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Effect of Soil Types and Phosphorus Fertilizer Interaction on the Growth and Yield of Maize (*Zea mays.L*)

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Abstract

A pot experiment was conducted to examine the effect of soil types and phosphorus fertilizer application on maize (variety DMR-L-SR) growth and yield in the rain forest zone of Nigeria. This was done at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso. The experimental treatments consists of four soil types (Itagunmodi, Egbeda, Majeroku and Iwo series) and six varying phosphorus levels (0, 15, 30, 60, 75 and 90kg P_2O_5/ha i.e. 0, 0.6, 1.3, 2.5, 3.1 and 3.8 g/15kg soil respectively). The experiment was laid out in a split plot randomized complete block design with four replications. Data were collected on growth and yield parameters. Soil type effect was significant on plant height, number of leaves, cob weight, number of grains per cob and number of grain rows per cob. Plants planted on Majeroku soil produced the most luxuriant growth which significantly (p=0.05) differed from other soil types. For grain yield, the highest grain yield of 172 g/15kg soil was produced from Majeroku soil while the least (95.46 g/15kg soil) was produced in Egbeda soil. Soil types and phosphorus levels interaction was significant for most of the parameters considered. However, crops on Majeroku soil had the highest grain yield of 172 g/15kg soil at 30kg P_2O_5/ha, Itagunmodi and Egebeda soils also had the highest grain yield of 139.75g and 116.25g respectively at 15kg P_2O_5/ha but the highest yield of crops on Iwo soil was at 75 kg P_2O_5/ha (158.50 g/15kg soil). This yield at varying phosphorus levels is an indication that soil types do have an effect on the yield of crops. Since all the soils are used in planting maize one soil type cannot be said to be better than the other, however to optimize grain yield for Itagunmodi and Egbeda soils application of 15 kg P_2O_5/ha is sufficient while for Majeroku and Iwo soils, 30 and 75 kg P_2O_5/ha respectively as against the blanket recommendation of 60 kg P_2O_5/ha.

Keywords: soil types, phosphorus levels, maize growth and yield

Introduction

Maize is a plant belonging to the family Graminae from the tribe Maydae (Simmonds, 1984). It is one of the oldest cultivated world's cereals. It is an important source of carbohydrates and if eaten in the immature state, it provides useful quantities of vitamin C. For normal growth, maize requires a wide range of well drained soils, sandy loam to clayey loam, rich in organic matter and plant nutrients (Norman *et al;* 1995). Maize does poorly on heavy sandy or gravelly soil and it strives between pH 4 and pH 7. Phosphorus (P) is one of the three major elements (nitrogen, potassium and phosphorus) required by plants for their growth. Its level is low in most soils such that high concentrations are often an indication of past animal or human activity in the area. An adequate supply of phosphorus is associated with greater straw strength in cereals. More over the quality of certain fruit, forage, vegetable and grain crops (alfafa, corn and soybean) is improved and disease resistance increased when these crops have satisfactory P nutrition (Holford, 1997). The availability of phosphorus is influenced by soil types (Torres-Dorante *et al;* 2006). Differences in soil chemistry results from differences in drainage, texture, mode of soil formation and parent rock. Although maize is grown all over Western Nigeria, the nutrient available to it varies from one region to another. This is due to differences in the soil types as a result of different parent materials. Soil is the major component of land and the potential yield of a crop can only be realized through a proper integration of crop variety, climate and soil management. Majority of the soils in humid tropical Africa are infertile (Palm and Sanchez, 1991) thus a considerable portion of agricultural soils in Nigeria can be classified as low fertile soils. In Nigeria, severity of agents of soil depletion varies from one geographical location to another and this also accounts for differences in soil fertility gradient across the country. The obvious consequence of this is variation in performance of crops grown on the soil. Apart from this, soil parent rock and microbial activities have influence on the nature and fertility level of soil in a particular location (Sartain, 1985, Aghatise, 1992). The objective of this study was to determine the interactive effect of soil types and phosphorus fertilizer application on the growth and yield of maize.

Materials and Methods

A pot experiment was conducted at the Teaching and Research Farm of the Faculty of Agricultural Sciences, Ladoke Akintola University of Technology, Ogbomoso. The treatments consisted of four soil types (Itagunmodi, Egbeda, Majeroku and Iwo series, described by Smyth and Montgomery, 1962) and six phosphorus levels (0, 15, 30, 60, 75 and 90kg P_2O_5/ha i.e. 0, 0.6, 1.3, 2.5, 3.1 and 3.8g/15kg soil respectively). The maize variety DMR-L-SR was used. Samples of each soil type were analyzed for physical and chemical properties before planting (IITA, 1982) and the result is presented in Table 1. The experiment was laid out in a 4x6 split plot randomized complete block design with four replications. 20kg size horticultural pots were used for the experiment. Each pot was perforated at the bottom to control drainage and aeration. Each pot was filled with 15kg soil leaving about 5cm to the brim to conveniently permit watering. Three seeds of the maize variety DMR-L-SR were sown. Supplying was done a week after planting while thinning was done to a plant per pot two weeks after planting. Fertilizer was applied at planting (phosphorus in the form of single superphosphate, nitrogen in the form of urea and potassium in the form of muriate of potash). The quantity of urea (120kg N/ha i.e. 2g/15kg soil) and muriate of potash (60kg K_2O/ha i.e. 0.8g/15kg soil) applied to the soils were in equal amounts and were applied as basal dressing while the phosphorus fertilizer applied varied as laid out in the treatments. The quantities of fertilizers applied were determined by calculating the equivalent amount required by 1 ha of land (standard measurement) against 15kg soil used in the experiment. Watering and weeding were done as required. Stem height and number of leaves were measured fortnightly from 2 WAP to 10 WAP. The stem height (measured with a tape rule) was taken from the base of the plant at soil level to the base of the last node of the plant while number of leaves was taken by counting the number of fully expanded green leaves carried by the plant. The yield parameters were taken after harvest: mean cob weight, mean cob length, mean number of grains per cob and mean number of grain rows per cob. Dry grain yield was also measured at 12% moisture content. All the plants were used in all the measurements taken. Data taken were subjected to analysis of variance (ANOVA) and least significant difference (LSD) at 5% probability value was used to compare the treatment means (SAS, 2005).

Results and Discussion

The general chemical and physical properties of the four soil types used for the experiment are presented in Table 1. All the soil types were strongly acidic with pH values ranging from 4.5 in Egbeda soil to 5.3 in Itagunmodi and Iwo soils. Soil organic carbon was lowest (3.41 g/kg) in Majeroku soil and highest (10.84 g/kg) in Egbeda soil. The available phosphorus (P) values were 1.92, 1.37, 5.19, 9.37 ug/g in Itagunmodi, Egbeda Majeroku and Iwo soil respectively. The P content of all the soils was low considering the 10 ug/g recommended for optimum maize growth in the tropics (Okalebo, 1987).

Table 2 shows the effect of soil types on the stem height of maize. The effect was significant from 4 to 10 WAP but not at 2 WAP. Iwo soil was superior to all other soil types from 4 to 8 WAP but in the 10th week, plants on Majeroku soil had the highest height (168.75cm). The vegetative growth patterns of the test crop were in line with the fertility of the soil types. Generally, Iwo soil consistently produced significantly higher values over other soil types for the agronomic parameters considered. The soil type effect was also significant on some yield parameters of maize as presented in Table 3. In terms of cob weight, plants on Iwo soil produced the heaviest cobs (251.13g) while those on Egbeda soil were the lightest (201.9g). Plants on Majeroku soil had the highest number of grain per cob (28.21) while plants on Itagunmodi soil had the least number (22.64). Highest dry gain yield of 115.45g/15kg soil was produced from crops on Majeroku soil. The dry grain yield of crops on Egbeda and Itagunmodi soils were not significantly different (95.50g/15kg soil and 95.46g/15kg soil respectively) from each other but were still lower than that of Iwo soil (108.54g/15kg soil). Positive correlation between soil nutrient and crop yield had been reported (Obi, 1987; Agboola and Sobulo, 1981). The quantity of nutrients readily available for plant use in the soil could set limit to plant performance. The higher level of nutrients in Majeroku and Iwo soils may be the reasons for better performance of maize plant grown on them. When the nutrients in the soil are not limiting, more nutrients will be made available for plant use. With low levels of soil nutrient contents especially in Itagunmodi and Egbeda soils, there were significant reductions in their growth and yield components.

The effects of phosphorus fertilizer on mean maize stem height is also presented in Table 4. The fertilizer effect was significant from 2 WAP to 10 WAP. The stem height increased with increase in the levels of phosphorus applied. Plants at 90kg P_2O_5/ha treatment had the tallest plants throughout the period under consideration. Plants without P fertilizer had the shortest height throughout the period. Some were spindly and not as strong as those treated with P fertilizer. The significant difference in maize plant height at no P fertilizer and other phosphorus levels was also observed by Ogoke *et al.,* (2004). This confirms that adequate phosphorus nutrition enhances aspects of physical physiology (Kolawole *et al.,* 2000). The varying performance of plants with the different levels of P fertilizer also agrees with the report of Aghatise (1992) which stated that variation in the supply of nutrients affects the growth of plants and may lead to changes in the components of fruit and seed yield. Figure 1 and Table 5 presents the interactive effect of soil types and phosphorus fertilizer on plant height and yield of maize respectively. In the experiment, the interactive effect was significant on all the parameters considered. At 4 WAP, plants on Egbeda soil were the tallest, at 6 to 10 WAP, plants on Iwo soil had the tallest plants all at 90kg P_2O_5/ha while plants on Itagunmodi soil had the shortest plants. The highest yield for each soil type was however at varying phosphorus levels. At 15 kg P_2O_5/ha, Egbeda and Itagunmodi soils had a yield of 116.25g and 139.75g/15 kg soil respectively while that of Iwo soil was 158.50 g/15kg soil at 75kg P_2O_5/ha. The highest yield of 172.0g/15kg soil was obtained on Majeroku soil at 30kg P_2O_5/ha. These varying levels of phosphorus fertilizer application at which different soil types produced the highest yield contradict the blanket recommendation of 60kg P_2O_5/ha for southwest Nigerian soils. Results of this experiment show that soil inherent fertility sets limits to crop performance and that soil tests are necessary before the application of fertilizer.

Table 1: Physical and Chemical properties of four soil types in rain forest zone of Nigeria

Properties	**Itagunmodi (Sandy Loam)**	**Egbeda (Loam)**	**Majeroku (Loamy sand)**	**Iwo (Loamy sand)**	**LSD (0.05)**
Sand (g/kg)	800	580	860	760	189.8
Silt (g/kg)	60	320	40	100	9.99
Clay (g/kg)	140	100	100	40	37.82
Soil pH	5.3	4.5	4.9	5.3	0.64
Ex.Ca (cmol/kg)	2.12	2.05	0.96	5.33	0.53
Ex. Mg (cmol/kg)	0.49	0.66	0.36	0.53	0.05
Ex. K (cmol/kg)	0.12	0.14	0.16	0.29	0.03
Ex. Na (cmol/kg)	0.31	0.31	0.37	0.36	0.04
Ex. Fe (ppm)	156.46	149.78	138.67	184.89	1.00
Available P (ug/g)	1.92	1.37	5.19	9.37	0.20
Total N (g/kg)	0.52	1.11	0.37	1.16	0.20
Organic C (g/kg)	5.39	10.84	3.41	12.46	0.43

Table 2 Effect of soil types on stem height (cm) of maize in a pot experiment

		Mean Maize Stem Height (cm) *Weeks after planting (WAP)*			
Soil type	**2**	**4**	**6**	**8**	**10**
Itagunmodi	8.66	17.71	38.27	102.17	135.92
Egbeda	8.27	22.33	46.10	115.75	163.88
Majeroku	7.75	20.40	47.63	111.90	168.75
Iwo	8.54	23.71	52.25	131.63	167.00
LSD	ns	2.86	6.71	17.57	14.86

Table 3 Effect of soil types on yield and yield parameters of maize in a pot experiment

	Soil Types					
Parameters	**Itagunmodi**	**Egbeda**	**Majeroku**	**Iwo**	**Mean**	**LSD (0.05)**
Cob weight (g)	210.54	201.96	243.88	251.13	226.88	38.75
Dry grain yield (g)	95.50	95.46	115.45	108.54	103.06	19.94
Cob girth (cm)	3.23	3.24	3.43	3.24	3.29	ns
Cob length (cm)	25.65	24.59	25.86	25.59	25.42	ns
Number of grain row/cob	12.17	12.04	12.42	12.71	12.34	ns
Number of grain /cob	22.64	24.00	28.21	27.00	25.96	ns

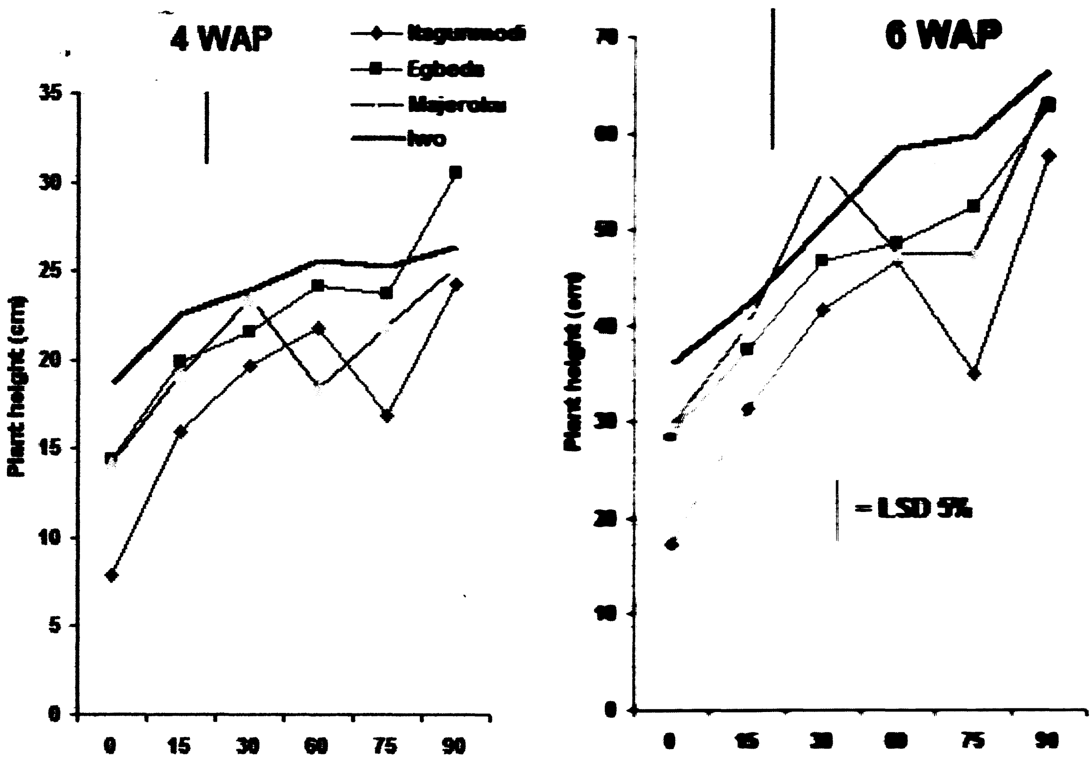
Table 4 Effect of varied levels of phosphorus fertilizer applied on stem height (cm) of maize in a pot experiment

Phosphorus levels		**Mean Maize Stem Height (cm) Weeks after Planting**			
Kg P_2O_5/ha	**2**	**4**	**6**	**8**	**10**
0	6.50	13.78	27.88	65.00	129.63
15	7.41	19.34	37.81	92.63	143.13
30	9.05	22.13	48.81	121.13	173.63
60	8.63	22.47	50.34	135.13	167.88
75	8.63	21.91	48.63	128.81	163.06
90	9.63	26.59	65.91	149.31	176.00
LSD (0.05)	1.29	3.50	8.22	21.51	18.20

Table 5: Soil type and phosphorus fertilizer interactive effects on the yield of maize in pot experiment

		P rate (kg P_2O_5/ha) Maize yield (g/15kg soil)					
Soil type	**0**	**15**	**30**	**60**	**75**	**90**	Soil type mean
Itagunmodi	50.50	139.75	55.25	112.00	96.75	118.75	95.50
Egbeda	66.25	116.25	100.00	81.00	107.50	101.75	95.46
Majeroku	96.50	94.25	172.00	104.00	94.25	126.75	115.45
Iwo	56.50	69.25	129.25	109.75	158.50	128.00	108.54
P rate mean	67.44	104.88	113.88	100.44	112.94	118.81	

LSD (s) = 19.94
LSD (p) = 24.42
LSD (s x p) = 486.93


4 WAP
Egbeda
Majeroku
Iwo
35
30
25
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5
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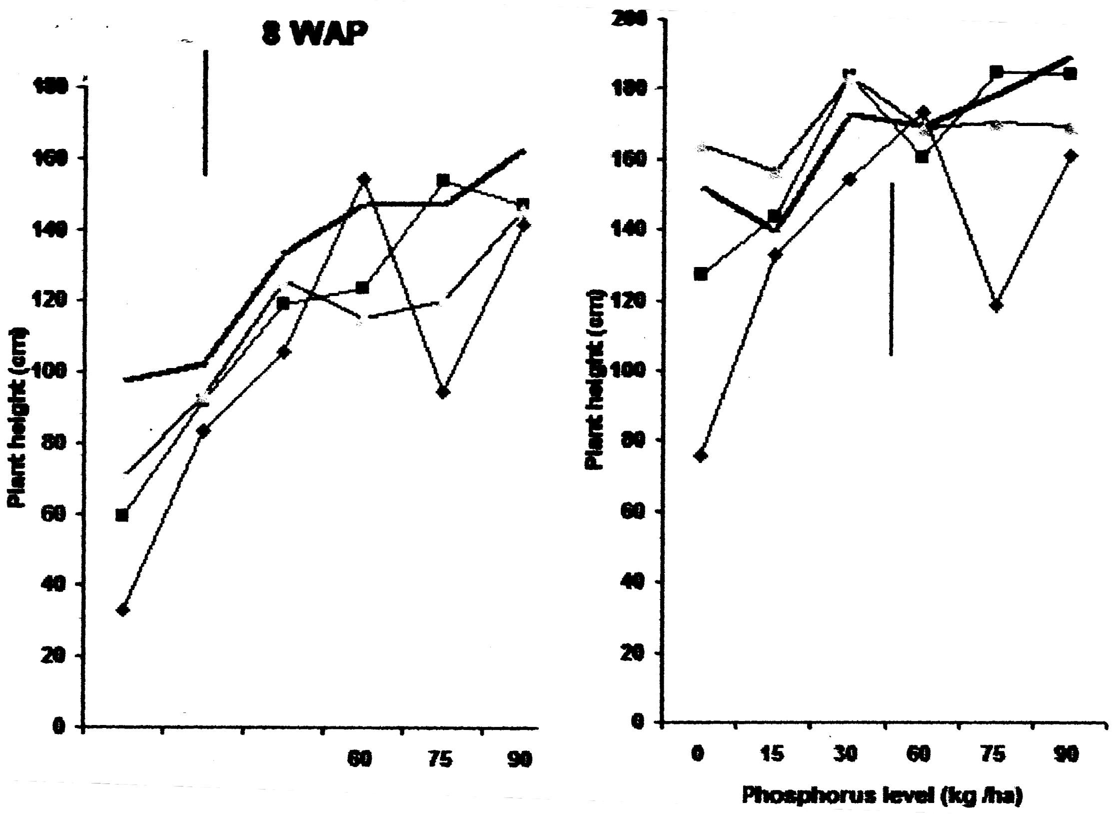
Plant height (cm)
0
15
30
60
75
90
6 WAP
= LSD 5%



Conclusion

The inherent nutrients of the soil types were generally low. It is therefore advisable to apply fertilizer to the soil types tested for proper growth and development of maize. Applied fertilizer enhances the growth and yield of maize as seen in the treatments applied when compared to the control. The phosphorus levels for optimum yield of each soil type varied and deviated from the 60kg P_2O_5/ha generally recommended for soils of Western Nigeria. Hence efforts should be made to conduct proper soil test and determine the nutrient levels before applying fertilizer instead of depending on conventional recommendation.

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