Effects of Different Levels of Phosphorus on the Performance of Maize (Zea mays L.) in Anyigba, North central, Kogi State, Nigeria

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ABSTRACT

This study was undertaken in Anyigba Kogi State of Nigeria in 2007 and 2008 cropping seasons respectively to determine the effects of different level of phosphorus application on the growth and yield of maize(Zea may L) Soils samples were collected from different sites and were analysed for physical and chemical properties. Total phosphorus (P) was determined by standard laboratory procedure. Maize variety Downey mildew resistance (DMRT) from IART Ibadan was used for the experiment. The experiments was conducted using randomized complete block design (RCBD) with three replications..Seven rates of phosphorus (0, 20,40,60,80,100 and 120 kg/ha) applied as single super phosphate (SSP) were used for phosphorus calibration study Nitrogen and potassium were below critical levels hence urea and muriate of potash were used to raise them above the critical level before planting was done. The result showed that application of phosphorus fertilizer at rates 100 and 120 Kgtha significantly (P=0.05) increase all the parameters (number of leaves, stem girth plant height and leave area) compare to the control in 2007 and 2008 cropping season. It also showed that optimum maize yield of 5.40 and 5.51ton/ha were obtained for 2007 and 2008 cropping season, respectively from the application of 100 and 120 kgP/ha. 100 and 120 kgP/ha are therefore recommended for maize cultivation in soils of Anyigba Kogi State of Nigeria.

Keywords: Phosphorus. Cretaceous Sediment, Cropping season.

INTRODUCTION

Phosphorus (P) after N is the most important macronutrient limiting agricultural production in the tropics (Bame, 1998; Buresh*, et al.,* 1997). It had been reported to be the most limiting nutrient to crop production in Northern Nigeria (Yusuf and Yusuf 2008). Phosphorus nutrient deficiency is the norm in native soils and the imbalance affect large areas (Lynch and Clair, 2004). Many of the agricultural soils in the tropical and sub tropical regions are low in both total and available P when compared with other major nutrients (Chien and Monion, 1995). Replenishment of soil P is often problematic as it is often fixed in soils with high sorption capacity rendering it less available. The deficiency of P occurs widely in the tropics and it is so acute that plant growth stops because the seed reserve is quickly exhausted during germination (Jones and Wild, 1975). Deficiency of P is usually associated with low supply of available P, soil mineralogical properties and some chemical reactions which might lead to P tied down. Some studies had been conducted on how to increase soil P level through fertilizer application in order to enhance significant agronomic yield response (Sample *et al.,* 1980; Gale, 2000).

Crops respond differently to different P-fertilizer treatment; Khasawneh and Samples (1979) suggested that the concentration of soil solution P required by cowpea for maximum growth potential may be only two-third the concentration required by maize. Thus, the relative agronomic effectiveness of rock phosphate would be higher for crops with lower P demands, such as legume crops than for cereal crops. Kogbe and Adedira (2003) found that application of 80KgP/ha depressed cereals yield. They observed that with higher rate of P application, the lower the phosphorus use efficiency. The efficiency of maize in P utilization decreased as the P fertilizer rate was increased. They obtained the highest phosphorus use efficiency at 40 and 20kg P2O5/ha at Ilora and Mokwa, respectively. Tabi *et al.* (2007) reported that when P is maximally accumulated in the plant, the utilization efficiency was 97 kg P/ha taken up but when P was maximally diluted in the plant (i.e. most efficiently utilized), the utilization efficiency was 600 kg grain kg/ha taken up. In North Central guinea savanna of Nigeria, where Kogi State belongs, the soils are inherently low in P because of the dry nature of the climate, low vegetation cover and generally sandy nature of the soil, whose clay mineralogy is dominated by inactive kaolinite materials (Uyovbisere, 1994). It is consequently recognized that profitable cropping is only possible where soil fertility is adequately maintained (Lombin, 1987; Sinang, *et al.* 2002). With increasing pressure on soils of this agro ecological zone, shifting cultivation is no longer

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sustainable and traditional bush fallow period for maintaining the productivity of the soil has become shorter; soils are no longer able to supply the quantity of nutrients required and as a result, yield level declines rapidly once cropping commences. There is paucity of information as regards P status in soils of North Central Guinea Savanna agro-ecology of Nigeria hence the objective of this study was to determine the effects of different levels of phosphorus fertilizer to the growth and yield of maize.

MATERIALS AND METHODS

The Study area Anyigba, lies between latitude 5^0 15^1 to 7^0 451 N and longitude 5^0 45^1 and 8^0 45^1 East of the equator. Anyigba has a bimodal rainfall with the peak pattern occurring in July and September. The mean annual rainfall was 1,808 mm at Anyigba. Rainfall is distributed from March to November with most rains in June and again in September and October. The dry season generally extends from November to March. Average monthly temperature varies from 17ºC to 36.2ºC. Relative humidity is moderately high and varies from an average of 65 -85% throughout the year. The main vegetations is the forest savanna mosaic zone. The geology of the area is Cretaceous sediments. Composite surface soil samples (0-15cm) were collected from pre-classified sites (FDALR, 1985; Hill, 1979). The soil samples collected were air dried, crushed with the aid of wooden roller and sieved through 2 mm sieve and stored in plastic container with covers for subsequent use. Particle size was determined by hydrometer method (Gee and Bauder, 1986). Soil pH was measured in a soil: water ratio of 1:1 with the aid of glass electrode pH meter (Maclean, 1982). Organic matter was determined by wet dichromate acid oxidation method (Nelson and Sommers, 1982). Exchangeable bases (Ca, Mg, K and Na) were extracted with 1N NH_4OA_C buffered at pH7 (Thomas, 1982). The Ca and Mg were determined using atomic absorption spectro photometer, K and Na were read on flame photometer. Exchange acidity was extracted with 1N KCL (Thomas, 1982) and determined by titration with 0.05N NaOH using phenolphthalein as indicator. Nitrogen was determined by Macro Kjedahl method (Bremner and Mulvaney, 1982). Effective cation exchange capacity (ECEC) was calculated by the summation exchangeable bases (Ca, Mg, K and Na) and exchange acidity (Carter, 1993). Extractable micronutrients (Mn, Fe, Zn and Cu) were determined by double acid method. Total phosphorus was determined by per-chloric acid ($HCLO_4$) digestion method (Murphy and Riley 1962). Organic phosphorus was determined by ignition method (Legg and Black, 1955). Available P was estimated by Bray P-1 (Bray and Kurtz, 1945).

Table 1: Physico-chemical properties of soils in the study area
Field Calibration Studies,

Sand	%	90.10
Silt	%	6.50
Clay	%	3.40
Textural Class	--	Sand
pH (H20)	pH	5.88
OM	g/kg	17.20
N	Cmol/kg	6.20
P	Cmol/kg“	5.51
Ca	Cmol/kg	4.08
Mg	Cmol/kg	2.00
Na	Cmol/kg	0.84
K	Cmol/kg	0.35
H+		0.20
A1	g/kg	0.20
ECEC	g/kg	7.63
Al2O3		45.50
Fe2o3		6.50

The field experiments spanned over two years 2007 and 2008 cropping season respectively. The experiments were conducted using randomized complete block design with three replications (RCB). The experimental plot size used was 3.00m x 1.75 ($5.25m^2$) and the entire experimental area was 15.25m x 11m ($167.75m^2$). Maize variety, Downey mildew resistant (DMRT) from IAR&T Ibadan was used for the experiment and the spacing adopted was 75cm by 25cm. This was manually planted (three seeds per hole) at 3-5cm depths. The seedlings were thinned down to one plant per stand two weeks after emergence. There were a total of 28 stands of maize plants in each plot, 196 stands in a block giving a plant population of 588 plants on the entire experimental site.

Seven different levels of single super phosphate (SSP) fertilizer were applied at the following rates 0, 20, 40, 60, 80, 100 and 120 kgP/ha coded P0, P1, P2, P3, P4, P5, P6,. respectively. Nitrogen and potassium were below critical levels; hence urea and muriate of potassium were used to raise them above the critical levels before planting was done. The fertilizers were mixed properly and applied banded on one side of the maize seeds using groove of 10 cm wide and 10 cm deep and 8 cm away from the seeds. The experimental plots were manually weeded by hoeing and by hand weeding as required.

Before planting in the fields, composite surface soil samples were collected from each the experimental sites and analyzed for their physico-chemical properties. The following agronomic traits, number of leaves, plant height, stem girth, leaf area were measured at 2, 4, 6, 8 and 10 weeks after

planting. For the yield, only 4 plants at the two middle rows were harvested from the 28 plants in each plot to eliminate the effects of cross feeding and yield was computed per hectare based on the area of the harvested cobs. The harvested cobs were dehusked, weighed, threshed weighed again and the grain yield adjusted to 13% moisture content. Maize agronomic traits and yields were subjected to statistical analysis. Mean comparisons were carried out using least significant differences (LSD) test only when F- value was significant (P=0.05).

RESULTS AND DISCUSSION

Effect of phosphorus fertilizer application on maize plant height in the studied area for 2007 and 2008 planting seasons are shown in Table 2a. In the soils, at 2WAP, phosphorus application significantly influenced plant height in 2007 when compared to the control. Application of 80 KgP/ha gave the highest maize height of 50.33 cm that was significantly different from 30.33 cm that was obtained from the control ($P<0.05$). Although other rates of phosphorus applications gave higher maize plant heights but were not significantly different from the control. Similarly application of 80 kgP/ha gave the highest maize plant of 52.58 cm at 2WAP in 2008 and was significantly different from 32.66 cm that was obtained from control. Application of 120 KgP/ha gave significantly higher plant height when also compared to the controls in 2008 planting seasons. At 6WAP, application of 80 KgP/ha in 2007 significantly gave the highest maize plant height of 162.00 cm when compared to 126.50 cm obtained from the control. In 2008, all the rates of P application significantly gave higher maize plant height when compared to the control.

Table 2a. Effect of phosphorus application on maize plant height (cm^2) in Soils of Anyigba.

	2007						2008				
Treatments	2WAP	4WAP	6WAP	8WAP	10WAP	Treatment	2WAP	4WAP	6WAP	8WAP	10WAP
P(kg/ha)						P(kg/ha)					
0	30.33 b	67,67 C	126.50 c	146.50d	168.33 c	0	32.66c	67.17d	102.83e	177.17c	198.67c
20	35,00 ab	78.67a bc	141.50 bc	185.67c d	212.00 ab	20	37.08ab c	82.50bc	143.83c d	193.83bc	213.83c
40	33.00 ab	77.33a bc	160.00 a	197.00b cd	197.50 ab	40	35.42bc	85.17bc	163.67b c	208.88abc	233.83b c
60	37.33 ab	73.83b c	128.33 bc	192.83b cd	205.33 ab	60	39.00ab c	76.17cd	133.83d	197.17bc	220.33b c
80	50.33 a	91.83a bc	162.00 a	206.93a bc	212.55 ab	80	52.58a	92.17ab	173.83b	215.17ab	234.33b c
100	47.17 ab	100.60 a	154.17 ab	232.00a	235.67 a	100	45,50ab c	102.83a	169.50b	237.83a	252.17a b
120	48.33 ab	95.50b	141.50 bc	225.67a b	208.17 ab	120	50.80ab	103.83a	208.50a	243.50a	274.50a

Means within the same vertical column followed by the same small letter(s) are not significantly different at 5% level of probability.

Responses of maize to applied phosphorus in 2008 were higher at 8WAP in 2008 when compared to 2007. Application of 100 and 120 KgP/ha in 2007 significantly gave higher plant height of 232.00 and 225.67 cm when compared to 146.50 cm obtained from the control (Table 2a).In 2008, application of 100 and 120 KgP/ha resulted to similar trend as in 2007 when compared to what was obtained from the control and the application of 20 and 60 kgP/ha, respectively. In general, maize responses to different rates of phosphorus fertilizer application were higher in 2008 than 2007 at 10WAP. In 2007, application of all phosphorus fertilizer rates resulted in plant height that were significantly higher than the control. In 2008, application of 120 KgP/ha significantly gave higher maize plant height of 274.50 cm when compared to 198.67 cm that was obtained from the control.

In 2007 at 2WAP, only the application of 120 kgP/ha gave significantly higher leaf area of 1506.84 cm^2 when compared to 901.44 cm^2 that was obtained from the control (Table 2b). At 8WAP application of all levels of P with the exception of 20 KgP/ha significantly gave higher leaf area when compared to the control. However, the application of 100 KgP/ha gave the highest leaf area of 5141.80 cm^2 when compared to 2553.58 cm^2 that was obtained from the control. At 10WAP, only the application of 100 kgP/ha significantly gave the highest leaf area of 7445.60 cm^2 that was comparably higher than 2648.00 cm^2 obtained from the control. At 2 and 4WAP in 2008, application of 120 kgP/ha significantly gave higher maize leaf area of 1262.04 and 2606.24 cm^2 when compared to 773.64 and 1030.16 cm^2 obtained from the control, respectively (Table 2b). Similarly, at 6, 8 and 10WAP, responses of leaf area to P application followed similar trend. The application of 120 KgP/ha significantly gave much higher leaf area (5403.30, 6857.78 and 6325.60)cm^2 when compared to what were obtained from the control (1371.00 1696.50 and 1858.00)cm^2. At 6 and 8WAP, all rates of applied P significantly gave higher stem girth when compared to the control. In both weeks after planting, application of 120 kgP/ha gave the highest stem girth of 9.11 cm and 9.67 cm relative to 6.13 cm and 6.42 cm^2 that were obtained from the controls. At 10WAP, all the rates of phosphorus fertilizer application resulted in stem girths that were significantly better than the control. In 2008, the trend revealed that application of 60, 80 100 and 120 KgP/ha at 2 and 4WAP gave significantly much higher stem girth when compared to the control (Table 3a). At 6WAP the highest mean stem girth of 9.57 cm was obtained from the application of 100 KgP/ha when compared to 3.80 cm obtained from the control. Similar trend was observed at 8WAP and10WAP. Application of 100 and 120 KgP/ha significantly gave the highest mean stem girth of 11.43 and 12.00 cm when compared to 3.92 and 4.57 cm obtained from the controls.

In 2007, application of 40, 60, 80 and 120 KgP/ha gave number of leaves that were significantly different from the controls. At 6 and 8WAP, phosphorus application gave significantly higher number of leaves when compared to the controls. At 10WAP, the trend differed slightly, application of 120 KgP/ha gave number of leaves of 11.67 when compared to 9.33 obtained from the control. In 2008, application of phosphorus fertilizer did not show increasing trend in terms of number of leaves at 2 and 4WAP (Table 3b). At 6 and 8WAP, application of phosphorus with the exception of 20 KgP/ha gave significantly higher number of maize leaves when compared to the control. Relative yield of 27.5% and 29.4% were obtained for 2007 and 2008 cropping seasons in soils respectively (Table 3b).

In soils of Anyigba, optimum maize grain yields of 5.40 and 5.51t/ha (Table 4) were obtained for 2007 and 2008 cropping seasons from the application of 100 and 120 kgP/ha. These findings were in agreement with what Kogbe and Adediran (2003) reported. They earlier reported a steady increase in grain yields of maize as P application increases. They obtained grain yield of 3.50ton/ha from the application of 60 kgPha. These findings were at variance with what was reported by some other workers, who suggested lower levels of phosphorus application (Irving; 1956., Elkased and Nnadi,1987). Enwezor (1979) had earlier criticized the low phosphorus application recommended by Irving (1956) and Igbokwe et al (1981) and questioned the validity of the general P fertilizer application of less than 18 kgPha. Hence, 100 and 120 kgP/ha were recommended for maize cultivation in soils of Kogi State of Nigeria.

2b Effect of phosphorus application on maize leaf area (cm^2) in Soils of Anyigba.

2007						2008					
Trt. P(kg/ha)	2WAP	4WAP	6WAP	8WAP	10WAP	Trt. P(kg/ha)	2WAP	4WAP	6WAP	8WAP	10WAP
0	901.44b	1408.32ns	2404.00ns	2553.58b	2648..00c	0	773,64c	1030.16d	1371.00f	1696.50e	1858.00e
20	1190.52ab	1828.50ns	2752.02ns	3390.66b	4068.00b	20	917.70bc	1462.36cd	2649.20e	3594.06d	3592.16dc
40	1140.80ab	1614.48ns	3486.10ns	4366.18a	3918.40b	40	1117.44b	1580.26cd	3439.70d	4023.46d	4774.60c
60	1005.36ab	1530.10ns	3490.40ns	4299,04a	4497.00b	60	964,20bc	1637.02cd	3605.50c	4083.76d	2686.24de
80	1282.56ab	1845.04ns	3803.30ns	4949.10a	4496.00b	80	1227.60b	1965.92bc	4221.90bc	5061.96c	4925.92b
100	1460.04ab	1845.04ns	4100.70ns	5141.80a	7445.60a	100	1251.48b	2262.92ab	2621.70b	6002.78b	5643.36ab
120	1506.84a	2173.74ns	3644.70ns	4710.34a	5618.00b	120	1262.04a	2606.24a	5403.30a	6857.78a	6325.60a

Means within the same vertical column followed by the same small letter(s) are not significantly different at 5% level of probabil

Table 3a) Effect of phosphorus application on maize stem girth (Cm^2) in Soils of Anyigba.

2007						2008					
Treatments	2WAP	4WAP	6WAP	8WAP	10WAP	Treatment	2WAP	4WAP	6WAP	8WAP	10WAP

P(kg/ha)						s P(kg/ha).					
0	3.23ns	4.58ns	6.13b	6.42b	6.48c	0	2,74d	2.74d	3.80d	3.92d	4.57d
20	3.92ns	5.13ns	8.12a	8.45a	8.67ab	20	3.81cd	3.81cd	5.48c	6.03c	6.27c
40	3.80ns	4.82ns	8.18a	8.75a	8.30b	40	3.99cd	3.99cd	6.25c	6.64c	6.92c
60	3..83ns	5.11ns	7.62a	8.58a	9.15ab	60	4.77bc	4.77bc	6.30c	6.86c	7.44c
80	3.96ns	6.38ns	7.75a	8.58a	9.15ab	80	5.97ab	5.93ab	6.73bc	8.33b	9.20b
100	5.17ns	7.00ns	8.88a	9.25a	9.45ab	100	6.78a	6.70a	9.57a	11.43a	12,00a
120	4.72ns	5.70ns	9.11a	9.67a	9.95a	120	6.30a	6,62a	8.09b	9.35b	10.22b

Means within the same vertical column followed by the same small letter(s) are not significantly different at 5% level of probability.

3b) Effect of phosphorus application on the number of leaves in Soils of Anyigba.

2007 **2008**

Treatments P(kg/ha)	2WAP	4WAP	6WAP	8WAP	10WAP	Treatments P (kg/ha)	2WAP	4WAP	6WAP	8WAP	10WAP
0	4.33b	7.00ns	8.00b	8.83ab	9.33b	0	5.33b	7.33b	8.17c	8.67d	8.50cd
20	5,67ab	8.50ns	10.67a	11.17a	10.83ab	20	6.33ab	7.50b	8.00c	8.83d	8.66d
40	6.50a	8.17ns	10.50a	11.67a	10.50ab	40	7.33a	8.83a	9.50b	10.00c	10.50cd
60	6.67a	7.83ns	10.33a	11.50a	10.64ab	60	7.50a	9.50a	10.17ab	11.50b	11.80bc
80	6.67a	8.50ns	11.00a	12.17a	10.67ab	80	7.17a	9.17a	10.17ab	11.50b	11.33bc
100	5.50ab	8.50ns	10.33a	12.00a	11.17a	100	6.833a	8.83a	10.67a	11.83ab	10.00b
120	6.00a	7.33ns	10.67a	12.50a	11.67a	120	7.00a	9.83a	10.50a	12.67a	12.00a

Means within the same vertical column followed by the same small letter (s) are not significantly different at 5% level of probability.

Table 4: Effect of Phosphorus on cob weight and grain yield (ton/ha) in Soils of Anyigba.

2007 **2008**

Treatment P(kg/ha)	Cob-wt (ton/ha)	Grain yield (t/ha)	Treatment P(Kg/ha)	Cob-wt (t/ha)	Grain yield (t/ha)

0	2.37d	1.49c	0	2.33d	1.62c
20	3.21cd	2.75b	20	3.20ed	2.25c
40	3.51cd	2.27b	40	3.57cd	2.45c
60	4.16bc	3.57b	60	4.35cb	3.64b
80	4.23bc	3.45b	80	4.56b	3.67b
100	6.77a	5.40a	100	7.22a	5.31a
120	7.40a	5.05a	120	6.93a	5.51a
LSD (P=0.05)	1.23	0.98		0.95	0.78

Relative Yield = 27.5% Relative Yield = 29%.

Means within the same vertical column followed by the same small letter (s} are not significantly different at 5% level of probability.

CONCLUSION .

In the soils, application of P fertilizer irrespective of rates significantly (P=0.05) increased the number of leaf, plant height, stem girth and leaf area in Anyigba. optimum grain yields of 5.40 and 5.51ton/ha were obtained for 2007 and 2008 cropping seasons, respectively from the application of 100 and 120 kgP/ha. The application of 100 and 120 kgP/ha rates are recommended for soils of Anygba, Kogi State of Nigeria

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