(s) within same column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

Table 4.10: Plant height of two maize varieties at harvest as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Plant height (cm)	
Treatments	2012wet season	2012/2013dry season
Variety (V)		
SAMMAZ-28	158.60b	178.00b
SAMMAZ-29	162.70a	187.70a
SE ±	4.324	2.637
Nitrogen (N) rate (kgha^{-1})		
0	147.80b	180.70
45	158.80ab	177.80
90	164.10ab	188.20
135	172.00a	184.70
SE ±	6.117	3.722
Intra-row spacing (R)		
15 cm	161.40	176.70b
20 cm	157.60	189.20a
25 cm	163.00	182.60ab
SE ±	5.297	3.224
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	NS	NS
N x V x R	NS	NS

Means followed by the same letter(s) within same column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

4.11 Flag Leaf Area at Anthesis

Table 4.11 shows the varietal difference, effect of nitrogen rate and spacing on flag leaf area of two maize varieties at Samaru in 2012 wet season and 2012/2013 dry season. There were significant differences in flag leaf area between the two varieties in both seasons. SAMMAZ-29 produced higher leaf area than SAMMAZ-28. Variation in N rate caused significant differences in flag leaf area. In 2012, 90 kg N ha^{-1}produced higher flag leaf area than the other N rates however, these other N rates gave comparable flag leaf area. In 2012/2013 dry season, increased nitrogen rate from 0 to 45 kg N ha^{-1} did not significantly affect flag leaf area, but further increase to 90 kg N ha^{-1}resulted in significantly higher leaf area; beyond this rates the flag leaf area dropped to a level still significantly higher than at 0 and 45 kg N ha^{-1} . There were no significant effect of spacing and its interaction with other parameters on flag leaf area in both seasons.

4.12 Ear Leaf Area at Anthesis

Varietal differences, effect of nitrogen rate and spacing on ear leaf area at anthesis of two maize varieties at Samaru in both seasons are shown in Table 4.12. The two maize varieties differed significantly in their ear leaf area in both seasons with SAMMAZ-29 producing higher ear leaf area in both seasons. Variation in nitrogen rate caused significant differences in ear leaf area at anthesis in both seasons. Application of 135 kg N ha^{-1}produced the highest ear leaf area in both seasons, but was comparable to 90 kg N ha^{-1} in 2012 and 45 and 90kg N ha^{-1} in 2012/2013 dry season. In 2012, 90 kg N ha^{-1} gave statistically similar ear leaf area to 45 kg N ha^{-1} but significantly higher than the control, while in 2012/2013, 90 kg N ha^{-1} and lower rate did not differ significantly in ear leaf area. Spacing had significant effect on ear leaf area at anthesis of maize; increase in spacing from 15 to 20 cm significantly increased the ear leaf area, and further increase to 25 cm did not significantly affect this parameter.

There were significant interactions between variety and spacing on ear leaf area only in 2012 wet season.

4.13Interaction

Interactions between intra-row spacing and variety on ear leaf area at anthesis in 2012 wet season show that SAMMAZ-28 at 15 cm intra-row spacing produced the highest ear leaf area followed by the same variety at 20 cm and 25 cm spacing which were comparable to SAMMAZ-29 at 15 cm and 25 cm spacing. SAMMAZ-29 at 20 cm spacing gave the least ear leaf area. Except at 25 cm spacing when they were comparable, SAMMAZ-28 produced higher ear leaf area than SAMMAZ-29.

Table 4.11: Flag leaf area at anthesis of two maize varieties as influenced by rate of nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Flag leaf area (cm^2)	
Treatments	2012 wet season	2012/2013 dry season
Variety (V)		
SAMMAZ-28	73.05b	101.70b
SAMMAZ-29	91.12a	331.70a
SE ±	3.132	183.07
Nitrogen (N) rate ($kgha^{-1}$)		
0	79.23b	85.00c
45	68.83b	77.20c
90	104.50a	598.70a
135	75.70b	106.00b
SE ±	4.430	258.90
Intra-row spacing (R)		
15 cm	85.78	93.00
20 cm	84.11	479.20
25 cm	76.35	78.10
SE ±	3.836	224.22
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	NS	NS
N x V x R	NS	NS

Means followed by the same letter(s) within column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

Table 4.12: Ear leaf area at anthesis of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Ear leaf area (cm^2)	
Treatments	2012 Wet season	2012/2013 dry season
Variety (V)		
SAMMAZ-28	400.70b	410.70b
SAMMAZ-29	453.40a	475.00a
SE ±	9.191	0.003
Nitrogen (N) rate ($kgha^{-1}$)		
0	387.30c	415.30b
45	437.20bc	452.20ab
90	411.20ab	437.10ab
135	472.60a	466.90a
SE ±	12.999	0.004
Intra-row spacing (R)		
15 cm	387.00b	407.10b
20 cm	432.60a	499.10a
25 cm	461.70a	472.40a
SE ±	11.257	0.004
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	*	NS
N x R x V	NS	NS

Means followed by the same letter(s) do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

***=** Significant at 5% level of probability

Table 4.13: Interaction between variety and intra-row spacing on ear leaf area of two maize varieties at Samaru during 2012 wet season

Treatment	Intra-row spacing (R)		
	15 cm	20 cm	25 cm
Variety(V)			
SAMMAZ-28	15.01a	13.42b	15.14b
SAMMAZ-29	12.89b	9.74c	12.43b
SE±		1.307	

Means followed by the same letter(s) do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT)

4.13 Nitrogen Content of Ear Leaf at Tasseling

Table 4.14 shows the effect of nitrogen content of ear leaf at tasseling of two maize varieties as influenced by varietal difference, rate of nitrogen and intra–row spacing at Samaru during 2012/2013 dry season. Varietal differences and spacing significantly affected nitrogen content of ear at tasseling. SAMMAZ-28 produced higher N content of ear leaf than SAMMAZ-29.

Varying nitrogen rate significantly affected nitrogen content of ear leaf at tasseling. Each increase in nitrogen rate resulted in significant increase in nitrogen content of ear leaf at tasseling. Significant differences in nitrogen content of ear at tasseling were observed with variation of intra-row spacing; each increase in spacing resulted in increase in nitrogen content of ear at tasseling. There were significant interactions between nitrogen and spacing, nitrogen and variety and between spacing and variety on nitrogen content of ear leaf.

4.13.1Interactions

Table 4.15 shows interactions of nitrogen rate and spacing on nitrogen content of ear leaf at tasselling of two maize varieties at Samaru during 2012/2013 dry season shows that nitrogen rate of 90 kg N ha^{-1}applied to maize sown at intra-row spacing of 20 cm resulted in significantly higher nitrogen content of ear at tasselling than the other spacing and nitrogen rates combinations; the least N content was observed at 0 kg N ha^{-1}with 15 cm spacing.

Table 4.16 shows the interactions between nitrogen and varieties on nitrogen content of ear at tasselling of maize at Samaru during 2012/2013 dry season.

SAMMAZ-28 treated with 135 kg N ha^{-1}produced significantly higher nitrogen content of ear leaf at tasselling than all other treatment combinations; while SAMMAZ-29 produced the least nitrogen content of ear leaf with 0 kg N ha^{-1}. SAMMAZ-28 showed a significant increase in ear leaf N content with increase in N rate while with SAMMAZ-29, increase in ear leaf N content with increase with applied N stopped at 90 kg N ha^{-1}.

Table 4.17 shows nitrogen content of ear leaf at tasselling of two maize varieties as influenced by interaction between spacing and variety at Samaru during 2012/2013 dry seasons. SAMMAZ-28 with 25 cm spacing produced significantly higher nitrogen content of ear leaf at tasseling than SAMMAZ-29, but the least N content was observed at 15 cm with both varieties. SAMMAZ-28 had similar ear leaf N content at 15 cm and 20 cm spacing but each significantly lower than at 25 cm spacing. With SAMMAZ-29 however, 20 cm spacing gave higher ear leaf N content followed by 15 cm spacing. Except at 15 cm when both varieties did not differ in ear leaf N content, SAMMAZ-28 had higher ear leaf N content than SAMMAZ-29 at all intra-row spacing

Table 4.14: nitrogen content of ear leaf at tasseling of two maize varieties as influenced by Nitrogen rate and intra-row spacing at Samaru during 2012/2013 dry season.

Treatments	Nitrogen content of ear leaf (%)
	2012/2013 dry season
Variety (V)	
SAMMAZ-28	2.09a
SAMMAZ-29	2.08b
SE ±	0.003
Nitrogen (N) rate (kgha^{-1})	
0	1.85d
45	2.05c
90	2.19b
135	2.25a
SE ±	0.004
Intra-row spacing (R)	
15 cm	2.01c
20 cm	2.08b
25 cm	2.16a
SE ±	0.004
Interaction	
N x S	*
N x V	*
S x V	*
N x S x V	NS

Means followed by the same letter(s) within same column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

*= Significant at 5% level of probability

Table 4.15: Interaction between nitrogen rate and intra-row spacing on nitrogen content of ear leaf at tasseling of two maize varieties at Samaru during 2012/2013 dry season.

Treatments	Intra-row spacing (R)		
Nitrogen (N) (kgha^{-1})	15 cm	20 cm	25 cm
0	0.270j	0.303g	0.186k
45	0.340d	0.331e	0.311f
90	0.285h	0.387a	0.278i
135	0.372b	0.359c	0.389j
		0.007	

Means followed by the same letter(s) do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

Table 4.16: Interactions between variety and nitrogen rate on nitrogen content of ear leaf at tasseling of two maize varieties at Samaru during 2012/2013 dry season

Treatments	Variety (V)	
Nitrogen (N) rate (kg/ha)	SAMMAZ-28	SAMMAZ-29
0	1.82f	1.88c
45	2.06e	2.05d
90	2.18b	2.21b
135	2.31a	2.18b
SE ±	4.437	

Means followed by the same letter(s) do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

Table 4.17: Interaction between variety and intra-row spacing on nitrogen content of ear leaf at tasseling of two maize varieties at Samaru during 2012/2013 dry season.

Treatments	Variety(V)	
Intra-row spacing (R)	SAMMAZ-28	SAMMAZ-29
15 cm	2.010c	2.080c
20 cm	2.087c	2.071d
25 cm	2.181a	2.147b
SE±	0.0069	

Means followed by the same letter(s) do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

4.14 Cob Length

Table 4.18 shows varietal differences, effect of nitrogen rate and spacing on cob length of two maize varieties at Samaru during 2012 wet season and 2012/2013 dry season.

There were no significant differences between the two varieties in both seasons. Varying nitrogen rate had significant effect on cob length of two maize varieties in both seasons. In 2012 wet season increase in nitrogen rate from 0 to 45 kg N ha^{-1} did not significantly affect cob length of maize, but further increase to 90 kg N ha^{-1}and caused a significant increase and beyond which the increase was not significant. In 2012/2013 dry season 135 kg N ha^{-1} gave the longest cob but was comparable to that treated with 90 kg N ha^{-1}. Spacing and its interaction with other factors had no significant effect on cob length of maize in both seasons.

4.15 Cob diameter

Varietal differences, effects of nitrogen rate and spacing on cob diameter of two maize varieties at Samaru during 2012 wet season and 2012/2013 dry season are as shown in Table 4.19. The two varieties differed significantly in their cob diameter in 2012 wet season only; SAMMAZ-28 produced thicker cobs than SAMMAZ-29.

Variation in N rate caused significant differences in cob diameter only in 2012 wet season. Application of 90 kg N ha^{-1}produced thicker cobs of maize than the other nitrogen rates applied, these was followed by 45 kg N ha^{-1} which was comparable to the other rates in cob diameter. Varying spacing and its interactions with other parameters in both seasons had no significant effect on cob diameter of maize.

Table 4.18: Cob length of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Cob length(cm)	
Treatments	2012 wet season	2012/2013 dry season
Variety (V)		
SAMMAZ-28	9.97	13.97
SAMMAZ-29	10.08	13.97
SE ±	0.394	0.203
Nitrogen (N) rate (kgha^{-1})		
0	8.32b	13.03c
45	9.04b	13.65bc
90	10.73a	14.27ab
135	12.01a	14.94a
SE ±	0.558	0.287
Intra-row spacing (R)		
15 cm	9.97	13.69
20 cm	10.17	14.03
25 cm	9.93	14.21
SE ±	0.483	0.248
Interaction		
N x S	NS	NS
N x V	NS	NS
V x S	NS	NS
N x S x V	NS	NS

Means followed by the same letter(s) within column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

Table 4.19: Cob diameter of two maize varieties as influenced by rate of nitrogen and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Cob diameter (cm)	
Treatments	2012 wet season	2012/2013 dry season
Variety (V)		
SAMMAZ-28	7.01a	8.14
SAMMAZ-29	7.45b	8.49
SE ±	0.084	1.476
Nitrogen (N) rate (kgha^{-1})		
0	6.85b	7.22
45	7.17b	6.65
90	7.89a	6.95
135	7.02b	7.24
SE ±	0.118	2.087
Intra-row spacing (R)		
15 cm	7.23	9.12
20 cm	7.27	8.94
25 cm	7.19	6.88
SE ±	0.102	1.807
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	NS	NS
N x R x V	NS	NS

Means followed by the same letter(s) within column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

4.16 Number of Grains per Cob

There were no significant differences in number of grains per cob of two maize varieties in 2012 wet season and 2012/2013 dry season (Table 4.20). Varying nitrogen rate significantly affected the number of grains per cob of maize. In 2012 wet season, each increase in nitrogen from 0 to 90 kg N ha^{-1} significantly increased number of grains per cob, further increase to 135 kg N ha^{-1} did not significantly affect this parameter. In 2012/2013 dry season, number of grains per cob at 135 kg N ha^{-1} was highest but statistically similar to that at 45 and 90 kg N ha^{-1}.

There was no significant effect of spacing on number grains per cob in both the seasons. Only the interactions between variety and spacing in 2012 significantly affected the number of grains per cob.

4.16.1 Interactions on number of grains per cob

Table 4.21 shows the effect of interactions between spacing and variety on number of grains per cob of maize at Samaru during 2012 wet season. The two varieties produced comparable number of grains per cob at 25 cm spacing, which were statistically higher than those obtained at the other spacing. However, SAMMAZ-28 produced the least number of grains at 20 cm, while SAMMAZ-29 produced the least number of grains at 15 cm spacing. SAMMAZ-28 showed a significant decrease in number of grains per cob with increase in spacing from 15 cm to 20 cm, but with a further increase in spacing the number of grains was highest with SAMMAZ-29, however, each increase in intra-row spacing resulted in a significant increase in number of grains per cob. At 15 cm spacing SAMMAZ-28 produced more grains per cob than SAMMAZ-29, while the reverse was the case at 20 cm spacing; at 25 cm spacing the were no significant differences in number of grains per cob between the two maize varieties.

4.17 Cob Weight per Plant

Table 4.22 shows the varietal differences, effect of nitrogen rate and spacing on cob weight of two maize varieties at Samaru during 2012 wet season and 2012/2013 dry season. The two varieties differed in their cob weight in 2012 wet season only; SAMMAZ-29 produced heavier cobs than SAMMAZ-28.Varying nitrogen rate significantly affected cob weight of maize in both seasons. In 2012 wet season, application of 135 kg N ha^{-1} produced significantly heavier cobs per plant than the other nitrogen rates applied. Similar trends was also observed in 2012/2013 dry season where 135 kg N ha-^{1} produced the heaviest cobs but was statistically at par with 45 and 90 kg N ha^{-1}.Varying spacing had significant effect on cob weight per plant of maize in 2012 only. Increase in spacing from 15 cm to 20 cm significantly increased cob weight per plant, but further increase to 25 cm did not significantly affect this parameter. Interactions among treatments had no significant effect on cob weight per plant of maize in both seasons.

Table 4.20: Number of grains per cob of two maize varieties as influenced nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	Number of grains per cob	
Treatments	2012 wet season	2012/2013 dry season
Variety (V)		
SAMMAZ-28	392.3	414.2
SAMMAZ-29	392.9	617.0
SE ±	3.378	97.63
Nitrogen (N) rate (kgha^{-1})		
0	323.6c	324.2b
45	365.8b	490.9ab
90	442.5a	462.0ab
135	438.6a	785.9a
SE ±	4.777	138.07
Intra-row spacing (R)		
15 cm	390.1	401.4
20 cm	388.8	570.9
25 cm	398.9	574.6
SE ±	4.137	119.57
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	*	NS
N x R x V	NS	NS

Means followed by the same letter(s) within column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

* = Significant at 5% level of probability

Table 4.21: Interaction between variety and intra-row spacing on number of grains per cob of two maize varieties at Samaru during 2012 wet season

Variety(V)	Intra-row spacing (R)		
	15 cm	20 cm	25 cm
SAMMAZ-28	392.75b	384.92c	399.42a
SAMMAZ-29	389.58c	393.83b	398.50a
SE±		5.908	

Means followed by the same letter(s) do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT)

Table 4.22: Cob weight per plant of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

Treatments	Cob weight per plant(g)	
	2012 wet season	2012/2013 dry season
Variety (V)		
SAMMAZ-28	59.19b	123.18
SAMMAZ-29	69.86a	122.34
SE ±	3.149	14.773
Nitrogen (N) rate (kgha^{-1})		
0	46.32c	93.16b
45	59.90b	108.47ab
90	68.81b	121.19ab
135	83.08a	168.22a
SE ±	4.453	20.892
Intra-row spacing (R)		
15 cm	56.29b	134.04
20 cm	68.97a	112.73
25 cm	68.24a	121.51
SE ±	3.857	18.093
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	NS	NS
N x R x V	NS	NS

Means followed by the same letter(s) within column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

4.18 100-grain Weight

Varietal difference, effect of nitrogen rate and spacing on 100-grain weight of two maize varieties at Samaru during 2012 wet season and 2012/2013 dry season are as shown in Table 4.23. The varieties did not significantly differ in 100-grain weight in both seasons; however, variation in nitrogen rates significantly affected 100-grain weight of maize in both seasons. In 2012 wet season, increase in N rate from 0 to 45 kg N ha^{-1} did not cause a significant change in 100-grain weight but a further increase to 90 kg N ha^{-1} did; increasing the N to 135 kg N ha^{-1} caused no further significant change. In 2012/2013 dry season 45 kg N ha^{-1} gave significantly higher 100-grain weight than the control, but it was comparable to 90 kg N ha^{-1} but both rates significantly lower than 135 kg N ha^{-1}. Varying intra-row spacing significantly influenced 100-grain weight in both seasons; increased intra- row spacing from 15 to 20 cm in 2012 significantly increased 100-grain weight, and further increase of spacing to 25 cm did not significantly affect this parameter. In 2012/2013 only change in spacing between 15 to 25 cm caused a significant increase in 100-grain weight; 100-grain weight at 25 cm spacing was comparable to that at 20 cm. Interactions among treatments had no significant effect on 100-grain weight in both seasons.

4.19 Grain yield Per Hectare

Table 4.24 shows the grain yield per hectare of two maize varieties as influenced by varietal differences, nitrogen rates and intra-row spacing at Samaru during 2012 wet season and 2012/2013 dry season. Varietal difference was not significant in each season and when averaged over both seasons.

Varying nitrogen rates significantly affected yield of maize in both seasons and the combined. Each increase in nitrogen rate from 0 to 90 kg N ha^{-1} significantly increased maize grain yield beyond which there was no significant effect on yield per hectare. When spacing was varied, it significantly affected maize yield such that in 2012 wet season increase in spacing from 15 to 20 cm significantly increased yield per hectare, but further increase to 25 cm did not significantly affect maize yield per hectare. In 2012/2013 dry season only change from 15 and 25 cm significantly increased maize grain yield as yield at 25 cm was comparable only to 20 cm .In the combined however, each increase in spacing caused a significant increase in maize grain yield. There were no significant interactions between factors on yield per hectare of maize in both seasons.

Table 4.23: 100-grain weight of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

	100-grain weight(g)	
Treatments	2012 wet season	2012/2013 dry season
Variety (V)		
SAMMAZ-28	20.27	23.90
SAMMAZ-29	22.93	24.01
SE ±	2.366	0.314
Nitrogen (N) rate (kgha^{-1})		
0	18.59c	21.66c
45	20.58c	23.83b
90	22.18ab	24.52b
135	25.07a	25.82a
SE ±	3.346	0.444
Intra-row spacing (R)		
15 cm	20.71b	23.39b
20 cm	23.14a	23.85ab
25 cm	20.96a	24.63a
SE ±	2.898	0.385
Interaction		
N x R	NS	NS
N x V	NS	NS
V x R	NS	NS
N x R x V	NS	NS

Means followed by the same letter(s) within column and treatment group do not differ significantly at5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

Table 4.24: Yield per hectare of two maize varieties as influenced by nitrogen rate and intra-row spacing at Samaru during 2012 wet and 2012/2013 dry seasons.

Treatments	2012 wet season	2012/2013 dry season	combined
Variety (V)			
SAMMAZ-28	996.6	3315.1	2155.85
SAMMAZ-29	992.9	3276.1	2134.5
SE ±	21.976	96.299	59.137
Nitrogen (N) rate (kgha^{-1})			
0	689.7c	2791.7c	1740.7c
45	905.3b	3171.4b	2038.35b
90	1187.3a	3784.8a	2486.05a
135	1196.6a	3934.4a	2565.50a
SE ±	31.079	136.189	83.634
Intra-row spacing (R)			
15 cm	940.0b	3113.0b	2026.5c
20 cm	1018.7a	3239.1ab	2128.9b
25 cm	1025.5a	3534.7a	2280.1a
SE ±	26.915	177.944	102.42
Interaction			
N x R	NS	NS	NS
N x V	NS	NS	NS
V x R	NS	NS	NS
N x R x V	NS	NS	NS

Means followed by the same letter(s) within column and treatment group do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

NS= Not Significant.

4.20 Correlation Analysis

Tables 4.25 and 4.26 showed the association between grain yield, growth and yield components of two maize varieties in both seasons. In 2012 wet season, maize grain yield was positive and highly significantly correlated with plant height at anthesis, cob weight, cob length and number of grains per cob while in 2012/2013 dry season the correlation was positive and highly significantly correlated with nitrogen content of ear leaf at tasseling, cob length, cob diameter and 100-grain weight. In 2012 wet season the correlation with yield was positive and significant with respect to all other parameters except number of days to 50% tasseling and silking in 2012, while in 2012/2013 dry season the correlation with yield was positive and significant with total dry matter, plant height at anthesis and cob weight per plant. The correlation was negative and significant only with number of days to 50% tasseling in 2012 while in 2012/2013 dry season, it was positive but not significant with stand count at anthesis and was negative but significant with number of days to 50% tasseling and silking.

4.22 Regression

Figure 1.1 shows that regression equations for nitrogen rate on yield ha^{-1} were both quadratic in both seasons. In 2012, SAMMAZ-28 (V1):- $Y=-0.133x^2+32.14x+1496$, $R^2=0.768$ and SAMMAZ-29 (V1):-$Yield=-0.043x^2+17.24x+1787$, $R^2=0.829$. In 2013 SAMMAZ-28 (V1):- $Y=-0.100x^2+22.14x+2764$, $R^2=0.709$ and SAMMAZ-29 (V1):- $-0.079x^2+14.90x+2683$, $R^2=0.868$. Such that the optimum yield of SAMMAZ-28 (V1) were 3437.6 kg ha^{-1} at 120 kg N ha^{-1} and 3989.4 kg ha^{-1} at 111 kg N ha^{-1} in 2012 and 2013 seasons respectively. For SAMMAZ-29 (V2), the optimum maize yield were 3512 kg ha^{-1} at 114 kg N ha^{-1} and 3385.56 kg ha^{-1} at 94 kg N ha^{-1} in 2012 and 2012/2013 seasons, respectively.

Table 4. 25 Correlation matrix between grain yield and other yield components of maize at Samaru during 2012 wet season.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.275□	1.000										
3	0.254□	0.337□	1.000									
4	0.288□	0.939□ □	0.273□	1.000								
5	0.479□ □	0.405□ □	0.524□ □	0.359□	1.000							
6	0.551□ □	0.205□	0.266□	0.142	0.651□ □	1.000						
7	0.361□	-0.0366	0.0565	0.003	0.17	0.006	1.000					
8	0.525□ □	0.135	0.359□	0.066	0.637□ □	0.567□ □	0.098	1.000				
9	0.369□	0.147	0.112	0.146	0.303□	0.452□ □	-0.156	0.419□ □	1.000			
10	0.881□ □	0.231□	0.249□	0.252□	0.406□ □	0.415□ □	0.413□ □	0.525□ □	0.269□	1.000		
11	-0.217□	-0.217	0.0147	-0.125	0.179	0.281□	0.044	0.2□	0.05	0.187	1.000	
12	-0.045	-0.196	0.145	-0.249□	0.084	0.086	0.246□	-0.025	-0.212□	-0.041	0.526□ □	1.000

□ □= signi.

□=sign.

Keys

1.Yield/ha

2.Crop growth rate

3.Leaf area index

4.Total dry matter
5.Plant height at anthesis
6.Cob weight
7.Cob diameter

8.Cob length

9.100-seed weight

10.Number of grains per cob

11.Number of days to 50% tasseling
12.Number of days to 50% silking

Table 4. 26 Correlation matrix between grain yield and other yield component of maize at Samaru during 2012/2013 dry season

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.244□	1.000										
3	0.279□	0.201□	1.000									
4	0.378□	0.009	-0.306□ □	1.000								
5	0.436□ □	-0.279□	-0.254□	0.702□	1.000							
6	0.237□	-0.092	-0.0759	0.0399	0.203□	1.000						
7	0.589□ □	-0.111	-0.115	0.11	0.512□ □	0.187	1.000					
8	0.459□ □	-0.0028	-0.0828	0.101	0.407□ □	-0.168	0.499□ □	1.000				
9	0.034	0.0697	-0.257□	0.113	0.343□ □	-0.242□	-0.015	0.119	1.000			
10	0.487□ □	-0.119	-0.255□	0.506□ □	0.63□ □	0.241□	0.533□ □	0.493□ □	0.175	1.000		
11	-0.101	0.033	0.105	0.195	0.23□	-0.029	0.015	0.096	-0.043	0.0061	1.000	
12	-0.174	-0.028	0.191	0.0374	-0.039	0.0086□	-0.139	0.0269	-0.262□	0.0931	0.619□ □	1.00

Key

1.Yield/ha

2.total dry matter

3.Relative growth rate

4.Plant height at anthesis

5.Nitrogen content at tasseling

6.Cob weight /plant

7.cob length

8.Cob diameter

9.Stand count at anthesis

10.100-seed weight

11.Number of days to 50% tasseling

12.Number of days to 50% silking

□ □=Highly sign.

□ =Sign.

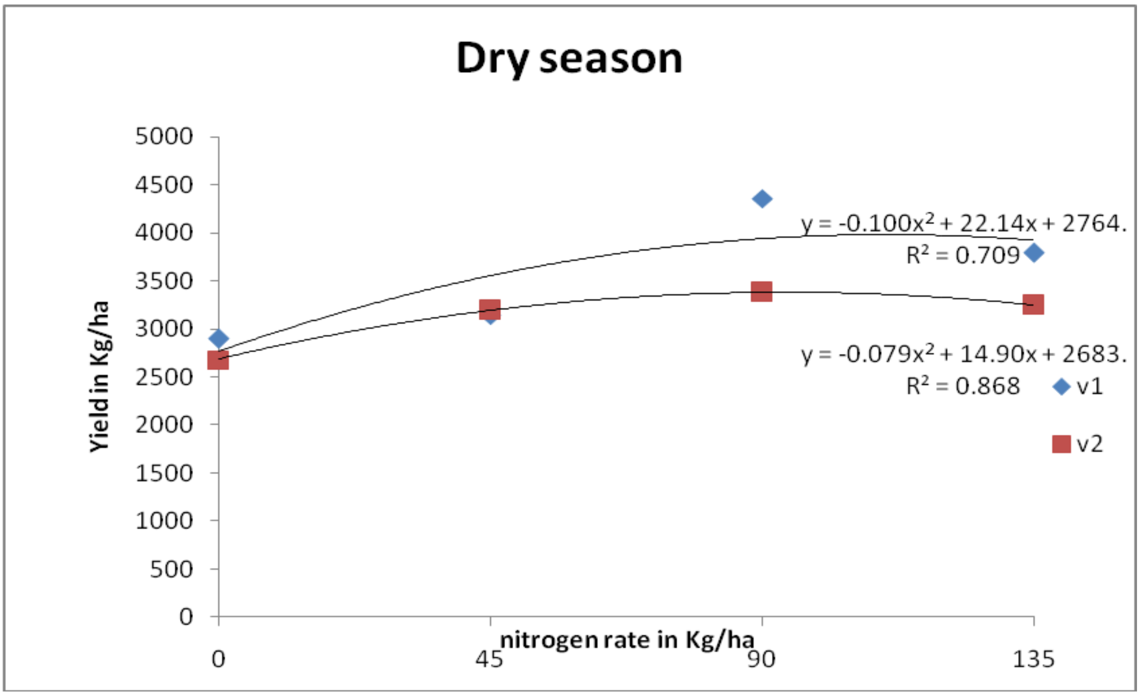

Figure 4. 1 Regression of maize yield against nitrogen rate in 2012 wet season

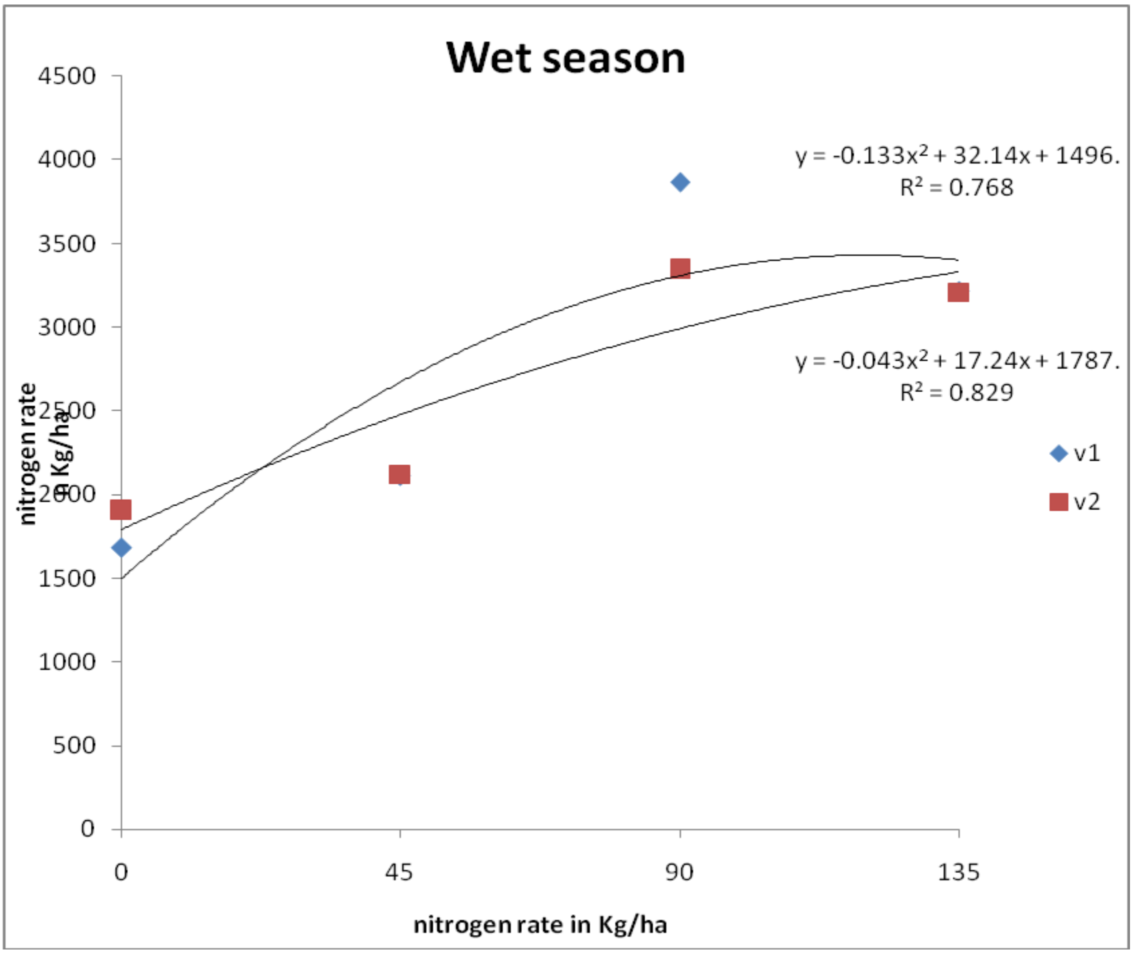

Figure 4. 2 Regression of maize yield against nitrogen rate in 2012/2013 dry season

CHAPTER FIVE

5.0 DISCUSSION

5.1 General Performance.

Higher growth, yield and yield components of maize, particularly total dry matter ,100-grain weight, leaf area index, plant height, number of grains per cob and yield ha^{-1} were observed in dry season compared with 2012 wet season. These could be attributed to the favorable agro-climatic conditions, particularly solar radiation, temperature and good water control by irrigation in 2012/2013 dry season. The lower growth, yield parameter and yield in 2012 could be attributed to the high cloud cover during the rainy season and consequently lower solar radiation reaching the crop surface. This phenomenon is responsible for the low productivity of maize crop in the southern part of Nigeria with high cloud cover, low solar radiation and high relative humidity compared with the productivity of this crop in the savannah with abundant solar radiation and low cloud cover. Another factor could be attributed to the low yield observed in 2012 was the heavy rainfall and poor drainage which caused water-logging, leaching of the nitrogen applied, poor soil aeration and plant metabolism ,thus inducing stunted growth and development and low yield. The high relative humidity (75.5%) recorded in September, 2012 wet season coincided with anthesis, negatively correlated with yield of maize, because at high relative humidity, pollens could have been washed away by heavy rain (Hussaini *et al.,* 2004).

5.2 Influence of Nitrogen on Growth Characters

In the present study, the following growth components were found to respond positively to nitrogen application. Leaf area index, flag leaf area and ear leaf area significantly increased with increase in N rates. This was due to nitrogen ability of enhancing cell division, cell expansion and chlorophyll production. Therefore it is not surprising the nitrogen application facilitated rapid growth as more assimilates were produced for active cell division, elongation and other physico-chemical processes which significantly increased all the growth parameters mentioned above. Idem (1989) reported similar case that nitrogen has favorable effect on growth of maize through increase in cell division, cell expansion and increase in size of all morphological parts. Also Terman *et al.* (1977) found that application of nitrogen increased chlorophyll production and therefore enhances longer leaf area duration, net assimilatory ratio, crop growth rates and relative growth rates.

Application of nitrogen in this study significantly affected growth characters and yield of two maize varieties. The application of nitrogen up to 90 kg N ha^{-1} increased leaf area index, flag leaf area and ear leaf area. This was expected considering the positive role nitrogen plays on growth and development of crops particularly if applied in soils with low fertility as was the characteristics of the experimental sites. Prasad and Singh (1990), Hassan (1999), Lawal (2000) and Hussaini *et al.* (2001) reported similar findings. The positive response of RGR, NAR and CGR to N applied .could be due to effect of nitrogen application on shoot dry matter; Ahmed *et al.* (1993) and Mohsan (1999) also reported similar findings.

The number of days to 50% tasseling and silking significantly increased with nitrogen application. This was because of the role of nitrogen in promoting growth through increase in meristmatic and physiological activities there-by resulting in delaying the process of development and synthesis of more assimilate which come to initiate early flowering of the crop as against the characteristic deficiency symptoms associated with lower level of N, which will hasten growth and development. Hassan (1999), Husain *et al.* (2001), Baba (2002), Mani (2004), Anonymous (2007) and Namakka *et al.*(2009) reported an increase in N application up to 120 kg N ha^{-1} delayed number of days to 50% tasseling and 50% silking.

5.3 Influence of nitrogen on Yield Components and Yields.

Yield component such as 100-grain weight, cob weight, number of grains per cob and grain yield ha^{-1} were all optimized at 90 kg N ha^{-1}. Grain yield was observed to increase significantly with optimum nitrogen application and beyond that resulted in yield reduction, because excessive nitrogen encouraged vegetative growth at the expense of grain yield due to luxury consumption. This finding confirmed those of Hussaini *et al.* (2001), Mani (2004), Sharifai *et al.* (2004) and Namakka *et al.* (2009). Significant increase in 100-grain was observed with increase in nitrogen application up to 80 kg N ha^{-1}.This was because an increase in nitrogen application positively enhanced chlorophyll content in plant thereby improving photosynthetic activities that promotes assimilate production and resulting the final yield. Hussaini *et al.* (2001) reported similar response; they attributed this significant increase in yield to favorable effect of nitrogen on cob length and cob diameter, which have direct bearing on the final grain yield. This increase in yield could be because of good dry matter production for grain filling.

5.4 Influence of Intra-row Spacing on Yield Components and Yield

Spacing (inter and intra-row) have effect on the performance of crops especially maize. Maize growth decreased and yield declines when intra-row spacing was reduced beyond certain levels primarily because of increase in inter plant competition for growth factors and reduction in the number of harvestable cobs. However, in the case of reduced spacing, intense inter plant completion for light, soil nutrients and soil moisture set in ,thereby resulting in low crop performance, This results in limited supplies of enough growth factors such as soil nitrogen, consequently increases barrenness and reduced grain number per plant (Inuwa, 2001). Maize intra-row spacing for maximum economic yield varies from 18 to 45cm depending on planting date, water availability, soil fertility, maturity and varietal canopy architecture (Sangoi, 2001). The result of this study showed a non-significant response to varying intra-row spacing by a growth parameter as well as yield component such as flag leaf area and number of grains per cob respectively, this could be genetic rather than environmental or treatments factors. Increasing intra-row spacing from 15 to significantly increased dry matter per plant, number of days to 50% tasseling, ear leaf area, 100-grain weight and yield per hectare. This could be as a result of less competition due to optimum plant population. This result confirmed the report made by Habib *et al.* (2002) that 1000-grain weight declined with increased plant population. However, the higher grain yield obtained at closer intra-row spacing (20 cm), could be attributed to higher number of plants and harvestable cobs at optimum spacing. This result was in conformity with the findings of Okan*et.al.* (2004) who obtained highest grain yield from closest intra-row spacing of 20 cm.

5.5 Varietal Difference

The significant increase in ear leaf area, net assimilation ratio, number of days to 50% tasseling and 50% silking, exhibited by SAMMAZ-28 over SAMMAZ-29 in both the seasons could be attributed to more responsiveness to fertilizer and genetic makeup, because these characters are genetically controlled and could be influenced by the environment to some extent. There were no significant differences in leaf area index, 100-grain weight, number of grains per cob, and yield ha^{-1} between the varieties. This finding confirmed the result obtained by Mani *et al.* (2002), who observed a non significant increase in plant height and grain yield ha^{-1} between varieties.

5.6 Interactions

The significant interactions between variety and spacing on ear leaf area and number of grains per cob observed in 2012 wet season could be attributed to the presence of favorable moisture condition for growth and development which resulted in better leaf development and overall plant growth provided by the moderate fertilizer rate and spacing as well as optimum environmental conditions.

5.7 Correlations

The correlation study shows a positive and significant association between grain yield and yield parameters such as cob weight per plant and 100-grain weight, two maize varieties. The relationship therefore indicates that the growth parameters such ear leaf area, flag leaf area, leaf area index at 8WAS and dry matter at 8WAS in both seasons are important yield contributors to grain yield of extra-early maize varieties. Similar results were reported by Atabo (1995) and Hassan (1999).

5.8 Regression

The regression analysis revealed that grain yield increased from the control to 111 kg N ha^{-1} in dry season and 114 kg N ha^{-1} in wet season beyond which a decline in yield was observed. The decline in grain yield beyond the aforementioned rates are probably due to the fact the optimum fertilizer level had been achieved and any further increase of nitrogen fertilizer will lead to luxury growth at the expense of grain yield. Similar observation was reported by Anon (2006).

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION

Two seasons field trials were conducted in 2012 wet and 2012/2013 dry seasons at the Institute for Agricultural Research (IAR) Farm, Samaru (11°11´ 07°38´E and 686m altitude) to study the response of two extra-early maize varieties to varying nitrogen rates and intra-row spacing. The trial consisted of two extra-early maize varieties (SAMMAZ-28 and SAMMAZ-29), four nitrogen rates (0, 45, 90 and 135 kg N ha^{-1}) and three intra-row spacing (15, 20 and 25 cm) arranged in a Randomized Complete Block Design and replicated three times. The result obtained showed that the varieties studied did show significant differences in terms of stand count at (2WAS and harvest), 50% tasseling and 50% silking, cob diameter flag leaf area. SAMMAZ-28 variety proved to be superior to SAMMAZ-29 Variety in terms of % stand count at (2WAS and harvest), 50% tasseling and silking and cob diameter. Regression analysis showed the optimum rate of nitrogen and yield for maize variety SAMMAZ-28(V1) were 3437.6 kg ha^{-1} at 120 kg N ha^{-1} and 3989.4 kg ha^{-1} at 111 kg N ha^{-1} for wet and dry seasons respectively; while for SAMMAZ-29 (V2) the optimum yield as 3521 kg ha^{-1} with 114 kg N ha^{-1} and 3385.56 kg ha^{-1} at 94 kg N ha^{-1} for wet and dry seasons respectively. In conclusion, it could be suggested that SAMMAZ-28 with 111 kg N ha^{-1} in dry season and SAMMAZ-29 with 114 kg N ha^{-1} in wet season each sown at spacing of 20 cm could be used by farmers in the northern Guinea savannah ecological zone of Nigeria for increased extra-early maize production.

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Appendix 1.1: Physico-chemical properties of soils at experimental fields at Samaru during 2012 wet and 2012/2013 dry seasons.

	2012 wet season	2012/2013 dry season
Soil depth (cm)	0-30 cm	0-30 cm
Soil characteristics		
Particle size distribution (gkg^{-1})		
Sand	43.0	48.0
Silt	46.8	42.2
Clay	10.2	9.8
Textural class	loam	loam
Chemical composition		
PH in H_2O (1:2.5)	5.9	6.47
Organic carbon (%)	0.45	1.2
Total nitrogen (%)	0.10	0.92
Available phosphorous (mgkg^{-1})	0.21	0.24
Exchangeable bases (cmolkg^{-1})		
Ca	0.74	1.1
Mg	0.51	0.53
K	0.12	0.34
Na	0.12	1.4
CEC	5.4	5.7

The soil samples were taken from IAR field Z6 and irrigation site and were analyzed in Department of Agronomy soil analysis laboratory.

Appendix 1.2: Meteorological data showing mean monthly air temperature, relative humidity, sunshine and total rainfall distribution at 10 days interval during the 2012 wet and 2012/2013 dry seasons at Samaru.

Cropping period	Month	Air Temp (°C)		(%) R. Humidity		Sun Shine (Hrs)	Rainfall (mm)
2012		Max	Min	10am	4pm		
Wet Season	July	30.29	20.10	82.6	67.7	5.26	165.3
	August	29.10	19.50	82.3	73.9	4.48	428.7
	Sept	30.36	19.80	77.3	73.8	5.02	270.3
	Oct	33.80	20.80	70.22	55.3	7.32	79.6
	Nov	34.3	17.43	32.9	28.23	8.59	-
2012/2013 dry season	March	39.29	22.77	38.12	14.61	7.62	-
	April	37.46	24.77	52.93	24.77	7.08	66.5
	May	35.38	24.87	64.64	50.87	7.73	167
	June	32.53	23.2	69.63	60.20	8.80	314.9
	July	30.58	22.42	80.03	67.64	5.67	

Meteorological data were obtained at the Institute for Agricultural Research, Ahmadu Bello University, meteorological weather station Samaru, Zaria.

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