Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

Growth and yield response of maize to different nitrogen and phosphorus rates in yola, Nigeria.

Kwaghe, E.J. [1] **and Gungula, D** [2]

[1] *Raw Materials Research and Development Council, Abuja, Nigeria*

[2] *Department of Crop Production and Horticulture, Federal University of Technology, Yola, Nigeria*

ARTICLE INFO

Article history:

Received September 17, 2020

Received in revised form October 7 2020

Accepted January, 2021

Available online March 18, 2021

Keywords:

Nitrogen

Phosphorus

Growth

Yield

Maize

Corresponding Author's E-mail Address:

ekwaghe16@gmail.com

234 803 913 0278

https://doi.org/10.36265/njss.2021.310108

ISSN-1597-4488 ©publishingrealtime.

ABSTRACT

Field studies were conducted during the 2000 and 2001 cropping seasons at the University Research Farm, Federal Universality of Technology, Yola to evaluate the response of maize (New Kaduna White) to different N and P rates in Yola, Nigeria. The study was a factorial type fitted in a Randomized Complete Block Design (RCBD) consisting of 8 treatments replicated three times. The treatments were four levels of N (0, 60, 120 and 180 kg N ha^{-1}) and two levels of P, (0 and 60 kg P ha^{-1}). Data collected were; plant heights at 4, 6, 8 and 10 weeks after planting (WAP), ear height at 12 WAP, shoot dry weight at 4, 6, and 8 WAP, cob weight, ear length, ear diameter, 100-grain weight, number of ears harvested per plot, and grain yield per hectare. Data collected were subjected to analysis of variance (ANOVA) appropriate to RCBD using statistical package SAS for Windows and least significant Difference (LSD) method was used to compare the difference between means. The results showed that the application of 120 kg N ha^{-1} and 60 kg P ha^{-1} significantly increased the growth and some yield components of maize than the other treatments. This study, therefore, suggests that for optimum grain yield in Yola and its environments, 120 kg N ha^{-1} and 60 kg P ha^{-1} is recommended for the study area.

1.0 Introduction

Maize is an important cereal crop that ranks third after wheat and rice in the world. Maize is grown in many countries of the world. According to Kochler (1986), the major producers are the USA (455,350, 000 tonnes) which account for 23 % of world production, India (65,000,000 tonnes), Italy (68,000,000 tonnes) and South Africa (8,300,000 tonnes). In Africa, the bulk of the maize produced is used as human food although it is widely utilized for livestock feed.

According to FAO (2002) data, the area planted maize in West and Central Africa alone increased from 3.2 million tonnes in 1961 to 8.9 million tonnes in 2001. This phenomenal expansion of the land area devoted to maize resulted in increased production from 2.4 million metric tonnes in 1961 to 10.6 million tonnes in 2001 (FAO, 2002). According to RMRDC (1997), in Nigeria, 5.22 million tonnes of maize was produced locally in 1988 which steadily rose to 5.87 million tonnes and 7.25 million tonnes in 1992 and 1995 respectively. Despite the increase in land areas under maize production, yield is still low. Some of the major causes of low yield are; declining soil fertility, insufficient use of fertilizer resulting in severe nutrient depletion of soils (Fada and Rayar, 1988). Maize requires an adequate supply of nutrients particularly nitrogen, phosphorus and potassium for good growth and yield. Lombin (1987), reported the enormous potential of the savannah zone for maize production can be fully exploited through adequate fertilization and national fertilizer program because, unlike sorghum and millet, maize requires relatively high soil fertility, particularly N and P. With the changeover from the traditional shifting cultivation to continuous cropping and the introduction of high yielding varieties in Nigeria, the fertility of the soil is declining steadily (Fada and Rayar, 1988). The more rapid method of restoring soil fertility is through the application of artificial fertilizer and this brings about the interaction between various nutrients which eventually affect various yield potential of crops especially high yielding varieties. The results of various fertilizer experiment in Nigeria showed that hybrid maize cultivars were found to require a high fertilization rate for optimum yield.

The presence of Nitrogen has been reported to promote phosphorus uptake, this is because N increases the availability of phosphorus by altering plant metabolism. Sobulo (1980), reported that maize responded to N better in the savannah than in the forest ecological zone. It was further suggested that 60-70 kg N ha $^{-1}$ served as an economic rate in the rain forest and over 100 kg N ha $^{-1}$ in the Savannah. N is a vital plant nutrient and a major yield determining factor required for maize production (Subedi and Ma, 2005). N is a component of nucleic acids and when N is suboptimal, growth is reduced (Hague et al 2001). Adeli and Varco (2001) reported an increase in dry matter yield of maize with total N accumulation and an increase in forage dry matter (DM) yield with 34 Kg N ha^{-1}. Each unit of linearly increased crude protein (CP) up to approximately 122 Kg N ha^{-1} respectively. N fertilizer also mediates the utilisation of phosphorus and potassium and other elements in plants (Brady and Weil, 2008). The increased application of N fertilizer helps to increase P uptake from the soil (Onasanya et al, 2009).

Phosphorus is another essential nutrient required for maize yield. It also affects the quality of grains and it may increase the plant resistance to disease (Bundy and Carter, 1988). Various factors could be responsible for phosphorus availability to crop plants. These include; the form of the native soil, the type of phosphorus applied to the soil and the soil reaction (Osiname, 1979). Soil phosphorus availability during maize seedling development is an important determinant of growth and yield and it is critical for the early growth and development of maize. This was attributed to more kernels per ear (Barry and Miller, 1989). The importance of phosphorus as a yield limiting factor in many Nigerian soils was well established (Adepetu and Corey, 1975). An increase in the grain yield of maize due to the application of mono-ammonium phosphate (MAP) in clay and sandy loam was reported by Grant et al. (1996). Phosphorus uptake depends on the morphological properties of the root system. Therefore, root growth and development are critical for early phosphorus uptake in maize since phosphorus is unavailable and immobile in many soils (Hoffman and Junk, 1995). According to Amnanullah et al., (2009b), phosphorus fertilization affected plant growth, yield and also increased plant height, grain weight, grain ear, grain and stover yields, shelling percentage and harvest index of maize compared with control.

The presence of the fertilizer N has been reported to promote phosphorus uptake by altering plant metabolism and by increasing root and top growth (Barber, 1984), by increasing biomass (Wilson and Tilman, 1991), by increasing both the aboveground and below ground parts (Day, 1993) and by affecting root length density and the entire root system (Weber and Day, 1996). Furthermore different levels of N and phosphorus have been reported to have a significant effect on plant height, number of rows per ear, 1000 grain weight, number of kernels per ear and yield per hectare (Joher et al, 2002).

The response of Maize to different rates of N and P and their optimum interactive optimum level for maize yield in Yola has not been investigated. This study aimed at evaluating the response of maize (*zea mays l.*) to different N and P rates and to determine their effects on its growth and yield properties of maize in Yola, Nigeria.

2.0 Materials and methods

2.1 Description of the study area

Yola is located between 9^0 19N latitudes and 12^0 30E longitudes in the Northern Guinea Savannah ecological zone of Nigeria at an altitude of 185.9 m above sea levels (Bashir, 2000). The main crops grown in the area are maize, sorghum, rice, cowpea and groundnut. The area had a total rainfall of 745.5 mm and 690 mm in the 2000 and 2001 cropping season. (Table 1a and b). Rainfall was distributed over 150 and 160 days and can effectively support high maize production. Yola and its environment have high solar radiation which indicated high photosynthetic potentials for crops like maize that are C4 and require warm temperature.

2.2 Experiment design and treatment

The hybrid variety of maize (New Kaduna) was used as a test crop to N and P fertilizers. The experimental design consists of a 4 x 2 factorial experiment in a randomized complete block design (RCBD) with three replications having factorial combinations of four levels of N (0, 60, 120 and 180 kg N ha^{-1}) and two levels of P (0 kg P ha^{-1} and 60 kg P ha^{-1}) was conducted during the main cropping seasons of 2000 and 2001 at the Research and Teaching Farm of the Department of Crop Production and Horticulture, Faculty of Agriculture, Federal University of Technology Yola. The total land area for the experiment was 430.5 m^2 which were demarcated and labelled into small plots of 10.5m^2 each made up of 3m x 3.5m. Each plot was demarcated into 5 rows with each row consisting of 12 hills.

2.3 Agronomic Practices

NPK 15: 15: 15 and Urea (46% N) were used as sources of N while only NPK 15: 15: 15 was used as a source of phosphorus. Basal application of 60 kg P ha^{-1} was applied at planting in all the plots except for the control where no P was applied. N fertilizer was applied in two split doses; a half dose using the NPK 15: 15: 15 at planting and the remaining half dose were applied four weeks later using Urea (46% N) as the source. Planting was done in early July for the two cropping seasons. The spacing between rows was 75 cm while the spacing within rows was 25 cm which gave a plant population of 53,333.33 plants per hectare. Weed control was done using a mixture of Atrazine and Garamazone herbicide which was supplemented with manual weeding as the field was removed.

3.0 Data collection

3.1 Collection and Analysis of soil sample

Soil sampling was done before the germination of crops at a depth of 0 -15 cm and 0-30 cm using an auger. Composite soil samples were taken from each plot bulked, labelled, air-dried in the shade and was taken to the laboratory to analyse for physicochemical properties.Percentage clay, silt and sand were analysed using Bounyous hydrometer method (Black, 1965); organic C determined by the dichromate wet oxidation method following the Walkey and Black method (Nelson and Sommer, 1996). Total N was determined by the macro-kjedal method (Bremmer, 1996); available P was determined using the bicarbonate method (Olsen et al. 1985), soil exchangeable cations (Na^+, K^+, Ca^{2+} and Mg^{2+}), were extracted with IN NH_4 Acetate solution. While Na^+ and K^+ were determined using the flame photometer, C^{2+} and Mg^{2+} were determined by titration with 0.02 N EDTA solution (Page et al. 1982). Soil pH was determined in 1:2:5 soil water ratio using a glass electrode attached to a digital pH meter.

3.2 Growth Parameters

Growth parameters measured include plant heights at 4, 6, 8 and 10 weeks after planting (WAP), ear height at 12 WAP, shoot dry weight at 4, 6, and 8 WAP. Plant height was determined by measuring the heights of the plant from the soil surface to the base of the unfolded leaf of five randomly selected plants in a plot. The average of the five plants was calculated and recorded as the average for that plant. Shoot dry weight was determined by destructive sampling involving three consecutive plants in a row. The plants were cut at ground level and separated into different parts and oven-dried at 70^0 C for 72 hours to obtain a constant weight.

3.3 Yield Parameters

Yield parameters were determined at maturity by counting and harvesting ten plants from the middle of the row (excluding two plants at both ends of each row). The ten samples harvested per plot were used to determine the yield parameters, which include: ear weight, cob weight, ear length, ear diameter, number of rows per ear, number of kernels per row and 100-grain weight.Furthermore, each plot was harvested and the total number of ears per plot was also recorded. Total ears per plot were later shelled, cleaned and weighed to determine the yield obtained per plot which was further extrapolated to yield per hectare as follows:

Grain Yield P ha^{-1} = Grain yield per plot x 10,000 m^2/Net plot size

3.2 Data Analysis

All data were subjected to analysis of variance (ANOVA) using Statistical Analysis Software (SAS, 2002). The difference among significant treatment means was tested using least significant difference (LSD) at 5% level of significance.

4.0 Results and Discussions

The meteorological information of the trial site for the 2000 and 2001 season is given in Tables 1a and 1b. Allaby (1998) reported that the factors of weather that affect the growth and development of maize include temperature, rainfall, amount of sunshine and relative humidity. The total rainfall in Yola during the 2000 cropping season was 775.45 mm as against 690.00 mm for the 2001 cropping season. This was considered sufficient for optimum maize production. It is mostly reported that maize is sensitive to drought stress during pollination when delayed emergence of silk may reduce fertilization (Jones, 1985). Drought stress as late as two to three weeks following 50% silking may also seed number (Frey, 1981). Similarly, temperature which is very important for phenological development and other physiological processes during the growth and development of crop, were found to vary during the 2000 and 2001 cropping seasons. The maximum temperature during June, July and August, which was 38.8^0C for year 2000 and 35.9^0C for the year 2001 were sufficient to hasten flowering and ear development. The sunshine during the first season was much more than in the second season. This was generally, sufficient in hours for good growth and development, which could be translated into grain yield for both the 2000 and 2001cropping season.

4.1 Soil texture and soil chemical analysis

The physical and chemical properties of the experimental sites are presented in Table 2. The results showed that the soils ranged from slightly to moderately acidic sandy loam with an average of 67% sand, 20% silt and 13% clay. The soils were therefore generally coarse-textured and well drained, characteristically low in org. C (0.74%), Avail. P (1.25 $mgkg^{-1}$), exchangeable bases (0.61 $cmolkg^{-1}$) and CEC (2.81 $cmolkg^{-1}$), suggesting low inherent fertility and productivity potential.

4.2 Effects of nitrogen and phosphorus on some growth parameters of maize in the year 2000 and 2001 cropping seasons

The mean squares for some growth parameters measured during the 2000 cropping season is presented in Table 3a. There were significant differences among means due to N treatments for plant heights at 6 and 10 WAP, ear height at 12 WAP and shoot dry weight at 4 WAP. The table further showed a significant difference among means due to P treatments for all the growth parameters measured except for plant height at 8 WAP which is not significant at 5% level of significance.

The mean squares for some growth parameters measured in the 2001 cropping season presented in Table 3b showed highly significant differences among means due to N treatments for plant eights at 4, 6, 8 and 10 WAP; ear height at 12 WAP and shoot dry weight at 4 and 8 WAP.

Table 1a: Weather information during the 2000 cropping season at Federal University of Technology (FUTY), Yola

Month	SRAD (hrs/day)	T MAX ^{0}C	T MIN ^{0}C	RAINFALL (mm)
Jan	5.6	55.6	21.3	0.00
Feb	6.6	34.3	21.1	0.00
March	11.1	40.6	25.3	0.00
April	9.5	41.1	23.8	4.75
May	7.5	37.8	26.1	99.9
June	8.2	31.9	24.4	115.1
July	8.1	31.0	23.7	122.7
August	6.1	38.8	23.0	248.4
September	6.6	31.8	23.1	155.1
October	7.4	34.6	23.4	29.5
November	7.8	38.0	20.2	0.00
December	5.1	34.5	18.3	0.00
TOTAL	89.3	430	273.8	775.45

SRAD = Solar radiation; T MAX ^{0}C = Maximum Temperature; T MIN ^{0}C = Minimum Temperature

Table 1b: Weather information during the 2001 cropping season at Federal University of Technology (FUTY), Yola

Month	**SRAD (hrs/day)**	**T MAX ^{0}C**	**T MIN ^{0}C**	**RAINFALL (mm)**
Jan	6.4	35.3	19.0	0.00
Feb	7.0	36.3	22.0	0.00
March	10.2	41.5	26.1	0.00
April	8.2	40.1	27.3	57.4
May	8.9	38.9	26.8	122.2
June	7.9	35.9	26.5	103.1
July	6.9	31.0	23.8	155.2
August	6.0	29.8	22.4	106.7
September	7.2	31.3	22.4	131.2
October	18.2	31.6	20.0	14.2
November	7.7	36.0	19.5	0.00
December	5.8	35.0	19.5	0.00
TOTAL	90.4	422.7	237	690

SRAD = Solar radiation; T MAX ^{0}C = Maximum Temperature; T MIN ^{0}C = Minimum Temperature

Table 2: Physicochemical properties of the soils of the experimental site for the 2000 and 2001 cropping seasons

Soil characteristics	Values for year 2000	Values for year 2001
Sand (%)	65	69
Silt (%)	21	19
Clay (%)	14	12
Soil texture	Sandy loam	sandy loam
Soil pH in H_2O	6.27	6.38
Organic carbon (%)	0.54	0.40
Total N (%)	0.06	0.08
Available P (mg kg^{-1})	0.8	0.9
Exchangeable Na^+ ($cmolkg^{-1}$)	0.28	0.32
Exchangeable K^+ ($cmolkg^{-1}$)	0.28	0.37
Exchangeable Mg^{2+} ($cmolkg^{-1}$)	0.41	0.62
Exchangeable Ca^{2+} ($cmolkg^{-1}$)	0.33	0.46
CEC ($cmolkg^{-1}$)	2.76	2.85

Table 3a: Analysis of variance Table showing the mean squares of growth parameters of maize measured during the 2000 cropping seasons

Source of variations	d.f.	Plant height (cm) at 4 WAP	Plant height (cm) at 6 WAP	Plant height (cm) at 8 WAP	Plant height (cm) at 10 WAP	Ear height cm at 12 WAP	Shoot dry weight (g) at 4 WAP	Shoot dry weight (g) at 6WAP	Shoot dry weight (g) at 8WAP
Replication	2	5.76	112.05	212.40	367.90	17.37	17.86	536.82	85.50
N	3	12.71^{ns}	94.20^{*}	2016.10	768.8^{*}	180.88^{*}	12.48^{*}	66.55^{ns}	187.8^{*}
P	1	105.76^{**}	829.08^{**}	2617^{**}	9456.5^{**}	1436.85^{**}	36.57^{**}	1308.18^{**}	3676.00^{**}
N x P	3	8.079^{ns}	56.95^{*}	1193^{ns}	67.7^{ns}	33.36^{ns}	4.67^{ns}	7.76^{ns}	175.5^{ns}
Error	14	4.06	12.56	1360	178.4	48.07	3.94	45.06	285.7

** = Significantly different at ($P \leq 0.01$); * = significantly different at ($P \leq 0.05$); ns = Not significantly different at ($P \leq 0.05$);
d.f. = degrees of freedom

Table 3b: ANOVA Table showing the mean squares of some growth parameters of maize measured during the 2001 cropping seasons

Source of variations	d.f.	Plant height (cm) at 4 WAP	Plant height (cm) at 6 WAP	Plant height (cm) at 8 WAP	Plant height (cm) at 10 WAP	Ear height cm at 12 WAP	Shoot dry weight (g) at4 WAP	Shoot dry weight (g) at 6WAP	Shoot dry weight (g) at 8WAP
Replication	2	169.16	1425.9	565.7	78.7	330.74	56.99	95.72	2293.4
N	3	113.33^{**}	658.5^{**}	1107.00^{**}	884.0^{**}	593.06^{**}	42.03^{**}	25.19	1248.30^{**}
P	1	908.45^{**}	9814^{**}	$27,448.20^{**}$	$13,162.40^{**}$	8844.50^{**}	552.64^{**}	992.95^{**}	13063.70^{**}
N x P	3	6.5^{ns}	28.70^{ns}	454.40^{ns}	49.40^{ns}	210.91^{ns}	5.18^{ns}	27.31^{ns}	116.20^{ns}
Error	14	20.38	124.3	181.00	119.00	81.93	9.49	43.29	253.6

** = Significantly different at ($P \leq 0.01$); * = Significantly different at ($P \leq 0.05$); ns = Not significantly different at ($P \leq 0.05$);
d.f. = degrees of freedom

The significant increases observed for plant heights at 4, 6and 8 WAP; ear height at 12 WAP; shot dry weight at 4 and 8 WAP during the 2000 and 2001 cropping season due to an increase in N from 0 to 120 kg N ha^{-1}could be attributed to an increase in the root which will increase both the above and below parts which were consistent with the observation by Tilman and Wilson (1991); Day (1993) and Barber (1994). Furthermore, significant increases in cob weight, number of rows ear, and grain yield per hectare in 2000 cropping season; ear weight, ear length, cob weight, number of rows per ear, number of ears harvested per plot, 100-grain weight and grain yield per hectare due to increased N in the year 2001 cropping season was consistent with the previous report by Adeli and Varco (2001) who reported increase performance and yield of maize due to increased N rates. Similarly, the table showed highly significant differences among means due to P treatments for plant heights at 4, 6, 8 and 10 WAP; shoot dry weight at 4, 6 and 8 WAP.

4.3 Effects of Nitrogen and Phosphorus on yield parameters of maize measured in 2000 and 2001 cropping seasons

The mean squares of yield and yield components measured in 2000 cropping season are presented in Table 4a. The table showed highly significant differences due to N treatments for cob weight, ear lengths, number of kernels per row, number of ears harvested per plot and grain yield per hectare. The table also showed highly significant differences among means due to P treatments for cob weight, ear weight, ear lengths, ear diameter, number of kernels per row, 100-grain weight, number of ears harvested per plot and grain yield per hectare. Interactions showed significant differences among means for the number of ears harvested per plot and highly significant differences among means for grain yield per hectare (Table 4a).

The mean squares for yield parameters measured during the 2001 cropping season are presented in Table 4b. The table showed highly significant differences among means due to N treatments for ear weight, cob weight, ear length, number of rows per ear, numbers of ears harvested per plots, 100-grain yield and grain yield per hectare. Similarly, the table showed highly significant differences among means due to P treatment for ear weight, cob eight, ear length, number of rows per ear, number of kernels per row, 100-grain weight, number of ears harvested per plot and grain yield per hectare, while N and P interactions showed highly significant differences among means for cob eight and significant differences among means for ear weight and grain yield per hectare during the 2001 cropping season (Table 4b).

4.4 Mean performance of some growth and yield parameters of maize measured during the 2000 cropping season

The Mean performance of some growth and yield parameters of maize measured during the 2000 cropping season are presented in Table 5a. Interactions of N and P on plant height at 6 WAP was highly significant where the increase in height due to N was only significant in the presence of applied P. The height response to P application was however significant at all levels of N including 0 kg N ha^{-1} .The combined application of 120 kg N ha^{-1}and 60 kg P ha^{-1}produced the tallest plants (39.43 cm). N and P interactions were also significant for days to 50% silking. The decrease in days to 50% silking was only significant in the

Table 4a: Analysis of variance Table showing the mean squares of yield parameters of maize measured during the 2000 cropping seasons

Source of variations	d.f	Ear weight (g)	Cob weight (g)	Ear length (cm)	Ear diameter (cm)	Number of rows per ear	Number of kernels per row	100 grain weight (g)	Number of ears harvested per plot	Yield(tonnes ha^{-1})
Replication	2	85.5	38.79	2.54	0.283	0.22	44.61	9.50	104.67	0.22
N	3	187.9^{ns}	60.06**	8.65**	0.91^{ns}	0.19^{ns}	59.10**	13.38	339.39**	7.59**
P	1	3676.6**	91.26**	17.04**	0.77**	0.38	23.94**	70.04**	504.17**	11.19**
N x P	3	175.5^{ns}	0.831^{ns}	2.71^{ns}	0.02^{ns}	0.41^{ns}	12.39^{ns}	7.93^{ns}	48.28*	1.36**
Error	14	285.7	3.86	0.87	0.57	0.97	7.27	7.26	12.95	0.15

** = Significantly different at ($P \leq 0.01$); * = Significantly different at ($P \leq 0.05$); ns = Not significantly different at ($P \leq 0.05$); d.f. = degrees of freedom

Table 4b: Analysis of variance Table showing the mean squares of yield parameters of maize measured during the 2001 cropping seasons

Source of variations	d.f	Ear weight (g)	Cob weight (g)	Ear length (cm)	Ear diameter (cm)	Number of rows per ear	Number of kernels per ear	100 grain weight (g)	Number of ears harvested per plot	Yield(tonnes ha^{-1})
Replication	3	901.82	3.28	1.54	0.53	0.56	132.77	7.41	1.49.58	0.20
N	3	948.99**	84.62**	3.77**	0.36^{ns}	2.61**	16.48^{ns}	0.62**	270.83**	10.37**
P	1	24,436.88**	672.53**	71.40**	1.49	14.72**	1004.42**	173.45**	220.5	8.54**
N x P	3	321.88*	17.50**	0.44^{ns}	0.87^{ns}	0.08^{ns}	74.82^{ns}	1.68^{ns}	25.33^{ns}	0.78*
Error		2190.61	4.09	0.51	0.41	20.38	71.46	0.86	14.39	0.19

** = Significantly different at ($P \leq 0.01$); * = Significantly different at ($P \leq 0.05$); ns = Not significantly different at ($P \leq 0.05$); d.f. = degrees of freedom

Table 5a: Mean performance of some growth and yield parameters of maize measured during the 2000 cropping seasons due to nitrogen and phosphorus interactions

	Plant height (cm)		Days to 50% silking		Number of ears per cob		Yield per plot(tonnes ha^{-1})	
	P rates (kg ha-1)							
N rates (kg ha^{-1})	0	60	0	60	0	60	0	60
0	17.20	37.80	66.67	66.33	27.00	28.67	1.42	2.29
60	24.39	35.60	65.00	27.33	27.33	42.67	2.01	3.61
120	32.50	39.43	67.67	64.00	39.00	48.67	2.88	5.46
180	30.53	38.80	66.00	66.00	38.00	48.00	3.95	4.35
LSD	6.205	6.205	1.981	1.981	6.303	6.303	0.6659	0.6659
F Prob.	0.003	0.003	0.017	0.017	0.037	0.037	0.001	0.001

WAP =Weeks After Planting; LSD = Least Significance Difference

presence of 60 kg P ha^{-1}, while the response of days to 50% silking was significant at all levels of N. The shortest days to silking was observed for plots treated with the combined application of 120 kg N $ha^{-1}$and 60 kg P ha^{-1}. An increase in the number of ear per plot was highly significant due to N and P interactions. A significant increase in the number of ears in the absence of P was only observed with the application of 120 kg N. There was however significant increase in the number of ears per plot for all levels of N in the presence of 60 kg P ha^{-1}. The highest number of ears harvested per plot (48.07) was for the combined application of 120 kg N $ha^{-1}$and 60 kg P $ha^{-1.}$

Yield response to N and P interactions was significant during the year 2000 cropping season. Yield response to N was significant in the presence of P. In the absence of P the highest yield obtained (3.95 tonnes per hectare) was with the application of 180 kg N ha^{-1}. However, in the presence of 60 kg P ha^{-1} the yield almost doubled, giving the highest yield of 5.46 tonnes ha^{-1} with the combined application of 120 kg N $ha^{-1}$and 60 kg P ha^{-1} (Table 5a).

4.5 Mean performance of some growth and yield parameters of maize measured during the 2001 cropping season.

The effects of the combined application of N and P interactions on some growth and yield parameters of maize during the 2001 cropping season are presented in Table 5b. The table showed that ear weight response to N was significant only with the application of 60 kg N ha^{-1}. In the absence of P, N response was not significant. The highest ear weight observed (135 g) was for the combined application 120 kg N $ha^{-1}$and 60 kg P ha^{-1}. The result revealed significant increases in cob weight with higher N rates. The heaviest cob weight was obtained with the combined application of 120 kg N $ha^{-1}$and 60 kg P ha^{-1}(Table 5b).

The Table further revealed higher yields with increased N rates in both the absence and presence of P. However, a significant yield response was observed due to N and P interactions. In the absence of P, the highest yield obtained (3.27 tonnes ha^{-1}) was achieved with the application of 180 kg N ha-1). However, the highest yield of 5.01 tonnes ha^{-1} was obtained with the combined application 120 kg N $ha^{-1}$and 60 kg P ha^{-1} (Table 5b). Similarly, the significant increases in plant height at 6WAP, 10 WAP and ear height at 12 WAP during the 2000 cropping season due to increased P rates from 0 to 60 Kg ha^{-1} and the significant increases in all growth parameters measured during the 2001 cropping season could be attributed to the effect of P in hastening early maize growth as previously reported by Mallarino et al (1999) who reported that phosphorus fertilization increased early maize growth significantly.

Furthermore, the significant increases in the ear-weight, cob weight ear length, number of kernels per row, number of ears harvested per plot and grain yield per hectare during the 2000 cropping season and the highly significant increases in ear weight, cob weight, ear length, number of kernels per row, number of ears harvested per plot and grain yield per hectare during the 2001 cropping season could be attributed to the indispensable role of P in the stimulation and hastening of maturity, fruiting and seed production as reported by Miller and Donahue (1990); Grant et al. (1996) who reported the increase in grain yield of maize due to the application of mono ammonium phosphate (MAP). This report is also consistent with earlier reports by Joher et al. (2002), who reported that different levels of N and P had a significant effect on plant height, number of ears per row, 1000 grain weight, number of kernels per ear and yield per hectare.

Application of various types of fertilizers to soils inevitably results in interactions among various nutrients of which eventually affect the yield potential of crops especially high yielding varieties. The combined application of nitrogen and phosphorus (N and P) during the 2000 and 2001 cropping seasons influenced the growth and yield parameters of maize measured during each of the cropping seasons. The significant interaction of N and P on the growth and yield of maize is largely due to the synergistic relationship between N and P in which the presence of one affects the uptake of the other.

This explains the higher mean values of growth and yield parameters measured during the two cropping seasons for all the plots treated with the combined application of N and P than for those plots treated with just either N or P only. Thus the shortest days to 50 % anthesis (62.67 days), the shortest days to silking ((64 days), the highest

Table 5b**:** Mean performance of some growth and yield parameters of maize measured during the 2001 cropping season.

	Ear Weight (cm)		Cob weight (g)		Yield (tonnes ha^{-1})	
	P rates (kg ha-1)					
N rates (kg ha^{-1})	0	60	0	60	0	60
0	53.20	97.40	11.20	16.17	1.28	1.93
60	64.30	135.50	14.22	25.47	2.04	2.69
120	764.30	135.50	14.22	26.55	3.05	5.01
180	866.7	126.40	15.30	25.47	3.27	4.14
LSD	14.00	14.00	0.97	0.97	0.65	0.65
F Prob.	0.032	0.032	0.017	0.017	0.020	0.020

WAP =Weeks After Planting; LSD = Least Significance Difference

yield per hectare (5.46 tonnes ha^{-1}) recorded during the 2000 cropping season and (5.01 tonne ha^{-1}) recorded during the 2001 cropping season were observed for plots treated with the combined application of 120 kg N ha^{-1} and 60 kg P ha^{-1}. This report is therefore consistent with earlier reports of Tisdale et al. (1993) and Wonde et al. (2007) who reported that the combined application of N and P significantly increased grain yield of hybrid maize cultivars and also improved some soil chemical properties such as available P, cation exchange capacity (CEC), total N, the texture, structure and water holding capacity of the soil; Bekeko, (2013) who reported that the combined application of 100 kg ha^{-1} and 80 kg P ha^{-1} resulted in the highest grain yield (4 Kg ha^{-1}) of hybrid maize (BH-140) in Western Haraghe Zone, Oromia Regional State Ethiopia and Onasanya et al. (2009) who confirmed that the combined application of 120 kg N ha^{-1} and 60 kg P ha^{-1} in South Western Nigeriaenhanced hybrid maize (TZB-SR) grain yield to 6.04 tonnes per hectare, even though the highest grain yield (7.13 tonnes ha^{-1}) was achieved with the combined application of 120 kg N ha^{-1} and 40 kg P ha^{-1}for that ecological zone.

5.0 Conclusion

This study confirms the role of N and P fertilizers in increasing the growth and grain yield of maize on alfisol on alfisols of Yola, North eastern Nigeria . The effects of N on growth in the 2000 cropping season were significant at 6 and 8 WAP with the application of 120 kg N ha^{-1}. However, in 2001, all the growth parameters measured were highly significant with the application of 120kg Nha^{-1} except shoot dry weight which was not significant at 5 % level of significance. Also, the application of 120kg N ha^{-1} significantly increased the ears harvested per plot and final grain yield during either the 2000 or2001 cropping season. Similarly, the application of 60 kg P ha^{-1} significantly increased all growth parameters measured in both the 2000 and 2001 cropping season except for plant height at 8 WAP in the 2000 cropping season. Yields were also significantly higher with P application during the two cropping seasons. However, with the combined application of 120 kg N ha^{-1} and 60 kg P ha^{-1}, the highest yield of 5.46 tonnes ha^{-1}and 5.01 tonnes ha^{-1}were recorded in the year 2000 and 2001 respectively.

From the result of this study, we wish to make the following conclusions: N and P interactions have a significant effect on the performance of maize on an alfisol. Therefore the levels of N and P rates that is recommended to ensure optimum high yields to farmers on the alfisol of Yola in the Northern Guinea Savanah zone of Nigeria and its environment with New Kaduna White maize variety is 120 kg N ha^{-1} and 60 kg P ha^{-1}. Furthermore, these results may be tested under various soil and climatic conditions in further studies.

6.0 Acknowledgements

The authors wish to express their appreciation to Mr Ibok U Ibok and Mr Amos of the Department of Food Science and Technology, Federal Polytechnic, Mubi for giving me access to use the laboratory oven to dry my samples. Also my appreciation goes to Mr Sale and other Laboratory Assistants of the Department of Crop Production and Horticulture, Federal University of Technology Yola for their considerable assistance with field and laboratory work.

References

Adeli, A and Varco, J.J (2001). Swine lagoon effluent as a source of nitrogen and phosphorus for summer forage grasses. *Agronomy journal*. Vol. 93, pp1174

Adepetu J.A. and Cornel, R.B. (1976). The relative importance of organic phosphorus as predictor to available phosphorus in soils of Southern Nigeria. *Soil Sc*. Vo.122 (3), pp 159-164

Allaby, M. (1988). MacmillanDictionary of Environment. 3rd Edition. Londonpp358-359

Ammanullah, M., Asif, S., Malhi, I. and Khattack, S. (2009b). Effects of phosphorus fertilization on plant density, growth and yield of maize in north westeren Pakistan. *J plant Nut*. Vol. 32 (2), pp2080-2093

Barber, S.A. (1994). *Soil nutrition Bioavailability*. A mechanistic approach, John Wiley and Sons Inc: New York, pp 176-179

Barry, D.A.J. and Miller, M.H. (1989). Phosphorus nutritional requirements of maize seedlings for maximum yield. *Agronomy Journal* Vol.81. pp 95-99

Bekeko, Z. (2013). Improving and sustaining soil fertility by use of enriched farmyard manure and inorganic fertilizers forn hybrid maize (BH-140) production at West Hararghe Zone, Oromia, Eastern Ethiopia. *African Journal of Agricultural Research.* Vol.8 (4), pp1218

Black, C.A. (1965). Method of Soil Analysis. *Agronomy* No. 9 part 2. Am Soc. Agron. Madison Wisconsin

Bremmer, J.M. (1996). Total Nitrogen. In Black C.A. (ed). Method of Soil Analysis, part 2. ASA, Madison, Winscosin. Vol. 9, pp 914-926

Bundy, G.L. and Carter, P.R. (1988). Corn hybrid response to nitrogen fertilization in northern Corn Belt. *J. Prod. Agriculture,* Vol.1 (2), pp 99-104

Brady, N.C. & Weil, R.R., (2008). The nature and properties of soils, 14th Ed. Prentice Hall, New Jersey.

Day, F.P. (1993). Plant response to nitrogen fertilizations on a barren Island due to chromosequences. *Biological Ecological Society of America*. Vol.74, pp 210

Dewis, J. and Freitas, P. (1970). Physical and chemical methods of Soil Analysis. FAO Bull. No.10, Rome. pp271

Fada, B. and Rayar, A.J. (1988). Agricultural Management Strategies in and Arid Environment.*Journal of Arid Agriculture*, Vol. 1, pp1-4

FAO (2002). Food crops and shortages. No.2 Food and Agricultural Organizations of the United Nations, April, 2002, pp1-10

Frey, N. M. (1981). Dry matter accumulations in maize kernels of maize. *Crop Science* Vol. 1: pp 118-122

Grant, C.A., Bailey, L.D. and Thierien, M.C. (1996). Fertilizer Research: *An international Journal covering all aspects of fertilizers*. Vol.48No. 2, Kluwar Academic Press, pp156-157

Haque, M, M., Hamid, A. and Bhuiyan, N. I. (2001). Nutrient uptake and productivity as affected by nitrogen and potassium levels in maize and sweet potato intercropping system. *Korean J. Crop Science.* Vol. 46 (1), pp1 -5

Hoffman, C. and Jungk, A. (1995). *International Journal on plant-soil relationship*. Vol176, pp17 and 19

Joher, A., Jehen, B., Mohammed, S. and Wajid, A (2002). Effects of various levels of nitrogen and phosphorus on yield and yield components of maize. *Pakistan Journal of Agron*. Vol.1, pp12-14

Jones, C.A. (1985). C_4 Grasses and Cereals. Growth, Development and stress response. Wiley, New York: pp16

Kochler, S.L. (1986). Tropical crops. A text book of economic botany. London, Macmillan: pp88-98

Lombin, G. (1987). Towards efficiency of fertilizer use in Nigeria

Malarrino, A.P.; Bordolli, J.M and Borgues, R. (1999). Phosphorus and potassium placement effects on early growth and nutrient uptake of No-Till Corn and relationships with grain yield. *Agronomy Journal*, Vol.91: pp7-45

Miller, R. W. and Donahue, R. L. (1990). An Introduction to Soil and Plant Growth. 6th Edition. Prentice Hall. pp250

Nelson, D.M. and Sommers, L. (1996). Total carbon, organic carbon and organic matter. In: D.L. Spark (eds). Methods of Soil Analysis

Olsen, S.R.; Watanabe, F.S. and Dean, L.A. (1985). Estimation of available P in the soil by extraction with sodium bicarbonate. USDA: pp939

Onasanya, Q.P., Aiyelari, A., Onasanya, S.,Oikeh, F.E., and Oyelakin, C.O. (2009).Growth and Yield response of Maize to different rates of Nitrogen and Phosphorus fertilizers in Southern Nigeria. *World J. Agric. Sci*. Vol. 5(4),pp400-407

Osiname, O.A. (1979). Maize response to phosphorus fertilization in ecological zones of West Africa. *Niger. J. Agric Sc.* Vol.1 (1), pp 9-13

Page, A. L.; Miller, P.H. and Keeney, D.R. (1982). Methods of Soil Analysis Part 2. Chemical and Microbiological properties. 2nd Edition. ASA. Inc. Madison Wisconsin, USA.

RMRDC. (1997). Raw Materials Sourcing for Manufacturing in Nigeria. 3rd Edition, Abuja, pp146\

(SAS 2002). Version 9.2. SAS Institute Inc. Cary, NC., USA

Sobulo, R.A. (1980). Nitrogen and phosphorus balance in maize in the humid tropics. Proceedings of International Conference on Nitrogen cycling in West Africa Ecosystems, pp. 311-375

Subedi, K.D. and Mal, B.L. (2005). Effects of N deficiency-and timing of N supply on the recovery and distribution of labelled 15N in contrasting maize hybrids. Plant and Science J. Vol. 273 91-2), pp 189-202

Tisdale,S.L., Nelson, W.L., Beaton, J.D., Havlin, J.L. (1993). Soil Fertility and Fertilizers(5th Ed.) Macmillan Publishing Company, UA

Weber, E.P. and Day, F.P. (1996). Effects of Nitrogen fertilization on the phenology of Roots. *Plant and SoilJ.* Vol. Kluwar Academic Publisher, pp 139-148

Wilson, S.D. and Tilman, D. (1991). Component of Plant Competition during an experimental gradient of nitrogen availability. *Ecology*. Vol.72, pp1000-1005

Wonde, A., Mossisa, W., berhanu, T. Legesse, W.,Alpha, D. and Tumassi, A. (2997). Performance of CIMMTY maize germplasm under low nitrogen soil conditions in the mid altitude sub humid agro ecology of Ethiopia. *Af. . Sci. conf. Proc*. 18: 15-18