Original Research Article

EFFECT OF UREA AND COMPOST AMMENDMENTS ON SOIL MICROBIAL ACTIVITIES AND CHEMICAL PROPERTIES

ABSTRACT

A pot experiment was conducted in the screenhouse of the College of Plant Science and Crop Production, University of Agriculture, Abeokuta, Nigeria to investigate the effect of urea and compost on maize (*Zea mays* L.), soil microbial activities and chemical properties. The experiment consisted of two rates of urea (0, 0.25 t/ha), and three rates of compost (0, 10 and 20 tonnes per hectares). Data were collected on the following parameters: Microbial N, Microbial biomass C, Microbial biomass P, Percentage nitrogen, Microbial respiration, C/N ratio, protease, urease, cellulase, plant height, stem girth and number of leaves. The data collected were subjected to analysis of variance. The plants in pots amended with urea had significantly higher ($p \leq 0.05$) plant height, leaf area stem girth, fresh and dry root weight, fresh and dry shoot weight and soils amended with urea had significantly higher ($p \leq 0.05$) microbial biomass (P), microbial respiration, phosphorus, organic carbon, protease, urease and cellulase. Plants amended with compost had significantly higher ($p \leq 0.05$) plant height, leaf area number of leaves, fresh and dry root weight, fresh and dry shoot weight, urease, and cellulose. Compost did not have significant effect on stem girth. Similarly, soils amended with compost had significantly higher microbial biomass (N, P, and C), microbial respiration, phosphorus and organic carbon. Interaction of compost control (0 t/h) and urea was significantly lower that urea + 10 t/h compost and urea + 20 t/h for urease, protease, cellulose, phosphorous and organic carbon. It was however insignificant in the other treatments. Similarly, absolute control was significantly less than non urea + 10 t/h and non-urea + 20 t/h in plant height, stem girth, number of leaves, microbial respiration, urease, cellulose, phosphorus and organic carbon while the others were insignificant. Conclusively, integration of urea fertilizers with organic manures can be used with optimum rates to improve crop productivity on sustainable basis. However, this study will be useful in maintaining sustainable nutrient management programs in future to improve crop productivity with high efficiency and minimum nutrient loss.

Keywords: compost, maize, microbial biomass, soil enzymes, soil chemical properties, urea

INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal worldwide (Ashraf *et al*., 2016). It is ranked third after wheat and rice with respect to cultivated area in the world and the third most important cereal crop after millet and sorghum in Nigeria (Agboola and Tijani-Eniola, 1991). Maize is grown on more than 110 million hectares throughout the world out of which more than 52 million hectares are well distributed in developing countries (FAO, 1986, 2009, 2012). Average world yield of maize is about 4.04 tonnes per hectare. Also, about 26 million ton of maize were produced annually on 20 million hectares of land in Africa (Byerlec and Eicher, 1997). The phenomenal increase in maize products over the past few decades was brought about by positive government policies which facilitated its cultivation, the development and availability of farm inputs (like fertilizers) resulting in increased yield (IITA, 2016). The composition of maize grain is about 76-88 % carbohydrate, 6-15 % protein, 4 % ether extract, 2 % crude fibre, 0.25 % lysine, 0.18 %, methionine and 0.01 %

calcium and 0.09 % available phosphorus (Randjelovic *et al*., 2011). Many factors like soil fertility, imbalanced nutrition, disturbed soil properties, cultivars being grown weed infestation etc. limit its yield worldwide. In recent times, different management practices are adopted to increase and optimize the maize yields. For example, use of organic manures alongside inorganic fertilizers often lead to increased soil organic matter (SOM), soil structure, water holding capacity and improved nutrient cycling and helps to maintain soil nutrient status, cation exchange capacity (CEC) and soil's biological activity (Saha *et al*., 2008). Although chemical fertilizers are important input to get higher crop productivity, but over reliance on chemical fertilizers is associated with decline in some soil properties and crop yields over time (Hepperly *et al*., 2009). Fertilizers are very important inputs in crop production. Fertilizers are however limited due to the fact that they are not environmentally friendly; they are costly and not readily available. Interest in food production through the use of organic materials is generally increasing. Organic farming has been defined as an Agricultural production system that avoids the use of synthetic materials. It relies upon agricultural practices like the application of animal and green manure, biological pest control, supplement of plant nutrient, insect control and weed control (USDA, 1980). Past research has shown environmental impacts of organic and conventional practices to differ considerably with the farmer presenting fewer hazards to wildlife, farm worker and rural residents (Montalvo, 2008; Lichtenberg, 1992). Keeping all these aspects in consideration, the present study was therefore conducted to evaluate the effects of inorganic fertiliser and manures on soil chemical and microbiological properties.

MATERIALS AND METHODS

Soil sample collection and preparation: Soil samples were collected from top soil (0-15 cm) at FADAMA, University of Agriculture Abeokuta. The samples were sieved with a 4 mm screen soil sieve to remove stones and gravels. It was then transferred into buckets in the screenhouse for experiments.

Urea collection and Preparation: The urea used in the experiment was collected from the Ministry of Agriculture, Abeokuta, Ogun State. About 0.25 t/h of urea was applied per pot, because it is the equivalence of the recommended rate of 80 kg per hectare.

Composting Material: It included animal waste and plant residue, white and black nylon, etc. the compost was moistened for two weeks before planning to ensure mineralization.

Screenhouse Experiment: The screenhouse is located beside College of Plant Science and Crop Production, University of Agriculture Abeokuta. The design was a complete randomized design (CRD), there were two factors urea (with or without) and compost (0 tonnes/hectare, 10 tonnes/hectare, 20 tonnes/hectare). This brought about six treatments replicated thrice resulting in 18 buckets. Four seeds of maize (*Zea mays* L.) variety, Oba Super 2 were planted at the rate of 4 seeds per bucket. This was later thinned to two plants per bucket. The experiment lasted for four weeks and the plant was harvested from the soil in such a way that the root and stem of the plant was intact after harvest.
Chemical Analysis carried out include: Soil pH, Cation Exchange Capacity, Organic Matter Determination, Total Nitrogen. Others were: Particle Size Analysis, Total Nitrogen Determination, Available phosphorus determination and Microbiological Analysis.

Statistical Analysis: The data collected was subjected to analysis of variance (ANOVA). The means were separated using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Physical and chemical properties of the soil before the experiment

The percentage sand, silt and clay of the experimental soil were 88.24, 10.92, and 0.84 respectively. Using the textural triangle, the soil was found to be sandy. The pH of the soil was 6.41 making it slightly acidic (Table 1). However, the pH is within the optimum value for crop production (Landon, 1991). The total nitrogen was 1.36 which is within the critical minimum for crop production (Pagel *et al*. 1982).

Table 1: Chemical and Physical properties of the soil

Property	Value
% Sand	88.24
% Silt	10.92
% Clay	0.84
Soil textural class	Sandy
pH (soil :water)	6.41
% Organic carbon	0.61
% Nitrogen	1.36
Available phosphorus (ppm)	4.52
% Organic matter	0.28
Ca (cmol/kg)	0.6
Mg (cmol/kg)	0.09
K (cmol/kg)	0.03
Na (cmol/kg)	0.023
Exchangeable acidity	4.1
Cation exchange capacity (cmol/kg)	5.48

Effect of urea and compost on microbial biomass (N, C and P) and microbial respiration

Table 2 shows that the soils in pots amended with urea and significantly higher ($p \leq 0.05$) microbial biomass P than soils without urea amendments. There was however no significant difference in soils treated with compost, urea + compost and non urea + compost. Microbial biomass N: There was no significant difference with soils in pots amended with urea, compost, urea + compost and non urea + compost. Microbial biomass C: Soils in pots amended with urea did not have significant difference with soils in pots without urea. Similarly compost did not have a significant effect on the soil microbial biomass for C. both the interaction between urea with compost and non urea with compost did not have significant effect on microbial biomass C. Microbial respiration: Soils in pots amended with urea were significantly higher ($p \leq 0.05$) than soils without urea. There was no significant difference in soils amended with compost and urea + compost. Non urea + 0 t/h was significantly lower than non urea + 10 t/h and non urea +20 t/h.

Table 2: Effect of urea on compost microbial biomass N, C and P (mg/kg) and microbial respiration

TREATMENT	Microbial biomass (N)	Microbial biomass (C)	Microbial biomass (P)	Microbial respiration
Urea (12)	128.85[a]	141.6[a]	275.86[a]	3.25[a]
Non urea (Ni1)	119.72[a]	132.9[a]	257.8[b]	2.57[b]
Compost (ton/ha)				
0	122.42[a]	134.67[a]	263.13[a]	2.73[a]
10	123.72[a]	137.6[a]	265.67[a]	2.99[a]
20	126.73[a]	139.53[a]	271.68[a]	3.01[a]
Interactions				
Urea+0t/h compost	128.33[a]	139.37[a]	267.97[a]	3.06[ab]
Urea+10t/h compost	128.93[c]	142.33[a]	268.97[a]	3.32[a]
Urea+20t/h compost	129.30[a]	143.23[a]	280.63[a]	3.38[a]
Non urea+0t/h compost	116.50[a]	129.97[a]	252.37[a]	2.39[b]
Non urea+10t/h compost	118.5[a]	132.87[a]	258.30[a]	2.65[a]
Non urea+20t/h compost	124.57[a]	135.83[a]	262.73[a]	2.66[ab]

Effect of urea and compost on protease, urease and cellulase

Table 3 shows that the soil in pots amended with urea had significantly higher ($p \leq 0.05$) protease activity than soils without urea. There was no significant difference in the three rates of compost. In the interaction of compost and urea, soil with urea + 0 t/h compost were significantly lower than urea +10 t/h and urea +20 t/h compost. However, there was no significant difference in the interaction between non urea and compost. Urease: Soils in pots amended with urea had significantly higher ($p \leq 0.05$) urease activity than soils without urea. Soils in pots with compost control (0 t/h) were significantly less than soils in pots amended with 10 t/h compost and 20 t/h compost. Similarly, soils in pots that contained urea +0 t/h compost were significantly lower than soils that contained urea + 10 t/h compost and urea +20 t/h compost. Also in the interaction on non urea and compost, soils in pots that had absolute control was significantly lower than soils that contained non urea + 10 t/h compost and non urea + 20 t/h compost. Cellulase: Soils in pots amended with urea had significantly higher ($p \leq 0.05$) cellulose activity than soils in pots without urea. Soils in pots that had 0 t/h compost were significantly lower than soils in pots that amended with 10 t/h compost and 20 t/h compost.

Table 3: Effect of urea and compost on Soil Protease, Urease and Cellulase.

TREATMENT	PROTEASE	UREASE	CELLULASE
Urea (12)	0.13^{a}	0.13^{a}	0.138^{a}
Non urea (Ni1)	0.11^{b}	0.11^{b}	0.115^{b}
Compost (ton/ha)			
0	0.113^{a}	0.113^{b}	0.12^{b}
10	0.122^{a}	0.124^{a}	0.125^{ab}
20	0.123^{a}	0.125^{a}	0.14^{a}
Interactions			
Urea+0t/h compost	0.12^{b}	0.121^{b}	0.127^{bc}
Urea+10t/h compost	0.13^{a}	0.134^{a}	0.133^{b}
Urea+20t/h compost	0.13^{a}	0.136^{a}	0.155^{a}
Non urea+0t/h compost	0.112^{bc}	0.105^{c}	0.11^{c}
Non urea+10t/h compost	0.112^{bc}	0.113^{bc}	0.12^{bc}
Non urea+20t/h compost	0.113^{bc}	0.114^{bc}	0.12^{bc}

Effect of urea and compost on Organic carbon, Nitrogen and Phosphorus

Table 4 shows that there was no significant difference for all the treatments i.e. urea, compost (0, 10 and 20 t/h), urea + compost (0, 10 and 20 t/h) and non urea + compost (0, 10 and 20 t/h) on nitrogen. Phosphorus: Soils in pots that were amended with urea were significantly higher ($p \leq 0.05$) than those without urea. There was no significant difference in the three rates of compost. There was no significant difference between urea + 0t/h compost, urea + 10 t/h compost and urea + 20 t/h compost. In the interaction between non urea and compost, the soils in pots containing the absolute control (non urea + 0 t/h) compost were significantly less than soils in pots amended with non urea + 10 t/h compost and non urea + 20 t/h. Organic carbon: Soils in pots that were amended with urea were significantly higher ($p \leq 0.05$) than those without urea. There was no significant difference in the compost rates. There was also no significant difference in the interaction of compost and urea (i.e. urea + 0 t/h compost, urea + 10 t/h compost and urea + 20 t/h compost. In the interaction between non urea and compost, the soils in pots containing the absolute control (non urea + 0 t/h) compost were significantly less than soils in pots amended with non urea + 10 t/h compost and non urea + 20 t/h compost.

Table 4: Effect of urea and compost on Organic carbon, Nitrogen, Phosphorus

TREATMENT	NITROGEN	PHOSPHORUS	ORGANIC CARBON
Urea (12)	0.12^{a}	11.66^{a}	11.6^{a}
Non urea (Ni1)	0.09^{a}	9.52^{b}	9.58^{b}
Compost (ton/ha)			
0	0.09^{a}	9.86^{a}	10.17^{a}
10	0.1^{a}	10.88^{a}	10.75^{a}
20	0.12^{a}	11.02^{a}	10.88^{a}
Interactions			
Urea+0t/h compost	0.11^{a}	10.74^{ab}	11.33^{ab}
Urea+10t/h compost	0.12^{a}	11.99^{a}	11.73^{a}
Urea+20t/h compost	0.13^{a}	12.34^{a}	11.78^{a}
Non urea+0t/h compost	0.07^{a}	8.99^{c}	9.0^{b}
Non urea+10t/h compost	0.9^{a}	9.50^{bc}	9.77^{ab}
Non urea+20t/h compost	0.1^{a}	9.77^{bc}	9.98^{ab}

The effect of urea and compost on Plant Nitrogen, Phosphorus and Organic Carbon

Plants in pots treated with urea did not have significant difference from plants not treated urea on nitrogen, phosphorus and organic carbon. Plants in pots with 0 t/h compost were significantly lower ($p \geq 0.05$) than plants in pots with 10 t/h and plants in pots with 20 t/h compost. In interaction between urea and compost, urea + 0 t/h compost was significantly less than urea + 10 t/h compost and urea + 20 t/h compost. Similarly, in the interaction between non urea and compost, plants containing non urea + 0 t/h compost was significantly less than non urea + 10 t/h compost and non urea + 20 t/h. Plants in pots treated with urea were not significantly different from plants not treated without urea. Also in the interaction between non urea and compost, non urea + t/h compost was significantly less than non urea + 10 t/h compost and non urea + 20 t/h compost. Plants in pots that contained urea did not have significant difference from plants not treated without urea. (Table 5).

Table 5: Effect of urea and compost on Plant Nitrogen, Phosphorus and Organic Carbon

TREATMENT	NITROGEN	PHOSPHORUS	ORGANIC CARBON
Urea (12)	0.27^{a}	0.5^{a}	10.26^{a}

Non urea (Ni1)	0.26^{a}	0.5^{a}	10.27^{a}
Compost (ton/ha)			
0	0.17^{b}	0.41^{b}	8.72^{b}
10	0.2^{a}	0.53^{a}	10.93^{a}
20	0.34^{a}	0.57^{a}	11.15^{a}
Interactions			
Urea+0t/h compost	0.17^{b}	0.14^{c}	8.70^{b}
Urea+10t/h compost	0.30^{a}	0.52^{abc}	10.92^{a}
Urea+20t/h compost	0.34^{a}	0.52^{abc}	10.92^{a}
Non urea+0t/h compost	0.17^{b}	0.14^{c}	8.73^{b}
Non urea+10t/h compost	0.28^{ab}	0.53^{ab}	10.95^{a}
Non urea+20t/h compost	0.34^{a}	0.57^{a}	11.4^{a}

Correlation analysis between Plant Growth parameter and microbial analysis

Table 6 shows that there was no significant correlation between the plant growth parameters and microbial properties. All the correlations were insignificant. This means that rate of plant growth was not influenced by the microbial properties.

Table 6: Correlation analysis between Plant Growth parameter and microbial analysis

	MBN	MBP	MBC	CELLULASE	UREASE	PROTEASE	M. RESP
FRW	0.266	0.3	0.311	0.442	0.392	0.404	0.315
FSW	0.265	0.296	0.26	-0.078	0.178	-0.078	0.199
P. CONC	-0.136	0.032	-0.121	-0.386	-0.185	-0.386	-0.246
N. CONC	-0.081	0.084	-0.08	-0.355	-0.138	0.355	-0.179

**Correlation is significant at the 0.01 level ; *Correlation is significant at the 0.05 level

FSW: Fresh Shoot Weight **FRW:** Fresh Root Weight

P. CONC: Phosphorus Concentration **N. CONC:** Nitrogen Concentration

Correlation analysis between Plant Growth parameter and some chemical properties

Table 7 shows that there was no significant correlation between the plant growth parameters with soil phosphorus and soil nitrogen. However, there was positive and significant correlation between the plant growth parameters and organic carbon. The correlation between organic carbon and fresh root weight was significant at 0.05. Fresh shoot weight, plant P and plant N correlation with chemical properties was significant at 0.01.

Table 7: Correlation between Plant Growth parameter and some chemical properties

	Organic Carbon	Soil Phosphorus	Soil Nitrogen
Fresh Root Weight	0.549*	0.411	0.208
Fresh Shoot Weight	0.727**	0.245	0.223
Phosphorus Concentration	0.913**	-0.134	-0.107
Nitrogen Concentration	0.926**	-0.08	-0.042

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed).

DISCUSSION

Zero ton/ha rate of compost and urea produced more significance on plant height, leaf area, stem girth, leaf number, protease, urease, cellulase, fresh root, fresh and dry shoot. In the interaction between urea and compost, urea + 0 t/h of compost produced more significance on protease, urease, cellulase, plant N, P and OC, fresh and dry root, fresh and dry shoot weight. These results are in confirmatory with Lima *et al*. (2009) who stated that incorporation of organic manures improves soil physico-chemical properties that may have a direct or indirect effect on plant growth and yield attributes. Regarding nutrient status of the soil, organic manures with inorganic fertilizers improved plant growth and yield with a significant improvement in NPK contents of the soil that affirmed enhanced nutrient use efficiency in the presence of organic manures. Organic amendments with reduced dose of chemical fertilizers might have resulted in elicited microbial activity and nutrient availability more than application of chemical fertilizer alone and/or unfertilized control. Application of organic amendments improved soil N, P and K concentrations when applied with inorganic fertilizers (Hao *et al*., 2008). Organic manures have more beneficial effects on soil quality than inorganic fertilizers thereby improving nutrient release and their availability to the plants (Birkhofer *et al*., 2008).

Conclusion:

Application of organic manures has significant influence on maize productivity and soil physical/chemical and microbiological properties. Manure efficacy regarding morphological parameters of maize was found to be rather significant when applied with chemical fertilizers. Furthermore, C: N ratio, soil organic carbon and total NPK increased while soil pH and soil bulk density were decreased with the integrative application of organic manures and chemical fertilizer. Therefore, organic manures can be applied with chemical fertilizers in organic carbon depleted soils to improve soil properties and enhance crop productivity.

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