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EFFECT OF NITROGEN AND MICRONUTRIENTS ON GRAIN YIELD OF MAIZE VARIETIES IN THE NORTHERN GUINEA SAVANNA ALFISOL.

Olowookere, B.T.[1], Uyovbisere, E.O.[2] and Ojeniyi, S.O.[3]
[1]*Department of Soil Science, University of Abuja, Abuja.*
[2]*Department of Soil Science, Ahmadu Bello University, Zaria.*
[3]*Department of Crop, Soil and Pest Management, Fed. University of Technology, Akure*

ABSTRACT

Field experiments were conducted in 2008 and 2009 in the Guinea Savanna ecology of Nigeria to investigate the effects of nitrogen fertilizer and micronutrients on the grain yield of two quality maize and two normal maize varieties. The treatments were four rates of inorganic fertilizer N (0, 50, 100, 150 kg Nha^{-1}) and two rates of cocktail micronutrient mixtures. These were tested in a Randomized Complete Block Design with three replications and the treatments were factorially combined. The results from the study revealed that the quality protein maize varieties (SUSUMA and SAMMAZ 14) attained maximum performance at 100 kg Nha^{-1} relative to 150 kg Nha^{-1} by the normal varieties (SAMMAZ 12 and SAMMAZ 11) which means the QPM were more N efficient and superior to normal maize in yield by 21.43 %. SUSUMA and SAMMAZ 14 responded to the micronutrients added which suggested that the soil was slightly deficient in micronutrients as yield levels of maize were increased consistently by margins of 18-26% with the application of micronutrient cocktail. SAMMAZ 14 and SUSUMA (QPM) varieties were recommended because they were more economical in the use of nitrogen fertilizer.

INTRODUCTION

Maize is progressively assuming the position as the major crop of the sub-humid and semi-arid savanna with respect to economic prospects for the farmers. In fact, it is replacing the traditional cereals such as millet and sorghum (Onwueme and Sinha, 1991). It is a staple food crop in the ecological zone. All types of maize require heavy fertilizer application for optimum yield (Singh, 1987; Awotundun, 2005). Mineral fertilizer at a rate of 100 - 150 kg N, 40-50 P_2O_5 and 80-100 kg K_2O ha^{-1} has been recommended for maize in the savanna zone (Onyinbe *et al.,* 2006). Despite the widespread use across the country however, it is devoid of some major amino acids, such as lysine and tryptophan (Obi, 1982; Okai *et al.*, 2005; Vassal, 2006). The development of QPM varieties improved the nutritional properties of maize and has given hope to many as a source of affordable protein for good health.

The soils of the savanna are under continuous cultivation and are poorly managed with the use of heavy implements which increase soil compaction and erosion that leads to rapid decline in organic matter, leaching of basic cations and high rates of acidification (Jones and Wild, 1975; Vanlauwe and Saginga, 2004; Ogunwole, 2008). Therefore, there is the need for the use of mineral fertilizers on such soil to produce crop and maintain the soil fertility.

Micronutrients are essential and play an active role in gene expression, biosynthesis of protein, nucleic acids, plant metabolism processes starting from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation and reduction (Bishnu *et al.,* 2010). Micronutrients are becoming increasingly important to world agriculture as crop removal of these essential element increases (Adhikary *et al.,* 2010). Increasing attention is being given to micronutrient deficiencies because increasing crop yield have led to increased uptake of micronutrients and most chemical fertilizers do not include the micronutrients.This study is to investigate the effect of nitrogen fertilizer and micronutrients on grain yield of maize.

MATERIALS AND METHODS

Description of study area: The experiment was carried out during the 2008 and 2009 cropping seasons at Samaru, Zaria. Samaru is located in Zaria in the Northern Guinea Savanna ecological Zone of Nigeria. Samaru is located at latitude 11^0 11' N, longtitude 7^0 38' E at 686 m above sea level in the Northern Guinea Savanna zone of Nigeria with annual rainfall average of about 1060 mm (Owonubi *et al.*,1991).The soil is classified as Alfisol in the USDA Soil classification system.

Experimental design

The experiment was laid out in a Randomized Complete Block Design with three replications and treatments were factorially combined. The site was divided into three blocks each, consisting 32 plots, giving a total of 96 plots and each plot measuring 12 m^2.There were 4 ridges in a plot, 3m long at 0.75 m x 0.25 m spacing on a row. The maize planted were two quality protein maize (QPM) – Sammaz 14 and Susuma and two normal maize varieties – Sammaz 12 and Sammaz 11. Three maize seeds were sown in drills and thinned to one per stand.Weeding was done in each year with the use of hand and hoe.

Nitrogen was applied in 2 split doses at 2WAP and 4WAP at the rate of (0, 50, 100, 150 $kgha^{-1}$) as Urea (46 %). Basal application of phosphorus and potassium were applied at 60 kg P_2O_5 ha^{-1} as single super phosphate (SSP), and 60 kg K_2O ha^{-1} potash (MOP), (60 %) respectively. The micronutrients- Fe, Zn, B, Mo, and Cu were applied at zero and cocktail mixtures. The P, K and micronutrients were all applied 2 weeks after planting immediately after thinning to one plant per stand.

Field observations were made in each plot. The response of maize varieties to the various treatments was evaluated and maize grain yieldwas determined at harvest.

Data Analysis

The statistical analysis was performed using Genstat Statistical Package for the analysis of variance (ANOVA). Treatment means were compared by using Least Significant Difference at 5 % probability.

RESULTS AND DISCUSSION

The table below shows properties of the soil used for the experiment

The soil is sandy –loam in texture and very low in N and available P. Micronutrient contents indicated low to moderate. It is expected that the maize varieties would benefit from the added fertilizers.

The response of maize grain to applications

Table 1: Physico –chemical properties of the soil used for the study

	Field Study	
Parameters	0-15 (cm)	15-30 (cm)
Sand (gkg^{-1})	540	525
Silt (gkg^{-1})	330	350
Clay (gkg^{-1})	130	125
Textural class	Sandy-loam	
pH_{H20}	5.70	5.60
pH_{CaCl2}	5.40	5.20
Organic carbon ($g\ kg^{-1}$)	5.20	5.00
Total nitrogen (%)	0.06	0.07
Available P ($mgkg^{-1}$)	7.58	6.80
Exchangeable acidity ($cmolkg^{-1}$)	0.60	0.62
Exchangeable bases ($cmolkg^{-1}$)		
Calcium	3.98	4.50
Magnesium	1.36	1.59
Sodium	0.40	0.30
Potassium	0.70	0.58
Effective CEC ($cmolkg^{-1}$)	2.60	3.45
Micronutrients ($mgkg^{-1}$)		
Extractable Zinc	16.75	18.40
Extractable Iron	52.00	45.50
Extractable Copper	0.58	0.55
Extractable Molybdenum	11.00	11.08
Extractable Boron	0.10	0.11

of varying rates of nitrogen fertilizers over the two years is given in Table 2.

Combining the yield for the two years showed the quality protein maize varieties, SAMMAZ 14 and SUSUMA (QPM) recorded a yield of 2552.94 kg ha^{-1} and 2665.65 kg ha^{-1} at 100 kg N ha^{-1} while the normal maize variety SAMMAZ 12 and 11 had the combined yield of 1933.31 kg ha^{-1} and 2349.79 $kgha^{-1}$ at the highest rate of nitrogen application (150 kg N ha^{-1}). The QPM (SAMMAZ 14 and SUSUMA) were more superior to normal maize SAMMAZ (12 and 11) by 21.43 %. The response of the maize to nitrogen fertilizer is known to be related to the level of OM, total nitrogen content of the soil and the variety of the maize used (Singh and Singh, 1979). Similar results were obtained by (Ajayi *et al.*, 1998 and Mani and Dadari, 2005). The contrast analysis revealed a highly significant difference ($P< 0.05$) in performance between the QPM and the normal varieties.

The response of maize grain to applications of varying rates of nitrogen fertilizer as influenced by mixtures of micronutrients over the two years is presented in Table 3.

Maize yield were observed to respond to applications of nitrogen fertilizer and micronutrient additions. The combined yield showed that SAMMAZ 14 (QPM) and SUSUMA responded to micronutrients addition with a corresponding yield of 3156.9 $kgha^{-1}$ and 2581.6 $kgha^{-1}$ at the highest rate of nitrogen.

SAMMAZ 12 and SAMMAZ 11 (normal maize) though responded to nitrogen fertilization but responded poorly to micronutrient additions. SAMMAZ 12 had a combined yield

Table 2: Effects of nitrogen on grain yield of maize varieties

		Grain yield (kg ha^{-1})		
Variety	Nitrogen(kg ha^{-1})	2008	2009	Combined
SAMMAZ 14	0	245.16	1111.09	678.05
	50	681.90	2776.94	1729.42
	100	2397.05	2708.82	2552.94
	150	1820.77	3082.32	2451.55
Mean		1096.31	2508.27	1802.34
SUSUMA	0	990.93	1354.11	1127.02
	50	368.01	2263.88	1315.94
	100	1809.09	3522.21	2665.65
	150	1231.87	2894.43	2063.15
Mean		707.22	2258.66	1632.94
	0	515.22	1486.09	1000.65
SAMMAZ 12	50	561.03	1805.55	1183.29
	100	981.89	2106.55	1571.22
	150	1366.63	2499.99	1933.31
Mean		865.19	1988.04	1422.12
	0	690.23	1312.49	1012.75
SAMMAZ 11	50	760.49	1944.44	1352.47
	100	1212.45	2129.54	1671.02
	150	1637.42	3062.16	2349.79
		1265.06	2023.83	1644.45
Mean		975.37	2285.06	1639.45
SE+		341.90	296.15	173.28
CV (%)		85.86	31.75	52.03
V X N		NS	NS	NS
		CONTRAST		
QPM vs Normal		**	**	**
QPM_A vs QPM_B		**	**	**
With vs Without micronutrient		NS	NS	NS

of 2179.1 kg ha^{-1} with no micronutrients while SAMMAZ 11 showed the combined yield was 2329.7 kgha^{-1} with added micronutrients. This indicated that the addition of micronutrients might have helped the varieties to yield better. When the analysis was compared, the quality protein maize showed a highly significant difference ($P< 0.05$) from the normal maize at added micronutrients and the comparison between the QPM varieties was also significant ($P< 0.05$) with added micronutrients.

The result shows that the addition of micronutrients might have helped the varieties to yield better. Bishnu *et al.* (2010) recorded the highest grain yield with the crop which was supplied with all the micronutrients (B, Zn, S, Mn and Mo) applied in combination with NPK fertilizers at 120: 60:60 kgha^{-1}. The result also showed

Table 3: Grain yield response of maize varieties to nitrogen levels as influenced by micronutrients

		Micronutrient (gha^{-1})				
	2008		2009		Combined	
Variety XN levelNha^{-1}	-M	+M	-M	+M	-M	+M
SAMMAZ 14						
0	172.1	452.7	1111.1	1111.2	641.6	844.3
50	727.7	611.1	2138.9	1749.9	1445.8	1180.5
100	1263.8	2011.1	3277.2	2888.9	2270.8	2449.9
150	2261.1	1380.9	2902.2	3222.2	2301.6	2581.6
Mean	1106.2	1188.9	2357.3	2243.3	1784.0	1694.0
SUSUMA						
0	294.4	400.0	1236.1	1472.2	665.2	788.8
50	322.2	413.2	2222.2	2305.6	1313.9	1318.0
100	636.1	827.7	2469.4	3319.4	1552.8	2073.6
150	1333.3	1924.9	3777.8	4388.9	2194.4	3156.9
Mean	668.9	744.4	2600.0	2698.1	1593.7	1672.2
SAMMAZ 12						
0	405.5	624.9	972.2	1722.2	688.8	1312.5
50	538.8	583.3	1888.9	1999.9	1213.8	1152.7
100	930.5	622.2	2041.7	2279.4	1691.6	1450.8
150	1316.6	1802.7	2444.4	2555.5	2179.1	1687.5
Mean	797.8	908.3	1986.1	1934.4	1320.5	1523.8
SAMMAZ 11						
0	366.0	119.4	1430.6	1194.4	1333.3	669.4
50	891.6	913.9	2175.8	2083.3	1283.7	1498.6
100	1816.6	1533.3	2472.2	2583.3	1862.9	2058.3
150	1236.0	2977.5	2834.3	3081.7	2144.4	2329.7
Mean	1077.7	1385.9	2255.9	2235.0	1656.1	1814.0
SE ±	1057.89	194.22	2283.84	222.29	171.33	173.19
R^2	0.61	99.40	0.83	30.71	0.70	0.72
CV(%)	0.71	73.44	0.62	38.93	52.59	51.22
V x N	NS	NS	NS	NS	NS	NS
CONTRAST						
QPM vs Normal	* *	* *	*	* *	NS	**
QPM_Avs QPM_B	NS	NS	NS	NS	NS	*

M+ = with added micronutrient M- = with no added micronutrient NS = Not significant at (P< 0.05) ** = Significant at(P< 0.05) QPMA = SAMMAZ 14 VarietyQPMB = SUSUMA Variety

that both the QPM and the conventional maize when subjected to the same environmental factors can utilize micronutrients differently for yield increase. The maize varieties responded differently to nitrogen fertilizer with micronutrient mixtures.The added micronutrients enhanced the yield performance of quality protein maize (SAMMAZ 14 and SUSUMA). The normal maize SAMMAZ 12 and SAMMAZ 11 were not enhanced by the added micronutrients although SAMMAZ 11 yield was better at the addition of micronutrients but the yield was not significantly different from SAMMAZ 12. This shows the synergetic role of micronutrients in improving plant growth and other biochemical and physiological activities. Bishnu *et al.* (2010) in their findings recorded the highest grain yield with the crop which was supplied with all the micronutrients (B, Zn, S, Mn and Mo) applied in combination with NPK fertilizers at 120: 60:60 kg/ha. Kanwal *et al.* (2010) found that zinc application to soil had a positive significant effect on grain yield and Rogo *et al.* (2001) reported an increase in grain yield of maize to zinc application. The result also showed that both the QPM and the conventional maize when subjected to the same environmental factors can utilize micronutrients differently for yield increase.

CONCLUSION

The quality protein maize varieties (SAMMAZ 14 and SUSUMA) attained maximum performance at 100 kg Nha^{-1} relative to 150 kg Nha^{-1} for normal maize (SAMMAZ 12 and SAMMAZ 11) and so were more N efficient and superior to normal maize in yield by 21.43 %.

SUSUMA and SAMMAZ 14 responded to the micronutrients added which suggested that the soil was slightly deficient in micronutrients as yield levels of maize were increased consistently by margins of 18-26 % with the application of micronutrient cocktail.

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