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Effect of bioslurry application on soil chemical properties and growth of maize (*Zea mays L.*) in an Alfisol in Maiduguri area, Nigeria

[1]Adam Lawan Ngala, [1]Auwal Bukar Bularafa, and [2]Aishatu Buba

[1.]Department of Soil Science, Faculty of Agriculture, University of Maiduguri. P. M. B. 1069, Maiduguri, Nigeria.

[2.] Department of Farming System, Lake Chad Research Institute, Maiduguri.

Abstract

The use of biochar as a low-cost adsorbent to remove nutrients from aqueous solutions is getting great attention lately due to its many environmental applications and benefits. Although, biochar has been widely used to remove phosphate from aqueous solutions, inconsistencies still exist with regards to biochar properties responsible for the adsorption process. This research was therefore, carried out to determine the influence of some biochar properties on maximum phosphate adsorption capacity of biochar produced from four different feed-stocks. The biochars used for this study were prepared from two plant materials; (Maize cob and rice husk) and two animal wastes (cow dung and poultry litter) at 600 °C. The different biochars were subjected to a laboratory batch sorption experiment. Data obtained were fitted into the linear forms of the Langmuir, Freundlich, Temkin and Dubinin-Radushkevich (D-R) adsorption isotherms while least square regression analysis was used to test the goodness of fit using the coefficient of determination (R^2). Similarly, stepwise regression analysis was carried out to determine the nature and extent of relationships between the biochar properties and maximum phosphate adsorption capacity using statistical analysis software (SAS 9.4). Results revealed higher R^2 values for the D-R adsorption isotherm (> 0.97) across all the treatments suggest better fit of the D-R adsorption isotherm for phosphate adsorption onto the biochar materials. The maximum phosphate adsorption capacity of the biochar materials is in the order: maize cob biochar > poultry litter biochar > cow dung biochar > rice husk biochar. Stepwise regression analysis revealed that 99 % of the change in maximum phosphate adsorption is influenced by the combined effects of biochar EC, moisture content and specific surface area. Hence, modification of biochar EC, moisture content and specific surface area is essential for improving phosphate adsorption by biochar.

Keywords: Maize; nutrient-uptake; biomass yield; soil nutrient content.

Corresponding Author's E-mail Address: adamngala@yahoo.com: Phone: +2348052614007
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1.0. Introduction

A Pot experiment was conducted at the screen house of the Faculty of Agriculture, University of Maiduguri. to determine the effect of bioslurry (BS) application on soil NPK contents and growth and dry matter yield of maize. The treatments included bioslurry rates at 0.0, 2.5, 5.0, 7.5 and 10.0 t/ha; NPK fertilizer at recommended rate and half the recommended rate + 5.0 t/ha BS. The treatments were arranged in CRD and replicated three times. Soil and plant samples were collected and analyzed for nutrient status. Plant height, number of leaves, stem girth, shoot fresh and dry weights, and root fresh and dry weight were measured. Plant shoot NPK content and uptake were also calculated. Data obtained were subjected to analysis of variance (ANOVA), and treatment means separated using Duncan Multiple Range Test (DMRT) at 5% level of probability. The result of soil NPK content was similar at 7.5 and 10.0 t/ha BS but significantly improved over all other treatments. Bioslurry at 10.0t/ha, half NPK +5.0 t/ha BS, and recommended NPK were similar in effect on plant height, number of leaves, and stem girth, but significantly superior to other treatments, with plant height, the number of leaves, and stem girth of 10.0 t/ha BS at 10 WAS increased by 41%, 22%, and 132%, respectively over the control. Higher soil nutrient availability after application of BS can be credited to their high nutrient contents, which also increased plant height, number of leaves, and stem girth. Half NPK + 5.0 t/ha BS gave significantly higher root fresh (87.73 g) and dry (16.30 g) weights and higher shoot fresh (280.30 g) and dry (45.83 g) weights, which were 360% and 665%, and 312 and 188% increase over control, respectively. The 10.0 t/ha BS was at par with recommended NPK and half NPK + 5.0 t/ha BS for NPK uptake, but significantly higher than all other treatments. It can be concluded that the application of 10.0 t/ha and combined application of bioslurry and NPK at half the recommended rates had greater potential to improve soil nutrient content, nutrient uptake, and growth of maize.

2.0. Materials and methods

A pot experiment was conducted at the Screen House of the Faculty of Agriculture, the University of Maiduguri during the dry season of 2019 to evaluate the effect of bioslurry as an organic soil amendment on soil NPK content and uptake, growth, and biomass production by maize.

2.1 Experimental Procedure

Bulk soil sample used for the experiment was collected at a depth of 0-20 cm at the University of Maiduguri Teaching and Research Farm, located at latitude 11^{o} 85` N and longitude of 13$^{o}$ 16` E. The soil collected was air-dried and passed through a 2 mm sieve, and 5 kg weighed into plastic pots. A pre-sowing soil sub-samples were collected and analyzed for selected soil properties. The bioslurry used was collected as a waste product from a biogas plant at the Department of the Biological Science University of Maiduguri, air-dried, and applied according to the treatments. Three maize seeds (extra-early maturing) were planted in each pot and later thinned to two stands after establishment. The pots were watered at two-day intervals; plant height, number of leaves, and stem girth measured at two-week intervals to observe the response of the maize plant to the applied treatments. At 10 weeks after sowing (WAS), fresh and dry root and shoot weights were measured. Soil and plant samples were collected after crop harvest and subjected to NPK analysis and subsequent uptake calculated.

2.2 Analytical Procedure

Soil sub-samples collected were air-dried and screened through a 2 mm sieve and used for the determination of selected physicochemical properties before initiation of the pot experiment. The texture of the soil was determined by the hydrometer method. The chemical properties of the soil samples were analyzed according to the methods of Page *et al*. (1982). Electrical conductivity (EC) was determined using the conductivity meter, soil pH using pH meter, organic carbon by wet oxidation method, total nitrogen by micro Kjeldahl procedure, available phosphorus by Bray-1 method, exchangeable bases determined after extraction using ammonium acetate. Calcium (Ca) and Magnesium (Mg) were determined by the EDTA titration method, while potassium (K) by flame photometer. Bioslurry sample was also collected and analyzed for NPK (Table 2) through the standard procedure as described by Ryan *et al*. (2001). Nutrient contents in plant samples were also analyzed. Plant samples were digested with 4% v/v perchloric acid in sulphuric acid. The digest was used to determine N by micro Kjeldahl and titration method; P by colorimetry using the vanado-molybdate method with a spectrophotometer and K by using a flame photometer.

Table 1: Selected physical and chemical properties of the soil used for planting

Property	Value
pH(H_2O)	7.0
EC (dS/m)	0.19
OC (g/kg)	6.40
Total N (g/kg)	1.10
Available P (mg/kg)	10.20
Exchangeable cations (cmol/kg)	
K	0.64
Na	0.36
Ca	4.41
Mg	1.73
Exchangeable acidity (cmol/kg)	0.50
CEC (cmol/kg)	20.20
Particle size distribution (%)	
Sand	68.00
Silt	20.00
Clay	12.00
Textural class	Sandy loam

Table 2: NPK content of the bioslurry

Nutrient (%)	Value
N	1.90
P	0.32
K	6.50

2.3 Treatments and Experimental Design

The experiment consisted of seven (7) treatments which included bioslurry (BS) rates at 0.0, 2.5, 5.0, 7.5, and 10.0 t/ha; and NPK fertilizer at the recommended rate and half the recommended rate + 5.0 t/ha BS to serve as a check. The treatments were replicated three times and arranged in a completely randomized design (CRD).

Statistical Analysis

Data obtained from the experiment were subjected to analysis of variance (ANOVA) and differences between treatment means were separated using least significant difference (LSD) at 5% level of probability with the help of a statistical package *"Statistix 10.0"*.

3.0. Results and Discussion

3.1 Effects of bioslurry on residual soil NPK contents

The effect of bioslurry application on residual soil nutrient contents is presented in Table 3. The N content of the applied treatments did not differ significantly ($P > 0.05$) when compared with one another, except with the recommended application of mineral fertilizer which was significantly ($P < 0.05$) lower than all other treatments. The difference between treatment means of P at 5.0 to 10.0 t/ha BS application was similar, but significantly higher compared to other treatments. The 10.0 t/ha BS application increased P content by 232% over the values obtained with control. In a similar vein, among the K fertilizer treatments, recommended NPKgave the least K content in the soil after harvest with a value of 12.57 Cmol/kg, followed closely by application of half NPK + 50 t/ha BS with a value of 15.17 Cmol/kg. Values of soil K obtained with application of 7.5 and 10.0 t/ha BS were at par, but significantly higher than the other treatment means. Application of 7.5 t/ha BS increased K content by 494 over the control (0.0 t/ha BS) treatment.

A positive change in nutrient dynamics was noted with treatment application. In general improvement in soil nitrogen, phosphorus and potassium were observed when bioslurry was applied. Bioslurry contains higher amounts of nitrogen which is readily mineralized and becomes plant available. Therefore, the application of bioslurry is related to higher nitrate availability. Haque *et al*. (2015) noted that using bioslurry in soil increased the availability of nitrogen in soils. Our findings indicated that the application of bioslurry in soil not only increased NO_3^-−N content of soil but also increased its plant uptake when applied in integration with mineral nitrogen fertilizers.

The increase in soil available P might be attributed to organic manure, which helped in releasing the higher amount of P from the soil. Similar results were observed by Tolanur and Badanur (2003) in pigeon pea. It was also observed that the sole application of 100% NPK resulted in lower N and available P as compared to other treatment combinations. Most crops do not take up more than 10-15% of the P added in fertilizers during the first year of application. This is due not only to the tendency of the soil to fix the added P but also to the slow rate of movement of this element to the plant roots in the soil solution (Brady and Weil, 2002). It was observed that the increased available P content of the soil with organic matter application might be due to the release of organic acids during decomposition which in turn helped in releasing P. Therefore, the application of bioslurry is expected to enhance the availability of soil P and promote the efficiency of P fertilizers. The assumptions drawn from these data lead to say that application of bioslurry alone and in combination with chemical fertilizers had contributed more than chemical fertilizers alone in building up the nitrogen, phosphorus,

Table 3: Effect of bioslurry on residual soil NPK content

Treatments	Soil nutrient content		
	N (g/kg)	**P (mg/kg)**	**K (cmol/kg)**
0.0 t/ha BS	1.02^{ab}	6.27^{e}	0.49^{f}
2.5 t/ha BS	1.36^{a}	17.50^{b}	1.28^{e}
5.0 t/ha BS	0.83^{b}	19.40^{a}	1.93^{b}
7.5 t/ha BS	1.09^{ab}	20.77^{a}	2.91^{a}
10.0 t/ha BS	1.08^{ab}	20.80^{a}	2.91^{a}
$N_{120}P_{60}K_{30}$	0.77^{b}	12.57^{d}	1.54^{c}
$N_{60}P_{30}K_{15}$ + 5.0 t/ha BS	1.07^{ab}	15.17^{c}	1.40^{d}
SE (±)	0.16	0.48	0.01

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT).

and potassium status of the soil.

3.2 Effect of bioslurry on plant height, number of leaves, and stem girth of maize

The result of plant height, number of leaves per plant, and stem girth of maize as affected by treatment application are presented in Tables 4 - 6. Plant height at 2 WAS did not differ significantly among the treatments but subsequently differ at two-week intervals (Table 4). Significantly taller plants were observed with the mineral fertilizer application at both recommended NPK and half NPK + 50 t/ha BS. The bioslurry did not influence the plant height of maize for the period of the experiment. The number of leaves per maize plant followed a similar trend to that of the plant height in which only the mineral fertilizer gave the significant effect, except at 10 WAS where 10.0 t/ha BS gave a similar value. In all the measurement times, the number of leaves per plant was minimum in control. Stem girths were thinner with control and increased with increasing treatment rates (Table 6). Significantly ($P < 0.05$) highest values were observed with the application of recommended NPK and half NPK +50 t/ha BS compared to the other BS treatment means up to 6 WAS. Further, similar values were observed except in control and 2.5 t/ha BS,

Table 4: Effect of bioslurry on plant height of maize

Treatments	Plant height (cm)				
	2 WAS	4 WAS	6 WAS	8 WAS	10 WAS
0.0 t/ha BS	29.00^{ab}	45.36^{c}	65.80	71.77^{b}	95.23^{c}
2.5 t/ha BS	31.16^{b}	67.23^{ab}	79.90^{b}	88.23^{b}	108.00^{bc}
5.0 t/ha BS	28.40^{ab}	53.90^{bc}	77.60^{b}	89.27^{b}	118.43^{bc}
7.5 t/ha BS	23.26^{b}	50.30^{bc}	70.43^{b}	90.37^{b}	117.87^{bc}
10.0 t/ha BS	38.53^{a}	65.46^{abc}	78.37^{b}	102.43^{b}	134.57^{b}
$N_{120}P_{60}K_{30}$	38.23^{a}	87.23^{a}	118.37^{a}	139.10^{a}	172.30^{a}
$N_{60}P_{30}K_{15}$ + 5.0 t/ha BS	38.26^{a}	75.23^{a}	108.07^{a}	130.50^{a}	169.33^{a}
SE (±)	5.62	10.15	11.30	9.23	15.90

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT).

which produce significantly slimmer stem girth.

Application of mineral fertilizer produced better results as compared to the sole application of the organic amendment.The promoting effect of mineral N on the growth parameters was observed with the treatments. Thiscan be explained based on the fact that readily supply of N and other nutrients increase the number of meristematic cells and their growth leading to the formation of taller shoots in addition to leaf expansion and number (Rahman *et al.* 2008).The number of leaves in all the treatments was statistically similar to each other, except with mineral fertilizers application. In general, the increase in plant height, number of leaves per plant and stem girth in the mineral fertilizer treatments compared with the bioslurry treatments might be due to balanced nutrient supply in the root zone that may have enhanced nutrient uptake of the plant for better growth. The superiority observed due to the combined application of organic and inorganic nutrient sources compared to the sole BS application and control (without fertilizer) may be due to direct promotion of root growth (Glala*et al.*, 2010) and the release of the fixed nutrients, hence increasing the concentration and

Table 5: Effect of bioslurry on number of leaves per plant of maize

Treatments	Number of leaves				
	2 WAS	4 WAS	6 WAS	8 WAS	10 WAS
0.0 t/ha BS	3.66^{a}	5.00^{b}	6.00^{b}	7.66^{d}	8.66^{d}
2.5 t/ha BS	3.66^{a}	5.00^{b}	6.00^{b}	8.33^{cd}	9.33^{cd}
5.0 t/ha BS	4.33^{a}	5.33^{b}	7.00^{b}	8.66^{cd}	9.66^{bcd}
7.5 t/ha BS	3.33^{a}	5.33^{b}	6.66^{b}	8.33^{cd}	9.00^{cd}
10.0 t/ha BS	3.66^{a}	5.00^{b}	7.00^{b}	9.66^{bc}	11.00^{abc}
$N_{120}P_{60}K_{30}$	4.33^{a}	7.66^{a}	8.00^{a}	10.66^{ab}	12.66^{a}
$N_{60}P_{30}K_{15}$ + 5.0 t/ha BS	4.00^{a}	8.00^{a}	10.00^{a}	12.00^{a}	11.66^{ab}
SE (±)	0.62	0.69	0.76	0.82	1.01

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT).

Table 6: Effect of bioslurry on stem girth of maize

Treatments	Stem girth (cm)				
	2 WAS	4 WAS	6 WAS	8 WAS	10 WAS
0.0 t/ha BS	0.047[a]	0.063[bc]	0.20[c]	0.83[c]	1.06[c]
2.5 t/ha BS	0.050[a]	0.097[b]	1.01[b]	1.09[bc]	1.29[bc]
5.0 t/ha BS	0.040[a]	0.090[bc]	1.03[b]	1.34[abc]	2.02[ab]
7.5 t/ha BS	0.043[a]	0.057[c]	1.01[b]	1.19[bc]	1.76[abc]
10.0 t/ha BS	0.050[a]	0.093[b]	1.01[b]	1.90[a]	2.46[a]
$N_{120}P_{60}K_{30}$	0.050[a]	0.173[a]	1.40[ab]	1.64[ab]	2.10[a]
$N_{60}P_{30}K_{15}$ + 5.0 t/ha BS	0.043[a]	0.140[a]	1.69[a]	1.99[a]	2.34[a]
SE (±)	4.88	0.01	0.165	0.23	0.25

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT).

availability of nutrients in the root zone that increase plant growth and development.

3.3 Effect of bioslurry on fresh and dry root and shoot weights

Effects of bioslurry application on root and shoot weights of maize are presented in Table 7. An increase in both fresh and dry root and shoot weights with increasing bioslurry rates were observed. The different slurry rates did not produce significantly different fresh and dry root mean values, but significantly ($P < 0.05$) produced lower values than the root mean values obtained with recommended NPK and half NPK + 5.0 t/ha BS treatments. Fresh shoot weight also followed a similar trend to that of root weight. The dry shoot weight of 10.0 t/ha BS was at par with the values obtained when mineral fertilizer treatments were involved, but significantly higher than all other slurry rates. The increase over the control with this rate was 83.49%.

Maximum physiological growth in terms of yield attributes was observed in the treatments that involved mineral fertilizers of recommended NPK and half NPK+5.0 t/ha bioslurry. This shows that although the slurry might have contributed nutrients to the growing plants, the readily available nutrients from the mineral fertilizers might have enhanced luxurious plant growth and biomass production. Dauden and Quilez (2004) conducted a maize yield experiment using different levels of pig slurry, and observed no significant differences in plant height or biomass yield between the different treatments, but did observe that yield decreased as the rate of slurry N increased. The observed increase in green forage yield in response to mineral nitrogen might have been due to its positive effect on cell elongation, cell division, the formation of nucleotide and coenzyme in meristematic activity, and increasing photosynthetic surface, resulting in more production and accumulation of photosynthetic compounds.

Table 7: Effect of bioslurry on root and shoot weights of maize

Treatments	Root weight (g)		Shoot weight (g)	
	Fresh	Dry	Fresh	Dry
0.0 t/ha BS	8.93[b]	2.07[b]	67.97[b]	15.93[b]
2.5 t/ha BS	9.07[b]	2.13[b]	85.77[b]	16.83[b]
5.0 t/ha BS	11.93[b]	3.30[b]	90.60[b]	19.67[cd]
7.5 t/ha BS	18.87[b]	5.10[b]	106.57[b]	21.00[b]
10.0 t/ha BS	19.17 [b]	5.30[b]	116.20[b]	29.23[ab]
$N_{120}P_{60}K_{30}$	65.27[a]	30.30[a]	278.50[a]	45.83[a]
$N_{60}P_{30}K_{15}$ + 5.0 t/ha BS	87.73[a]	16.23[ab]	280.30[a]	47.57[a]
SE (±)	12.50	5.73	30.28	6.77

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability according to New Duncan's Multiple Range Test (DMRT).

The high P content of the slurry might also have positively contributed to the biomass yield of maize.

3.4 Effect of Bioslurry on Nutrient contents and uptake by maize

Sole application of bioslurry improved N content and uptake by the plant, though not significant. Nitrogen uptake in the shoot was almost the same in all the treatments; however, the result showed a significant increase in N uptake on the application of full NPK and half NPK + 5.0 t/ha Bioslurry as compared to sole application of bioslurry and control treatments (Table 8). The highest concentration of P in the shoot was recorded from the application of full bioslurry at the rate of 7.5 t/ha, which increased by 42.85% over control. Similar to P uptake, the highest K uptake was observed at the sole application of bioslurry at the rate of 10.0 t/ha recommended and half NPK+5.0 t/ha bioslurry. However, the lowest uptake of K was observed in control. A combination of bioslurry and chemical fertilizer also proved helpful in increasing the organic matter level of the soil, thereby increase K uptake. The status of organic matter in the soil had a relationship with the quantity of nutrients available for uptake.

Application of N and P increased the levels of available N and P in the soil which in turn enhanced uptake by the plants and improved plant growth and development thereby increasing the number of nutrients assimilated by the plant tissue and in the whole plants. This result indicated that applied N increased the crop removal of all nutrients while added P had little or no effect. These facts had also been described in Brady and Weil (2002) that manure is known to influence the availability of inorganic phosphorus as organic matter influences phosphorus availability in many ways. This could be because the application of bioslurry which contains high N increased the level of available N in the soil which in turn enhances uptake by the plant and improves plant growth and development thereby increasing the amount of nutrients assimilation in the whole plant. However, the lowest content of P was observed in control.

Higher amounts of nitrogen were mineralized after the application of organic amendments that were planted available and hence increased the concentrations in maize plants. Abbasi and Anwar (2015) while working on biochar and slurry reported increased nitrogen contents in maize and wheat plants after biochar addition either alone or combined application with mineral nitrogen. Shahbaz *et al*. (2014) reported improvement in nitrogen contents of okra after the application of bioslurry. The higher concentration of phosphorus in maize plants can be attributed to the higher availability of phosphorus in soil resulting from bioslurry use. The increase in soil available P might be attributed to organic manure, which helped in releasing the higher amount of P from the soil. Similar results were observed by Tolanur and Badanur (2003) in pigeon pea. It was also observed that the sole application of recommended NPK resulted in lower available P and exchangeable K as compared to other treatment combinations. Most crops do not take up more than about 10-15% of the P added in fertilizers during the first year of application. This is due not only to the tendency of the soil to fix the added P but also to the slow rate of movement of this element to the plant roots in the soil solution. This finding is supported by Tolanur and Badanur (2003). They reported that the increased available P content of the soil might be due to the release of organic acids during decomposition which in turn helped in releasing P. Therefore, the application of bioslurry can be expected to enhance the availability of soil P and promote the efficiency of P fertilizers. The assumptions drawn from these data lead to say that application of bioslurry alone and in combination with chemical fertilizers contribute more than chemical fertilizers alone in building up the

Table 8: Effect of bioslurry on NPK content and uptake by maize

Treatments	**Dry matter (g)**	**Nutrient contents (%)**			**Nutrient uptakes (g/pot)**		
		N	**P**	**K**	**N**	**P**	**K**
0.0 t/ha BS	15.83^{b}	1.81^{d}	0.21^{c}	0.53^{c}	0.29^{d}	0.03^{d}	0.08^{d}
2.5 t/ha BS	16.83^{b}	1.91^{cd}	0.27^{b}	0.90^{bc}	0.32^{cd}	0.05^{c}	0.15^{c}
5.0 t/ha BS	19.67^{b}	2.13^{bcd}	0.27^{b}	0.66^{c}	0.42^{bc}	0.05^{c}	0.13^{cd}
7.5 t/ha BS	21.00^{b}	2.30^{bc}	0.30^{a}	1.01^{bc}	0.48^{bc}	0.06^{bc}	0.21^{b}
10.0 t/ha BS	25.33^{b}	2.50^{b}	0.29^{a}	1.31^{a}	0.63^{b}	0.07^{b}	0.33^{b}
$N_{120}P_{60}K_{30}$	45.83^{a}	3.02^{a}	0.23^{bc}	0.81^{ab}	1.38^{a}	0.11^{b}	0.37^{ab}
$N_{60}P_{30}K_{15}$ + 5.0 t/ha BS	47.57^{a}	2.98^{a}	0.26^{ab}	0.98^{a}	1.42^{a}	0.12^{a}	0.47^{a}
SE (±)	8.11	0.138	0.064	0.107	0.26	0.003	0.001

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT).

phosphorus status of the soil.

4.0. Conclusion and Recommendations

The present study showed that the application of bioslurry in conjunction with inorganic fertilizer resulted in a significant increment in plant height, number of leaves, and stem girth. However, the application of lower rates of bioslurry alone resulted in a slight increase in the number of leaves, stem girth, fresh and dry root, and shoot weights. Soil NPK content was higher at 7.5 and 10.0 t/ha BS. Bioslurry at 10.0t/ha, half NPK +5.0 t/ha BS and recommended NPK were similar in effect on plant height, number of leaves, and stem girth, but significantly superior to other treatments, Higher soil nutrient availability after application of BS can be credited to their high nutrient contents, which also increased plant height, number of leaves and stem girth. Half NPK + 5.0 t/ha BS gave significantly higher root fresh and dry weights and higher shoot fresh and dry weights. The 10.0 t/ha BS was at par with the recommended NPK and half NPK + 5.0 t/ha BS for NPK uptake. It can be concluded that the application of 10.0 t/ha and combined application of bioslurry and NPK at half the recommended rates had more significant potential to improve soil nutrient content, nutrient uptake, and growth of maize.

From the preceding discussion, it could be recommended that this experiment be replicated in the field to see the effects of the applied treatments up to grain yield. It could also be recommended that the bioslurry assay to include other properties other than the one assessed be determined. This is because the response of maize may be due to other factors other than the NPK supplied by the slurry and the fertilizers alone.

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