RESPONSE OF MAIZE *(Zea mays L.)* TO NITROGEN AND PHOSPHORUS FERTILIZER RATES IN TROPICAL ULTISOL OF SOUTH EASTERN NIGERIA

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ABSTRACT
Field experiments were conducted at the Teaching and Research Farm of the Department of Agronomy Michael Okpara University of Agriculture, Umudike during 2008 and 2009 cropping seasons to determine the response of maize *(Zea mays L.)* to nitrogen and phosphorus fertilizer rates in tropical ultisol of South Eastern Nigeria. In each year, the experiment was laid out as a factorial in a Randomized Complete Block Design (RCBD) replicated three times. Treatments comprised four rates of nitrogen (0, 40, 80 and 120 Kg N/ha) and three rates of phosphorus (0, 15 and 30Kg P/ha). Nitrogen application up to 80Kg N/ha) significantly ($p < 0.05$) increased days to 50% tasseling, days to 50% silking, plant height, number of leaves per plant, leaf area, leaf area index, cob length, number of grains per cob, 100 grain weight, marketable fresh weight with sheath, marketable fresh weight without sheath, with exception of grain yield which increased with further application upto 120Kg N/ha. Phosphorus application of 30 Kg P/ha significantly ($p < 0.05$) increased all growth and yield parameters. Combined application of 80Kg N/ha and 30 Kg P/ha gave the optimum Maize average grain yield of 1,422 Kg/ha and is therefore recommended for Umudike soil.

Keywords: Nitrogen, Phosphorus, Growth, Yield, Maize and South Eastern Nigeria

INTRODUCTION

Maize *(Zea mays L.)* production has become very popular in the world. Maize is grown in all major agro-ecological zones, from the humid forest to Sudan Savannah and from sea level to the high lands, (Schulthese *et al.*, 2004). Maize constitutes the most important cereal grain crop in the world after wheat and rice (Anzagaku and Anzaku, 2002). It is grown in both tropical and temperate regions of the world (Olanite *et al.*, 2002). Maize contains on the average 60% starch, 13% water, 10% protein, 4% oil, 20% sugar and 3% fibre (Udoh *et al.*, 2005). Maize is a popular grain used for food fresh or processed into various forms for human consumption. It can be processed for oil, starch and alcohol, used in industry for making adhesive, explosives, paint, ceramics, shoe polish, dyes, rubber substitutes (Udoh *et al.*, 2005). Maize stalk serves as silage and can be used for feeding livestock.

In recent times, production of maize has been given wide attention among researchers and farmers in Nigeria. However, maize is well known for its high demand for plant nutrient and other production inputs (Kogbe and Adediran, 2003). Fertilizer management is an important attribute of crop yield because it is associated with many factors of the plant environment which influence growth and yield of maize and other crops (Mushayi, 2001). Onasanya *et al.* (2009) reported that maize crop responds well to nitrogen and phosphorus fertilizer and hereby resulting in increased yield. Chaudhry *et al.* (1991) reported maximum yield of about 3.0 tons/ha in maize when 92Kg N/ha and 40 Kg P/ha were applied. The yield of maize, however varies among varieties, locations and also depends on the availability of essential factors such as soil nutrient status and fertilizer application.

Nitrogen is a vital plant nutrient and yield determining factor required for maize production (Shanti *et al*., 1997). It is not available in sufficient quantity during the growing season, especially in humid tropical ultisol of South Eastern Nigeria where erosion and leaching are prevalent. Most farmers in developing countries usually rely on the natural soil fertility for crop production. Oikeh and Horst (2001) reported that nitrogen availability encourages vegetative growth and improve yield. It's unavailability as reported by (Birch and Vos, 2000) causes reduction in leaf area, leaf area duration, radiation interception and radiation efficiency. Haque *et al.* (2001) also reported that nitrogen deficiency accelerates senescence through decrease in chlorophyll concentration thereby causing yellowing of leaves. Opening up of a long fallow land may provide adequate nutrient to food crops. Productive cropping of such land is only successful within few years after opening of the fallowed land. Due to depleted soil fertility, subsequent cropping requires additional fertilizer input especially nitrogen to maintain good yields.

Phosphorus is another limiting nutrient in maize production. Various factors could be responsible for phosphorus unavailability to crop plants. These include the form of native soil phosphorus, type of phosphorus applied to the soil and soil reaction (Bunemann, 2003). Phosphorus availability has been shown to affect root growth, notably on maize. Authors generally agree that phosphorus deficiency results to a higher root to shoot ratio (Masoni *et al.*, 2002). It has been reported that total phosphorus was higher in rainforest soils than in the savannah (Adepetu and Corey, 1975). Agricultural crops show varied response to phosphorus fertilization.

The result of various fertilizer experiments carried out in Nigeria had led fertilizer recommendations that gave blanket nutrient requirements for maize ecologies having varying soil conditions and under varying levels of soil management (FPDD, 1990). This practice is aimed at giving farmers a fairly appreciable economic return from the fertilizer input. For example, maize cultivation was found to require high fertilizer rates for optimum yield (Kogbe and Adediran, 2003). Findings from these work indicated that maize responded to nitrogen better in the savanna than in the rain forest ecology (Sobulo, 1980). It was further suggested that 60-70Kg N/ha served as economic rate for maize in the rainforest and over 100 Kg N/ha in the savanna. The difference between the two zones was however, attributed to the presence of higher insulation in the savanna (Sobulo, 1980). Some work earlier carried out with phosphorus fertilizer indicated positive response of maize to low rates of 30Kg P/ha (Adepetu and Corey, 1975). Application of high rate was reported to be capable of causing nutrient imbalance and consequently yield depression of western yellow maize (Osiname, *et al.*, 2000).

There has been no sufficient information on combined nitrogen and phosphorus requirements of maize introduced to farmers in Nigeria. Farmers mainly reply on the blanket recommendation for maize production. However, new high yielding maize varieties are continually being released for farmer's use. There is the need to determine their nutrient requirements especially combined application of nitrogen and phosphorus. Also changes in soil fertility levels with combined cultivation necessitate the reassessment of fertilizer application. This work therefore examined the response of maize to nitrogen and phosphorus fertilizer rate in tropical ultisol of South Eastern Nigeria.

MATERIALS AND METHODS

The study was conducted in 2008 and 2009 cropping season at Michael Okpara University of Agriculture, Umudike Teaching and Research Farm. Umudike is located at longitude 7^{o}33'E and latitude 5^{o}29'N, 122m above sea level. Each year, the experiment was planted on a fresh site that had been under fallow for two years for the 2008 and 2009 experiments respectively. The land used for the experiment was slashed on 6th May, ploughed on 10th May and harrowed on 14th May in both years, while sowing was done on 21st May for 2008 and 2009. The experimental field was marked out into three blocks of 43m x 9.5m (408.50m^2). Each block was further divided into 12 experimental plots of 3.0m x 2.5m (7.5m^2). The blocks were separated from one another by 1m path. A composite soil sample from representative field location was collected with soil auger to a depth of 0-15cm for physical and chemical analyses before planting.

The experiment was a 4 x 3 factorial arranged in a randomized complete block design (RCBD) with three replications. Treatments comprised all possible combinations of one maize variety (oba super 2), four rates of nitrogen (0, 40, 80 and 120Kg N/ha) and three levels of phosphorus (0, 15 and 30 Kg P/ha). These treatments were assigned randomly using table of random numbers. Various nitrogen and phosphorus rates were applied according to the treatment at two weeks after planting. 30Kg K/ ha was applied as muriate of potash at 2 weeks after planting as blanket application to all plots. Seeds of Oba super 2 maize variety was obtained from National Seed Council Umudike. Seeds were planted on flat at the rate of two seeds per hole at a spacing of 75cm between rows and 25cm within rows. They were later thinned to one stand at 2 weeks after planting to give a plant population of 53,333 plant/ha. Hoe weeding was done at 2 weeks and 8 weeks after planting.

For the purpose of data collection, twelve plants from two middle rows were randomly selected. Out of these, six were further randomly selected for growth, data collection and remaining six plants for the yield parameters. The following agronomic attributes were determined: days to 50% tasseling, days to 50% silking, plant height, leaf area, leaf area index, number of leaves, cob length, number of grains per cob, 100 grain weight, marketable fresh weight with sheath, marketable fresh weight without sheath and grain yield. All the data collected were subjected to analysis of variance (ANOVA) and significant differences among treatment means separated using fisher's least significant difference (Gomez and Gomez, 1984).

RESULTS

The soil of the experimental sites were sandyloam and slightly acidic with low pH of 5.14 in 2008 and 5.54 in 2009. The soils were low in N, K and Organic matter but P was moderate in 2008 and high in 2009 (Table 1)

Table 1: Some Mechanical and Chemical Properties of the Soil for the Experiments in 2008 and 2009 Cropping Season.

Mechanical Properties	**Experiment 1 (2008)**	**Experiment 2 (2009)**
Sandy (%)	78.12	78.14
Silt (%)	7.60	7.40
Clay (%)	14.28	14.46
Textural class	Sandy loam	Sandy loam
Chemical Properties:		
pH (H2O)	5.14	5.54
Available P (Mg Kg)	15.20	22.00
Total N (%)	0.09	0.05
Organic carbon (%)	0.61	1.02
Organic matter (%)	1.06	1.75
Exchangeable Bases:		
C2+	2.20	2.80
Mg2+	1.40	1.60
K2+	0.14	0.12
Na2+	0.08	0.08
Exchangeable acidity	1.96	1.82
Effective CEC	5.78	6.43
Base saturation (%)	66.17	71.47

The results revealed that incremental application of nitrogen up to 80Kg N/ha significantly increased plants height, number of leaves per plant, leaf area and leaf area index in 2008 and 2009 cropping season and thereafter declined (Tables 2a and 2b).

Table 2a: Growth attributes of maize as influenced nitrogen and phosphorus fertilizer rates at Umudike in 2008 Cropping Season.

	Nitrogen (Kg/ha)				
Phosphorus (Kg/ha)	**0**	**40**	**80**	**120**	**Mean**
Days to 50% tasseling					
0	74.3	68.7	67.7	70.3	70.3
15	73.7	68.0	67.7	70.0	69.8
30	72.7	66.0	59.0	70.7	67.1
Mean	73.6	67.6	64.8	70.3	
Days to 50% silking					
0	80.7	75.0	73.3	74.7	75.9
15	79.3	73.7	73.3	76.0	75.6
30	78.7	72.3	65.0	76.7	73.2
Mean	79.6	73.2	70.6	75.8	
Plant height (cm)					
0	69.6	121.8	120.3	115.3	106.7
15	72.9	122.3	113.5	111.6	105.1
30	80.8	120.8	177.2	128.6	126.8
Mean	74.4	121.6	137.0	118.5	
Number of Leaves per plant					
0	7.3	9.7	9.0	10.0	9.0
15	8.2	9.6	9.4	9.3	9.1
30	8.1	10.2	12.6	10.0	10.2
Mean	7.8	9.8	10.3	9.8	
Leaf area (cm^2)					
0	1004	2524	2170	2364	2016
15	1016	2429	2462	2136	2011
30	1156	2718	4343	3557	2943
Mean	1059	2557	2991	2686	
Leaf area index					
0	0.6	1.4	1.2	1.3	1.1
15	0.6	1.4	1.4	1.2	1.1
30	0.6	1.5	2.4	2.0	1.6
Mean	0.6	1.4	1.7	1.5	

	Days to 50% tasseling	**Days to 50% silking**	**Plant height(cm)**
LSD 0.05 (N)	2.0	2.2	2.5
LSD 0.05 (P)	1.7	1.9	2.2
LSD 0.05 (N X P)	3.5	3.8	4.4

	No. of leaves per plant	**Leaf area (cm^2)**	**Leaf area index**
LSD 0.05 (N)	0.8	666.6	0.4
LSD 0.05 (P)	0.7	577.3	0.3
LSD 0.05 (N X P)	1.4	NS	NS

Table 2b: Growth Attributes of Maize as Influenced Nitrogen and Phosphorus Fertilizer Rates at Umudike in 2009 Cropping Season

	Nitrogen (Kg/ha)				
Phosphorus(Kg/ha)	**0**	**40**	**80**	**120**	**Mean**
	Days to 50% tasseling				
0	71.8	69.7	68.7	70.0	70.0
15	69.0	69.0	68.5	70.1	69.2
30	69.2	60.8	57.7	60.3	62.0
Mean	70.0	66.5	64.9	66.8	
	Days to 50% silking				
0	81.7	80.7	79.2	78.2	79.9
15	80.5	79.5	77.3	78.3	78.9
30	79.8	73.8	64.8	68.5	71.8
Mean	80.6	78.0	73.7	75.0	
	Plant height (cm)				
0	107.5	131.1	155.0	156.0	137.4
15	145.0	178.0	191.7	193.5	177.1
30	163.5	195.2	224.5	207.0	197.6
Mean	138.6	168.1	190.4	185.5	
	Number of Leaves per plant				
0	8.1	10.1	10.2	10.0	9.6
15	9.1	10.0	10.9	10.6	10.2
30	10.0	10.1	14.6	11.5	11.6
Mean	9.0	10.0	11.9	10.7	
	Leaf area (cm^2)				
0	1733	2707	3753	3178	2843
15	2400	3652	4356	3990	3599
30	3445	5078	8218	5779	5630
Mean	2526	3812	5442	4315	
	Leaf area index				
0	1.0	1.5	2.1	1.8	1.6
15	1.3	2.0	2.4	2.2	2.0
30	1.9	2.8	4.6	3.2	3.1
Mean	1.4	2.1	3.0	2.4	

	Days to 50% tasseling	**Days to 50% silking**	**Plant height (cm)**
LSD 0.05 (N)	0.9	0.9	1.7
LSD 0.05 (P)	0.9	0.9	1.7
LSD 0.05 (N X P)	1.8	1.9	3.4

	No. of leaves per plant	**Leaf area cm^2**	**Leaf area index**
LSD 0.05 (N)	0.1	172.4	0.1
LSD 0.05 (P)	0.1	172.4	0.1
LSD 0.05 (N X P)	0.1	344.8	0.2

The plants tasseled and silked earliest with 80Kg N/ha than zero application in both cropping season. Also application of phosphorus upto 30Kg P/ha significantly increased plant height, number of leaves per plant, leaf area and leaf index and reduced days to 50% tasseling and silking than 0Kg P/ha and 15Kg P/ha in 2008 and2009 cropping season respectively. Interaction between N and P showed that within P rates, N significantly increased days to 50% tasseling, days to 50% silking, plant height, and number of leaves up to 80Kg N/ha in both cropping season and thereafter declined. Similarly for each N rate, application of P significantly increased days to 50% tasseling, days to 50% silking, plant height and number of leaves per plant. In 2008, interaction between N and P did not significantly affect leaf area and leaf area index.

Nitrogen application up to 80Kg N/ha significantly increased cob length, number of grains per cob, 100 grain weight marketable fresh weight with sheath and marketable fresh weight without sheath in both cropping season. However, application of nitrogen up to 120Kg N/ha increased grain yield in 2008 and 2009 cropping season (Tables 3a and 3b). Incremental application of phosphorus up to 30Kg P/ha significantly increased cob length, number of grains per cob, 100 grain weight, marketable fresh weight with sheath, marketable fresh weight without sheath and grain yield in both years. Interaction between N and P showed that within P rates, N. Significantly increased cob length, number of grains per cob, marketable fresh weight with sheath and without sheath. Similarly, for each N rate, application of P significantly increased all the yield and yield components up to 30Kg P/ha for both years. However, there were no significant difference on combined N and P on 100 grain weight in both years.

DISCUSSION

The result of the study showed that maize growth and yield parameters generally increased as nitrogen rates increased up to 80Kg N/ha except for grain yield which was greatest at 120Kg N/ha. This trend could be attributed to the effect of nitrogen as an essential constituent of chlorophyll, protein, cell walls, nucleic acids, cytoplasm and vast array of other cell components (Haque *et al*., 2001). During the vegetative growth of crops, the nitrogen nutrition of the plant to a large extent controls the growth rate of the plants as meristematic tissues have very active protein metabolism (Amanuuah *et al.*, 2009). Hani *et al*. (2006) reported that N application up to 80Kg N/ha remarkably increased days to 50% tasseling, plant height, stem diameter, leaf area index and dry matter production. This result is also consistent with the report of Namakka *et al.* (2008) that increase in nitrogen up to 80Kg N/ha increased cob length, cob diameter and cob weight. Nitrogen rate of 120Kg N/ha resulted in the highest grain yield. This could be attributed to the fact that initial soil nitrogen of 0.09% and 0.05% for 2008 and 2009 cropping seasons respectively obtained in the present study were below the critical value of 0.15% N reported by Chude *et al*. (2004) and therefore shows the maize response to N application. For phosphorus, growth and yield parameters also increased as P increased up to 30Kg P/ha. This effect of phosphorus on maize was attributed to its role in crop maturation, flowering, fruiting and seed production (Maqsood *et al.*, 2001). Some work earlier carried out with P fertilizer indicated positive response of maize to low rate of 30Kg P/ha (Osiname *et al*., 2000). The result from this study showed that maize growth and yield parameters responded to fertilizer application up to 80Kg N/ha and 30Kg P/ha. This trend could be attributed to the fact that nitrogen nutrition for optimum growth during the vegetative period was balanced by the presence of adequate amount of other plant nutrients (Ezeaku, 2008).

Table 3a: Yield attributes of maize as influenced nitrogen and phosphorus fertilizer Rates at Umudike in 2008 cropping season

Phosphorus(Kg/ha)	Nitrogen (Kg/ha) 0	40	80	120	Mean
			Cob length (cm)		
0	16.9	17.4	18.1	19.0	17.9
15	16.9	22.1	27.8	24.5	22.8
30	2.0	25.1	35.9	24.7	26.4
Mean	17.9	21.5	27.3	22.7	
			Number of grains per cob		
0	136	239	193	306	218
15	167	226	347	248	247
30	226	352	621	336	384
Mean	176	272	387	297	
			100 grain weight (g)		
0	19.7	26.0	27.3	28.1	25.3
15	26.1	22.8	27.0	26.9	25.7
30	26.5	27.7	39.1	29.1	30.6
Mean	24.1	25.5	31.1	28.0	
			Marketable fresh weight with sheath per plant (g)		
0	383.3	600.0	500.0	500.0	495.8
15	450.0	416.7	550.0	550.0	491.7
30	450.0	650.0	966.7	600.0	666.7
Mean	427.8	555.6	672.2	550.0	
			Marketable fresh weight without sheath per plant (g)		
0	108.3	163.3	139.2	140.8	137.9
15	125.0	116.7	150.0	150.0	135.4
30	125.0	175.8	254.2	162.5	179.4
Mean	119.4	151.9	181.1	151.1	
			Grain yield (Kg/ha)		
0	667.1	710.2	730.6	838.7	736.7
15	669.3	837.8	1266.0	1261.8	1008.7
30	682.1	1096.5	1430.1	1368.3	1144.3
Mean	672.8	881.5	1142.2	1156.3	

	Cob length (cm)	**No. of grains per cob**	**100 grain weight (g)**
LSD 0.05 (N)	1.1	64.7	3.7
LSD 0.05 (P)	0.9	56.1	3.2
LSD 0.05 (N X P)	0.8	112.1	NS

	Marketable fresh weight with sheath (g)	**Marketable fresh weight without sheath (g)**	**Grain yield(Kg/ha)**
LSD 0.05 (N)	36.8	9.36	3.2
LSD 0.05 (P)	31.8	8.11	2.8
LSD 0.05 (N X P)	63.7	16.2	5.6

Table 3b: Yield Attributes of Maize as Influenced Nitrogen and Phosphorus Fertilizer Rates at Umudike in 2009 Cropping Season

Phosphorus (Kg/ha)	Nitrogen (Kg/ha) 0	40	80	120	Mean
			Cob length (cm)		
0	16.0	22.1	23.5	22.9	21.1
15	17.5	20.1	20.7	19.9	19.5
30	19.5	23.9	31.5	29.4	26.1
Mean	17.6	22.0	25.2	24.0	
			Number of grains per cob		
0	141.6	155.3	166.4	163.2	156.6
15	145.3	203.8	382.8	379.6	277.8
30	184.2	210.9	563.0	549.6	376.9
Mean	157.0	190.0	370.7	364.1	
			100 grain weight (g)		
0	18.8	19.0	22.9	22.9	20.9
15	18.8	27.6	30.8	30.2	26.8
30	18.8	27.8	41.2	35.8	30.9
Mean	18.8	24.8	31.6	29.6	
			Marketable fresh weight with sheath per plant (g)		
0	162.9	191.3	220.0	210.8	196.2
15	185.4	208.8	241.3	234.2	217.4
30	188.7	242.1	670.8	595.0	424.2
Mean	178.9	214.0	377.3	346.6	
			Marketable fresh weight without sheath per plant (g)		
0	132.9	165.0	192.5	182.9	168.3
15	158.7	182.5	215.8	207.1	191.0
30	160.8	215.0	420.0	342.1	284.5
Mean	150.8	187.5	276.1	244.0	
			Grain yield (Kg/ha)		
0	664.2	711.7	731.1	839.1	736.4
15	670.1	839.4	1266.2	1261.4	1009.3
30	680.8	1094.6	1415	1373.2	1141.0
Mean	671.7	881.9	1137.4	1157.9	

	Cob length (cm)	No. of grains per cob	100 grain weight (g)
LSD 0.05 (N)	0.4	4.4	0.5
LSD 0.05 (P)	0.4	4.4	0.5
LSD 0.05 (N X P)	0.8	8.7	10.0

	Marketable fresh weight with sheath (g)	Marketable fresh weight without sheath (g)	Grain yield (Kg/ha)
LSD 0.05 (N)	6.6	6.8	1.8
LSD 0.05 (P)	6.6	6.8	1.8
LSD 0.05 (N X P)	13.2	13.5	3.6

CONCLUSION

Under condition of this study maize growth and yield were increased with increase in nitrogen application up to 80Kg N/ha with the exception of grain yield which increased with further application up to 120Kg N/ha. Phosphorus fertilizer application up to 30Kg P/ha increased growth and yield of maize. Combined application of 80Kg N/ha and 30Kg P/ha gave the optimum grain yield and therefore should be recommended for Umudike soil.

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