Effect of Urine Sources on Some Soil Health indicators, Maize yield and Its Heavy Metals Uptake in Abakaliki, Southeastern Nigeria

Abstract:

An experiment was carried out at the Plant and Screen house to study effect of urine sources on some soil health indicators, maize yield and its heavy metals uptake. Completely Randomized Design was used with four treatments of control (0kgNha^{-1}) and 100kgNh^{-1} each of human, cattle and goat urine sources. The treatments were replicated five times to give a total of twenty experimental pots filled with 5kg of soil each. Results showed significantly (P<0.05) higher effect of urine sources on soil pH, total N and organic matter relative to control. Human urine had significantly (P<0.05) higher treatment effect on soil pH, percent total N and organic matter compared to other sources of urine. Similarly, human urine was 9-10%, 15-27%, 10-47% and 6-5% higher in number of leaves, plant height, grain yield and leaf area index when compared to those of cattle and goat urine sources. Significantly (P<0.05) higher copper uptake by maize grains was obtained in control relative to those of urine sources. Copper and lead uptake by maize grains were 20, 80, 87% and 87, 47, 7% higher in control compared to human, cattle and goat urine sources. Generally, heavy metals uptake by maize grains is below recommended safe limits for toxicity.

Key words: Effect, Maize yield, Heavy metals uptake, Urine sources, Soil health indicators

INTRODUCTION

Traditional agriculture relies heavily on mineral fertilizer NPK for crop production in Nigeria and other developing countries. Incidentally, use of fertilizer is confronted with myriads of problems such as unavailability, high cost and increase in soil acidity as well as contributing to climate change. This, therefore, makes use of fertilizer counterproductive and there's need to consider alternative sources of fertilizer. Urine is one of those alternatives due to the fact that it could be available and cheap. Everyday, both human beings and animals produce urine which contains some nutrient elements that are needed in plant nutrition and can be used as fertilizers for plants (Adeoluwa and Sulaiman, 2002). These chemical elements circulate continuously in natural biogeochemical circles which constitute the only truly sustainable source of soil nutrient (Heinnonen-Tanski and Van Wijk-Sibesma, 2005). 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, urine contains mineral elements such as Nitrogen, Phosphorus and Potassium (NPK), Ca and Mg that are needed for plant nutrition (Marino, 2008). The composition of urine is dependent on age and ration fed to the animal (Marino, 2008).

Generally, urine is usually regarded as menace or nuisance in the environment especially when poorly disposed. This arises 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 many 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 (Kichman 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 Heinnonen-Tanski, 1999).

Consequently, in view of the worldwide shortage of chemical fertilizers and its anticipated adverse effect on food production, the zeal to discover and develop efficient usage of urine cannot be over emphasized. 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 100kgha^{-1} for one growth period of 90-110 days (Richert *et al.*, 2002).

There is no doubt that acceptability of urine as fertilizer for crops production especially when it involves maize for human consumption might face serious social acceptance problem in Nigeria and in some other parts of the world, however, there might not be any basis for such resistance if urine used for soil fertilization is first screened and treated free from any carrier of health hazards. In Nigeria food crops that grow around urinals or where urine is disposed are normally eaten by human beings and animals without any complaints of health problems. The objective of this experiment was to study effect of urine sources on some soil health indicators, maize yield and its heavy metals uptake under Abakaliki agroecological environment.

MATERIALS AND METHODS

Experimental site

The research was conducted in 2014 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 by 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 thunderstorm 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 animals used were of matured age. The urine was stored in air-tight plastic containers for 6 months before application. This was to ensure proper fermentation of urine. Urine treatments used as fertilizer was based on a mean of 4.55 gN/liter content of urine (Table 1) 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.

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

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. Plant height was measured with metric ruler from the base of plant to tallest plant leaf at tasseling. Leaf area index (LAI) was determined by the formular according to Nwite *et al.* (2014).

$$LAI = \frac{\text{Leaf area } (m^2)}{\text{Ground cover } (m^2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Soil 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.

Laboratory methods

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 Micro-kjeldahl procedure (Bremner, 1996). Available phosphorus determination was done using Bray-2 method as outlined in Page *et al*. (1982). Organic matter was determined by Walkley and Black (1934) digestion method. Exchangeable bases of calcium (Ca), Magnesium (Mg), Potassium (K), and Sodium (Na) were extracted using ammonium acetate (NH_4OAC) extraction method. Potassium and sodium were determined using flame photometer. The elements concentrations in urine were determined by Atomic Absorption spectrophotometer as well as crop uptake copper (Cu) lead (Pb) using Dewis and Freitas (1976) procedure.

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 urine sources 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. Cattle and goat urine contained 0.10 (g/litre) each of copper (Cu) and lead (Pb) but was not found in human urine. The comparable composition of elemental concentrations in animal urine could be attributed to their adult age, omnivorous nature as well as similarity in their dietary needs.

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
Copper (g/litre)	-	0.10	-
Lead (g/litre)	-	-	0.10

Properties of Soil before initiation of study

Table 2 shows physicochemical properties of soil before initiation of study. Sand fraction was dominant in the particle size distribution. The textural class was sandy loam. The pH was 5.0 indicating that soil condition was strongly acidic (Landon, 1991). Total nitrogen was 0.13% and rated very low (Enwezor *et al.*, 1981) while organic matter with 2.2% value was moderate according to Benchmark set by Federal Ministry of Agriculture and Water Resources Development (2002) for Nigerian soils. Available phosphorus (20.40 $mgkg^{-1}$) was high (Enwezor *et al.*, 1989). Exchangeable calcium was of medium value (Asadu and Nweke, 1999) but magnesium, potassium and sodium were very low as recommended by Asadu and Nweke (1999) for arable soils of Nigeria. Exchangeable calcium and magnesium dominated the exchange complex of soil. Cation exchange capacity was very low (Asadu and Nweke, 1999).

This shows that the soil used for the experiment was low in fertility, degraded and simulates most soils in Abakaliki agroecology used for maize crop production as well as other crops.

Table 2. Properties of soil before initiation of study

Soil properties	Values
Sand (gkg^{-1})	750
Silt (gkg^{-1})	140
Clay (gkg^{-1})	110
Texture class	Sandy Loam
pH (H_2O)	5.0
Total Nitrogen (%)	0.13
Organic matter (%)	2.2

Available phosphorus (mgkg^{-1})	20.40
Calcium (cmol kg^{-1})	3.10
Magnesium (cmol kg^{-1})	0.92
Potassium (cmol kg^{-1})	[illegible]7
Sodium (cmol kg^{-1})	0.10
Cation exchange capacity (cmol kg^{-1})	7.50

Effect of Urine Sources on Some Soil Health Indicators

Effect of urine sources on some soil health indicators is shown in Table 3. Urine sources had significantly (P<0.05) higher treatment effect on pH when compared with the control. Human source of urine had significantly (P<0.05) higher pH than those of cattle and goat urine sources, respectively. On the other hand, human urine was 5 and 6% higher in pH than the urine from cattle and goat. Similarly, significantly (P<0.05) higher treatment effect was obtained in percent total nitrogen in human and cattle sources of urine relative to control. Furthermore, human urine showed significantly (P<0.05) higher treatment effect on percent total nitrogen compared to those of cattle and goat sources of urine. Available phosphorus obtained in different urine sources slightly varied from that of the control. The available phosphorus of human source of urine was 14% higher than control and generally marginally higher than those of cattle and goat sources of urine. There was significantly (P<0.05) higher treatment effect of urine sources on percent organic matter relative to control. Urine obtained from human and goat was significantly (P<0.05) higher in percent organic matter than the one from cattle. This represents 21 and 14% increments in percent organic matter in human and goat sources of urine compared to that of cattle source.

The significant increments of pH, percent nitrogen, organic matter and improvement of available phosphorus show that these soil health indicators were released into the soil by urine sources. This finding indicates that urine could substitute mineral inorganic fertilizer as it could be used as fertilizer to supply essential and major nutrients to soil on one land and on the other improve soil health status.

These findings are in line with the report of Adeoluwa and Sulaiman (2012) that urine treatment improved soil fertility. Improvement in percent soil total nitrogen was particularly 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 general significant increase of all soil health indicators except available phosphorus of urine sources and superior performance of human urine treatment indicates that urine sources have great potential as alternative fertilizer and more potential than other urine sources for soil treatment. This observation is supported by the report of Benge (2006) and supported by Adeoluwa and Sulaiman (2012) that human urine was a useful fertilizer that improved soil fertility and productivity. This by extension suggests that indeed, urine sources and particularly human urine could serve as useful alternative fertilizer for crop production.

The positive impacts of the urine fertilizer on soil health indicators indicate an improvement on the soil health status. The human urine source improved the soil pH keeping it within a safe range of 5.6-6.0 percent, nitrogen and organic matter at significant levels than other sources. Peverly and Gates (1973) stated that organic fertilizers perform better with some crops. This is further supported by Adeoluwa and Cofie (2012) findings that urine fertilizer improved some health indicators.

Table 3. Effect of urine sources on some soil health indicators

Treatment	pH (H_2O)	Total N(%)	P(mgkg^{-1})	OM(%)
Control	5.1	0.10	25.60	1.05
Human urine	6.0	0.14	29.65	1.76
Cattle urine	5.7	0.12	28.24	1.40
Goat urine	5.6	0.11	28.30	1.62
FLSD(0.05)	0.1	0.02	NS	0.05

P – Available phosphorus, OM(%) – Percent organic matter, N(%)-Percent Total nitrogen.

Effect of Urine Sources on Agronomic Yield of Maize

Table 4 shows effect of urine sources on agronomic yield of maize. Urine sources had higher number of leaves, plant height, taller maize plants and larger leaf area when compared with the control, respectively. Human urine source was 9-10%, 15%-27%, 10-47% and 6-5% higher in these maize agronomic yield than those of cattle and goat urine sources. The effect of urine sources not having any significant effect on agronomic parameters of maize could be linked to inherent capability of the maize plant to thrive in degraded soil (Benge, 2006). It could also be due to release of comparable amounts of nutrients; thus, they were practically the same in terms of producing relatively equal maize agronomic parameters. The generally higher agronomic yield of maize in urine sources relative to control could be attributed to improved soil health status by urine treatment. This showed that urine applied as fertilizer could increase agronomic yield of maize as well as useful fertilizer alternative for maize crops production. The superior performance of human urine source relative to other sources of urine in increasing agronomic yield of maize was due to its inherent high nutrients (Table 1) in first place and its ability to release same into the soil indicating its great potential as an alternative fertilizer for crop production. Benge (2006) had earlier reported the possibility of improved performance of Jathropha with improved soil fertility resulting from human urine application. This result was corroborated by researchers (Adeoluwa and Sulaiman, 2012) that improvement in weights of Jathropha plants suggested that human urine could be useful fertilizer alternative for some crops.

Table 4. Effect of urine sources on agronomic yield of maize

Treatment	**No of leaf**	**Plant height (cm)**	**Grain yield (g/pot)**	**LAI**
Control	11.2	58.12	2.0	0.60
Human urines	13.4	85.08	4.2	0.66
Cattle urine	12.2	72.14	3.8	0.62
Goat urine	12.0	61.98	2.2	0.63
FLSD (0.05)	NS	NS	NS	NS

LAI – Leaf area index.

Effect of Urine Sources on Heavy Metals Uptake by Maize Grains

Effect of urine sources on heavy metals uptake by maize grains is shown in Table 5. The result showed significantly (P<0.05) higher effect of copper uptake by maize grains in control compared to urine sources of human, cattle and goat. This accounted for 20, 80 and 37% increments of copper uptake in maize grains in control respectively when compared to human, cattle and goat sources of urine. Lead uptake by maize grains was 87, 47 and 7% higher in control relative to human, cattle and goat sources of urine.

The significantly higher copper uptake by maize grains grown in control plot compared to those grown in urine sources treated plots could be attributed to inputs from soil rather than urine fertilizer. Analysis of urine sources indicated very low presence of copper and lead (Table 1). The same trend of higher Cu uptake by maize grains was shown by control in Pb uptake by maize grains compared to those obtained under urine sources treatment. These findings show that urine could be used as fertilizer for crop production without placing man at a risk of ecotoxicity of heavy metals. This finding could be attributed to improved health status of soil (Table 3) and low presence of heavy metals in urine sources. The likelihood of heavy metals to build up in soil amended with urine fertilizer appears to be higher in soils treated with goat and cattle urine than human urine. Adewole *et al*. (2008) reported heavy metal uptake by crops in their work and noted that these heavy metals were stored in crop parts. Anikwe and Nwobodo (2002) and corroborated by Asadu *et al*. (2008) in their findings observed that human beings were at risk of heavy metals toxicity if they could utilize crops grown around areas contaminated with heavy metals due to eco-toxicity. This could be possible through recycling of heavy metals through food chain. Heavy metal of lead has the capacity to cause brain, renal or reproductive disorders in human beings. The heavy metals of copper and lead are below 0.0-2.0 and 0.01 rated as medium to low (LASEPA, 2005) values and far below 0.0-5.0 (WHO, 1996) or 2-1500 and 2-300 recommended as normal by Alloway (1990). However, the interesting result is that heavy metal uptake by maize grains could not be linked to urine treatment of soil.

Table 5. Effect of urine sources on heavy metals uptake by maize grains

Treatment	→ **mgkg^{-1}** ←	
	Cu	**Pb**
Control	0.30	0.30
Human urine	0.04	0.04
Cattle urine	0.24	0.16
Goat urine	0.06	0.28

FLSD (0.05)	0.05	NS

Conclusion

This study has shown that urine sources could improve soil health status and serve as useful alternative fertilizer for maize crop production. Urine sources significantly improved soil health indicators. Agronomic parameters responded positively to improved soil health status and performed better in urine sources than control. Perhaps, the greatest beneficial aspect of use of urine as fertilizer is low input of heavy metals which keep them below safe limits and without any danger of eco-toxicity. In view of its superior performance over other urine sources, human urine could be harvested for treatment of soil for higher productivity rather than be allowed to be wasted through improper disposal.

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