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Effect of different urine sources on soil chemical properties and maize yield in Abakaliki, Southeastern Nigeria

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ABSTRACT

The challenge of producing enough food to match ever increasing population demands exploring and expanding frontiers of research. Thus, this experiment was carried out to study the effect of different sources of urine on soil chemical properties and maize yield. The experiment was arranged in completely randomized design (CRD) with four treatments of control (0 kgNha^{-1}) and 100 kgNha^{-1} of human urine, cattle urine and goat urine. These treatments were replicated six times to give a total of twenty four experimental pots filled with 5 kg of soil each. The results obtained show that there was significantly (P<0.05) higher effect of different sources of urine on total nitrogen, available phosphorus and exchangeable Ca and Mg when compared with the Control. Similarly, significantly (P<0.05) higher total nitrogen was obtained under human and cattle urine treatments relative to goat urine treated pots. The results further show significant (P<0.05) differences among the different sources of urine in available phosphorus, exchangeable Ca and Mg. Organic carbon obtained in human urine treated pot was 22% each higher than the ones recorded in cattle and goat urine treated pots. There was no difference among the treatments in plant height. Significantly (P<0.05) higher maize grain yield was obtained in different sources of urine relative to the Control. Generally, human urine treatment produced taller plants (124.85 cm/pot) and gave higher yield of maize (60.2 g/pot) which were higher by 2, 8, 3, 4%; and 67, 53, 54% respectively, when compared with the Control. It is recommended that the experiment be further carried out at field trial to validate these findings.

INTRODUCTION

The challenge of producing adequate food for the ever increasing population demands exploring and expanding new frontiers of research. Our traditional approach of use of mineral fertilizer NPK as a common fertilizer in most developing countries for crop productions (Adeoluwa and Sulaiman, 2012) can no longer be relied upon especially as its use is being confronted with cost economics and unavailability when needed by farmers. Thus, there is a need to consider alternative sources of fertilizer. Urine is one of those alternatives due to the fact that it could be readily available and cheap. Every day, both human beings and animals produce urine which contains some nutrient elements that are needed in plant nutrition and can thus be used as fertilizers for plants (Adeoluwa and Sulaiman, 2012). Heinnonen-Tanski and Van wijk-Sibesma (2005) reported that these chemical elements circulate continuously in natural biogeochemical circles which constitute the only truly sustainable source of soil nutrients. As products of ecological sanitation, urine is therefore in many ways suited for use as fertilizer as they contain essential nutrients needed for plant growth. For instance, according to Marino (2008), urine contains mineral elements such as Nitrogen, Phosphorus and Potassium (NPK), Ca and Mg that are needed for plant nutrition. The composition of urine is dependent on age and ration fed to the animal (Marino, 2008).

Urine generally is usually regarded as menace or nuisance in the environment especially when poorly disposed. This is because of the inability to convert urine, an organic waste to human use in urban and peri-urban centres (Adeoluwa and Sulaiman, 2012). Improper urine disposal constitute bad odour problems in the society. These problems come as a result of accumulation of fresh urine at pH of 6.7 (Hoglung, 2001). In many cases, human urine has been actively considered as a fertilizer for use in food crop agriculture in developed countries. Gardeners in Sweden, Germany and Belgium often use urine water dilution to raise pot plants and flower bed during the growing season (Heinnonen-Tanski and Van wijk-Sibesma, 2005). It is equally possible to use pure urine for soil fertilization. Its agricultural value has been studied with Barley (*Hordeum vulgare* L.) in pot experiments (Kirchman and Peterson, 1995) and in the field (Steineck et al., 1999; Richert et al., 2002) as well as in home gardens with grass, potatoes and in different unspecified berries, vegetables and ornamentals (Malkki and Heinonen-Tanski, 1999).

In view of the current worldwide shortage of chemical fertilizers and it's anticipated adverse effect on food production, the zeal to discover and develop efficient usage of urine cannot be underscored. If urine fertilizer is done carefully at the correct time, using moderate quantity and the urine is incorporated directly (Adeoluwa and Sulaiman, 2012) into the soil, urine nitrogen has the same agricultural value as nitrogen of commercial mineral fertilizer. Barley has been found to absorb almost all urine nitrogen supplied to the soil under Swedish climatic conditions at 100 $kgha^{-1}$ for one growth period of 90-110 days (Richert et al., 2002).

There is no doubt that acceptability of use of urine as fertilizer for production of crops especially when it involves maize for human consumption might face serious social acceptance problem in some parts of the world; however, there might not be any basis for such resistance if urine used for soil fertilization is first screened free of any carrier of health hazards.

The objective of this research was to study effect of different sources of urine on soil chemical properties and maize yield under Abakaliki ecological environment.

MATERIALS AND METHODS

Experimental site

The research was conducted in 2013 at Plant and Screen House of Teaching and Research Farm, Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The area is located at latitude 06° 4' N and longitude 08° 65' E in the derived savanna of southeast agro-ecological zone of Nigeria. The area experiences bimodal pattern of rainfall which is spread from April-July and September-November of each year. There is a break in August normally referred by residents as "August break". At the beginning of rainfall, it is torrential and violent and is characterized by thunder storm and lightening. The minimum and maximum rainfalls are 1700 and 2000 mm with a mean of 1800 mm (ODNRI, 1989). The temperature during rainy season is usually low (27°C) but increases to 31°C in dry season. Relative humidity is 80% in rainy season which declines to 60% during the cold Harmattan periods and dry season of the year (ODNRI, 1989) being characteristics of tropical climate.

The soil is derived from sedimentary deposits from cretaceous and tertiary periods. According to Federal Department of Agricultural Land Resources (FDALR, 1985), Abakaliki agricultural zone lies within "Asu River" and is associated with olive brown Shale, fine grained sandstones and mudstone. It is unconsolidated within 1 m depth (Shale residuum) and belongs to the order ultisol classified as *typic haplustult*. The area was grown of short vegetation and medium to tall trees. There is also growth of native grasses, herbs and shrubs with patches of ground.

Experimental design and treatment application

The experimental design used in this study was Completely Randomized Design (CRD). Human urine of male adult was collected from researchers immediate family while cattle and goat urine was sourced from Animal Farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The urine was stored in air-tight plastic containers for 6 months before application. Urine treatments used as fertilizer was based on a mean of 4.55 gN/liter content of urine (Table1) as follows:

Human urine = 100 $LNha^{-1}$ (0.05 litre) equivalent to 100 kg Nha^{-1}
Cattle urine = 100 $LNha^{-1}$ (0.05 litre) equivalent to 100 kg Nha^{-1}
Goat urine = 100 $LNha^{-1}$ (0.05 litre) equivalent to 100 kg Nha^{-1}
Control = 0 $LNha^{-1}$ (0 litre) equivalent to 0 kg Nha^{-1}

The urine rates were applied to 5kg of soil weighed into pots two weeks after germination of maize seeds. These treatments were replicated six times to give a total of twenty four experimental pots in the experiment. The pots were watered to field capacity as often as moisture is required.

Table 1. Proximate analysis of urine.

Parameter	Human urine	Cattle urine	Goat urine
pH	9.2	9.1	9.0
Total solids (g/litre)	32	30	29
Urea (g/litre)	0.46	0.44	0.42
Ammonia (g/litre)	0.02	0.02	0.02
Total nitrogen (g/litre)	4.56	4.55	4.53
Phosphorus (g/litre)	0.04	0.04	0.03
Potassium (g/litre)	0.05	0.03	0.03
Sodium (g/litre)	0.30	0.29	0.29
Chloride (g/litre)	0.25	0.26	0.24

The pots were separated by 0.5m spaces while replicates were set 1 m apart.

Planting of maize

Maize variety (Oba super II hybrid) (*Zea mays* L.) collected from Ebonyi State Agricultural Development Programme (EBADEP), Onu Ebonyi Izzi, Abakaliki was used as a test crop. The maize seeds were planted at two seeds per hole and at 5 cm depth in each pot. Two weeks after germination (WAG), thinning was carried out to allow one plant per stand. Weeds were removed by handpicking at regular intervals till harvest.

Agronomic parameters

Plant height was measured with metric ruler from the base of plant to tallest plant leaf at tasseling. A total of twelve tagged maize plants were used for study. When the husks were dried, the cobs were harvested, dehusked, shelled and grain yield adjusted to 14% moisture content.

Sampling

Auger sampler was used to collect soil samples at 0-20 cm depth from site where soil used for experiment was collected. The samples were bulked and used for routine laboratory analysis. Samples were further collected from each pot for post - harvest chemical properties determination.

The samples were dried, ground and passed through 2 mm sieve and used to determine soil properties. Particle size distribution of the experimental soil was determined using the Bouyoucous method as outlined in Gee and Or (2002) procedure. Soil pH determination was carried out in soil/water solution ratio of 1:2.5. The pH values were read off using pH meter with glass electrode (Peech, 1965). Total nitrogen was determined using Microkjeldahl procedure (Bremmer, 1996). Available phosphorus determination was done using Bray-2 method as outlined in Page et al. (1982). Organic carbon was determined by Walkley and Black (1934) digestion method. Exchange-able bases of calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) were extracted using ammonium acetate (NH_4OAC) extraction method. Potassium and sodium was determined using flame photometer. The elements concentrations in urine were determined by Atomic Absorption spectrophotometer (AAS).

Data analysis

Data collected from the experiment were subjected to Analysis of variance (ANOVA). Means were separated using Fishers' Least Significant Difference (FLSD) as outlined in Steel and Torrie (1980). Significance was reported at 5% probability level.

RESULTS AND DISCUSSION

Composition of urine

Table 1 shows proximate analysis of different sources of urine used as fertilizer treatment. The urine compositions slightly varied from each other. Human urine had the highest values of pH, total solids, urea, total nitrogen, potassium and sodium (g/litre) compared to cattle and goat urine, respectively, although comparable. This comparable composition of elemental concentrations in animal urine could be attributed to omnivorous nature of the animals and similarity in their dietary needs.

Experimental soil

Table 2 shows the physical and chemical properties of the soil before planting. The textural class was sandy

Table 2. Soil properties before planting.

Soil properties	Value
Sand (gkg^{-1})	760
Silt (gkg^{-1})	140
Clay (gkg^{-1})	100
Textural class	Sandy loam
pH (kCL)	4.6
Total nitrogen (%)	0.07
Organic carbon (%)	0.6
Available phosphorus ($mgkg^{-1}$)	14.0
Calcium ($cmolkg^{-1}$)	1.6
Magnesium ($cmolkg^{-1}$)	0.8
Potassium ($cmolkg^{-1}$)	0.2
Sodium ($cmolkg^{-1}$)	0.1
Base saturation (%)	86

Table 3. Effect of different sources of urine on chemical properties of soil.

Source of urine	pH KCL	N%	OC%	$Pmgkg^{-1}$	Ca	Mg	K	Na
					$cmolkg^{-1}$			
Control	4.6	0.06	0.6	14.7	1.6	0.8	0.2	0.1
Human urine	4.8	0.16	0.9	28.4	4.5	1.7	0.3	0.2
Cattle urine	4.9	0.15	0.7	26.1	5.0	3.0	0.3	0.2
Goat urine	4.7	0.12	0.7	17.6	3.3	1.3	0.2	0.3
FLSD (0.05)	NS	0.03	NS	0.6	0.5	0.2	NS	NS

loam. The pH was 4.7 indicating that soil condition was extremely acidic (Landon, 1991). Total nitrogen and organic carbon were 0.07 and 0.6% and rated very low (Enwezor et al., 1981) and low according to Benchmark set by Federal Ministry of Agriculture and Water Resources (2002) for Nigerian soils. Available phosphorus is moderate (Landon, 1991). Exchangeable bases of calcium, magnesium, potassium and sodium are low (Asadu and Nweke, 1999), though calcium and magnesium dominated the exchange complex of soil. Percent base saturation was 86% and according to ratings of Asadu and Nweke (1999) for arable soils of Nigeria is high.

This shows that the soil used for the experiment was degraded in terms of fertility trend. It however, simulates most of the soils in Abakaliki agroecology used for arable crops production such as maize.

Effect of different sources of urine on chemical properties of soil

Effect of different sources of urine on chemical properties of soil is shown in Table 3. The results indicated that different sources of urine had significantly (P<0.05) higher effect on total nitrogen, available phosphorus, exchangeable Ca and Mg when compared with control. Similarly, significantly (P<0.05) higher total nitrogen was obtained under human and cattle urine treatments relative to the one treated with goat urine. Furthermore, there were significant (P<0.05) differences among the different sources of urine treatments in available phosphorus, exchangeable calcium and magnesium, respectively. Again, total nitrogen and available phosphorus recorded highest values of 0.16% and 28. 4 $mgkg^{-1}$ in human urine which are 6, 25 and 8, 38% higher compared to cattle and goat urine treated pots.

However, exchangeable Ca and Mg were 5.0 and 3.0 $cmolkg^{-1}$ higher in cattle urine treated pots and these represent 34 and 57% increments relative to goat urine treatment. Although, there were not significant differences among the treatments in pH, organic carbon, exchangeable K and Na, the values for these parameters under different sources of urine treatments were respectively higher than the control ones. Highest pH of 4.9 was obtained under cattle urine treated pot and 4% higher than the one recorded under goat urine treatment.

Similarly, the highest value of 0.9 for carbon was

Table 4. Effect of different sources of urine on agronomic parameter of maize.

Treatment	Plant height (cm)	Maize grain yield (g/pot)
Control	90.41	20.0
Human urine	124.85	60.2
Cattle urine	121.18	28.0
Goat urine	120.25	27.7
FLSD (0.05)	NS	0.8

obtained under human urine treated pot and this was 22 and 22% higher than the ones from cattle and goat urine treatment, respectively. Exchangeable cations were slightly higher in human and cattle urine than in goat urine.

The significant improvements of total N, available phosphorus and exchangeable Ca and Mg in different sources of urine treatments indicate that urine could be used as a useful fertilizer for soil treatment. Similarly, the general increase of chemical properties in pots treated with different sources of urine suggests that urine treatment can act as fertilizer by increasing soil nutrients and as a result enhances soil fertility and productivity.

These findings are supported by the report of Adeoluwa and Sulaiman (2012) that urine treatment improved soil fertility. Improvement in soil nitrogen was reported by Gutser et al. (2005) and Schonning (2001) that urine had short term nitrogen release efficiency. This was further corroborated by Adeoluwa and Cofie (2012) that urine treatment improved fertility and general conditions of soil. The significant increase in some soil chemical properties and general superior performance of human urine treatment indicates that it has more potential than other sources of urine for soil treatment. This observation had earlier been reported by Benge (2006) and supported by Adeoluwa and Sulaiman (2012) that human urine was a useful fertilizer that improved soil fertility and productivity for production of Jathropha.

Agronomic parameters of maize

Table 4 shows effect of different sources of urine on agronomic parameters of maize. Urine sources had taller maize plants compared to those of control. Human urine was 28, 3 and 4 % taller than control, cattle and goat urine.

The results further showed that there was significantly (P<0.05) higher maize grain yield in different sources of urine treated pots relative to control. Similarly, maize grain yield of human urine treated pot was significantly (P<0.05) higher by 67, 53 and 54% compared to control, cattle and goat urine treated ones, respectively.

The effect of different sources of urine on maize plant height not showing any significant difference among the treatments could be related to inherent capability of the maize plants to thrive in degraded soil (Benge, 2006). The different sources of urine released comparable amounts of nutrients, thus they were practically the same in terms of producing relatively equal plant heights. Nwite (2013) in his study of organic wastes amendments on soil reported no significant difference among treatments in grain yield of maize due to comparable release of nutrients by amendments.

The significantly higher effect of different sources of urine on maize grain yield could be attributable to improved soil conditions by urine treatments. The trend showed that urine applied as fertilizer could significantly increase maize grain yield and could be useful fertilizer alternative for maize crops. The general superior performance of human urine relative to other sources of urine in improving agronomic yield of maize is was due to high nutrients released indicating its great potential as an alternative fertilizer for crop production. Benge (2006) reported the possibility of improved performance of Jathropha with improved soil fertility resulting from human urine application. This finding was corroborated by researchers (Adeoluwa and Sulaiman, 2012, Adeoluwa and Cofie, 2012) that improvement in weights of Jathropha plants suggested that human urine could be useful fertilizer alternative for some crops.

Conclusion

The results of this study have shown that different sources of urine applied to the soil as fertilizer improved soil nutrient status and agronomic yield parameters of maize. Even though, maize plant can grow on any soil under Abakaliki agroecology, its better growth and yield can be enhanced through fertilizer application. Consequently, different sources of urine which is seen as waste and nuisance to the environment could be harvested and used as fertilizer for soil treatment. Different sources of urine increased soil pH, total N, organic carbon, available phosphorus and exchangeable cations of soil as well as maize grain yield. Human urine performed better in terms of improving soil fertility trend and as well as agronomic parameters compared to other sources.

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