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Effects of Nitrogen and Phosphorus on the Growth Performance of Maize (*Zea mays*) in Selected Soils of Delta State, Nigeria

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Abstract

The study was carried out in Delta State, Nigeria. Soil samples were collected from nine locations within Delta State namely Agbor, Asaba and Ubulu-uku (Delta North), Abraka, Oghara-Eki, Sapele (Delta Central), Oleh, Ozoro, Patani (Delta South). Surface soils (0-15 cm) and sub-surface soils (15-30 cm) depth. These were analyzed for their physical and chemical properties. In one of the locations (Agbor) found to be deficient in nitrogen (N) and phosphorus (P) field trials on the effects of these nutrients on the performance of maize (*Zea mays)* were carried out. The variety ACR-89DMRESR-W was used. The design was a 4 × 4 factorial scheme fitted into a randomized complete block design given sixteen treatments combinations with three replicates. The following treatments combinations were applied N_0P_{20}kg/ha, N_0P_{40}kg/ha, N_0P_{60}kg/ha, $N_{20}P_0$kg/ha, $N_{20}P_{20}$kg/ha, $N_{20}P_{40}$kg/ha, $N_{20}P_{60}$kg/ha, $N_{40}P_0$kg/ha, $N_{40}P_{20}$kg/ha, $N_{40}P_{40}$kg/ha, $N_{40}P_{60}$kg/ha, $N_{60}P_0$kg/ha, $N_{60}P_{20}$kg/ha, $N_{60}P_{40}$kg/ha, and $N_{60}P_{60}$kg/ha. The parameter measured were plant height and leaf number at 3, 6 and 9 weeks after planting (WAP), respectively. Combined application of 40 kgN/ha+40 kgP/ha significantly increased maize plant height and leaf number among all the treatments. Therefore combined application of 40 kgN/ha+40 kgP/ha is recommended for optimum growth of maize in the study area.

Keywords: Nitrogen; Phosphorus; Growth performance; Nigeria; Maize; Delta state

Introduction

Maize (*Zea mays L*) is a cereal crop which belongs to the family poaceae [1]. It is an important food crop in Nigeria. It forms a major part of cereal crops consumed by man [2] and serve as a source of dietary carbohydrates [3]. It is used for livestock feed and it is the cheapest and palatable livestock feed for animals such as pig, cattle, sheep, and poultry [4]. It is also a source of raw materials for the production of corn sugar, corn starch, corn syrub and corn oil [5].

Nitrogen is a vital plant nutrient and a major yield determining factor for maize production [6]. Its availability in sufficient quantity throughout the growing season is essential for optimum growth of maize. Most farmers in developing countries usually rely on natural soil fertility for crop production.

An application of urea and triple superphosphate (TSP) fertilizers in combination with farmyard manure was found to enhance the effectiveness of N and P fertilizers [7]. Opening up of a long fallow land may provide adequate nutrients to crops; however, cropping such land is only successful within a few years after its opening. Thereafter, subsequent cropping requires fertilizer input most importantly nitrogen to maintain good yields. Studies conducted by Stewart et al. [8] and Niehues et al. [9] revealed that starter nitrogen was able to stimulate the early growth and yield of maize.

Phosphorus is closely concerned with many growth processes in crop plants. It is involved in many biochemical reactions and concerned with the metabolism of carbohydrates, fats and protein and play roles in the breakdown of carbohydrates; phosphorus (P) is another limiting nutrient in maize production. According to Rehman et al. [10] nutrient P affects leaf growth and senescence dynamics in maize. Various factors could be responsible for P availability to crop plants. These include the form of native soil P, the type of P applied to the soil and reaction.

Some of the problems associated with the soil for cultivation of maize in Delta State Nigeria are deficiencies of Nitrogen and Phosphorus, leaching, continuous cropping, oil spillage and exploration [11]. For maize to reach full production capacity there is need to address nutrient deficiency and response to N and P fertilization in Delta State. Thus the objective was to determine the effect of N and P on maize plant height and leave number.

Materials and Methods

The study was carried out in the rain forest belt of Delta State which lies between 5°N and 8°N and longitude 5°W and 7°E of the equator. The soils have loose brownish top soil over a great depth of large differentiated, non-molten, non gravelly, porous sub soil with coarse sand ass the predominant fraction and clay content is up to 35%. The characteristic management and potentials of all these soils for maize cultivation have been reviewed by Omoti et al. [12]. There are two distinct seasons usually the dry season and the rainy season. Temperature is very high during the day and with cool night [13].

The samples were collected from nine locations within Delta State namely Agbor, Asaba and Ubuly-uku (Delta North), Abraka, Oghara-Eki, Sapele (Delta Central), Oleh, Ozoro, Patani (Delta South). These were chosen to reflect the differences in soil and vegetation characteristics. Surface soils (0-15 cm) and sub surface soils (15-30 cm) were sampled with a tabular sampling augur. Representative soil samples were taken and then bulked for each depth and location.

Based on the analysis, soil obtained (0-15 cm) from Agbor was found to be deficient in Nitrogen and Phosphorus against the established critical values. Consequently, the field trial was established in this location.

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The design was a 4 × 4 factorial scheme fitted into a randomized complete block design giving sixteen treatment combinations with three replicates. The following treatment combinations were applied N_0P_{20}kg/ha, N_0P_{40}kg/ha, N_0P_{6o}kg/ha, $N_{20}P_0$kg/ha, $N_{20}P_{20}$kg/ha, $N_{20}P_{40}$kg/ha, $N_{20}P_{60}$kg/ha, $N_{40}P_0$kg/ha, $N_{40}P_{20}$kg/ha, $N_{40}P_{40}$kg/ha, $N_{40}P_{60}$kg/ha, $N_{60}P_0$kg/ha, $N_{60}P_{20}$kg/ha, $N_{60}P_{40}$kg/ha, and $N_{60}P_{60}$kg/ha. Each plot measured 2.1 × 1 m^2 with alley of 1 m between plot and replicates. There were a total of 48 plots (16 × 3). The experimental area used was 329.6 m^2.

Maize seeds (ACR-89 DMERSR-W) obtained from International Institute of Tropical Agriculture (IITA) were sown on the 13th of April 2014 at 2 seeds per hole and later thinned to one plant per stand. The spacing was 70 cm × 25 cm giving a plant population of 20 plants per plot. Reading was done at interval 3, 4 and 10 weeks after planting (WAP) respectively.

Plant height readings were taken at 3, 6 and 9 weeks after planting, a tape rule was used to measure the height of the plant from the soil surface to the apex. The mean value was recorded in centimeters. Number of leaves were counted per plant, per plot at 3, 6 and 9 weeks and recorded respectively.

Plant height and number of leaves determined were subjected to appropriate statistical analysis; ANOVA and correlation coefficient.

Results and Discussion

Plant height

Mean plant height at 3 weeks after planting (WAP) ranged from 11.60-12.90 cm and 10.60 cm-13.60 cm when treated only to Nitrogen and Phosphorus fertilizers respectively (Table 1). The mean plant height value was highest when 40 kg/N/ha and 40 kg P/ha were applied and lowest in the control treatment. Application of fertilizer had no significant effect on plant height.

Treatments					
Nitrogen (Kg/ha)		**Phosphorus**			**Mean**
	0	20	40	60	
		Cm			
3 weeks					
0	9.83	11.42	13.00	13.88	12.0a
20	9.37	12.50	13.17	11.50	11.6a
40	12.48	10.78	15.27	12.87	12.9a
60	10.7	11.12	12.82	14.75	12.4a
Mean	10.6a	11.5a	13.6a	13.3a	
6 weeks					
0	56.50	59.50	68.50	67.83	63.1b
20	61.83	70.33	69.00	65.83	66.7b
40	69.17	65.50	78.50	73.33	71.6b
60	61.33	72.67	81.33	87.00	75.8ab
Mean	62.2b	67.0ab	74.3a	73.5a	
LSD (N=8.76) P=8.76)					
9 weeks					
0	120.5	122.0	143.7	140.3	131.6b
20	156.7	167.0	156.0	151.3	157.8a
40	162.2	166.3	184.5	179.2	173.1a
60	154.7	167.2	167.0	192.3	170.3a
Mean	148.5a	155.6a	162.8a	165.8a	
LSD (N=20.7)					

Figures in the column and rows for each week followed by the same letter are not significantly different at 5% level.

Table 1: Effect of Nitrogen and Phosphorus fertilizer on mean plant height of maize.

Treatments					
Nitrogen (Kg/ha)		**Phosphorus**			**Mean**
	0	20	40	60	
		Cm			
3 weeks					
0	6.17	6.33	6.00	6.00	6.1a
20	6.00	6.17	6.17	6.00	6.1a
40	6.17	6.00	6.83	6.33	6.3a
60	6.33	6.00	6.50	6.67	6.4a
Mean	6.2a	6.1a	6.4a	6.3a	
6 weeks					
0	10.0	10.2	11.0	11.3	10.63b
20	11.7	12.2	11.8	10.3	11.50a
40	12.0	11.7	13.5	13.0	12.55a
60	11.5	11.5	12.2	13.3	12.13a
Mean	11.30a	11.40a	12.13a	11.98a	
LSD (N=1.26)					
9 weeks					
0	14.8	14.3	15.3	14.3	14.68b
20	16.5	16.3	16.0	16.0	16.20a
40	14.8	15.3	15.8	15.7	15.28b
60	16.7	15.8	15.8	17.2	16.38a
Mean	15.7a	15.4a	15.6a	15.8a	16.38a
LSD (N=0.84)					

Figures in the column and rows for each week followed by the same letter are not significantly different at 5% level.

Table 2: Effect of Nitrogen and Phosphorus fertilizer on the number of leaves.

At 6 WAP, the mean plant height ranged from 63.1 to 75.8 and 62.2 to 74.3 cm when treated with Nitrogen and phosphorus fertilizer respectively. The application of P at 40 kg/ha significantly increased plant in comparison to the control but was not significantly different from other rates. The highest height was obtained at 40 kg/N/ha and 40 kg P/ha combined at three weeks after planting and 60 kgP and 40 kgN at six weeks after planting.

At 9 WAP, plant height was not significantly improved by phosphorus fertilization but was with nitrogen fertilizer. Mean plant height ranged from 148.5 to 165.8 cm and 131.6 to 173.1 cm when treated with phosphorus and nitrogen fertilizers respectively. Mean plant height increased with increasing levels of application of phosphorus and nitrogen fertilizers which is in line with studies conducted by Stewart et al. [8] and Niehues et al. [9] revealed that starter nitrogen was able to stimulate the early growth and yield of maize.

Number of Leaves

The mean number of leaves at 3WAP ranged from 6.1 to 6.4 when treated with phosphorus and nitrogen fertilizers respectively (Table 2). The mean values were not significantly different for both fertilizers rates of application.

At 6 WAP, mean number of leaves ranged from 11.30 to 12.13 and 10.63 to 12.55 when treated with phosphorus and nitrogen fertilizers respectively. The values obtained from treatments which received fertilizers were higher than the control.

At 9 WAP, mean number of leaves varied from 14.68 to 16.38 and 15.4 to 15.8 as a result of phosphorus and nitrogen fertilization. The values did not follow definite pattern with increasing fertilizer rates. Nitrogen fertilizer significantly increased mean number of leaves. The rates of 20

kgN/ha and 60 kgN/ha were significantly different from control which is in agreement with Rehman et al. [10] Who stated that nutrient P affects leaf growth and senescence dynamics in maize and Duncan [7] who reported that an application of urea and triple superphosphate (TSP) fertilizers in combination with farmyard manure was found to enhance the effectiveness of N and P fertilizers in maize production.

Conclusion and Recommendations

Nitrogen and phosphorus fertilization are important in the management of soil of the study area due to deficiency of both nutrients. The study revealed that maize growth was significantly enhanced by the application of Nitrogen fertilizer at the rate of 40 to 60 kg/ha compared to other rates of application. Maize response to applied phosphorus was not significantly different. However, the combined application of 40 kgN/ha plus 40 kgP/ha performed better in enhancing growth of maize. It is therefore recommended that the application of 40 kgN/ha plus 40 kgP/ha will effectively enhance maize growth since nitrogen has been reported to favour vegetative growth especially at the initial stage of growth [14].

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