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EFFECTS OF PLANT RESIDUE AND UREA FERTILIZER APPLICATION ON THE PERFORMANCE OF MAIZE (*ZEA MAYS L.)* IN 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 2006 and 2007 cropping seasons to evaluate the effects of plant residue and urea fertilizer application on growth and yield of maize (*Zea mays* L.). The experiment was laid out in a randomized complete block design, with three replications. The treatments included: control i.e. no plant residue addition, no fertilizer application (-PR-F), plant residue with no fertilizer addition (PR), fertilizer application with no plant residue addition (F) and plant residue plus fertilizer application (PR + F). The results obtained indicated that there were significant differences ($P \leq 0.05$) among the various treatments in growth and yield of maize. The two – year average values indicated that plant residue, urea fertilizer and their combination significantly increased maize leaf area from 0.52 m^2/plant for –PR-F to 0.67, 0.80 and 0.91 m^2/plant for PR, F, and PR+F, respectively. Similarly, plant residue, urea fertilizer and their combination significantly increased maize grain yield from 1.97 t ha^{-1} for –PR-F to 3.71, 4.62 and 5.90 t ha^{-1} for PR, F, and PR+F, respectively.

Keywords: Fertilizer, maize, plant residue.

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 bases (de Ridder and van Keulen, 1990; Gazel, 2005). The problem of inherently low fertility status of most tropical soils has necessitated growing search for many soil fertility improvement techniques, such as adoption of appropriate and adequate fertilizer packages, involving the use of organic and / or inorganic fertilizers (Tankou, 2004). Although, the use of inorganic fertilizers in improving soil fertility has been reported to be ineffective due to certain limitations, such as declined soil organic matter contents, soil acidification, as well as degradation of certain soil physical properties with resultant increased incidence of soil erosion (Avery, 1995; Rodale, 1995). Consequent upon this, the use of organic manure has been recommended, especially for highly weathered tropical soils (Tankou, 2004). However, the use of organic fertilizers in improving soil fertility has certain demerits of slow release and non – synchronization of nutrient release with critical period of growth of short – term arable crops (Nyathi and Campbell, 1995). These problems, notwithstanding, many agricultural researchers (Adebo, 2004; Usor, 2005; Bai, 2007) have recommended the use of either organic and / or inorganic fertilizers for soil fertility improvement.

Plant residues and other biomass constitute an important resource, as they have a potential of maintaining soil fertility (Ojeniyi and Falade, 1997; Awodun and Ojeniyi, 1999; Aribe, 2003; Ray, 2007). Residue management, quantity and quality of biomass applied to the soil, has a significant impact on soil quality and resilience and agronomic productivity (Aribe, 2003; Ray, 2007). Singh (2005) noted that the amount of N, P and K nutrients contained in crop residues is 60 times as large as the nutrients applied through fertilizers. Some studies (Ojeniyi and Falade, 1997; Awodun and Ojeniyi, 1999; Aribe, 2003; Ray, 2007) have demonstrated significant effects of incorporated plant residues, such as the residues of *Gliricidia sepium*, *Chromolaena odorata*, *Leucaena leucocephala*, *Panicum maximum* and *Pennisetum purpureum* on the improvement of soil physical, chemical and biological properties, as well as crop yields.

Ojeniyi and Awodun (1993); Ojeniyi and Falade (1997); Awodun and Ojeniyi (1999); Aribe (2003) and Ray (2007) reported that residues of *Gliricidia sepium* and *Chromolaena odorata* increased the organic carbon, total nitrogen, potassium, available phosphorus content of the soil, as well as the yields of crops. The beneficial effects of the use of plant residues on crop performance emanate from the prevention of Aluminium toxicity due to increased soil pH and base saturation (Pichot *et al*., 1981; Bationo *et al.*, 1987), as well as being a source of trace elements which are absent in traditional NPK fertilizers (Poulain, 1980).

Maize (*Zea mays* L.) requires relatively high soil fertility, particularly nitrogen, phosphorus and potassium for high yields (Aitu, 2004; Caitt, 2005; Veen, 2007). Significant responses of maize to nitrogen – fertilizers have been demonstrated by many studies (Osundare, 2001; Aitu, 2004; Caitt, 2005; Veen, 2007). In all these studies, significant increases in growth and yield components of maize due to nitrogen application were reported. However, too liberal application of N to maize, results in excessive vegetative growth and increased lodging (Caitt, 2005; Veen, 2007). Been *et al.* (2006), however, noted that the degree of responsiveness of maize to applied N, depends on the nature of the preceding crop (s). They concluded that where maize is preceded by soybeans, the latter is likely to have contributed about 30 – 50 kg N ha^{-1} to maize crops.

In view of increasing wave of scarcity and high cost of synthetic fertilizers in Nigeria, following changes in Government policies on subsidy, procurement and distribution of inorganic fertilizers, consequently, resource – poor farmers can no longer afford their use to maintain soil fertility. Therefore, the evaluation of suitability of certain organic wastes in maintaining and improving soil fertility and crop productivity is imperative. Thus, this study was undertaken with a view to appraising effects of plant residues combined with urea fertilizer on the performance of maize.

MATERIALS AND METHODS

Study site

The two – year field experiment was carried out at the Teaching and Research Farm of the University of Ado - Ekiti, Nigeria, during 2006 and 2007 cropping seasons. The soil of the study site belongs to the broad group alfisols. The soil is well drained, with an appreciable amount of quartz stones and gravels. The study site had earlier been cultivated to a variety of arable crops, such as yam, cassava, maize, sweet potato, melon etc before it was left to fallow for three years before 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 analyzed for physical and chemical properties. The composite sample was air-dried, ground, and passed through a 2 mm sieve. The sieved sample was then 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 Walkey – Black oxidation and Kjeldahl digestion techniques, respectively. Exchangeable 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 the Atomic Absorption Spectrophotometry. Effective Cation Exchange Capacity was obtained 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 experiment was laid out in a randomised complete block, with three replications. The treatments included: control i.e. no plant residue addition, no fertilizer application (-PR-F); plant residue with no fertilizer addition (PR); no plant residue plus fertilizer addition (F); and plant residue plus fertilizer addition (PR + F). The gross plot size was 6 m x 6 m, with 1 m margin round each plot. The plant residue (*Leucaena leucocephala*) was applied at the rate of 30 t ha^{-1} (Ojeniyi and Ighomore, 2004), worked into the soil with a hoe. The urea fertilizer was applied at the rate of 400 kg ha^{-1} (Fondufe, 1995), in two split doses, at three and six weeks after planting (WAP).

Planting, collection and analysis of data

In 2006 and 2007, planting was done on March 18 and March 23, respectively. Seeds of Oba Super 1 maize variety, dressed with Apron Plus were planted on the flat at a spacing of 1.0 m x 0.5 m (20,000 plants ha^{-1}). Weeding was done at four and eight weeks after planting, using a hand hoe.

Data were collected from five randomly selected maize crops from the two central rows of each plot in accordance with information for maize trial management in IITA's 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 girth was measured by using Venier caliper. Dry seed weight was measured on a metler weighing balance. Analysis of variance was carried out, and means were compared, using the Least Significant Difference (LSD) at 5% level of probability.

RESULTS

The physical and chemical properties of soil of the study site prior to planting are shown in Table 1. The soil was sandy loam in texture, with a pH of 5.3. Organic C and total N were 3.06 and 2.00 g kg^{-1}, respectively. Available P was 1.91 mg kg^{-1}. The exchangeable bases – K, Ca, Mg and Na were 0.86, 1.93, 1.73 and 0.71 $cmolkg^{-1}$, respectively. Exchangeable acidity and effective cation exchange capacity were 0.40 and 5.63 $cmolkg^{-1}$, respectively.

Maize leaf area

Table 2 shows the effects of plant residue, urea fertilizer, and their combination on maize leaf area. The two – year average values indicated that plant residue, urea fertilizer, and their combination significantly increased maise leaf area from 0.52 m^2/plant for -PR-F to 0.67, 0.80 and 0.91 m^2/plant for PR, F, and PR + F, respectively.

Maize stem girth

The effects of plant residue, urea fertilizer and their combination on maize stem girth are presented in Table 3. Plant residue, urea fertilizer and their combination significantly increased maize stem girth from 4.46 cm for –PR-F to 4.59, 4.76 and 4.87 cm for PR, F, and PR+F, respectively.

Grain yield and number of days to 50% tasselling of maize

Grain yield and number of days to 50% tasselling of maize as affected by plant residue, urea fertilizer and their combination are presented in Table 4. Plant residue, urea fertilizer and their combination significantly increased maize grain yield from 1.97 t ha^{-1} for –PR-F to 3.71, 4.62 and 5.90 t ha^{-1} for PR, F, and PR+F, respectively. The two – year average values indicated existence of non – significant difference in number of days to 50% tasselling of maize between –PR-F and PR. Similarly, no significant difference existed between F and PR+F in number of days to 50% tasselling of maize.

DISCUSSION

The significantly higher values of growth and yield of maize for inorganic fertilizer (urea) than those of growth and yield of maize for organic fertilizer (*Leucaena* residue) agree with the findings of Aitu (2004); Caitt (2005); Veen (2007). These authors reported significant difference in growth and yield of maize between Leucaena residue and urea fertilizer. This implies that maize did not benefit much from application of the organic fertilizer (plant residue), unlike the inorganic fertilizer counterpart. This observation points to the superiority of inorganic fertilizers to the organic fertilizer counterpart, as far as the nutrition of maize is concerned. The superiority emanates from the fast release of nutrients from the inorganic fertilizers with resultant timely provision of nutrients for maize crops in the early stages of growth, unlike the slow release of nutrients by the organic fertilizer counterpart (Ojeniyi and Adetoro, 1993; Ojeniyi and Falade, 1997; Awodun and Ojeniyi, 1999; Ray, 2007). This means that only long – season crops, such as cassava, yam etc that can benefit immensely from the application of organic fertilizers.

The best performance (in terms of growth and yield) of maize associated with the integration of Leucaena residue and urea fertilizer agrees with the findings of Usor (2005); Bai (2007). This observation suggests the superiority of integration of organic and inorganic fertilizers to other fertilizer types evaluated in this study as regards maize nutrition. This shows that neither the application of organic fertilizer nor inorganic fertilizer alone is sufficient for satisfactory growth and development of maize. Kuer (2003); Tankou (2004) noted that the most satisfactory fertilizer package for raising maize yield should involve a judicious and balanced combination of organic and inorganic fertilizers. This is because nutrients, if and when supplied in the combined form, seem more efficiently utilized by crops (Kuer, 2003; Tankou, 2004). Nottidge *et al.* 2005) and Carel (2006) reported that the complimentary functional role of addition of organic fertilizer to mineral fertilizers has been shown to increase the nutrient use efficiency of crops more than inorganic fertilizer alone. Organic fertilizers, apart from being a store – house of plant nutrients, as a major contributor to the cation exchange capacity, and as a buffering agent against pH fluctuation, organic fertilizers play a key role of sustaining the desirable soil physical, chemical and biological conditions for satisfactory growth and development of crops (Tankou, 2004; Gazel, 2005). So, another factor that can be implicated for the best performance of maize associated with *Leucaena* residue + urea fertilizer is that of the improvement of soil physical, chemical and biological properties by the *Leucaena* residue component with resultant provision of favourable soil conditions for maize crops.

CONCLUSION

The results of this study have shown that *Leucaena* residue + urea fertilizer gave the highest values of growth and yield of maize. This suggests that a practical option for sustainable maize production should be a judicious combination of organic and inorganic fertilizers.

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Table 1: The physical and chemical properties of soil in the study site prior to cropping

Parameters	Values
pH	5.3
Organic carbon (g kg^{-1})	3.06
Total nitrogen (g kg^{-1})	2.00
Available phosphorus (mg kg^{-1})	1.91
Exchangeable K (cmol kg^{-1})	0.86
,, Ca ,,	1.93
,, Mg ,,	1.73
,, Na ,,	0.71
,, Acidity ,,	0.40
,, ECEC ,,	5.63
Texture (g kg^{-1})	
Sand	650
Silt	225
Clay	125

Table 2: Effects of plant residue and urea fertilizer application on maize leaf area

	Maize leaf area (m^2 $plant^{-1}$)						
	3 WAP		6 WAP		9 WAP		
Treatments	2006	2007	2006	2007	2006	2007	Mean
- PR – F (control)	0.28a	0.31a	0.51d	0.54d	0.71d	0.77d	0.52
PR	0.31a	0.31a	0.68c	0.71c	0.99c	1.04c	0.67
F	0.29a	0.30a	0.80b	0.88b	1.24b	1.31b	0.80
PR + F	0.32a	0.34a	0.93a	0.96a	1.40a	1.48a	0.91

Values followed by the same letter in the same column are not significantly different at P= 0.05

WAP = Weeks After Planting
- PR – F = Control i.e. no plant residue addition, no fertilizer application
PR = Plant residue addition only
F = Fertilizer application only
PR + F = Plant residue addition plus fertilizer application

Table 3: Effects of plant residue and urea fertilizer application on maize stem girth

	Maize stem - girth (cm)						
	3 WAP		6 WAP		9 WAP		
Treatments	2006	2007	2006	2007	2006	2007	Mean
-PR – F (control)	2.27a	2.29a	5.17d	5.21d	5.88d	5.93d	4.46
PR	2.30a	2.32a	5.38c	5.43c	6.02c	6.07c	4. 59
F	2.31a	2.33a	5.53b	5.60b	6.36b	6.41b	4.76
PR + F	2.31a	2.32a	5.68a	5.76a	6.53a	6.60a	4.87

Values followed by the same letter in the same column are not significantly different at P= 0.05

WAP = Weeks After Planting
- PR – F = Control i.e. no plant residue addition, no fertilizer application
PR = Plant residue addition only
F = Fertilizer application only
PR + F = Plant residue addition plus fertilizer application.

Table 4: Effects of plant residue and urea fertilizer on grain yield and number of days to 50% tasselling of maize

	Maize grain yield (t ha-1)			Number of days to 50% tasselling of maize		
Treatments	2006	2007	Mean	2006	2007	Mean
-PR – F (control)	1.93d	2.00d	1.97	70a	70a	70
PR	3.68c	3.73c	3.71	70a	71a	71
F	4.59b	4.65b	4.62	65b	65b	65
PR + F	5.86a	5.94a	5.90	65b	65b	65

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