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

Abstract:

The need to find alternative to inorganic fertilizer which is costly and not easily affordable to local farmers necessitates research in rare areas. Thus, this 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 in laying the experiment. 20kg of sieved soil was treated with different urine sources replicated five times. The result indicates that soil pH, total N and organic matter were significantly ($P<0.05$) higher in different urine sources than 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 respectively higher by 20, 80, 87% and 87, 47, 7% in control when compared to human, cattle and goat urine sources. Generally, heavy metals uptake by maize grains is below recommended safe limits for toxicity. Urine from adult animals is recommended as credible alternative for improvement of soil health status and sustainable productivity.

Key words: effect, heavy metals uptake, indicators, maize yield, soil health, urine sources.

INTRODUCTION

Traditional agriculture relies heavily on mineral fertilizer NPK for crop production in Nigeria and other developing countries (Nwite, 2015) and incidentally, use of fertilizer is confronted with problems of unavailability, high cost and increase in soil acidity. As a result, use of fertilizer is considered to be counterproductive and there is need for its alternative source. This alternative source is urine since it is easily affordable as it could be accessed from livestock and man. It has been reported by Adeoluwa and Sulaiman, (2002) that urine contains useful nutrients which if carefully harnessed could sustain soil health status and increase its productivity. Well preserved urine has good quality and could have the same effect as inorganic fertilizer in optimizing soil fertility status (Nwite, 2015). Research shows that urine contains major nutrients including nitrogen, phosphorus, potassium as well as calcium and magnesium which is dependent on age and feed of the animals (Marino, 2008).

When there is no planned disposal of urine it naturally constitutes health hazard due to its pungent odour which could be curtailed through its proper treatment and conversion in treating soil for higher productivity (Nwite, 2015). This offensive odour is attributed to freshly accumulated urine at pH of 6.7 (Hoglung, 2001). Researchers (Heinnonen Tanski and Van Wijk-Sibesma, 2005; Kichman and Peterson, 1995; Steineck *et al.,* 1999; Richert *et al.,*2002; Malkki and Heinnonen-Tanski, 1999) have shown that human urine source was successfully used as fertilizer in crop production and raising flowers in Europe and other countries. Confirmatory studies have been carried out using Barley and under crop and field trials or even under home gardening (Richert *et al.,* 2002).

With the wide spread scarcity of inorganic fertilizer and its associated problems in food production, there is need for alternative source. If appropriate quantity of urine is applied to the soil at right time, its nitrogen contents could have the same value as that of inorganic fertilizer (Adeoluwa and Sulaiman, 2012). For instance, 100kg N per hectare of urine improved Barley production between 90 – 110 days of planting in Sweden (Richert *et al.,*2002).

Naturally, human being could not easily accept food crops produced with urine due to suspicion of its health hazard status and safe for consumption. This, however, could be overcome by treating urine for quality assurance and safe from health hazards (Nwite, 2015). 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 between latitude (06° 4′N and 08° 65′E) in the South-Eastern 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 lightning. 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 prison inmates while cattle and goat urine was sourced from Cattle and Goats' market located at Gariki and Hossana, Abakaliki respectively. This was to reduce the time needed to collect enough quantity of urine for the study. Plastic containers of 5litres each were provided to both prison and Animal attendance for the purpose of collection of urine. The animals used were of matured age. The choice of these animals was based on ease of accessibility since every farming family in the locality can afford to keep them. These animals too are omnivorous and have common feeding habit at adult age. The urine was stored in air-tight plastic containers for 6 months before application to ensure sanitation process. The urine treatments were based on hectare equivalence of 20kg soil.

Human urine = 50,000 $mgha^{-1}$ equivalent to 100 $mgkg^{-1}$ soil

Cattle urine = 50000 $mgha^{-1}$ equivalent to 100 $mgkg^{-1}$soil

Goat urine = 50000 $mgha^{-1}$ equivalent to 100 $mgkg^{-1}$ soil

Control = 0 $mgha^{-1}$ equivalent to 0 $mgkg^{-1}$ soil

The urine rates were applied to 20kg of soil weighed into perforated polybags two weeks after germination of maize seeds. These treatments were replicated six times to give a total of twenty four experimental polybags in the experiment. The polybags were watered to field capacity as often as moisture is required. The polybags 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 ten maize plants were randomly selected and tagged 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.

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, air dried and passed through 2mm sieve and used for routine laboratory analysis. Samples were further collected from each polybag for some post-harvest chemical properties determination.

Laboratory methods

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 compositions of 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 some major nutrients and heavy metals composition of urine source. There were variations in values of nutrients and heavy metals in urine source. Nevertheless, human urine have highest values of nutrients when compared to livestock sources although, comparable. Cattle and goat urine contained 0.10 $mgkg^{-1}$ 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. Compositions of some major nutrients and heavy metals in urine sources

Parameter	Human urine	Cattle urine	Goat urine
pH H_2O	9.1	9.0	8.9
Ammonia $mgkg^{-1}$	0.01	0.01	0.01
Nitrogen %	4.54	4.52	4.51
Phosphorus $mgkg^{-1}$	0.04	0.03	0.02
Potassium $cmol/kg^{-1}$	0.05	0.03	0.03
Sodium $cmol/kg^{-1}$	0.29	0.28	0.28
Copper $mgkg^{-1}$	-	0.10	-
Lead $mgkg^{-1}$	-	-	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 which indicates strongly acidic soil (Landon, 1991). Nitrogen was 0.13% and according to Enwezor *et al*. (1981) is very low and organic matter which had 2.2% value was moderate using Benchmark of FMAWRD (2002) for Tropical soils. Phosphorus (20.40 $mgkg^{-1}$) was high (Enwezor *et al*., 1989). Exchangeable calcium was of medium value but magnesium, potassium and sodium were very low (Asadu and Nweke (1999). Cation exchange capacity recorded very low values (Asadu and Nweke, 1999). It implies that the soil was of low fertility status as obtained in Abakaliki areas for soils used for maize 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}	0.17
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. Soil health indicators are used in this study to indicate parameters that are determinant of soil fertility status. 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 used as fertilizer improved soil health status. Several researchers (Gutser *et al.*, 2005; Schonning, 2001; Adeoluwa and Cofie, 2012) reported positive impact of urine on nitrogen which increased and sustained soil fertility. Higher significant positive effect of human urine source on soil health indicators suggests that it could be more superior to other urine sources in improving soil health indicators (Nwite, 2015). This finding had earlier been reported by Benge, (2006) and Adeoluwa and Sulaiman (2012). This implies that urine sources especially 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, 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	5.1d	0.10b	25.60	1.05d
Human urine	6.0a	0.14a	29.65	1.76a
Cattle urine	5.7b	0.12b	28.24	1.40a
Goat urine	5.6c	0.11b	28.30	1.62b
FLSD(0.05)	0.1	0.02	NS	0.05

P – Available phosphorus, OM % – Percent organic matter, N % -Percent Total nitrogen. Treatment means with different letters indicate significant differences ($P<0.05$).

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 and taller maize plants when compared with the control, respectively. Human urine source was 9-10%, 15%-27%, and 10-47% higher in these maize agronomic yields 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 (Benge, 2006). Results in Table 1 did not show much variations on nutrients compositions and this could have influenced 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 by implication underscores the usefulness of urine as credible of alternative to inorganic fertilizer for sustenance of soil fertility status and in increased maize production that is safe for human consumption. Human urine increased agronomic yield of maize due to its high nutrients (Table 1) and its ability to release same into the soil. Benge (2006) and Adeoluwa and Sulaiman (2012) pointed out that human urine increased soil fertility and Jathropha production.

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

Treatment	**No of leaf**	**Plant height (cm)**	**Grain yield (g/pot)**
Control	11.2	58.12	2.0
Human urine	13.4	85.08	4.2
Cattle urine	12.2	72.14	3.8
Goat urine	12.0	61.98	2.2
FLSD (0.05)	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	0.30a	0.30
Human urine	0.04a	0.04
Cattle urine	0.24b	0.16
Goat urine	0.06c	0.28
FLSD (0.05)	0.05	NS

Cu – Copper, Pb – Lead, Treatment means with different letters indicate significant differences from each other (P<0.05).

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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