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Response of Maize (Zea mays L) Yield and Yield Components to Rates of Applied Phosphorus Fertilizer in the Guinea Savanna Soils of Kogi State, Nigeria

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Abstract

Crops respond differently to P-fertilizer treatments. The role of phosphorus in soils for sustainable crop production cannot be over emphasis. It has been observed that P after nitrogen is the most important macro nutrient limiting crop production in the tropics. Thus multi - location studies undertaken in Kogi State University, Anyigba, Kogi State, Nigeria in 2007 and 2008 cropping seasons assessed the response of maize crop to phosphorus additions. The experiment, a Randomized Complete Block Design with three replications had seven rates of P (0, 20, 40, 60, 80, 100 and 120kg ha^{-1}) applied as Single Super Phosphate for P calibration studies. Maize agronomic traits and yields were subjected to statistical analysis and means found to be statistically significant ($p<0.05$) were compared using the Least Significant Difference (LSD). In this trial, application of P fertilizer irrespective of rates significantly increased plant height, number of leaves, leaf area, stem girth and grain yields in both locations. The magnitude of increases in all these parameters revealed that the application of 100 and 120kgP ha^{-1} compared favorably in both locations and significantly better than the control. Obtained data showed that in Anyigba soils, optimum maize yield of 5.40 and 5.51 ton/ha were obtained for 2007 and 2008 cropping season, from the application of 100 and 120kg P ha^{-1}, respectively while in Ofere soils, optimum maize yield of 3.93 and 3.86 ton/ha were obtained for 2007 and 2008 cropping season, respectively from the application of 120kg P ha^{-1}. 100 and 120kg P ha^{-1} are recommended for maize cultivation in soils of Anyigba and Ofere, respectively based on better grain yields obtained with this treatments.

Key words: Phosphorus, maize, agronomic traits, yield components and yield

1. Introduction

Crop outputs are often severely constrained by complex interacting factors such as soil fertility, farmers' resources, pests, diseases, and crop factors (Alofe *et al*., 1996; Smaling *et al*., 1996; Sinclair *et al*., 1997; Tian *et al*., 2000). Farmers resources will often among other things limit their responses to fertilizer treatments. With consistent land use in Nigeria coupled with alternating wet and dry seasons in the Nigerian savanna characterized by intense heat, which has led to rapid decomposition of soil organic matter and loss of soil fertility, soils often requires fertilizer application. Indiscriminate burning of fallows and crop residues by farmers also reduces the accumulation of organic matter in the soil thus compounding the problem of soil fertility. Therefore most Nigerian soils have lost their productivity under cultivation (Adams, *et al*., 1998). Because soil organic matter is low, native soil N is also low P and S deficiencies are also widespread in most soils. Due to low buffer capacities, it is relatively easy to cause ionic in-balance and acidity by incorrect use of fertilizers (Adams, *et al.*, 1998), therefore requiring absolute care and understanding of the most economic rates that will give the best response.

Crop responses differ with P-fertilizer treatments, thus, Khasawneh and Samples (1979) observed that the concentration of soil solution P required by cowpea for maximum growth potential may be only two-third the concentration required by maize. Therefore the relative agronomic effectiveness of rock phosphate would be higher for crops with lower P demands, such as legumes than for cereal crops. Kogbe and Adediran (2003) found that the application of 80KgP ha^{-1} depressed maize yield. While observing that higher rates of P lowered the phosphorus use efficiency of the maize crop, they added that the efficiency of maize in P utilization decreased as P fertilizer rate was increased, with the highest phosphorus use efficiency obtained at 40 and 20 kg P_2O_5 ha^{-1} at Ilora and Mokwa, Nigeria, respectively. The authors reported that the control (O kg P_2O_5) gave the least yield of maize when compared to other rates. However, a steady increase in grain yields to 3.5 ton ha^{-1} of the hybrid maize was obtained when up to 60kg Pha^{-1} was added. In conclusion, they opined that emphasis should be placed on N and P application for maize production, especially where K is found to be adequate in the soils. Results of various fertilizer experiments conducted in Nigeria had led to fertilizer recommendations that gave blanket nutrient requirements for maize in different ecological zones, having varying soil conditions and under varying levels of soil management, contrary to the observation by Kogbe and Adediran (2003) that the response of maize to P fertilizer application varies with location, and was found to be highest in the southern Guinea savanna than in the derived savanna.

In P deficient soils, poor establishment of seedlings results from a general reduction in growth of stem and root system. Sometimes, a general darkening of the leaves in dicotyledons plants lead to brown leaf patches, while a reddish tinge is seen in monocotyledons. Adequate P nutrition enhances many aspects of plant physiology, including the fundamental process of photosynthesis, nitrogen fixation, flowering (including seed production) and maturation (Brady and Weil, 1999). Brady and Weil (1999) reported that P deficiency is generally not easy to recognize in plants. They pointed out that P deficient plant is stunted, thin-stemmed and spindly, but its foliage is often dark, almost bluish-green. They stressed that unless healthy plants are present to make a comparison, P deficient plants often seem quite normal in appearance. In severe cases, though, P deficiency can cause yellowing and senescence of leaves. Furthermore, they reported that some plants develop purple colors in their leaves and also stem as a result of P deficiency. They, however, reported that P is very mobile within the plant, so when the supply is short, P in the older leaves is mobilized and transferred to the younger and, rapidly growing ones. They added, thus, both the purpling and premature senescence associated with P deficiency are therefore more prominent in the older leaves than in younger ones. They summed up P problem in the soil as three fold: that the total P level in the soil is low, usually not more than one-fourth that of N and one-twentieth that of K. Secondly, the P compounds commonly found in soils are mostly unavailable for plant uptake, often because they are highly insoluble and, thirdly, when soluble sources of P, such as those in fertilizers and manures, are added to soils, they are fixed - changed to unavailable forms, and in time, forms highly insoluble compounds. Many factors influence P availability to crops, including the form of native soil P, the type of P applied to the soil and soil reaction. An early trial with P fertilizer indicated that 11kgP ha^{-1} was the optimum rate of phosphate fertilization in the savanna zone of Nigeria. However, based on recent experiments, with improved cultivars, it was observed that maize could respond to high rates of P application. Thus, the objective of this study was to determine the effect of P on the yield components and yield of maize in the Guinea savanna soils of Kogi State, Nigeria using two locations: Ofere and Anyigba.

2. Materials and Methods

2.*1 Study Areas:*

The study area, Kogi State, lies between latitudes 5^0 15^1 to 7^0 45^1 N and longitudes 5^0 45^1 and 8^0 45^1 East of the equator. The State has a total land area of about 25,948 square kilometers. Over seventy per cent (70%) of the population live in the rural area and their main occupation is farming. It is bounded by the Federal Capital Territory, Niger and Plateau States in the North; Kwara State in the west, Benue State in the East and Ondo, Edo and Enugu States in the south. Kogi state has a bimodal rainfall with the peak pattern occurring in July and September. The mean annual rainfall ranges from 1,560 mm at Kabba in West to 1,808 mm at Anyigba in the East (Table 1a). The temperature shows some variation throughout the years. Average monthly temperature varies from 17 ^{0}C to 36.2 ^{0}C. Relative humidity is moderately high and varies from an average of 65 - 85% throughout the year. The State has two main vegetations; the forest savanna mosaic zone and the southern guinea zone. The state has two main geological formations; they are the Basement complex rocks to the west while the other half is on Cretaceous sediments, to the North of the confluence and East of River Niger.

2.2 Field Calibration Studies:

On the basis of geological formation, two locations were chosen, one from each of the distinct geological formation: Ofere (Basement complex soils), and Anyigba (Cretaceous Sediments) in Kogi state, Nigeria. The field trial spanned two years: 2007 and 2008 cropping seasons. The experiment was conducted using Randomized Complete Block Design with three replications (RCBD) with an experimental sub plot size measuring 3.00 m x 1.75 m (5.25 m^2) while the entire experimental area was 15.25 m x 11 m (167.75 m^2). Maize variety, Downey mildew resistant (DMRT) obtained from IAR&T Ibadan, Nigeria was used for the trial, adopting plant spacing of 75 cm by 25 cm. Seeds were manually sown, three seeds per hole at 3 - 5 cm depth and thinned down to one plant per stand two weeks after seedling 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 120kg ha^{-1} coded P_0, P_1, P_2, P_3, P_4, P_5, $P_{6,}$ respectively. Nitrogen and potassium were below critical levels; hence urea and muriate of potash 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. Banding of fertilizer especially for micro-nutrients was found to be more effective for maize (Tisdale et al., 1985). The experimental plots were manually weeded by hoeing and by hand weeding as required. Before sowing in the fields, composite surface soil samples (0 – 15 cm and 15 – 30 cm) were collected from each the experimental sites and analyzed for their physico-chemical properties (Table 1b).

The following agronomic traits: plant height, number of leaves per plant, leaf area, stem girth were measured at 2, 4, 6, 8 and 10 weeks after seed sowing using 10 per cent sampled population from the net plot. Plant height before tasseling was measured from soil level to the tip of the longest leaf. After tasseling, it was measured from soil level to the tip of the tassel. Leaf area determination was carried out using the method described by Egharevba (1978) for millet crop. The apparent leaf area obtained as a product of length x width was multiplied by a constant factor (0.751). For yield determination, cobs from four plants sampled from two middle rows (to eliminate the effects of cross feeding) were harvested from the 28 plants in each plot and yields were computed per hectare based on the area of the harvested cobs. The harvested cobs were de-husked, weighed, threshed and weighed again and the grain yield adjusted to 13 per cent moisture content. Maize agronomic traits and yields were subjected to analysis of variance using SAS Computer Statistical Package (SAS Institute, 1996) as described for RCBD. Mean comparisons were carried out using Least Significant Differences (LSD) test only when F- value was significant.

2. Results and Discussion

Plants cannot grow without phosphorus. It is an essential component of the organic compound often called the energy currency of the living cell: adenosine triphosphate (ATP) (Brady and Weil, 1999). However, phosphorus deficiency symptoms are not very distinctive. In this trial, application of P fertilizer irrespective of rates significantly increased plant height, number of leaves, leaf area, and stem girth in both locations studied (Tables 2, 3, 4, 5, 6, 7, 8 and 9). The magnitude of increases in all these parameters revealed that the application of 100 and 120kgP ha^{-1} compared favorably in both locations and significantly better than the control. At the termination of the trials (10WAS), all phosphorus rates resulted in plants that were significantly taller than the control (Table 2), similar responses were obtained in other parameters measured (Tables 3, 4, 5, 6, 7, 8 and 9). These observations have both positive and negative implications for the maize crop. Increase in plant height will increase lodging in the crop, this is coupled with the increase in foliage production, which will contribute to plant's above ground weight with negative implication for lodging. However, production of more leaves with P fertilization, should enhance the crop's ability to intercept solar radiation, impacting on dry matter accumulation and subsequently on crop yield (Hay and Walker, 1989). In line with these observations, previous reports have shown that on several species, phosphorus deficiency was shown to severely reduce leaf growth and subsequently the amount of solar radiation intercepted by plants (Rodriguez *et al.*, 1998). Other authors have shown that P deficiency affects the photosynthesis per unit of leaf area (Jacob and Lawlor, 1991; Qiu and Isreal, 1994). This suggests that both effects (reduction of leaf area and reduction of net photosynthesis per unit of leaf area) may contribute to the final reduction of biomass production.

Effect of phosphorus application on the cob weight and grain yield (ton ha^{-1}) in soils of Anyigba and Ofere in 2007 and 2008 is shown in Tables 10 and 11. The result obtained showed significant response of maize to the different rates of P application in both locations: Anyigba (Cretaceous sediments) and Ofere (Basement complex). In 2007 cropping season in soils of Anyigba, application of 120kgP ha^{-1} gave the highest cob weight (7.40 ton ha^{-1}), while optimum grain yield of 5.40 ton ha^{-1} was obtained from the application of 100kgP ha^{-1}. However, the optimum grain yield from the application of 100kgP ha^{-1} was not significantly ($p > 0.05$) different from that obtained from the application of 120kgP ha^{-1} (5.05 ton ha^{-1}). It was, however significantly different from that obtained from other P rates in this study. In 2008, application of 100kgP ha^{-1} gave the highest cob yield of 7.22 ton ha^{-1} while optimum grain yield of 5.51 ton ha^{-1} was obtained from the application of both 100 and 120kgP ha^{-1}. Generally, relative yields of 27.5% and 29.4% were obtained for 2007 and 2008 cropping seasons, respectively in soils of Anyigba (Table 2). In 2007 cropping season in soils of Ofere, the highest cob weight of 4.68ton ha^{-1} was obtained from the application of 100 and 120kgP ha^{-1}, this was not significantly different from what resulted from the application of 60 and 80kgP ha^{-1}. Optimum grain yield of 3.93ton ha^{-1} was obtained from the application of 120kgP ha^{-1} (Table 2). In 2008, the highest cob weight of 6.09ton ha^{-1} was also obtained from the application of 120kgP ha^{-1}. This was, however not significantly different from what were obtained from the application of 60, 80 and 100 kgP ha^{-1}. Optimum grain yield of 4.86ton ha^{-1} was obtained from the application of 120kgP ha^{-1}. While relative yields of 22.7% and 29.5% were obtained for 2007 and 2008, respectively in Ofere location (Table 2). This finding was in agreement with Kogbe and Adediran (2003), who earlier reported a steady increase in grain yields of maize as P application increases obtaining grain yield of 3.50 ton ha^{-1} from the application of 60kgP ha^{-1}. Better crop yields obtained with P fertilization in this trial, could be explain by increase in forage with P fertilization, which must have enhanced the crop's ability to intercept solar radiation, impacting on dry matter accumulation and subsequently on crop yield (Hay and Walker, 1989). However, the finding was at variance with what was reported by some other workers, who suggested lower levels of P application (Irving, 1956., Elkased and Nnadi,1987). Enwezor (1979) had earlier criticized the low P application recommended by Irving (1956) and Igbokwe *et al* (1981) and questioned the validity of the general P fertilizer application of less than 18kgP ha^{-1}. In line with the observed increased in maize yield with fertilization, in a trial conducted by Plenet *et al.* (2000) on the growth analysis of maize field crops under P deficiency, they observed that grain yield was significantly reduced in P0 (no treatment). Above ground biomass accumulation was severely reduced, with the maximum difference between treatment (60% in P0). The lower biomass production in P0 was accounted for by the reduction in the amount of photo synthetically active radiation (PAR) absorbed by the canopy, which was a consequence of the reduced leaf area index.

3. Conclusion

In soils of Anyigba, optimum grain yields of 5.40 and 5.51ton ha^{-1} were obtained for 2007 and 2008 cropping seasons while in soils of Ofere, optimum yields of 3.93 and 3.86ton ha^{-1} were obtained for 2007 and 2008 cropping seasons, respectively from the application of 100 and 120kgP ha^{-1} in both locations. Application of

P fertilizer irrespective of rates significantly increased the number of leaf, plant height, stem girth and leaf area in both locations. Hence 100 and 120kgP ha^{-1} were recommended for maize cultivation in soils of Anyigba and Ofere, respectively as these treatments gave the best responses in respect of grain yield in these areas.

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Table 1a: Monthly total and mean rainfall and temperature records for field experimental sites

Month	**Anyigba**		**Ofere**	
	Rainfall (mm)	**Temperature ^{0}C**	**Rainfall (mm)**	**Temperature ^{0}C**
January	-	32.5	-	30.7
February	-	34.1	3.0	33.3
March	27.5	28.7	10.7	29.7
April	76.0	22 1	129.0	20.5
May	331.0	24.1	136.8	21.9
June	224.1	19.6	226.8	18.9
July	332.5	19 7	321.50	17
August	348.0	20.3	309.6	20.6
September	207.8	23.1	208.1	24.1
October	220.3	29.2	245.0	28 7
November	37.2	35 7	-	33.9
December	-	36.2	-	35
Total	1808	352.3	1584.5	314.3
Mean	150.4	27.11	132.0	26.19

Table 1b: Selected physical and chemical properties of experimental soil

Soil property	Cretaceous sediment	Basement complex
Texture	Sandy loam	Loamy sand
Sand g/kg	887.50	872.50
Silt g/kg	6.90	83.30
Clay g/kg	50.01	40.80
pH (H_2O)	5.7	6.1
ECEC cmol/kg	7.41	12.55
Ex. acidity cmol/kg	0.75	0.72
Organic matter (g/kg)	8.7	14.14
Bray P-1 (mg/kg)	9.59	7.10
Total N (g/kg)	4.04	4.72

Table 2: Effect of phosphorus application on maize height (cm) in Soils of Anyigba

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

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

Table 3: Effect of phosphorus application on the number of leaves in Soils of Anyigba

Treatment	2007					2008				
P(kg/ha)	2WAS	4WAS	6WAS	8WAS	10WAS	2WAS	4WAS	6WAS	8WAS	10WAS
0	4.33^{b}	7.00^{ns}	8.00^{b}	8.83^{ab}	9.33^{b}	5.33^{b}	7.33^{b}	8.17^{c}	8.67^{d}	8.50^{cd}
20	5,67^{ab}	8.50^{ns}	10.67^{a}	11.17^{a}	10.83^{ab}	6.33^{ab}	7.50^{b}	8.00^{c}	8.83^{d}	8.66^{d}
40	6.50^{a}	8.17^{ns}	10.50^{a}	11.67^{a}	10.50^{ab}	7.33^{a}	8.83^{a}	9.50^{b}	10.00^{c}	10.50^{cd}
60	6.67^{a}	7.83^{ns}	10.33^{a}	11.50^{a}	10.64^{ab}	7.50^{a}	9.50^{a}	10.17^{ab}	11.50^{b}	11.80^{bc}
80	6.67^{a}	8.50^{ns}	11.00^{a}	12.17^{a}	10.67^{ab}	7.17^{a}	9.17^{a}	10.17^{ab}	11.50^{b}	11.33^{bc}
100	5.50^{ab}	8.50^{ns}	10.33^{a}	12.00^{a}	11.17^{a}	6.833^{a}	8.83^{a}	10.67^{a}	11.83^{ab}	10.00^{b}
120	6.00^{a}	7.33^{ns}	10.67^{a}	12.50^{a}	11.67^{a}	7.00^{a}	9.83^{a}	10.50^{a}	12.67^{a}	12.00^{a}

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 application on maize leaf area (cm^2) in Soils of Anyigba

Treatment	2007					2008				
P(kg/ha)	2WAS	4WAS	6WAS	8WAS	10WAS	2WAS	4WAS	6WAS	8WAS	10WAS
0	901.44^{b}	1408.32^{ns}	2404.00^{ns}	2553.58^{b}	$2648..00^{c}$	$773,64^{c}$	1030.16^{d}	1371.00^{f}	1696.50^{e}	1858.00^{e}
20	1190.52^{ab}	1828.50^{ns}	2752.02^{ns}	3390.66^{b}	4068.00^{b}	917.70^{bc}	1462.36^{cd}	2649.20^{e}	3594.06^{d}	3592.16^{dc}
40	1240.80^{ab}	1614.48^{ns}	3486.10^{ns}	4366.18^{a}	3918.40^{b}	1117.44^{b}	1580.26^{cd}	3439.70^{d}	4023.46^{d}	4774.60^{c}
60	1005.36^{ab}	1530.10^{ns}	3490.40^{ns}	$4299,04^{a}$	4497.00^{b}	$964,20^{bc}$	1637.02^{cd}	3605.50^{c}	4083.76^{d}	2686.24^{de}
80	1282.56^{ab}	1845.04^{ns}	3803.30^{ns}	4949.10^{a}	4496.00^{b}	1227.60^{b}	1965.92^{bc}	4221.90^{bc}	5061.96^{c}	4925.92^{b}
100	1460.04^{ab}	1845.04^{ns}	4100.70^{ns}	5141.80^{a}	7445.60^{a}	1251.48^{b}	2262.92^{ab}	2621.70^{b}	6002.78^{b}	5643.36^{ab}
120	1506.84^{a}	2173.74^{ns}	3644.70^{ns}	4710.34^{a}	5618.00^{b}	1262.04^{a}	2606.24^{a}	5403.30^{a}	6857.78^{a}	6325.60^{a}

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

Table 5: Effect of phosphorus application on maize stem girth (Cm) in Soils of Anyigba

Treatment	2007					2008				
P(kg/ha)	2WAS	4WAS	6WAS	8WAS	10WAS	2WAS	4WAS	6WAS	8WAS	10WAS
0	3.23^{ns}	4.58^{ns}	6.13^{b}	6.42^{b}	6.48^{c}	$2,74^{d}$	2.74^{d}	3.80^{d}	3.92^{d}	4.57^{d}
20	3.92^{ns}	5.13^{ns}	8.12^{a}	8.45^{a}	8.67^{ab}	3.81^{cd}	3.81^{cd}	5.48^{c}	6.03^{c}	6.27^{c}
40	3.80^{ns}	4.82^{ns}	8.18^{a}	8.75^{a}	8.30^{b}	3.99^{cd}	3.99^{cd}	6.25^{c}	6.64^{c}	6.92^{c}
60	$3..83^{ns}$	5.11^{ns}	7.62^{a}	8.58^{a}	9.15^{ab}	4.77^{bc}	4.77^{bc}	6.30^{c}	6.86^{c}	7.44^{c}
80	3.96^{ns}	6.38^{ns}	7.75^{a}	8.58^{a}	9.15^{ab}	5.97^{ab}	5.93^{ab}	6.73^{bc}	8.33^{b}	9.20^{b}
100	5.17^{ns}	7.00^{ns}	8.88^{a}	9.25^{a}	9.45^{ab}	6.78^{a}	6.70^{a}	9.57^{a}	11.43^{a}	$12,00^{a}$
120	4.72^{ns}	5.70^{ns}	9.11^{a}	9.67^{a}	9.95^{a}	6.30^{a}	$6,62^{a}$	8.09^{b}	9.35^{b}	10.22^{b}

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

Table 6: Effect of phosphorus application on maize plant height (cm^2) in Soils of Ofere

Treatment	2007					2008				
P(kg/ha)	2WAS	4WAS	6WAS	8WAS	10WAS	2WAS	4WAS	6WAS	8WAS	10WAS
0	24.50ns	47.83^{b}	62.83^{c}	96.33^{b}	124.33^{b}	25.50^{b}	45.83^{b}	56.50^{c}	67.50^{b}	73.17^{c}
20	38.17ns	76.67^{a}	130.00^{ab}	155.67^{a}	180.33^{a}	44.73^{a}	70.17^{a}	71.17^{bc}	87.50^{ab}	92.17^{bc}
40	29.66ns	60.83^{ab}	105.33^{ab}	162.67^{a}	184.83^{a}	40.87^{ab}	63.88^{ab}	75.17^{abc}	89.17^{ab}	98.17^{abc}
60	27.67ns	56.33^{ab}	137.33^{b}	173.88^{a}	194.15^{a}	34.53^{ab}	59.17^{ab}	70.33^{abc}	81.50^{ab}	91.50^{bc}
80	32,00ns	62.33^{ab}	148.67^{a}	174.00^{a}	187.17^{a}	39.18^{ab}	68.53^{ab}	87.17^{ab}	105.50^{a}	118.83^{a}
100	23.17ns	57.17^{ab}	130.00^{ab}	168.33^{a}	198.15^{a}	29.82^{ab}	68.17^{ab}	81.83^{abc}	96.83^{a}	114.17^{ab}
120	34.73ns	64.33^{ab}	161.67^{a}	174.33^{a}	185.67^{a}	42.15^{a}	76.83^{a}	91.33^{a}	103.17^{a}	119.17^{a}

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

Table 7: Effect of phosphorus application on maize number of leaves in Soils of Ofere

Treatment	2007					2008				
P(kg/ha)	2WAS	4WAS	6WAS	8WAS	10WAS	2WAS	4WAS	6WAS	8WAS	10WAS
0	4.33^{c}	6.00^{b}	6.03^{b}	6.33^{b}	7.00^{b}	1.53^{c}	6.50^{e}	7.83^{e}	8.50^{d}	8.83^{d}
20	6.67^{ab}	8.00^{a}	9.00^{a}	10.83^{a}	11.67^{a}	6.83^{ab}	8.33^{bc}	9.83^{cd}	10.83^{b}	11.00^{b}
40	6.67^{ab}	7.83^{a}	8.50^{a}	11.17^{a}	12.33^{a}	7.83^{a}	9.17^{c}	10.17^{c}	11.33^{b}	11.67^{b}
60	6.00^{b}	7.33^{ab}	9.50^{a}	11.67^{a}	12.33^{a}	6.00^{bc}	7.33^{cd}	8.83^{de}	9.83^{c}	9.83^{c}
80	6.50ab	7.40^{ab}	9.50^{a}	11.17^{a}	12.33^{a}	6.33^{ab}	8.83c^{bc}	9.83^{cd}	10.83^{b}	11.50^{b}
100	5.01^{b}	7.17^{ab}	10.33^{a}	11.00^{a}	11.83^{a}	7.00ab	9.50^{b}	11.33^{b}	13.67^{a}	14.00^{a}
120	7.50^{a}	8.00^{a}	10.33^{a}	11.00^{a}	12.33^{a}	7.17^{ab}	11.00^{a}	12.67^{a}	14.33^{a}	14.00^{a}

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

Table 8: Effect of phosphorus application on maize leaf area (cm^2) in Soils of Ofere

Treatment	2007					2008				
P (kg/ha)	2WAS	4WAS	6WAS	8WAS	10WAS	2WAS	4WAS	6WAS	8WAS	10WAS
0	657.6^{bc}	780.24^{c}	809.24^{c}	1417.40^{c}	1560.88^{b}	641.40^{bc}	866.58^{b}	1402.20^{c}	1446.68^{c}	1690.86^{d}
20	1033.20^{ab}	2921.98^{b}	3227.68^{b}	3334.52^{abc}	3251.98^{ab}	1096.80^{abc}	1344.76^{ab}	3722.60^{ab}	3588.95^{b}	3829.36^{bc}
40	705.62^{abc}	2693.04^{b}	2831.12^{b}	3005.70^{bc}	3473.13^{ab}	630.24^{abc}	1355.54^{ab}	3468.70^{b}	3527.56^{b}	3669.36^{abc}
60	371.76^{c}	3442.36^{b}	3174.30^{b}	3370.10^{ab}	3633.20^{a}	603.30^{c}	812.44^{b}	3478.70^{ab}	3750.70^{ab}	3906.58^{abc}
80	625.44^{bc}	3128.2^{b}	3454.84^{b}	3696.74^{ab}	3784.34^{a}	746.46^{ab}	864.36^{b}	3853.70^{ab}	3933.11^{ab}	3954.40^{abc}
100	1148.76^{ab}	4243.20^{a}	4709.71^{a}	5130.50^{ab}	5595.92^{a}	1347.60^{ab}	1381.94^{ab}	4205.30^{ab}	4421.18^{a}	4592.08^{a}
120	1335.96^{a}	4429.46^{a}	4969.18^{a}	5394.52^{a}	5674.46^{a}	1458.84^{a}	1489.62^{a}	4633.22^{a}	4837.20^{a}	4991.22^{ab}

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

Table 9: Effect of phosphorus application on maize stem girth (cm^2) in Soils of Ofere

Treatment	**2007**					**2008**				
P(kg/ha)	**2WAS**	**4WAS**	**6WAS**	**8WAS**	**10WAS**	**2WAS**	**4WAS**	**6WAS**	**8WAS**	**10WAS**
0	3.22^{d}	4.00^{ab}	4.42^{c}	5.02^{b}	5.60^{b}	3.23^{e}	3.83^{d}	4.25^{c}	4.53^{c}	4.78^{c}
20	4.17^{cd}	5.58^{ab}	5.77^{bc}	5.88^{b}	6.67^{b}	4.00^{de}	5.32^{c}	5.00^{b}	6.45^{b}	7.22^{b}
40	4.23^{cd}	5.30^{ab}	5.75^{bc}	6.22^{b}	6.61^{b}	4.05^{de}	5.68^{c}	6.29^{b}	6.87^{b}	7.60^{b}
60	4.82^{bc}	5.50^{ab}	7.17^{ab}	8.17^{a}	8.75^{a}	5.02^{cd}	5.65^{c}	6.15^{b}	6.65^{b}	7.37^{b}
80	5.43^{bc}	6.00^{a}	6.90^{ab}	8.18^{a}	9.13^{a}	5.67^{bc}	6.57^{bc}	7.15^{b}	7.88^{b}	8.48^{b}
100	5.87^{ab}	5.93^{ab}	7.13^{ab}	8.23^{a}	9.10^{a}	6.72^{ab}	7.83^{ab}	8.67^{a}	9.62^{a}	11.03^{a}
120	6.58^{a}	6.67^{a}	8.50^{a}	9.58^{a}	10.32^{a}	7.27^{a}	8.47^{a}	9.25^{a}	10.25^{a}	12.75^{a}

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

Table 11: Effect of Phosphorus on cob weight and grain yield (ton ha^{-1}) in Soils of Ofere

Treatment	**2007**	**2008**	**2007**	**2008**
P (kg/ha)	**Cob-wt (ton/ha)**	**Grain yield (t/ha)**	**P (kg/ha)**	**Cob-wt (ton/ha)**
0	2.01^{b}	0.89^{d}	2.23^{b}	1.43^{d}
20	2.66^{b}	1.41^{d}	5.00^{a}	2.34^{cd}
40	2.75^{b}	1.63^{cd}	4.90^{a}	2.18^{cd}
60	4.13^{a}	2.38^{bc}	5.94^{a}	2.73^{bcd}
80	3.79^{a}	2.74^{b}	5.94	3.23^{bc}
100	4.68^{a}	2.88^{b}	6.09^{a}	3.58^{bc}
120	4.68^{a}	3.93^{a}	5.50^{a}	4.86^{a}
LSD	0.97	0.93	2.25	1.04
	Relative yield = 22.7%		Relative yield 22.50%	

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