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EFFECTS OF DIFFERENT NITROGEN SOURCES AND VARYING ORGANIC FERTILIZER RATES ON THE PERFORMANCE OF MAIZE (*Zea mays l.*) IN EKITI STATE, SOUTHWESTERN NIGERIA

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ABSTRACT

A two – year field experiment was conducted at the Teaching and Research Farm of the University of Ado - Ekiti, Nigeria, during the 2006 and 2007 cropping seasons to appraise the influence of different N – sources, organic fertilizer rates, and the interactions between these two factors on growth and yield indices of maize (*Zea mays* L.). The design was a split – plot, laid out in a randomized complete block, with three replicates. N sources constituted the main – plot treatment, namely: control, urea, calcium ammonium nitrate (CAN), and NPK 15-15-15. Organic fertilizer rates constituted the sub – plot treatment, which were: 0 (control), 2, 4, 6, and 8 t ha^{-1}. The results indicated that there were significant differences ($p \leq 0.05$) between the treatments in growth and yield parameters of maize. The two – year average values indicated that N - sources significantly increased maize leaf area from 0.52 m^2/plant for control to 0.74, 0.91 and 1.04 m^2/plant for urea, CAN, and NPK, respectively. Similarly, organic fertilizer rates significantly increased maize leaf area from 0.48 m^2/plant for 0 (control) to 0.66, 0.79, 0.93 and 1.09 m^2/plant for 2, 4, 6, and 8t ha^{-1}, respectively. N – sources significantly increased maize grain yield from 1.94 t ha^{-1} for control to 3.78, 5.27, and 6.47 t ha^{-1} for urea, CAN and NPK, respectively. Similarly, increase in organic fertilizer rates resulted in a significant increase in maize grain yield from 1.67t ha^{-1} for 0 (control) to 2.03, 2.50, 3.06 and 3.72t ha^{-1} for 2, 4, 6, and 8t ha^{-1}, respectively. The interactions between N sources and organic fertilizer rates significantly increased growth and yield components of maize. The treatment combination of NPK fertilizer and 8 t ha^{-1} organic fertilizer resulted in the highest values of growth and yield components of maize in both years.

Keywords: Maize yield, N sources, organic fertilizer

INTRODUCTION

One of the major constraints to crop production in the tropics is the inherently low fertility status of most of the soils, characterized by low activity clay, low level of organic matter status, nitrogen, phosphorus and exchangeable cations (De Ridder and van Keulen, 1990; Gazel, 2005). In recent times, many soil – fertility maintenance techniques have been recommended, which included the adoption of an adequate fertilizer package, involving the use of organic and/or inorganic fertilizers (Tankou, 2004). However, the use of inorganic fertilizers in improving soil fertility has been reported to be ineffective due to certain limitations (Rodale, 1995). Some of these limitations include declined soil organic matter content, soil acidification as well as soil physical degradation, with resultant increased incidence of soil erosion (Avery, 1995). Consequent upon this, the use of organic manure has been recommended, especially for highly weathered tropical soils (Tankou, 2004; Gazel, 2005). However, the use of organic manure has the disadvantage of slow release and non – synchronization of nutrient release with the period of growth for most short – term arable crops like maize. In addition, organic manure is usually required in large quantities to sustain crop production (Nyathi and Campbell, 1995). These problems, notwithstanding, numerous agricultural researchers have recommended the use of either organic and/or inorganic fertilizers for improvement and maintenance of soil fertility in the tropics (Adebo, 2004; Usor, 2005; Bai, 2007).

In many parts of the world, some of the sources of nitrogen are Diammonium phosphate (DAP), Calcium ammonium nitrate (CAN), Sulphate of ammonia (SA) and compound fertilizers such as NPK 15-15-15, 20-20-20, etc (Kurtz, 2004; SAS, 2006). Other sources of N, such as urea, ammonium sulphate, ammonium nitrate and CAN are also used, depending on their local availability (Kurtz, 2004). Sulphate of ammonia, because of its residual acidity, has been discontinued, and therefore not recommended (Kurtz, 2004; SAS, 2006). The most widely used N source is CAN, due to its very low residual acidity, and calcium content which particularly, in the savanna areas helps to neutralize soil acidity (SAS, 2006). Significant responses of maize to different N – sources have been demonstrated by many studies (Risse, 2004; Powel, 2005; Kantey, 2007; Mehra, 2007). In all these studies, significant differences in growth and yield of maize among various N sources were reported.

In Southwestern Nigeria, many aspects of the nutrition of maize have been researched, with a view to raising the present level of maize yield on farmers' farms. However, very little work has been published on the influence of different N sources, organic fertilizer rates, and the interactions between these two treatments on growth and yield of maize. Thus, this paper reports a two – year trial, aimed at determining the influence of N – sources, organic fertilizer rates, and the interactions between these two factors on growth and yield of maize, with a view to coming up with the recommendation of appropriate N source and organic fertilizer rate for the cultivation of maize.

MATERIALS AND METHODS

Study site: The two - year experiment was conducted at the Teaching and Research Farm of the University of Ado - Ekiti, Nigeria, during the 2006 and 2007 cropping seasons. The soil of the study site belongs to the broad group Alfisols (SSS, 2002). The soil was strongly leached, with low to medium organic matter content, deep red clay profile, with top sandy loam texture, slightly acidic to neutral. The study site had earlier been cultivated with a variety of crops such as cassava, maize, sweet potato and melon, before it was left fallow for three years, prior to the commencement of this study. The fallow vegetation was manually slashed, residues were burnt, and the land was ploughed and harrowed.

Collection and analysis of soil samples: Prior to planting, ten core soil samples, randomly collected from 0-15 cm top-soil were mixed to form a composite sample, which was analysed for physical and chemical properties. The soil samples were air – dried, ground, and passed through a 2 mm sieve. The sieved samples were not necessary analysed. The pH was determined by glass electrode pH meter. Bray P – 1 extractant was used to extract available P, organic C and total N were determined by the Walkey – Black oxidation and Kjeldahl digestion techniques, respectively. Exchangeable bases – K, Ca, Mg and Na were extracted by neutral normal ammonium acetate. K, Ca, and Na were determined by flame photometry, while Mg was by Atomic Absorption Spectrophotometry. Effective cation exchange capacity was determined by summation method (i.e., sum of K, Ca, Mg, Na and exchangeable acidity). The determination of exchangeable acidity was by extraction – titration method described by Mclean (1965). Particle size distribution was done by the hydrometer method of soil mechanical analysis as outlined by Bouyoucos (1951).

Experimental design and treatments: The design was a split – plot, laid out in a randomized complete block, with three replications. N sources constituted the main – plot treatment, namely: control, urea, calcium ammonium nitrate (CAN), and NPK 15-15-15. Organic fertilizer rates were the sub – plot treatment, which included: 0 (control), 2, 4, 6, and 8 t ha^{-1}. N was applied at the rate of 150 kg N ha^{-1} (Fondufe, 1995), in two split doses, at three and six weeks after planting (WAP). The organic fertilizer was a mixture of 5 t ha^{-1} poultry droppings and 5 t ha^{-1} composted and sorted town refuse (Alabi, 2005). It was applied two weeks before planting, and worked into the soil with a hoe.

Planting, collection and analysis of data: In 2006 and 2007 cropping seasons, planting was done on April 8 and April 16, respectively. Seeds of Oba Super 1 maize variety, dressed with Apron Plus were planted on the flat at 100 cm x 50 cm (20,000 plants ha^{-1}). Three seeds were planted per stand, but later thinned to one seedling per stand. Data were collected from five randomly selected maize crops from two central rows of each plot, in accordance with information for maize trial management in IITA maize Research Programme Pamphlet on growth and yield parameters. Leaf area was determined by finding the product of the length and breadth of the leaf, and then multiplying by a factor of 0.75 (Saxena and Singh, 1965). Stem diameter (girth) was measured by using Venier calipers. Dry seed weight was measured on a metler weighing balance. Analysis of variance was carried out, and treatment means were compared, using the Duncan Multiple Range Test at 0.05 level of probability.

RESULTS

Table 1 shows the physical and chemical properties of soil of the study site before cropping. The soil was sandy loam in texture, with a pH of 5.3. The soil organic carbon and total nitrogen were 2.96 and 1.90 gkg^{-1}, respectively. The available P was 1.81 mgkg^{-1}. The exchangeable bases – K, Ca, Mg and Na were 0.24, 1.84, 1.58 and 0.19 cmolkg^{-1}, respectively. The exchangeable acidity and effective cation exchange capacity were 0.25 and 4.10 cmolkg^{-1}, respectively

Maize leaf area

Maize leaf area as affected by N sources and varying organic fertilizer rates is presented in Table 2. The two – year average values showed that N sources significantly increased maize leaf area from 0.52 m^2/plant for control to 0.74, 0.91 and 1.04 m^2/plant for urea, CAN, and NPK, respectively. Similarly, organic fertilizer rates significantly increased maize leaf area from 0.48 m^2/plant for control to 0.66, 0.79, 0.93 and 1.09 m^2/ plant for 2, 4, 6, and 8 t ha^{-1} respectively.

Table1: The physical and chemical properties of soil of the study site before cropping and the organic fertilizer used

Soil sample		Organic fertilizer	
Parameters	Values	Parameters	Values
pH	5.3	C (%)	12
Organic C (g kg^{-1})	2.96	N (%)	2.9
Total N (g kg^{-1})	1.90	P (%)	1.4
Available P (mg kg^{-1})	1.81	K (%)	0.8
Exchangeable K ($cmolkg^{-1}$)	0.24		
Exchangeable Ca ($cmolkg^{-1}$)	1.84		
Exchangeable Mg ($cmolkg^{-1}$)	1.58		
Exchangeable Na ($cmolkg^{-1}$)	0.19		
Exchangeable acidity ($cmolkg^{-1}$)	0.25		
ECEC ($cmolkg^{-1}$)	4.10		
Texture (g kg^{-1})			
Sand	650		
Silt	225		
Clay	125		

The interactions between N sources and organic fertilizer rates significantly increased maize leaf area.

Maize stem girth

Table 3 shows the effects of N sources and varying organic fertilizer rates on maize stem girth. The mean effects of N sources on maize stem girth were 1.84, 2.04, 2.27, and 2.53 cm for control, urea, CAN, and NPK, respectively. Organic fertilizer application resulted in a significant increase in maize stem girth from 1.77 cm for control to 2.01, 2.25, 2.50 and 2.64 cm for 2, 4, 6, and 8 t ha^{-1}, respectively. The interactions between N sources and organic fertilizer rates significantly increased maize stem girth

Grain yield, stover yield, and number of days to 50% flowering of maize: The effects of N sources and varying organic fertilizer rates on grain yield, stover yield, and number of days to 50% flowering of maize are presented in Table 4. N sources significantly increased maize grain yield from 1.94 t ha^{-1} for control to 3.78, 5.27 and 6.47 t ha^{-1} for urea, CAN, and NPK treatments respectively. Similarly, organic fertilizer application significantly increased maize grain yield from 1.67 t ha^{-1} for control to 2.03, 2.50, 3.06, and 3.72 t ha^{-1} for 2, 4, 6, and 8 t ha^{-1} respectively.

Table 2: Effects of different N – sources and varying organic fertilizer rates on maize leaf area

	3WAP		6WAP		9WAP		
Treatments	2006	2007	2006	2007	2006	2007	Mean
N sources							
control	0.22a	0.18a	0.58d	0.61d	0.75d	0.80d	0.52
Urea	0.21a	0.18a	0.71c	0.79c	1.25c	1.30c	0.74
CAN	0.19a	0.21a	0.86b	0.91b	1.60b	1.67b	0.91
NPK (15-15-15)	0.22a	0.22a	0.98a	1.04a	1.88a	1.91a	1.04
Organic fertilizer rates (t ha^{-1})							
0 (control)	0.19a	0.21a	0.48e	0.52e	0.72e	0.76e	0.48
2	0.21a	0.20a	0.59d	0.63d	1.15d	1.19d	0.66
4	0.20a	0.19a	0.66c	0.71c	1.49c	1.51c	0.79
6	0.19a	0.19a	0.79b	0.83b	1.76b	1.81b	0.93
8	0.22a	0.20a	0.96a	1.11a	1.99a	2.04a	1.09
N x O interaction LSD (0.05)	0.14s	0.16s	0.56s	0.60s	1.50s	1.46s	

Values followed by the same letter in the same column under each treatment are not significantly different at p=0.05.
WAP = Weeks After Planting, N = N sources, O = organic fertilizer, S = significant.

The mean effects of N sources on maize stover yield were 0.50, 1.68, 2.36 and 2.69 t ha^{-1} for control, urea, CAN and NPK, respectively. The mean effects of organic fertilizer application on maize stover yield were 0.42, 0.90, 1.29, 1.91 and 2.48 t ha^{-1} for control, 2, 4, 6 and 8 t ha^{-1}, respectively. N sources significantly decreased number of days to 50% flowering of maize from 75 days for control to 70, 70, and 65 days for urea, CAN and NPK, respectively. Similarly, number of days to 50% flowering was decreased by organic fertilizer application from 75 for control to 65, 65, and 65 days for 4, 6 and 8 t ha^{-1}, respectively. The interactions between N sources and organic fertilizer rates significantly increased grain yield, stover yield, and number of days to 50% flowering of maize.

DISCUSSION

The significantly higher values of growth and yield of maize for CAN than urea source of N agree with the findings of Risse (2004); Powell (2005); Kantey (2007); Mehra (2007),

Table 3: Effects of different N – sources and varying organic fertilizer rates on maize stem girth

	3 WAP		6WAP		9WAP		
Treatments	2006	2007	2006	2007	2006	2007	Mean
N sources							
control	1.14a	1.16a	1.77d	1.81d	2.54d	2.61d	1.84
Urea	1.12a	1.16a	1.99c	2.03c	2.96c	3.00c	2.04
CAN	1.12a	1.14a	2.27b	2.31b	3.36b	3.40b	2.27
NPK (15-15-15)	1.14a	1.12a	2.56a	2.61a	3.85a	3.90a	2.53
Organic fertilizer rates (t ha^{-1})							
0 (control)	1.11a	1.14a	1.66e	1.70e	2.48e	2.51e	1.77
2	1.13a	1.12a	1.89d	1.92d	2.96d	3.02d	2.01
4	1.14a	1.11a	2.21c	2.28c	3.34c	3.41c	2.25
6	1.12a	1.12a	2.46b	2.50b	3.88b	3.94b	2.50
8	1.12a	1.13a	2.94a	2.06a	4.26a	4.30a	2.64
N x O interactions LSD (0.05)	1.04s	1.01s	1.71s	1.63s	2.57s	2.60s	

Values followed by the same letter in the same column under each treatment are not significantly different at p=0.05.
WAP = Weeks After Planting, N = N sources, O = organic fertilizer, S = significant.

who noted a significant difference in growth and yield components of maize between CAN and urea sources of N. This observation points to the superiority of CAN to urea as far as growth and yield of maize are concerned. The superiority emanates from the ability of CAN to supply N in the forms of NH_4^+ and NO_3^-, compared to urea that can only supply N in form of NH^{+4}. Thus, the presence of NH_4^+ and NO_3^- in CAN accounts for the better performance of maize for CAN than urea (Osaki *et al*., 1995; Powell, 2005; Mehra, 2007). Besides, CAN has calcium ions (Ca^{2+}) which are extremely important elements in the maintenance of cell membrane integrity, and cell division, hence, stimulating growth and development of plants. Also, the calcium element (an exchangeable base) helps in the neutralization of soil acidity, thereby enhancing the availability of certain nutrients in the soil (Risse, 2004; Kantey, 2007; Mehra, 2007). Much as the significant difference in growth and yield of maize between CAN and urea can be ascribed to the afore – mentioned factors, however, another factor that can be implicated for the significant difference between CAN and urea in growth and yield of maize is the loss of N in the form of ammonia gas in urea, as urea is very susceptible to volatilization, unlike CAN (Powell, 2005; Kantey, 2007). Although, there may also have been loss of N through NH_3 volatilization in CAN as in urea, as CAN is equally an ammonium (NH^+_4) – containing fertilizer, only

Table 4: Effects of different N – sources and varying organic fertilizer rates on grain yield, fresh stover yield, and number of days to 50% tasselling of maize

Treatments	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean
N sources									
control	1.88d	2.00d	1.94	0.47d	0.53d	0.50	75a	74a	75
urea	3.72c	3.83c	3.78	1.66c	1.70c	1.68	70b	70b	70
CAN	5.20b	5.33b	5.27	2.31b	2.40b	2.36	70b	70b	70
NPK (15-15-15)	6.41a	6.52a	6.47	2.66a	2.71a	2.69	65c	65c	65
Organic fertilizer (t ha^{-1})									
0 (control)	1.61e	1.72e	1.67	0.39e	0.44e	0.42	75a	75a	75
2	1.99d	2.06d	2.03	0.86d	0.94d	0.90	75a	75a	75
4	2.49c	2.51c	2.50	1.27c	1.30c	1.29	65b	64b	65
6	3.01b	3.10b	3.06	1.88b	1.94b	1.91	65b	65b	65
8	3.69a	3.74a	3.72	2.44a	2.51a	2.48	65b	65b	65
N x O interaction LSD (0.05)	1.71s	1.80s		1.63s	1.55s		40s	40s	

half of the N is in the NH_4^+ form, and half in the NO_4^- form. Hence, only half of the applied N (i.e. NH_4^+ form) is susceptible to NH_3 volatilisation, which is a distinct advantage of CAN over urea (Powell, 2005; Mehra, 2007). It follows therefore, that the magnitude of N lost through NH_3 volatilization, among other factors, depends on the type of N – fertilizer(s) concerned, especially in terms of composition, properties and form of N (Risse, 2004).

The percentage of N in CAN is 26, which is lower than that of N in urea (46). Nevertheless, CAN proved superior to urea according to the findings of this study. This suggests that the degree of effectiveness of N – fertilizers in supporting high crop yields does not only depend on the concentration of N therein, but on other qualities of the N – fertilizer (Powell, 2005, Kantey, 2007). The highest values of growth and yield of maize associated with NPK – N source also agreed with the findings of Risse (2004); Kantey (2007). This observation testifies to the superiority of NPK, as an N source to other N sources appraised in this study. The superiority can be ascribed to the complementary roles of P and K in the nutrition of maize. This means that neither the addition of a P – nor K – fertilizer alone is sufficient for satisfactory growth and yield of maize. Thus, the recommendation of an appropriate N source, which involves a judicious and balanced combination of these nutrient elements (N, P and K) for maize cultivation is imperative (Kantey, 2007; Mehra, 2007).

The significant increases in growth and yield indices of maize that attended increasing organic fertilizer rates agree with the findings of Kurtz (2004); Orallo (2006); Turkey (2007), who reported increased growth and grain yield of maize with increasing rates of organic manure. These observations can be attributed to the long – term desirable effects of organic fertilizers on improving both the physical, chemical, and biological properties of the soil with resultant provision of suitable soil conditions for crops (Orallo, 2006; Bai, 2007).

Research has established that organic fertilizers act as a store – house of plant nutrients, as a major contributor to cation exchange capacity, and as a buffering agent against pH fluctuation (Adebo, 2004; Usor, 2005; Gazel, 2005; Orallo, 2006; Turkey, 2007; Bai, 2007). The significant interactions between N sources and organic fertilizer imply that the magnitude of the difference in growth and yield of maize among various N sources was affected by organic fertilizer.

CONCLUSION

Growth and yield of maize in the current study were mostly affected by the application of NPK and increasing doses of organic fertilizer.

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