Nigerian Journal of Biotechnology and Life Sciences
ISSN: 2814-0281
Vol. 3 No 2a (2026) p. 334 - 342
http://www.njbls.fud.edu.ng/
Original Research Article

Assessment of Fertilizer Activity of Human Urine and Wood Ash on Growth of Amaranthus in a field Experiment, Bayero University Kano.

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https://doi.org/10.67601/njbls.v3i2a.56

Article into

Date received
06/08/2026
Date accepted
18/08/2026
Available online
11/09/2026

Keywords

Nutrient recycling, Plant growth, Soil amendment, Sustainable agriculture.

Abstract

As response to poor soil quality or low nutrient levels of our soil, the application of conventional fertilizer to boost yield became very popular with farmers in Kano State particularly. Prohibitive cost and adulteration are some of the challenges of fertilizer use. In rural areas, some farmers resort to the use of household waste largely composed of compounds of ashes and decayed food materials. In this study, the effectiveness of urine and *Anogeissus leiocarpa* ash was tested on common spinach, *Amaranthus* in a field experiment. Urine was selectively collected, stored in a plastic jerry can for 60 days. The dry wood of *Anogeissus leiocarpa* was combusted to ash. Some of the concentrated urine was diluted by distilled water to 50%. 50% and 100% concentrated urine showed different performance on growth (plant height) of *Amaranthus*. By the 7th week of the test, the performance of 50% concentrated urine was better than 100% concentrated. The mean height of the plant for 50% was 31.3cm while for 100% it was 26.3cm. The treatment with 400g and 200g of wood ash recorded mean values of 18.68 and 19.50 respectively. The difference observed by these two test materials was not significant. The main finding of this study is that 50% concentrated urine is more effective in promoting growth (plant height) in the plant *Amaranthus*. In conclusion, both test materials, urine and wood ash are potential plant growth promoting compounds compared to control thus acting as fertilizers. However, further investigation is required to determine the most effective concentration level of urine as well as ash on vegetables and other crop plants.

Introduction

The worldwide demand of NPK fertilizer is increasing through the years and is caused mostly by population and economic growth, agriculture productions, demand and the government (FAO, 2008). The increase in fertilizer demand leads inevitably to the instability of its price. Insufficient fertilizer application causes low yields of agricultural productions, especially in developing countries, where majority of the farmers are poor and therefore cannot afford chemical/industrial fertilizer when needed (Sene, 2013). Human urine is a natural resource and it is available in all societies even the poorest ones (Rajani et al., 2015). Urine contains rich plant nutrients since the human kidney is the main excretory organ and it contains most of the nutrients that are present in human food which have not been utilized for new cell growth and energy consumption.

The chemical composition of human urine usually depends on the time of the day, diet, climate, physical activity and body size (Sullivan & Grantham, 1998). In general, urine contains water and plant nutrients in water-soluble form (Nagyl & Zseni, 2017). Human urine carries very low levels of pathogens and it contains significant amounts of major plant fertilizing nutrients: nitrogen (N), phosphorous (P), potassium (K), Calcium (Ca), Sulfur (S) and Magnesium (Mg) (Esrey et al., 2001). Because of the high level of nutrients together with low levels of pathogens human urine is a potential candidate that is used as liquid fertilizer.

Urine contains most of the excreta's nutrients and is normally bacteria less. If microorganisms are present in urine, they usually die off quickly and do not pose any danger to further utilization of urine as soil fertilizer. Urea is the main nitrogen component present in human urine. About 70-90% of N is excreted as urea the remaining being in form of either ammonia or creatine (Lentner, 1981). The macronutrients such as nitrogen, phosphorous and potassium are regularly required for plant nutrition in large amounts than micronutrients (Jonsson et al., 2004). The phosphorus and potassium contents in urine are nearly 95-100% in organic form (Lentner, 1981). Urine can be considered as an almost perfect nutrient solution: nitrogen is mainly in form of urea, phosphorous as superphosphate and potassium in ionic form what is useful for plants.

In addition, urine contains micronutrients that are in a well-balanced way (Nagyl & Zseni, 2017). It is important to study the use of urine as fertilizer with different crop plants because of their different nutrient requirement and the variation in the nutrient content in urine. Urine has been and is presently used in agriculture as fertilizer for a diverse range of fruits and vegetables in many areas of the world (Pearson, 2007). Urine can be applied either undiluted or diluted, depending on the target. Although, the diluted form is more favourable because it has more advantages (Huuhtanen & Laukkanen, 2009).

Urine application brought about similar plant growth characteristics as compared to those using mineral fertilizers (Pradhan, 2007) or it led to enhanced plant height and leaf length in maize (Guzha, 2005). Similarly, test on tomatoes (Adamsson, 2000), red beet (Pradhan, 2010a), pumpkin (Pradhan, 2010b), maize (Mnkeni, 2008) and okra crops (Idiok, 2012) showed very similar results, all reporting an increased plant biomass as compared to no fertilization and a yield comparable to or higher than that from mineral fertilizers. Hence, there is a need to consider other sources of fertilizer. Urine is one of those alternatives due to the fact that it could be readily available and cheap (Nwite, 2015).

Application of urine can be scheduled as frequently done with nitrogen fertilizers. Any preparation of urine fertilization must take the transportation into account (Dubey et al., 2016). When compared with common fertilizers, the nutrient density of urine is low. Urine should be applied according to the needs of the plants, the risk of negative effects to plants or human beings is considered low if urine is spread on agricultural land at levels that are corresponding to the plant's needs (Richert et al., 2010). Good availability of nutrients is important in the early stages of cultivation, though once the crop enters its reproductive stage nutrient uptake reduces. From a health perspective this is good since the increased time between application and harvest decreases risk of pathogen transmission (Richert et al., 2010).

The annual amount of urine and faeces of an individual consists of equal amount of nutrients and more than what is required to grow grains for one person's annual food requirements (Malkki, 1995). Based on research/experiments in Sweden and Finland, it was reported that the most appropriate substitute to the use of artificial fertilizer is usage of human urine in agriculture (Nagyl & Zseni, 2017). The recovery of nutrient circle should be traced back to ancient times (Huuhtanen & Laukkanen, 2009). Human urine contains very few, if any, pathogens but contains the majority of plant fertilizing nutrients. This high nutrient, low pathogen combination means that urine can be used very easily and safely to increase the yields of food crops.

Wood ash is the inorganic and organic residue from wood combustion and it has been confirmed to be a good source of potassium, phosphorus, magnesium, calcium and the micronutrients (Kakier & Summer, 1996; Demeyer et al., 2001; Saarsalmi et al., 2001). The generated wood ash is alkaline in nature and it contains essential nutrients that are needed for growth of different plant species. Commercial lime has the same liming effect as wood ash as indicated by previous studies and in several studies wood ash had been compared to traditional limestone, the result had confirmed wood ash to give better plant growth responses than limestone because of the additional nutrients that the ash contained (Roger & Sharland, 1997; Awodun et al., 2007).

Although wood ash is deficient in nitrogen (N), it comprises of oxides and hydroxides of basic cations such that its soil application in agriculture raises soil pH, a process which increases the availability of nutrient such as phosphorus (P) (Karki, 2002). In Nigeria, crop production is closely tied to the application of organic and chemical fertilizers. However, inadequate supply, cost, adulteration and insufficient knowledge and skills of fertilizer use constitute a serious limitation. The knowledge of urine as a source of nutrients such as nitrates/nitrogen, phosphates and others provide opportunity for exploration and adoption to complement crop production at local level.

Material and Methods

Study Area

The field experiment was conducted at the botanical garden of the Faculty of Life Science, Department of Plant Biology, Bayero University Kano in the North Western region of Nigeria having a tropical savannah climate. It is located at latitude 11.98°N and longitude 8.48°E and it is 484m above sea level. The area has a mean annual total rainfall of 696.4mm and mean annual temperature range from 26℃ to 32℃. The garden is not covered but it is shaded with trees.

Experimental Design and Treatment

The experiment was laid out in a completely randomized block design using 36 pots with three treatments in a 2kg pots arranged in the garden having an area of 2.97m^2. The treatment consisted of different concentration of urine and wood ash as fertilizer with control for each treatment (T_0: Control/ non-fertilized treatment, T_1: 100% urine, T_2: 50% urine, T_3: 400g wood ash and T_4: 200g wood ash). The pots were spaced at 30cm horizontally and 15cm vertically. Each treatment was replicated eight times and control had 4 pots, giving a total of 36 experimental pots. The pots were administered distilled water (for control), different concentration for urine and then wood ash. Urine should be handled in closed tanks and containers. It should be applied directly onto the soil and not on the plant in N-doses that is equivalent to what is recommended for urea and ammonium fertilizers. In the small scale, the use plastic watering cans are suitable for spreading the urine, while in larger scale, spreaders for slurry are suitable. In order to minimize ammonia losses air contact should be avoided and the urine should be incorporated into the soil as soon as possible (Richert et al., 2010).

Urine Collection

The urine was collected from volunteer female students of Nana Hall residence, Bayero University Kano. Urine samples were placed in a 10L containers. The urine was later stored for about 2 months at a temperature of 25.14℃. Storage is employed to raise pH and kill potential pathogens in the urine as reported by Lahr et al., (2016) and Goetsch et al., (2018). The urine was subjected to the laboratory for determination of chemical composition among others.

Wood Ash Collection

The wood ash was collected from household at Rijiyan Zaki a settlement along Gwarzo road, urban Kano. The wood ash was obtained from burnt wood of African Birch tree (*Anogeissus leiocarpa*) commonly known as “chew stick tree” or “Marke” in Hausa. The collected ash was air dried, sieved through a 2mm sized mesh and stored in a 120ml specimen container (Kendall Precision). The ash was also taken to the laboratory for the determination of chemical properties.

Soil Sample Collection

The soil sample that was taken from the botanical garden of the Department of Plant Biology was that of sandy loam. The soil was air dried, sieved through a 2mm sized mesh and stored in a 120ml specimen container which was taken to the laboratory for determination of chemical properties among others. The same soil type was used in the cultivation of *Amaranthus.*

Plant Height

A meter rule was used to take the height of a tagged plant in each pot for 7 weeks. The height was measured from the ground level to the base of the highest fully expanded leaf as described by Omary (2013) and Abubakar (2015).

Number of Leaves

Leaves of a tagged plant in each pot were counted for 7 weeks. Leaves were counted manually based on Igboro et al. (2015).

Data Analysis

Data obtained were subjected to one-way Analysis of Variance (ANOVA) using SPSS version 16 with values for $p < 0.05$ considered significantly different. Results were presented in tables.

Results and Discussion

Results

In table 1, four parameters were measured in the soil. The pH, electrical conductivity, moisture content and water holding capacity were determined with values of 4.03, 0.02, 0.20, and 50 respectively.

Table 1: Mean values of Parameters of Soil Sample used for the Study, 2021

Soil Parameters	Mean values
pH	4.03
EC (dS/m)	0.02
M.C (%)	0.20
W.H.C (%)	50

Table 2 shows the analysis of wood ash used for the experiment. The parameters determined were pH, EC, M.C, Calcium, Magnesium, Potassium and Phosphorus in varying concentration.

Table 2: Mean values of Parameters of Wood ash Sample Used for the Study, 2021

Parameters	Mean Values
pH	11.30
EC (dS/m)	16.06
M.C (%)	0.60
Ca	1.4×10^{5} (mg/kg)
Mg	2.0×10^{4} (mg/kg)
K	1.9×10^{4} (mg/kg)
P	6.2×10^{3} (mg/kg)

Table 3 shows the parameters determined from the urine used for the study: pH, EC, potassium, phosphates, calcium, magnesium and urea in varying concentration.

Table 3: Mean values of Parameters of Urine Sample used for the Study, 2021.

Parameters	Mean Values
pH	8.70
EC ($\mu S/cm$)	8400
Urea (mg/dL)	10.44
Potassium (mg/dL)	769.53
Phosphate (mg/dL)	129.13
Calcium (mg/dL)	0.31
Magnesium (mg/dL)	1.35

Table 4 indicates the mean plant height of *Amaranthus* treated with human urine and wood ash for 7 weeks of the field experiment.

In table 5, it shows the statistical analysis of plant height of *Amaranthus* treated with human urine and wood ash for the total weeks of the field experiment.

Table 6 shows the mean number of leaves for the treatments for 7weeks which was obtained during the field experiment.

In table 7 it shows the statistical analysis of number of leaves of *Amaranthus* treated with human urine and wood ash for the total week of the field experiment.

Table 4: Mean Values of Plant Height (cm) of *Amaranthus* Treated with Human Urine and Wood ash

Treatment	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week
50% urine	5.1	6.5	8.0	9.3	13.8	24.1	31.3
100% Urine	4.5	5.2	5.5	5.7	13.1	15.1	26.3
200g WA	6.3	8.2	9.4	12	13.2	18.2	19.5
400g WA	5.9	8.3	10.8	12.5	14.5	16.7	18.68
Control	5.2	6.3	8.0	8.8	9.7	10.8	12.2

Table 5: Statistical Analysis One-way Analysis of Variance of Plant Height (cm) of *Amaranthus* Treated with Human Urine and Wood ash

Treatments	Mean±SD	Control	P value
50% Urine	14.02±9.5[a]	8.72±2.8[b]	0.03
100% Urine	10.76±11.6[a]	8.72±2.8[a]	0.40
400gWA	12.40±5.8[a]	8.72±2.8[a]	0.18
200g WA	12.46±4.4[a]	8.72±2.8[a]	0.17

Means within each column followed by the same letter are not significantly different at $p < 0.05$.

Table 6: Mean Number of Leaves of *Amaranthus* Treated with Human Urine and Wood ash

Treatment	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week
50% Urine	5.4	6.3	6.9	7.9	11.5	13.9	16.7
100% Urine	4.9	5.2	6.0	5.0	7.2	10.5	14.0
400g WA	6.1	6.9	8.2	10.2	10.5	9.4	10.8
200g WA	5.3	6.3	7.0	8.5	9.0	9.4	9.5
Control	5.9	5.7	6.6	7.7	7.6	8.4	8.8

Table 7: Statistical Analysis One-way Analysis of Variance of Number of leaves of *Amaranthus* Treated with Human Urine and Wood ash (WA)

Treatments	Mean±SD	Control	P value
50% Urine	9.80±4.1[a]	7.23±1.4[b]	0.03
100% Urine	7.54±6.4[a]	7.23±1.4[a]	0.80
400g WA	8.85±1.9[a]	7.23±1.4[a]	0.22
200g WA	7.86±1.6[a]	7.23±1.4[a]	0.64

Means within each column followed by the same letter are not significantly different at $p<0.05$.

The activity of the urine and ash in different concentration on spinach (*Amaranthus*) were shown in table 1. Diluted urine to 50% showed progressive growth in plant height from week 1 to week 7. While the 100% concentrated urine showed relatively poor plant height across the test period. By the 7th week, the mean height was 31.30cm for 50% concentrated urine. While for the 100% concentrated urine, the mean plant height was 26.30cm. Similarly, 200g and 400g ash treatment showed slight difference, 19.50cm height for 200g ash and 18.70cm for 400g ash. The mean number of leaves for 50% diluted urine in the 1st week was 5.4 and 16.70 in the 7th week. While for the 100% concentrated urine the mean number of leaves was 14.0 in the 7th week. At the end of the experiment, the mean number of leaves was 10.8 and 9.50 for 400g and 200g of ash treatments respectively.

Discussion

The results of the soil analysis showed that the soil was relatively acidic. This pH is considered to be normal for the growth of *Amaranthus* which grows best under pH range of 4.0-8.0 and 5.5-7.0 as reported by Cornell (2006) and Fern (2014). While the electrical conductivity, water holding capacity and moisture content of the soil gave 0.02dS/m, 50% and 0.20% respectively.

The analysis of the wood ash is shown as can be observed in Table 2. The results showed that the ash is strongly alkaline. It can neutralize soil acidity as in the case of the soil in this study being acidic. The electrical conductivity of the wood ash gave 16.06dS/m. The moisture content of the ash gave 0.6% which is similar to that reported by Mladenov (2011). The mean values of Ca and Mg in the wood ash treatment was considerably higher than K and P. These findings collaborate with the works of Boh et al. (2013). The mean value of Ca considered to be very high makes it a liming agent. Other workers including Soretire and Olayinka (2013a; 2013b) reported similar findings. In terms of element, the mean values of Ca, Mg, K and P were higher in ash than in the stored urine. These collaborate with the reports of Germer et al. (2011), Akpan-Idiok et al. (2012) and Neina et al. (2013).

The composition of human urine is shown in Table 3. The pH of the stored human urine was alkaline. Similar alkaline condition of the urine was also reported by Akpan-Idiok et al. (2012) and Sakthivel et al. (2012). The electrical conductivity value of 8400μS/cm (0.84S/m or 8.4dS/m) was also described as normal by Fazl (2009). Similarly, the mean values K and P were found to be high which relates to the findings of Pradhan et al. (2012). It is evident that both the urine and wood ash have similar compounds and elements as fertilizer. Thus, their use to potentiate growth of plants is practically possible.

The activity of the urine and ash in different concentration on spinach (*Amaranthus*) were shown in table 4a and 5a. Diluted urine to 50% showed progressive growth in plant height from week 1 to week 7. While the 100% concentrated urine showed relatively poor plant height across the test period. By the 7th week, the mean height was 31.30cm for 50% concentrated urine. While for the 100% concentrated urine, the mean plant height was 26.30cm. However, the difference in mean height is not significant statistically. Similarly, 200g and 400g ash treatment showed slight difference, 19.50cm height for 200g ash and 18.70cm for 400g ash. Comparing the height of plant treated with both urine and ash with the control treatment, the difference is relatively small. Only 50% concentrated urine that produce height much higher than the control. In terms of the number of leaves, 50% showed an increase from week 1 to week 7. The mean number of leaves was 16.70 in the 7th week. While for the 100% concentrated urine the mean number of leaves was 14.0. The fewer number of leaves in the 100% concentration was expected as reported by Addis et al. (2020). The mean number of leaves was 18.68 and 19.50 for 400g and 200g of ash treatments respectively. When comparing the number of leaves of all the treatments with control, only 50% concentrated urine was significantly different at $p<0.05$. However, 50% concentrated urine showed better growth performance (number of leaves). The wood ash and the control treatment were yellowish in colour. This might be due to the absence of nitrogen and in wood ash as stated by Rona (2006). The results in this study collaborates with the reports of Pradhan et al. (2007) where cabbages grown with human urine performs better than those treated with conventional fertilizers.

Conclusion

Stored human urine and *Anogeissus leiocarpa* wood ash contain considerable amount of essential compounds such as Ca, Mg, K and P that promotes growth, plant height and number of leaves in *Amaranthus*, However, 50% diluted urine is most effective on the growth of the plant in field experiment.

Acknowledgement

My sincere appreciation goes to my supervisor Dr Ibrahim Lawal Abdullahi and all the botanical garden technicians of the department of plant biology, Bayero University Kano.

Competing Interest

There are no competing financial interest, personal relationships or affiliations that could have influenced the outcome of this experiment.

Author Contribution

Yakubu, T. M.: Conceptualization, writing, data analysis and interpretation, manuscript drafting, Abdullahi, I. L.: Supervision.

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