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Improving Maize Yield on Ferric Lixisol by NPK Fertilizer Use

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Abstract

The experiment was conducted to refined profitable NPK fertilizer rate for maize production on *Tanchera* series (Ferric Lixisol, FAO, 2006) in the Sudan savanna agro-ecological zone of Ghana. RCBD design with four replications was used. Treatments evaluated were N = 0, 40, 80, 120, 160; P = 0, 45, 90 and K = 0, 45, 90 kg/ha. Results showed significant N rate effect on grain yield, benefit cost ratio and gross return ($P \leq 0.01$). P and K did not show significant effect among these parameters. Application of nitrogen from 80-120 kg/ha may be recommended for improve grain yield and gross return of maize production on Ferric lixisol. Due to poor nature of soils, application of P and K up to 45 kg/ha may also be recommended for maize production.

Keywords: profitable, NPK nutrient, maize, Ferric lixisol

1 Introduction

Maize is the most important cereal crop in most parts of West Africa (Fosu et al., 2004). In Ghana, it is the major staple especially in the northern part where it is even replacing sorghum and millet which were the major staples some years ago.

Average yield of maize is 1.7 t (MoFA, 2011) compared to world average of 4.9 t (Edgerton, 2009). Low soil fertility and low application of external input are the major causes of low yields of maize. Soils in maize producing areas especially Northern savanna agro-ecological zones are low in OC (< 2%), total N (< 0.02%), available P (< 10 mg/kg) and exchangeable K (< 100 mg/kg) (Adu and Asiamah, 2003). Average fertilizer nutrient application in Ghana is approximately 8 kg ha^{-1} (FAO, 2005). The use of old and blanket fertilizer recommendation in Sudan savanna agro-ecological zone of Ghana is not useful in recent times. FAO estimates show negative nutrient balance for all crops in Ghana. The escalating rate of soil nutrient mining is a serious threat to sustainability of agriculture.

This study was conducted to refine profitable NPK nutrient for improved maize production on Ferric lixisols in Sudan savanna agro-ecological zone of Ghana.

2 Materials and Methods

2.1 Study Area

The project was carried out in the Sudan savanna agro-ecological zone of the extreme north-east corner of Ghana. The area lies roughly between $10^{o}30'11''$ North latitude of the equator, $0^{o}1'30''$ West longitude of the zero meridian and has an altitude of 200 to 400 m above sea level. Mean annual rainfall for the study area is 921 mm with the highest amount recorded in August (Nyarko et al., 2008). The mean annual minimum and maximum temperatures are 22.3 and 34.3 ^{o}C, respectively.

2.2 Experimental Design

A field experiment was conducted for 2 years during the rainy seasons of 2010 and 2011. A randomized complete block design with 4 replications and a plot size of 6.0 m × 4.8 m was used. Treatments used in the experiments were: N = 0, 40, 80, 120, 160; P = 0, 45, 90 and K = 0, 45, 90 kg/ha. The source of N nutrient was from urea fertilizer, P from triple super phosphate fertilizer and K from muriate of potash fertilizer. Maize variety used was *obaatanpa*. It was planted at 2 seeds per hill at a spacing of 80 cm × 40 cm.

2.3 Soil Sampling and Chemical Analysis

Soil profile pit of 1 m × 2 m was excavated at the experimental site to a depth of 175 cm for characterizing the soil. A composite soil sample was taken diagonally across the field to determine the initial conditions of the soil. Sieved (< 2.0 mm) air-dried samples were analyzed for pH (1:1 H_2O), total N by Kjeldahl distillation and titration method (Bremner & Mulvaney, 1982), available P by Bray 1 extraction solution procedure (Bray & Kurtz, 1945), Exchangeable bases (Ca, Mg, K and Na) content in the soil were determined in 1.0 *M* ammonium acetate extract (Thomas, 1982) and organic carbon by modified Walkley and Black procedure as described by Nelson and Sommers (1982).

2.4 Data Collection

A known area of 9 m^2 was marked in middle of each plot for data collection on grain yield. Benefit cost ratio and gross return were estimated from grain yield, cost of inputs and labor used for production and price of grain yield.

2.5 Statistical Analysis

General linear model of Statistical Analysis System (SAS, Version 9.3) was used to analyze the above field data. Contrast analysis test at 5% was used to separate treatment means which were significantly different.

3 Results and Discussion

3.1 Characterization of Soil Profile

The soil of the field was derived from weathering products of granite which are imperfectly drained and belongs to *Pusiga* association. The soil series was *Tanchera* which belongs to Ferric Lixisol (FAO, 2006).

3.2 Initial Soil Chemical Properties

pH of the soil was acidic, organic carbon and organic matter were generally very low. Total nitrogen and available P were also low (Table 1). Results of the chemical analysis confirm findings of *Adu* and *Asiamah* (2003).

Table 1. Chemical properties of *Tanchera* series (Ferric lixisol, FAO 2006) at Navrongo

Parameter	Layer (cm)					
	0-20			20-40		
	2010	2011	Average	2010	2011	Average
pH 1:1 H_2O	5.15	5.64	5.40	5.30	5.33	5.32
Org. C (%)	0.28	0.26	0.27	0.15	0.17	0.16
Org. M (%)	0.48	0.45	0.47	0.26	0.29	0.28
Total N (%)	0.04	0.05	0.05	0.03	0.01	0.02
Av. P (mg/kg)	7.46	7.95	7.71	3.19	3.17	3.18
Exch. K (mg/kg)	54.56	41.70	48.13	58.59	59.61	59.10
Ca (mg/kg)	0.47	2.10	1.29	1.6	1.45	1.53
Mg (mg/kg)	0.34	0.30	0.32	0.94	0.50	0.72

Note. Org. C = Organic Carbon; Org. M = Organic Matter; Total N = Total Nitrogen; Av. P = Available Phousphorus; Exch. K = Exchangeable Potassium; Ca = Calcium; Mg = Magnessium.

3.3 Grain Yield

Grain yield was significantly affected by N rates at a probability level of 0.01 (Figure 1a). Grain yield showed linear response to N fertilizer rates and by contrast, application of N at 120 kg/ha recorded the highest grain yield (Table 3). P and K did not affect grain yield (Figures 1b and 1c, respectively). However, due poor nature of soil application of P and K up to 45 kg/ha may be recommended.

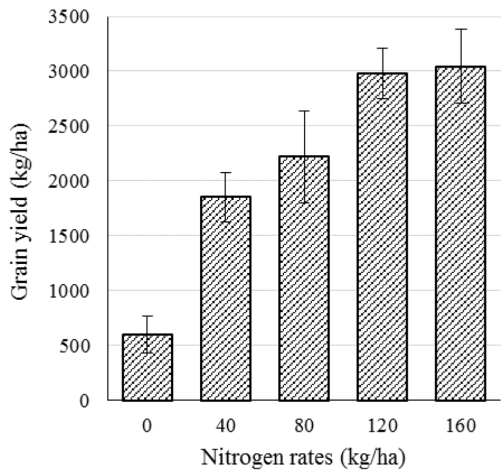

Figure 1a. N rates effect on maize grain yield at Navrongo

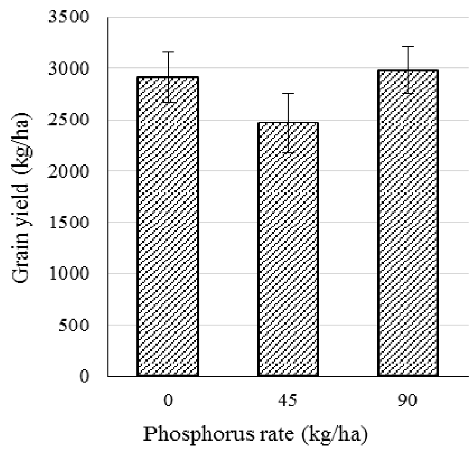

Figure 1b. P rates effect on maize grain yield at Navrongo

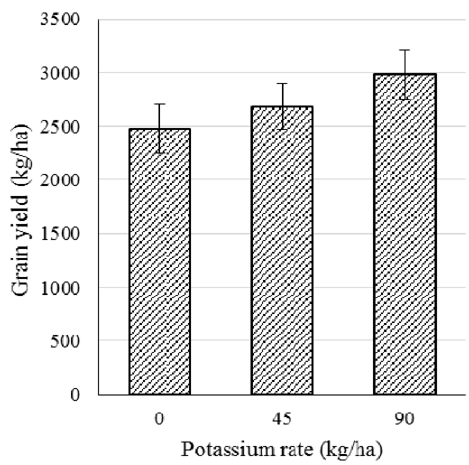

Figure 1c. K rates effect on maize grain yield at Navrongo

3.4 Benefit Cost Ratio

N rates affected benefit cost ratio at a probability level of 0.01 but P and K rates did not affect benefit cost ratio (Table 2). Benefit cost ratio showed both linear and quadratic response to N fertilizer rates and by contrast, application of N at 80 kg/ha recorded better benefit cost ratio (Table 3).

Table 2. NPK rates effect on benefit cost ratio and gross return

NPK rate (kg/ha)	Benefit cost ratio	Gross return ($/ha)
N rate		
0	0.5	-128.7
40	1.3	90.8
80	1.5	156.2
120	1.9	291.9
160	1.8	281.4
s.e	0.18	215.55
P-Value	<.0001	<.0001
P rate		
0	2.3	340.8
45	1.7	215.4
90	1.9	291.9
s.e	0.18	204.68
P-Value	ns	ns
P rate		
0	1.8	233.0
45	1.8	253.1
90	1.9	291.9
s.e	0.13	150.67
P-Value	ns	ns

Note. ns = not significant, April 2015 US$ to GHS rate was used in gross return calculation.

3.5 Gross Return

Gross return was significantly affected by N rates at a probability level of 0.01. P and K rates did not affect gross return (Table 2). Gross return per hectare showed linear response to N fertilizer rate and by contrast, application of N at 80 kg/ha recorded better gross return per hectare (Table 3).

Table 3. Contrast analysis estimates of N rates on maize grain yield, benefit cost ratio and gross return at Navrongo

N rate (kg/ha)	Grain yield (kg/ha)	Benefit cost ratio	Gross return ($/ha)
0 vs others	3847.03**	2.24**	667.53**
40 vs above	1344.20**	0.62*	228.52*
80 vs above	792.27*	0.32^{ns}	130.48^{ns}
120 vs 160	32.56^{ns}	0.04^{ns}	5.25^{ns}
N level- linear	**	**	**
N level- quadratic	ns	*	ns

Note. ns = not significant, * = significant at 5% and ** = significant at 1%.

4 Conclusions

N rates affected grain yield, benefit cost ratio and gross return. Application 80-120 kg/ha N may be recommended for improved and profitable production of maize on Ferric lixisol in Sudan savanna agro-ecological zone of Ghana. However, P and K did not show significant effect among grain yield, benefit cost ratio and gross return. Application of P and K up to 45 kg/ha may be recommended for maize production due to poor nature of soils.

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