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SOIL CHEMICAL PROPERTIES AND NUTRIENT (N, P, K) UPTAKE AS AFFECTED BY RESIDUAL EFFECT OF ORGANIC AND INORGANIC FERTILIZERS.

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ABSTRACT

Frequency of fertilizer application should be closely monitored to prevent excessive nutrient supply and environmental pollution. A field experiment was carried out in 2010 planting season at the Federal University of Agriculture, Abeokuta (FUNAAB) to determine the residual effect of organic and inorganic fertilizers on soil properties and maize yield. The treatments used were: compost (CP) derived from *Tithonia diversifolia* composted with poultry manure, green manure (GM) made of fresh *Tithonia diversifolia*, neem organo compound fertilizer (NF), sunshine organo-mineral fertilizer (OMF), poultry manure (PM) all at the rate of 10 t/ha each, chemical fertilizer (N-P-K- 20:10:10) at 120 kg N/ha and control. The treatments were replicated four times using randomized complete block design. Plant height, number of leaves, leaf area and yield of maize were assessed. The uptake of nitrogen, phosphorus and potassium by maize were determined, post planting soil samples were also routinely analyzed. Results of the experiment showed that the residual effect of organo-mineral fertilizer significantly increased maize height to 139.00 cm when compared with the control. Maize grain yield ranged between 1.64 and 5.54t/ha, CP application resulted in the highest yield. The residual effect of NF promoted the uptake of nitrogen and phosphorus (0.16 t/ha and 18.80 kg/ha respectively). Percentage increase in post planting soil nitrogen and potassium contents above the control were between 7.14 – 31.58 and 7.14 – 27.78 respectively. Highest percentage increase in nitrogen resulted from CP and PM application while potassium was from GM amended plots. Residual effect of CP significantly increased the pH and organic matter contents of post planting soil above the control. The yield of maize and soil quality were both improved on plots where CP was previously applied, thus subsequent crops on CP amended plots require no fertilization.

Key Words: Residual effect, organic fertilizer, inorganic fertilizer, compost, organo-mineral fertilizer

INTRODUCTION

Organic based fertilizers release their nutrients slowly therefore these nutrients are thereby stored in the soil for a longer time (Abou El – Magd et. al., 2005) while inorganic fertilizers release their nutrients immediately it is applied

to the soil provided there is adequate moisture. The percentage of nitrogen usually released to the immediate crops after application when organic based fertilizer is used has been reported to be 30 % (Jamaval, 2006). This according to Shaikh and Patil (2013) is because the release of plant – available form of nitrogen is slow. Gaskell *et al.,* (2006) also reported that gradual release of nutrients in organic fertilizers is due to the process of converting nutrients in organic form into inorganic forms by soil microbes before they could be made available to plants, the above therefore guarantees long supply of nutrients throughout the season (Gorge, 2011). This implies nutrient carry over effect on the subsequent crops (Davari *et al*., 2012). Materials which are plant and animal residues are used for organic fertilizers, these include poultry manure, cow dung, rice husk, pig manure, *Tithonia diversifolia, Chromolaena odorata,* compost e. t. c. These materials differ in chemical composition and will affect their release of nutrient and the amount of nutrient left in the soil after the first cropping. Therefore, the residual effect of organic based fertilizers in the soil should be given adequate attention to guide in deciding whether to apply fertilizer in the following planting season. Excessive fertilizer or nutrient application may lead to nutrient toxicity which in turn may have a detrimental effect on both the soil and plant. This research work was designed to investigate the residual effect of inorganic and different types of organic based fertilizers on the soil chemical properties and maize yield.

MATERIALS AND METHODS

Study Area

The experiment was conducted at the Federal University of Agriculture, Abeokuta (FUNAAB), South western Nigeria. Abeokuta is located in the Forest Savannah transition zone (latitude 7° 17´ N and longitude 3° 26´ E. Rainfall pattern in the area is bimodal with the first peak in June and the second in September.

Field Experiment

The experimental area measuring 884 m^2 used in 2009 and 2010 was manually cleared on May 30, 2011. Plots measuring 5 m by 4 m used in the above years were cleared. The following treatments had been applied to the plots in 2009 and 2010: *Tithonia diversifolia* composted with poultry manure (CP), fresh *Tithonia diversifolia* (GM), neem organo compound fertilizer (NF), sunshine organo-mineral fertilizer (OMF), poultry manure (PM) at the rate of 10 t/ha, N – P – K- 20 – 10 – 10 (NPK) at 120 kg N/ha and control. The treatments were arranged using a randomized block design with three replicates. Since it was a residual experiment, the above treatments were not applied in 2011. Maize seeds (Variety – SUWAN 1) obtained at the Institute of Agricultural Research and Training (I. A. R. & T.), Moor Plantation Ibadan, Oyo State were planted at the rate of four seeds per hole on June 4, 2011. Spacing used was 75 cm by 50 cm, maize seedlings were thinned to two per hole at two weeks after planting. The plots were kept weed free by the use of cutlass and hoe. Parameters evaluated at seven weeks after planting were: plant height with the aid of a graduated ruler, number of leaves by physical counting and leaf area by multiplying the leaf length and breadth by a constant (0.75) (Ellings, 2000). Maize cobs were harvested at maturity, oven dried to 14 % moisture content, shelled after which the grains were weighed. Ten maize plants were carefully cut at the soil level per plot at the initiation of tasselling, these were oven dried at 65° C to constant weight and milled for analysis. Soil samples were collected from each plot at the end of the experiment with the aid of a soil auger, bulked, sub sampled and air dried for routine analysis.

Plant Analysis

Plant samples collected from the field were oven dried at 65°C to constant weight, ground with mortar and pestle. Nitrogen in the samples was determined by micro – Kjeldahl method, phosphorus by vanado – molybdate method and potassium by flame photometry.

Organic carbon content of the organic based fertilizers was determined by wet oxidation method (Nelson and Sommers, 1996).

Soil Analysis

Soil samples were air dried, ground to pass 2 mm and 0.5 mm sieves. Nitrogen was determined by Kjeldahl method (Bremner, 1996), organic carbon by wet oxidation method, pH by glass electrode pH meter and phosphorus by Bray 1 method. Exchangeable potassium was determined by flame photometry.

Statistical Analysis

Data obtained were analyzed by the analysis of variance using SAS 2003 package and significant means were separated by Duncan's multiple range test at 5 % level of probability.

RESULTS AND DISCUSSION

Neem organo compound fertilizer excelled in nitrogen, phosphorus and potassium concentrations while sunshine organo mineral fertilizer had the highest organic carbon content (Table 1). Maize height ranged between 79.03 cm and 139.00 cm. The shortest plants were the unfertilized (control) ones while the tallest which were significantly ($P<0.05$) higher than the control were from plots previously treated with OMF 10t/ha (Table 2). The organic portion of the above fertilizer reduced nutrient leaching (Kramer *et al*, 2006) and therefore, retained nutrients not used by the previous crops which were made available to the following crops. This observation is in agreement with that of Leda *et al* (2009) who reported that the residual effect of organic fertilizer increased the height of cotton. Residual effect of organic based fertilizer with the exception of compost and *Tithonia diversifolia* significantly ($p<0.05$) increased the number of maize leaves over the control. The highest value (9.20) was observed on plants grown on NF previously treated plots. Increase in number of leaves of maize relative to fertilizer application followed this order: NF>OMF>PM>CP, NPK>GM>C (Table 1). The fertilizers with significantly higher number of leaves than control (NF, OMF and PM) have high nitrogen content, this could probably be the reason for the above observation since Miko and Munga (2008) observed that number of sorghum leaves was significantly influenced by nitrogen application. Residual effect of fertilizer application either organic or inorganic had no significant effect on maize leaf area. The biggest leaf area (424.13 cm^2) was however from OMF previously treated plots, this was followed by NF (404.83 cm^2) while the smallest (299.89 cm^2) was from unfertilized plants (Table 2). This observation could be probably because the residual nutrients of the fertilizers were not sufficient enough to increase the leaf area of maize. This is similar to the findings of Quansah, (2010) who reported that the residual effect of organic amendments did not significantly affect the growth parameters of maize.

The dry matter of weight increased by 49.74 % over the control as a result of the residual effect of OMF, this was followed by NPK (34.69 %), GM (34.25), NF (32.87 %), CP (27.27 %) and PM (25.58 %) (Table 3). The highest dry matter yield observed in OMF previously treated plot could have resulted from increased absorption of N, P, K (Bokhtair and Sakurai, 2005) which might have contributed to the dry weight of maize. Nitrogen uptake ranged between 0.07 t/ha to 0.16 t/ha, the highest value which was significantly ($P<0.05$) higher than PM, CP, GM and control plots was from plots on which NF was previously applied, A similar trend was observed for phosphorus uptake where plants on NF previously treated plots took up significantly ($P<0.05$) higher phosphorus (18.80 kg/ha) content compared with the control and inorganic fertilizer (Table 3). Neem organo compound fertilizer (NF) had the highest nitrogen and phosphorus contents (Table 1) coupled with the slow release of the above might have made the nutrients present in the soil the following year abundant for plants to take them up. Potassium uptake was

however not significantly affected by residual effect of organic or inorganic fertilizers. The residual effect of organic and inorganic fertilizers on maize grain yield is shown in Figure 1, maize plants on CP previously treated plot had the highest grain yield (5.54 t/ha). This value is significantly ($P<0.05$) higher than those of NPK, PM, GM and control. Increase in maize grain yield followed this order of fertilizer application: CP > NF > OMF > GM > PM > NPK > Control. Nutrient release from CP in the following year of application was sufficient to increase the yield of maize. Low maize grain yield observed in GM and NPK plots might have resulted from early release of nutrients while that of PM could be due to the high C:N ratio which might have prolonged the time of nutrient release than CP and NF.

Table 1: Chemical Properties of Organic based fertilizers

Fertilizer	N (%)	P (%)	K (%)	O. C.
Poultry manure (PM)	2.0	0.65	5.7	8.84
Sunshine organo mineral fertilizer (OMF)	3.5	1.0	1.2	8.98
Compost (CP)	2.6	0.36	3.5	8.81
Neem organo compound fertilizer (NF)	3.8	1.33	6.4	8.95
Tithonia diversifolia (GM)	3.5	0.35	5.9	8.17

Table 2: Residual effect of organic and inorganic fertilizers on maize height (cm), number of leaves (per plant) and leaf area (cm^2) at 7 WAP.

Fertilizer /ha		Maize height	Number of leaves	Le
Poultry manure (PM) 10t		84.87ab	8.93a	3
Sunshine organo mineral fertilizer (OMF)	10t	139.00a	9.07a	4
Compost (CP) 10	91.30ab	8.13ab	338.67	
Neem organo compound fertilizer (NF) 10t	110.47ab	9.20a	404.83	
Tithonia diversifolia (GM) 10t	91.17ab	8.00ab	329.99	
NPK 120 kg N	97.50ab	8.13ab	349.27	
Control	79.03b	7.07b	299.89	
			NS	

Means with the same letter(s) are not significantly different from each other at $p<0.05$

Table 3: Residual effect of organic and inorganic fertilizers on dry matter, N, P and K uptake by maize

Fertilizer /ha	Maize dry matter (g/plant)	N uptake (t/ha)	P uptake (Kg/ha)	K uptake (t/ha)
Poultry manure (PM) 10t	43.00b	0.09bc	13.80abc	0.88
Sunshine organo mineral fertilizer (OMF) 10t	63.67a	0.12abc	14.90abc	1.23
Compost (CP) 10t	44.00b	0.10bc	11.77abc	1.07
Neem organo compound fertilizer (NF) 10t	47.67ab	0.16a	18.80a	1.24
*Tithonia diversifolia (*GM)10t	48.67ab	0.07c	11.33bc	0.89
NPK 120 kg N	49.00ab	0.08c	17.00ab	1.24
Control	32.00b	0.07c	9.20c	0.88
				NS

Means with the same letter(s) are not significantly different from each other at $p<0.05$

The above observation is in agreement with the findings of Jannoura et. al., (2013) who reported that the residual effect of organic fertilizer significantly ($P<0.05$) improved the yield of wheat.

Significantly ($P<0.05$) higher pH over the control observed in CP and GM previously applied plots (7.20 and 7.13 respectively) (Table 4) could be due to the release of basic cations particularly calcium and magnesium from *Tithonia diversifolia* (Phiri et. al., 2001) which reduced the acidity of the soil. Post planting total nitrogen ranged between 0.13 % and 0.19 %. Plots previously treated with organic based fertilizers had significantly ($P<0.05$) higher nitrogen contents when compared with the control. Increase in total nitrogen followed this order of fertilizer application: PM, CP > OMF, GM >NF > NPK > Control. Highest value was observed on plots where PM and CP were previously applied. The above fertilizer had high C/N ratio (Table 1), this could have led to slower release of nitrogen in the previous year which made high contents to be released during the residual study. Available phosphorus of post planting soil was not significantly affected by previous fertilizer applications. OMF and CP plots however had highest value (20.15 mg/kg) while lowest value (14.9 mg/kg) was from

NPK and control plots (Table 4). Post planting potassium was increased significantly more than the control by previous fertilizer applications with the exception of CP and NF. Residual effect of organic based fertilizers was reported by Ayoola and Makinde (2009) to increase soil nitrogen, phosphorus and potassium.

CONCLUSION AND RECOMMENDATION

The results of this study showed that previous applications of OMF and NF improved the agronomic parameters of maize while previous application of NF promoted nutrient uptake by maize. Maize yield was increased by previous applications of CP and NF. Post planting soil chemical properties were increased on plots with previous applications of compost, PM and OMF, CP and GM. It is therefore recommended that compost application at the rate of 10 t/ha in the first two years would be sufficient for maize yield increase and improved soil quality in the following year.

Table 4: Residual effect of organic and inorganic fertilizers on post planting soil chemical properties

Fertilizer/ha	pH (1:1 soil : water)	Total nitrogen	Avail. P (mg/kg)	Potassium (cmol/kg)	O.C (%)
Poultry manure (PM) 10t	7.03abc	0.19a	18.29	0.17a	1.74bc
Sunshine organo mineral fertilizer (OMF) 10t	7.00abc	0.18ab	20.15	0.17a	2.10bc
Compost (CP) 10t	7.20a	0.19a	20.15	0.16ab	2.19a
Neem organo compound fertilizer (NF) 10t	6.93bc	0.17ab	15.5	0.16ab	1.99ab
Tithonia diversifolia (GM)	7.13ab	0.18ab	17.05	0.18a	2.12a
NPK 120 kg N	6.89c	0.14c	14.9	0.13n	1.67c
Control	6.90c	0.13c	14.9	0.14b	1.67c
			NS		

Means with the same letter(s) in a column are not significantly different from each other at P<0.05.

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