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YIELD AND YIELD ATTRIBUTES OF EXTRA-EARLY MAIZE (*Zea mays* L.) AS AFFECTED BY RATES OF NPK FERTILIZER SUCCEEDING CHILLI PEPPER (*Capsicum frutescens*) SUPPLIED WITH DIFFERENT RATES SHEEP MANURE

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ABSTRACT

Field experiment was conducted in 2005 and 2006 to study response of extra-early maize variety to rates of NPK and residual FYM applied to chilli pepper the previous season) in the semi-arid zone of Nigeria. Higher values for soil physical and chemical properties were obtained in plots supplied with manure the previous season with soil from 2006 experiment more fertile than for the first year, hence produced 21% more grain yield. All the applied NPK rates in 2005 and except 40:20:20 ha^{1} in 2006 had resulted in early maize crop as compared to control. Husked and de-husked cob and 100-grain weights and grain yield ha^{-1} were higher at 120:60:60 kg NPK ha^{-1}. Maize grown in plot supplied with 15 t FYM ha^{-1} the previous year matured earlier. Cobs and 100-grain weights and grain yield were highest in plot supplied with 10 t FYM ha^{-1}. The 10 t FYM ha^{-1} had 69% and 68% more grain yield than the control in 2005 and 2006, respectively. Highest maize yield was obtained at 120:60:60 kg NPK ha^{-1} or 10t FYM ha^{-1}. All the parameters measured significantly and positively related to each other when the two years data were combined.

Keywords: grain yield, maize, NPK, residual FYM, yield attributes

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop in the world after rice and wheat. Nigeria produced about 6.4m metric tones from 3.91 million hectares with average yield 1.7 t ha^{-1} (FAO, 2008). The climate in Nigeria is favourable for maize production and gradual shift in production from southern to northern part of the country where an increasing trend in the crops' potential is being observed.

The crop is gradually replacing sorghum and millet in the semi-arid zone of Nigeria as major staple crop, particularly with the introduction of early and extra early drought and *Striga* resistant varieties. Crop production per unit area in the dry savanna zones of West Africa is in the decline due to declining soil fertility emanating from intensive cultivation and poor nutrient status of the soils. The worsening economic conditions, high cost and general lack of availability of quality fertilizer has made the use of fertilizers (both organic and inorganic) and adherence to recommended practice almost difficult for many of the farmers. The recommended fertilizer rate for extra-early maize variety with yield potential of 3t ha^{-1} is 100:50:50 kg of $N:P_2O_5:K_2O$ ha^{-1} using recommended plant population of 53,300. The combined use of both organic and inorganic form of fertilizers has been reported beneficial for crop yield and soil improvement as well as in sustaining productivity for long time (Negassa *et al.,* 2001; FAO, 2005; Akande *et al.,* 2006; FAO, 2006). Both the organic and inorganic form of fertilizers was reported to produce significant effect on subsequent maize crop as well as reduce the amount of inorganic fertilizer required by subsequent crop (Negassa *et al.,* 2001; Rutunga and Neel, 2006). Efficient fertilizer use means matching the supply of nutrients to those of crops need. Nutrient supply of crop is affected by fertilizer applied to previous crop (FAO, 2007). Therefore, any sustainable technology that can help reduced the use of the scarce and unaffordable mineral fertilizer without necessarily reducing yield could go a long way in solving

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some of the hardship faced by small-scale farmers in the dry savannas of Nigeria. In the light of the above field experiments were conducted in 2005 and 2006 to study the residual effect of application of sheep manure (FYM) on pepper to extra-early maize variety with different rate of current season applied NPK fertilizer.

MATERIALS AND METHODS

Field experiments were conducted during the rainy seasons of 2005 and 2006 at the research farm of Institute for Agricultural Research (IAR), Ahmadu Bello University, Samaru (11^{o} 11'N, 07^{o} 38'E, 686 m above sea level), Zaria, Nigeria to evaluate the response of extra-early maize variety to residual farmyard manure and current season applied NPK fertilizer. The experiments followed another one conducted in 2004 and 2005 to study the response of chilli pepper to four rates of FYM (0, 5, 10 and 15 t ha^{-1}). The treatments consisted of four rates each of NPK (0:0:0, 40:20:20, 80:40:40 and 120:60:60 kg ha^{-1}) and previous year applied FYM (0, 5, 10 and 15 t ha^{-1}). The experimental design was randomized complete block design with split plot arrangement and replicated three times. The previous manure rates were the main lot while the NPK rates were randomly allocated as subplot within the main plots in each of the three replicate. The gross and net plot sizes were 9 m^2 and 3 m^2, respectively. Different location was used for each of the seasons. Information from IAR meteorological data station revealed that a total of 527 mm and 757 mm rainfall were received during the growing periods in 2005 and 2006 season respectively. Temperature varied from 18 to 33^{o}C for the two seasons

Random soil samples as per manure treatment were collected at 30 cm depth in each of the season and like treatment bulked, oven-dried and in each of the season analysed for physical and chemical properties. An extra-early maize variety 95TZEE Y_1 sourced from IAR seed unit was used. It is an extra-early maturing variety that matures in 75 days, resistant to foliar diseases and therefore suitable to low rainfall areas of the Sudan savanna zones. The variety has white flint and is open pollinated. The land was sprayed with 2 l ha^{-1} of glyphosate (360 Isopropyl amine salt) herbicide which controlled weeds. Two weeks later, the plot was disc harrowed and ridged at 75cm between ridges. Three maize seeds were sown per hill spaced 25cm between stand later thinned to 2 plants per stand at two weeks after sowing (WAS) giving plant population of approximately 106, 600 plants ha^{-1}. The experiment was established on July 17^{th} of each of the season. NPK fertilizer 20-10-10 was used and applied in two equal split doses at 1 and 4 weeks after sowing (WAS). Weeds were controlled through manual weeding at 3 WAS and during earth-up at 5 WAS.

Crop data collected include: days to 50% maturity, husked and dehusked weight per cob (g) and maize grain yield (t ha^{-1}). The data collected were subjected to statistical analysis using SAS model and the means separated using New Duncan's multiple range test (Duncan, 1955). The strength of relationships between parameters measure were also determined using correlation analysis procedure as described by Little and Hills (1978).

RESULTS AND DISCUSSION

RESULTS

Laboratory result of the soil analysis has shown the unfertilized plots to be generally low in nutrient with values generally higher in 2006 (Table 1). Values were mostly higher in the second season. Nutrients values were higher in the fertilized plots than the unfertilized plots with values increasing with increasing manure rate. The soils in the unfertilized plots were generally strongly acidic while those in the fertilized plots vary between strongly acidic to slightly acidic. The CEC values were low with values ranging between 9.6 meq $100g^{-1}$ in 2006 and 11.4 meq $100g^{-1}$ in 2005.

Table 1. The 2005 and 2006 soil physical and chemical properties for plots supplied with various FYM rates the previous season

	Rates of FYM applied							
	0		5		10		15	
	2005	2006	2005	2006	2005	2006	2005	2006
Soil Chemical Properties								
pH in water	4.95	4.70	5.69	4.69	5.94	4.91	6.43	6.11
Organic C(gkg^{-1})	5.17	6.40	21.39	7.80	22.08	8.50	28.29	11.14
Nitrogen (gkg^{-1})	0.70	1.40	1.70	1.40	1.70	1.70	1.50	1.40
Phosphorus (meqkg^{-1})	12.47	15.75	17.81	31.50	23.17	35.00	37.41	70.00
Potassium (meq100g^{-1})	0.49	1.11	0.59	1.46	0.49	2.61	0.49	2.99
Sodium (meq100g^{-1})	1.70	4.37						
Calcium (meq100g^{-1})	5.90	0.06						
Magnesium (meq100g^{-1})	0.32	0.54						
CEC (meq100g^{-1})	11.40	9.60						
Soil Physical Properties								
Clay	24	18						
Silt	60	38						
Sand	16	44						
Textural class	Silt loam	Loam						

Table 2. Days to 50% maturity of maize as influenced by rates of NPK and previous season applied FYM at Samaru during 2005 and 2006 rainy season and the combined

Treatment	Days to maturity (days)		
	2005	2006	Combined
Rate of NPK (kg ha^{-1})			
0	73.0a	82.2c	77.6b
40:20:20	70.3b	84.1bc	77.2b
80:40:40	70.3b	86.2ab	78.3b
120:60:60	71.4b	88.0a	79.7a
SE$\pm$	0.49	0.82	0.48
Rate of FYM (t ha^{-1}) applied the previous season			
0	72.1a	85.8	79.0
5	71.6ab	84.7	78.1
10	70.8ab	85.0	77.9
15	70.5b	84.9	77.7
SE$\pm$	0.49	0.82	0.48
Interaction			
NPK x FYM	NS	NS	NS

Remarks: Means followed by the same letter(s) within a treatment column are statistically similar (p = 0.05). NS = Not significant

The effect of rates of NPK and previous year applied FYM on days to 50% maturity and weight per husked and de-husked cob is presented in Table 2. Maize crop without NPK fertilization in 2005 and those that received highest dose of 120:60:60 in 2006 and the combined matured later than those at other NPK rates. The effect of previous year applied FYM on maize maturity period was significant only in 2005 when maize grown in plot supplied with 15 t FYM ha^{-1} the previous year matured much earlier only than those without manure.

Increasing NPK rate from 0 to 40:20:20 significantly did not affect husked cob weight in both seasons but further increase to 80:40:40 kg/ha had increased weight per husked cob (Table 3). Further increase to 120:60:60 improved the parameter significantly only in 2006 and the combined. Maize grown in plots supplied with 10 t FYM ha^{-1} the previous year had heavier husked cobs than for the control plots in both seasons and other rates in 2006 and the combined. The highest FYM rate of 15t ha^{-1} had further enhanced the parameter significantly when the two years data were combined.

Table 4 shows the significant response of 100-grain weight and grain yield per hectare to rates of current season applied NPK fertilizer and previous season applied FYM. Increasing NPK rate from 0:0:0 to 40:20:20 and further to 80:40:40 kg ha^{-1} increased 100-grain weight. The parameter remained significantly unaffected when the NPK rate was further raised to 120:60:60 kg ha^{-1}. The effect of previous year applied FYM on 100-grain weight was significant in 2006 and the combined, when the applied FYM treatments recorded statistically similar but heavier 100-grain than the control.

Each increase in NPK rate from 0:0:0 to 40:20:20 and further to 80:40:40 and 120:60:60 kg NPK ha^{-1} resulted in corresponding increase in grain yield/ha. Residual effect of 15 t ha^{-1} of FYM had higher grain yield than for the control in the two seasons and the combined as well as only more than that from 5 t FYM ha^{-1} in 2006. None of the interaction of factors on any of the parameter measure was significant.

Table 5 shows the relationships that exist between yield and yield attributes of maize during the 2005 and 2006 wet seasons and the combined. In both seasons and the combined the yield positively and significantly related with all except days to maturity (r=-0.2515) in 2005 in which the relationship was observed to be negatively insignificant. Likewise, the correlation among the rest of other parameters during the two seasons and the combined was also positive and significant except that between days to maturity and de-husked cob weight in 2006 which was positive and non significant on one hand and that between maturity and all other parameters that were negatively insignificant in 2005 on the other; the correlation between maturity period and husked cob weight (r=-0.3576*) though negative was significant. The strongest relationship was generally observed between husked and de-husked cob weight.

Table 3. Weights per husked and dehusked cob of maize as influenced by rates of NPK and previous season applied FYM at Samaru during 2005 and 2006 rainy season and the combined

	Weight per husked cob (g)			**Weight per dehusked cob (g)**		
Treatment	**2005**	**2006**	**Combined**	**2005**	**2006**	**Combined**
Rate of NPK (kg ha^{-1})						
0	79.3c	192.4c	135.8d	153.1c	165.0b	101.3d
40:20:20	131.0b	220.6c	175.8c	175.0c	180.0b	130.3c
80:40:40	158.1a	269.5b	213.8b	229.5a	229.5a	169.0b
120:60:60	171.8a	331.9a	251.9a	261.0a	261.0a	190.7a
SE±	8.98	10.23	8.33	10.82	14.03	6.46
Rate of FYM (t ha^{-1}) applied the previous season						
0	115.1b	206.0c	160.6d	164.9b	164.7b	120.9c
5	131.6ab	239.0b	185.3c	194.6b	196.6ab	142.3b
10	154.0a	298.7a	205.0b	231.9a	239.6a	169.0a
15	139.5ab	270.5a	226.4a	227.2a	234.7a	159.0ab
SE±	8.98	10.23	8.33	10.82	14.03	6.46
Interaction						
NPK x FYM	NS	NS		NS	NS	

Remarks: Means followed by the same letter(s) within a treatment column are statistically similar (p = 0.05). NS = Not significant

Table 4. 100-grain weight (g) and grain yield of maize as influenced by rates of NPK and previous season applied FYM at Samaru during 2005 and 2006 rainy season and the combined

Treatment	100-grain weight (g)			Maize grain yield (t ha^{-1})		
	2005	**2006**	**Combined**	**2005**	**2006**	**Combined**
Rate of NPK (kg ha^{-1})						
0	16.7c	20.3c	18.0c	2.73d	6.53d	4.63d
40:20:20	18.5b	22.8b	20.6b	4.83c	8.08c	6.45c
80:40:40	21.0a	25.3a	23.2a	6.53b	10.85b	8.70b
120:60:60	21.7a	26.4a	24.1a	7.76a	12.59a	10.17a
SE±	0.48	0.43	0.32	0.32	0.33	0.23
Rate of FYM (t ha^{-1}) applied the previous season						
0	18.6	21.8b	20.2b	4.78b	8.0c	6.39c
5	19.7	23.8a	21.8a	5.65ab	9.20b	7.43b
10	19.3	24.3a	21.8a	5.61ab	10.40a	8.00ab
15	19.2	24.9a	22.1a	5.82a	10.50a	8.14a
SE±	0.48	0.43	0.32	0.32	0.33	0.23
Interaction						
NPK x FYM	NS	NS		NS	NS	

Remarks: Means followed by the same letter(s) within a treatment column are statistically similar (p = 0.05). NS = Not significant

Table 5. Relationships between maize grain yield and other yield parameters at Samaru during the 2005 and 2006 wet seasons and the combined

Characters	1	2	3	4	5
			2005		
1. Grain yield	1.0000				
2. 100-grain weight	0.8095**	1.0000			
3. Husked cob weight	0.6568**	0.6653**	1.0000		
4. De-husked cob weight	0.6642**	0.6448**	0.8856**	1.0000	
5. Days to maturity	-0.2515	-0.2268	0.3576*	-0.2588	1.0000
			2006		
1. Grain yield	1.0000				
2. 100-grain weight	0.8667**	1.0000			
3. Husked cob weight	0.8862**	0.8105**	1.0000		
4. De-husked cob weight	0.8388**	0.8074**	0.8899**	1.0000	
5. Days to maturity	0.4674*	0.4095**	0.3927**	0.2592	1.0000
			Combined		
1. Grain yield	1.0000				
2. 100-grain weight	0.9171**	1.0000			
3. Husked cob weight	0.8803**	0.8484**	1.0000		
4. De-husked cob weight	0.8737**	0.8454**	0.9449**	1.0000	
5. Days to maturity	0.6290**	0.5926**	0.6723**	0.7016**	1.0000

Remarks: * & ** = Significant at 5 and 1 % level of significance

DISCUSSION

The low fertility status of the unfertilized plots could be as a result of long history of intensive cultivation of the experimental site as well as poor nutrient status of the savanna soils. The lower nutrient values recorded by soil on which the 2005 experiment was conducted as compared to that of 2006 could be as a result of the incidence of bush fire that occurred just before the cropping season of 2005. High temperature as a result of heat from fire and high temperature usually experienced in the months of February through May might have enhanced the rate of mineralization and volatilization of some of the nutrients particularly N.

The general low nutrient and CEC of the soils was attributed to fact that the savanna soil originated from old parent material deficient in nutrient-bearing minerals. Other factors contributing to low fertility of savanna soils include incessant nutrient mining, erosion desertification and bush burning among other things (Enwezor *et al.,* 1988; Chude, 1998; Dudal, 2002). The increase in soil nutrients values with increase in manure rate is expected as higher dose of manure is expected to carry more nutrients. The improvement in pH in the fertilized plots could be as a result of the positive role played by organic manure in improving soil physical and chemical properties (Negassa *et al.,* 2001).

Application of higher dose of NPK had resulted in late crop. This could have been due to positive role of the higher dose in supplying most of the major nutrients; thereby leading to robust and longer crop development period due to continuous supply of the essential nutrients. Mani *et al.* (2004) had earlier observed and reported early maize crop from high dose of NPK. The increase recorded in terms of yield and yield attributes as a result of the application of NPK fertilizer could be attributed to the positive role play by NPK fertilizer in supplying the crop with major nutrients (N, P and K) in reasonable quantity. Optimum yield was achieved at 120:60:60 kg NPK ha^{-1} which produced more yield than the control when the two years data were combined. Mani *et al.* (2004) and Jaliya *et al.* (2006a and 2006b) have also reported significant yield increase as a result of application of NPK fertilizer on maize crop. The continuous yield increase up to the highest NPK rate indicates that crop requirement for this important yield enhancing factor is yet to be achieved.

The significant response of maize yield and yield attributes to residual FYM is expected considering the positive role play by FYM in enhancing the soil nutrient, raising soil pH and improving water holding capacity and structure of the soil. The role of soil organic matter in the retention of soil nutrients could be another reason for the positive effect of the residual FYM on improving maize productivity (Negassa *et al.,* 2001: FAO, 2005: FAO, 2006).

Most of the yield parameters were optimized in plot that received 10 t FYM ha^{1} the previous season even though the values so obtained did not differ significantly from that of plots with 5 t FYM ha^{1}. The grain yield however was generally highest at 10t FYM ha^{1}. Maize grown in plot supplied with 15 t FYM ha^{1} the previous season had approximately 27% more yield than the control when combined. This further stressed the importance and potentials of FYM or organics in enhancing crop yields and land productivity as earlier observed and reported by Negassa *et al.* (2001) and Babaji *et al.* (2010). Other researchers such as Rutunga and Neel (2006) have also reported long –term beneficial effect of organics in raising the levels of organic matter in the soil and further concluded that the benefit can remain up to four years.

The narrowing of percent yield difference between the plot with optimum yield from 120% for NPK to 27% for FYM further indicates the importance of the former in readily making available the required nutrients. FYM are believed to release nutrients for use in small amount for a longer period. Likewise the influence of higher temperatures in faster minerilisation and volatilization as well as amount taken up by the previous crop (chilly pepper) might have contributed in more significant way in narrowing the yield gap between the control and the applied. The production 4.6t grain yield by no-NPK and 6.39 by no-FYM further explained the role each of the fertilizer source played in enhancing maize yield.

The introduction of residual FYM in the experiment had made it possible for the production of maize at population twice the recommended rate. From the result of this studied it was clear that grain yield more than double the crop potential yield of 3 t ha^{1} when either NPK fertilizer or residual FYM is used using twice the recommended plant population. This further indicates that with adequate organic matter in the soil doubling maize population and yield is possible at moderate fertilizer rate. This in turn may lead to increase in the efficient use of scarce and costly mineral fertilizer.

The significant and positive correlation recorded between maize grain yield and other yield characters like 100-grain weight and husked and de-husked cob weights has indicated these parameters as important yield determinants in maize. There production of larger cobs with large grain size could definitely improve the final grain yield/ha. The result further revealed that delay in maturity could further enhance yield probably as a result of the positive role of leaf area duration and therefore prolong photosynthetic period.

It could be therefore concluded that application of 120:60:60 kg NPK ha1 or growing maize in plot previously supplied with 10 t FYM ha^{1} had the highest maize grain yield. Grain yield was more than double the crops' potential yield estimate at fertilizer rate 20% more than the recommended rate and using twice the recommended plant population half the one used in this experiment.

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