

INFLUENCE OF HUMAN URINE-COMPOST MIXTURE ON SOME SOIL FERTILITY PROPERTIES, YIELD AND SHELF-LIFE OF TOMATO (*Solanum lycopersicon*)

ABSTRACT

Human urine, especially if combined with composts, could be a good source of fertilizer for improving soil fertility and ultimately, crop production. Thus, the focus of this experiment was to evaluate the influence of human urine-compost mixture on post-harvest soil fertility quality, yield and shelf-life of tomato (*Solanum lycopersicon*). The experiment had six treatments: urine, compost, ~~2:1 compost + 1:2 urine~~compost: urine, 1:2 ~~andcompost + 2:1~~^[BF1]urine, NPK 15:15:15 and the control (no soil additive) laid in a Randomized Completely Block Design (RCBD) with four replicates was conducted at the experimental field of ~~the Department of Agronomy, Faculty of Agriculture and Forestry,~~ University of Ibadan, Oyo State, Nigeria. The treatments were applied at the rate of 90 kg K ha⁻¹ and the effects on soil fertility status, number of fruits, fresh and dry weights, as well as shelf-life were observed using tomato as the test crop. The urine treated soils had the highest (P<0.05) number of fruits (16.50 fruits/plant) at the end of the first ~~plantinggrowth cycle~~^[BF2]. At the end of the second ~~plantinggrowth cycle~~, urine treatment had the highest mean dry weight of 141 kg ha⁻¹, while NPK 15:15:15 resulted into the lowest yield (70 kg ha⁻¹). Thus, human urine in combination with either 1:2 or 2:1 ~~compost nitrogen is recommended as alternative to mineral fertilizer (NPK)~~^[BF3]for tomato production, for improved yield, shelf-life and soil fertility.

Key words: *Solanum lycopersicon*, human urine, fertilizer, soil fertility, wastes management

Introduction

In several communities of the world, improper disposal of human urine continues to be a menace, contributing to environmental hazards ~~and infections~~^[BF4]. ~~Toxics~~^[BF5]compounds such as nitrogen dioxide (NO₂) and ammonia (NH₃) in this waste contaminates the environment and aquatic bodies, causing ~~reasonable disorderseutrophication and bad odours~~. ~~The presence of ammonia in an untreated urine release into the atmosphere causes stench~~. However, human urine can be treated and converted to valuable agricultural uses; human urine contains plant nutrients

which are cheap and readily available, useful for improving soil fertility and increase food production [14; 21]. ~~Useful potential~~_[BF6] ~~of similar human waste excreta has been documented.~~

According to Wolghast [30], the annual amount of human ~~excreta~~_[BF7] of one person corresponds to the amount of fertilizer needed to produce 250 kg of cereal that one person needs to consume per year; thus it is possible to have good quantity of human urine as fertilizer [17] for crop production. Adewole *et al.*, [4] AdeOluwa and Sobamowo, [3] elucidate that acceptability of urine as a fertilizer is a way of increasing farmers' gross margins. Positive impact was also reported with maize [8; 23; 24]._[BF8]

Organic fertilizers are sourced from organic wastes which contain large amounts of organic matter and have advantages ~~over-compared to synthetic-mineral~~ fertilizers [13]. Examples of organic fertilizers are compost, green manure, animal manure, other agricultural wastes, plant and human waste (excreta, and urine), etc. Cofie *et al.*, (11); AdeOluwa and Cofie, [2] reported that human urine was successfully used to raise some crops like amaranths, celosia, lettuce, carrot, etc. There is an increasing research interest in the fertilizer value of human wastes, with studies focused mainly on the yield potentials [24]. Thus, there was the need to evaluate the effects of human urine on tomato production._[BF9]

Tomato (*Solanum lycopersicon*) is one of the most important vegetable crops worldwide. It belongs to the family Solanaceae, with total world production of 159 million tonnes in a cultivated area of 4.7 million hectares and an average yield of 33.6 ton ha⁻¹[12]. Nigeria is ranked 16th on the global tomato production scale, and this accounts for 10.8% of Africa and 1.2% of total world production (5). Tomato is rich in minerals, vitamins, essential amino acids, sugars and dietary fibres. It contains a high level of antioxidants such as vitamin C, polyphenols (including flavonoids) and carotene (such as lycopene and β-caroten) [15]. Human urine, compost and their mixture have been found useful as sources of fertilizers, thus the main objective of this work was to evaluate the influence of human urine-compost mixture fertilizers on postharvest soil fertility quality, yield and shelf-life of tomato fruits._[BF10]

Materials and methods

The experimental site was ~~situated-carried out~~ at the ~~back-of~~ Department of Agronomy, University of Ibadan, Ibadan, Oyo state. The experimental plots (a long term trial with human

urine fertilizer) had received the same fertilizer treatments continuously for the six years prior to this experiment and planting was done twice. The soil was loamy sand, slightly acidic to slightly alkaline, low in nitrogen, moderate in organic carbon and potassium. The materials for the experiment included: tomatoes seeds (Roma VF), compost, NPK 15:15:15^[BF11], urine (harvested from Obafemi Awolowo hall of residence, University of Ibadan, Ibadan, Nigeria and stored for 6 months in air tight plastic containers before use [29]. The experiment was laid ~~in as~~ a Randomized Completely Randomized Block Design (RCBD), with four replicates.

Table 1: Primary macronutrient composition of fertilizer treatments

Fertilizer Source	Nutrient composition (g kg ⁻¹) ¹ _[BF12]		
	N	P	K
Urine	4.8	0.1	8.7
Compost	175	11.0	8.7

Agronomic study

The planting was done in two successions between May to August, 2012 and June to August, 2013 during the rainy~~ing~~ seasons. Land clearing^[BF13] was done manually and this was followed by seedbed preparation. Each experimental ~~bed~~ plot^[BF14] was 2 m by 1 m with 0.5 m spacing in between the ~~beds~~ plots. There was a total of 24 experimental plots and land area of 79.75 m² (14.4 m x 5.5 m). Transplanting of tomato seedlings was done at four weeks after sowing, ~~at 60 cm x 40 cm spacing~~, with twelve plants per plot. The fertilizer treatments were applied at the rate of 90 kg ha⁻¹^[BF15] ~~and in a two~~ splits in two applications^[BF16], using spot application method. The compost was applied one week before transplanting, while urine and NPK 15:15:15 fertilizer was applied at two days before transplanting. The second fertilizer application was done at the on-set of flowering of tomatoes, that is, four weeks after transplanting.^[BF17] Weeding was done manually as at when due with cutlass. Composite soil samples per ~~experimental plot~~ were collected at 0-15 cm depths, ~~randomly~~, for chemical and physical soil analysis^[BF18]. The soil samples were air-dried and sieved with a 2 mm sieve. Particle size distribution was determined by hydrometer method [9], as cited by Tel and Hargaty [26], using sodium hexametaphosphate (calgon) as the dispersing agent. Soil pH was determined with a pH meter^[BF19]. Organic carbon was determined using dichromate wet oxidation method and value of organic matter was

obtained by multiplying the Organic carbon value by a factor of 1.724. Total nitrogen was determined by macro Kjeldahl procedure. Available phosphorus was extracted by the method of Bray and Kurtz[10] method and determined colourimetrically using Molybdenum blue Method, while K, Ca, and Mg were first extracted using neutral normal NH_4OAc [BF20], thereafter K was determined by flame photometry, and Ca with a Buck Scientific Atomic Absorption Spectrophotometer (AAS) model 210/211VGP. Micronutrients (Mn, Fe and Cu) were extracted with Mehlich III extractant and determined with Buck Scientific Atomic Absorption Spectrophotometer (AAS) model 210/211VGP.

Crop production parameters observed were number of fruits, fresh weight of yield (t ha^{-1}), dry weight (kg ha^{-1}), and shelf-life (number-of-days to 50% and 100% deterioration). The data obtained were analysed subjected to analysis of variance (ANOVA $\alpha=0.05$) [25]. Data on shelf-life (days) were analyzed based on Mondal's method [19].

Results

Pre-planting chemical properties of the experimental soil [BF21]

Chemical properties of the soil before the commencement of the experiment are shown in Table 2. The result revealed that the pH of the plots ranged from 6.3 - 7.4. The NPK plot had the lowest pH at first planting (6.3) and at the second planting, the pH was 6.7. The organic carbon of the experimental plots at the first planting ranged from medium to high ($15\text{--}23.22 \text{ gkg}^{-1}$), with the control plot having the highest value (23.2 gkg^{-1}), closely followed by compost plot (21.7 gkg^{-1}). The lowest organic carbon (14.9 gkg^{-1}) was obtained from NPK plots. All the fertilizers used had high organic carbon, except the NPK treated soil, which was medium. At the second planting, the values of organic carbon ranged between $0.4\text{--}2.1 \text{ gkg}^{-1}$, with compost plot having the highest value. At the first planting, all the experimental plots had total nitrogen in the range of $0.4\text{--}1.4 \text{ g/kg}$. The highest total nitrogen value was observed from 2:1 compost + 1:2 urine plot (1.4 gkg^{-1}) and the lowest value in NPK plot (0.4 gkg^{-1}). At the second planting, all the experimental plots had low nitrogen ($0.1\text{--}0.2 \text{ gkg}^{-1}$), with urine plots having the highest value. At the first planting, the exchangeable K values of the plots ranged from medium to high ($0.3\text{--}0.9 \text{ cmolkg}^{-1}$). The plots with 1:2 compost+2:1 urine (0.4 cmolkg^{-1}) and the control (0.3 cmolkg^{-1}) were medium in exchangeable K. At the second planting, all the plots were low in exchangeable K. At the first

planting, extractible Fe in the experimental soil resented was at medium range with values (60-105 mgkg^{-1}). The plot of 100% compost had the highest Fe (105 mgkg^{-1}), while that of 1:2 compost+2:1 urine had the lowest (60 mgkg^{-1}). At the second planting, the extractible Fe in the soils were within 72-105 mgkg^{-1} , with the plots of urine having the highest (105 mgkg^{-1}) and 2:1 compost+1:2 urine plot having the lowest (72 mgkg^{-1}). Extractible Mn content of the experimental soils ranged within low to medium (58 – 104 mgkg^{-1}). The control plots had highest value (104 mgkg^{-1}), while the 1:2 compost+ 2:1 urine plots had the lowest (58 mgkg^{-1}). At the second planting, the reverse was the case, with 1:2 compost+ 2:1 urine plots having the highest value of 84 mgkg^{-1} Mn and control plots the least (71 mgkg^{-1}). The experimental soils were thus low in nitrogen, moderately low in organic carbon, moderate to high in potassium and adequate in other essential nutrients at beginning of the planting seasons.

Effects of applied treatments on soil nutrient properties

The effects of the applied fertilizer treatments on post planting soils are shown in Table 3. The soil pH before commencement of the experiment (first planting) was slightly acidic to slightly alkaline: control (7.0), compost (7.4), 2:1 compost + 1:2 urine (7.3), 1:2 compost + 2:1 urine (7.3), NPK 15:15:15 (6.3) and urine (7.2). At the end of the first planting, urine, 2:1 compost + 1:2 urine and 1:2 compost + 2:1 urine plots had their pH reduced from 6.5 to 6.8, 6.6 to 7.3 and 6.4 to 7.1 respectively. The soil organic matter was increased in the treated plots; with the urine treated plots having the highest organic carbon of 3.1 kg^{-1} at the end of second planting. The plots with 1:2 compost + 2:1 urine treatment had the highest total nitrogen value (2.8 g/kg) which is above the critical range of 1.5 - 2.0 g/kg [13].

Table: 2. Pre-planting chemical properties of the soil during 2012 and 2013 planting seasons [BF22]

Treatments		O.C	N	P	K	Ca	Fe	Mn	Cu
		g/kg		mg/kg		cmol/kg		mg/kg	
	pH								
1 st Planting (2012)									
Control	7.1	23	0.5	21	0.3	3.1	97	104	1
C	7.4	22	1.2	24	0.9	2.8	105	97	1
2:1C+1:2U	7.3	19	1.4	17	0.6	2.7	98	87	1
1:2C+2:1U	7.3	19	0.8	19	0.4	2.1	60	58	0

NPK	6.3	15	0.4	14	0.7	2.8	88	95	135
Urine	7.2	21	1.2	21	0.6	2.6	90	95	1
Mean	7.1	19.83	0.92	19	0.6	2.7	90	89	1
SD	0.40	2.86	0.41	4	0.2	0.3	16	16	1
2 nd Planting (2013)									
Control	7.0	1.3	0.1	27	0.2	2.9	90	71	2
100%C	7.1	2.1	0.1	36	0.2	4.9	95	81	2
2:1C+1:2U	6.9	1.3	0.1	15	0.1	4.4	72	82	1
1:2C+2:1U	6.6	0.4	0.1	20	0.2	3.8	95	84	2
NPK	6.7	0.4	0.1	16	0.2	2.9	85	79	2
Urine	6.6	1.7	0.2	24	0.1	3.1	105	78	2
Mean	6.8	1.20	0.12	23	0.2	3.7	90	79	2
SD	0.2	0.69	0.04	8	0.1	0.8	11	5	0

SD: standard deviation

Legend:

C= Ccompost

2:1C+1:2U= 2:1 compost + 1:2 urine

1:2C+2:1U= 1:2 compost + 2:1 urine

U= urine

Table: 3. Post-Planting chemical properties of the soil during 2012 and 2013 planting seasons

Treatment		O.C	N	P	K	Ca	Fe	Mn	Cu
		g/kg		mg/k g		cmol /kg		mg/k g	
pH									
1 st Planting (2012)									
Control	6.6	11.6	2.2	36	0.3	3.7	568	467	5
100%C	6.5	14.3	1.9	37	0.4	3.5	706	578	5
2:1C+1:2U	6.6	12.8	2.2	34	0.4	3.3	698	479	6
1:2C+2:1U	6.4	11.3	2.8	24	0.3	2.4	613	379	4
NPK	6.5	10.2	2.1	33	0.5	3.2	640	516	5

Urine	6.5	9.9	1.7	31	0.3	3.7	545	483	4
Mean	6.5	11.7	2.2	33	0.4	3.3	628	484	5
SD	0.1	1.7	0.4	5	0.1	0.5	66	65	1
2 nd Planting (2013)									
Control	7.0	1.6	0.1	30	0.2	4.4	100	77	1
100%C	7.4	1.6	0.1	48	0.5	11.0	214	90	1
2:1C+1:2U	7.3	1.1	0.1	28	0.3	4.1	152	88	1
1:2C+2:1U	7.1	1.1	0.2	28	0.4	3.9	149	87	1
NPK	6.9	1.3	0.1	38	0.2	11.7	242	95	1
Urine	6.8	3.1	0.1	51	0.2	10.7	175	105	2
Mean	7.1	1.6	0.1	37	0.3	7.6	172	90	1
SD	0.2	0.8	0.0	10	0.1	3.9	51	9	0

SD: standard deviation

Legend:

100% C: 100% compost

2:1C+1:2U: 2:1 compost + 1:2 urine

1:2C+2:1U: 1:2 compost + 2:1 urine

U: urine

Response of tomato to urine and its compost mixtures

The result of the yield parameters revealed that the plants performed better on performances of the organic fertilizers than on sources on the plant, compared to the mineral fertilizer (NPK). At the end of the first planting, the urine treated plots produced the highest significantly higher (P<0.05) number of fruits (16.50/plant) than ? [BF23], while the least lowest number of fruits (3.25/plant) was recorded in the control treatment [BF24]. At the end of the second planting, 2:1 compost + 1:2 urine treatment led to had the highest number of fruits (17.4/plant), while the least lowest number was recorded in the control treatment (3.07/plant) (Figure 1). [BF25] Detailed results presented in Figure 1.

The [BF26] 1:2 compost + 2:1 urine treated plants had the highest fresh fruit weight (1.76 t ha⁻¹), while the lowest fresh fruit weight was recorded by NPK and the control (0.5 t ha⁻¹); (Figure 2). Similarly, at the end of the first planting (Figure 3), the 2:1 urine + 1:2 compost treatment resulted into the highest significantly higher (P<0.05) mean dry weight (834 kg/ha) than ?, while

the control plots (no soil additive applied) recorded the lowest ~~yield~~ mean dry weight (149 t ha^{-1}). The 2:1 compost + 1:2 urine treated plots had ~~the highest~~ significantly higher ($P < 0.05$) mean fresh weight of 246 g/fruit (13 t ha^{-1}) ~~than ?~~. At the end of second planting, urine treatment had ~~the highest~~ significantly ($P < 0.05$) mean dry fruit weight (142 kg ha^{-1}) ~~than ?~~, while the NPK plots had the lowest (25 t ha^{-1}).

The results of the effects of fertilizer treatments on shelf-life of tomato fruits is shown in Figure 4. At days-to-50% deterioration, the treatments with compost and 2:1 compost + 1:2 urine (37.3 days) performed better ~~than compared to~~ NPK treatment (13.3 days) and the control treatment (11 days) at the first ~~planting~~^[BF27]. A ~~S~~ similar trend was recorded at the second planting.

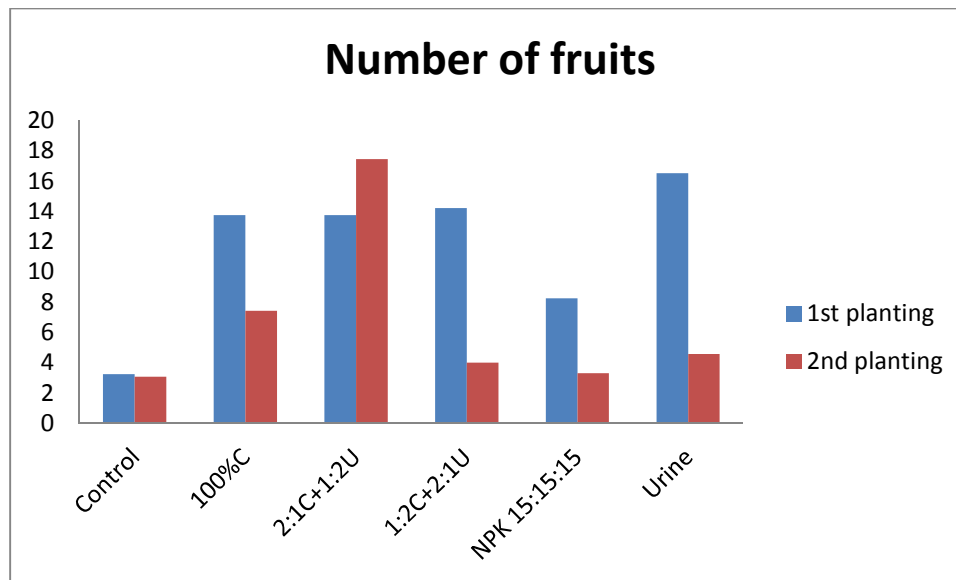


Fig. 1 Effects of treatments on number of fruits.

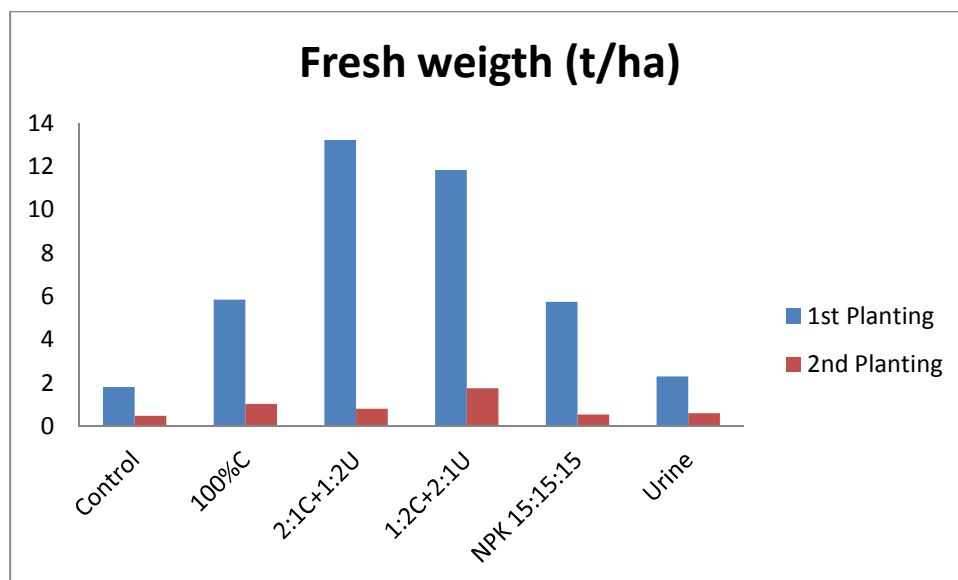


Fig. 2 Effect of treatments the fresh weight of tomatoes

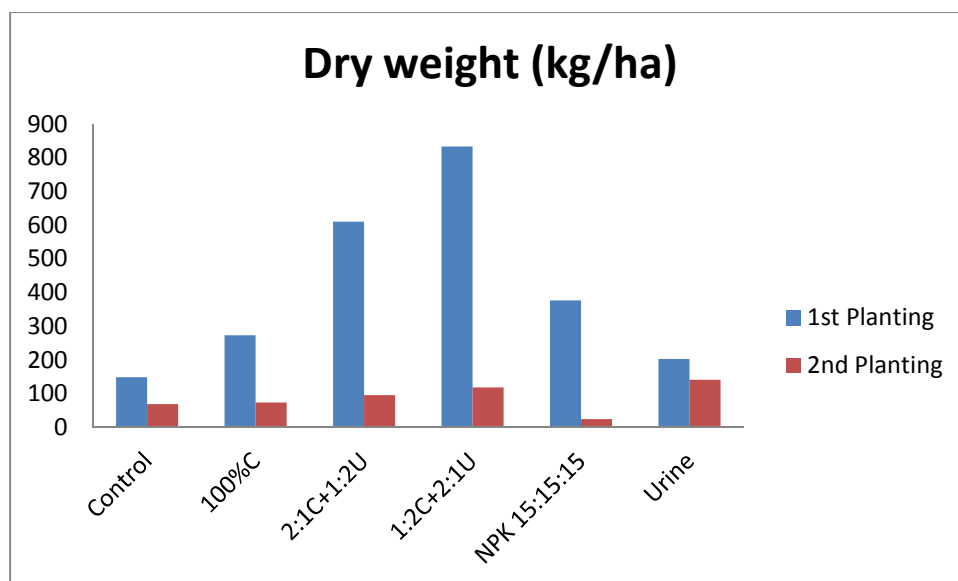


Fig. 3 Effect of the treatments on the dry weight of tomatoes

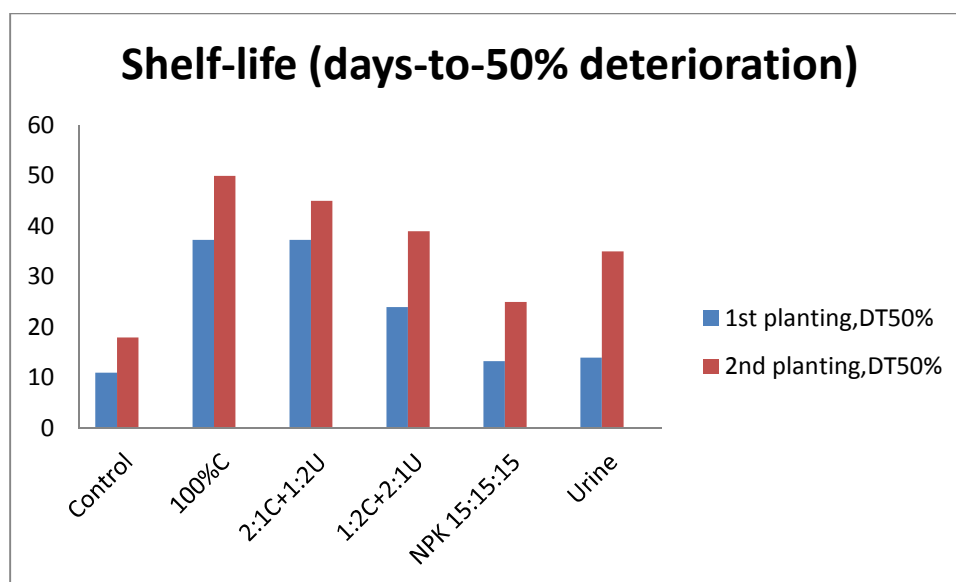


Fig. 4 Effects of the treatments on the shelf-life of tomato fruits after harvest

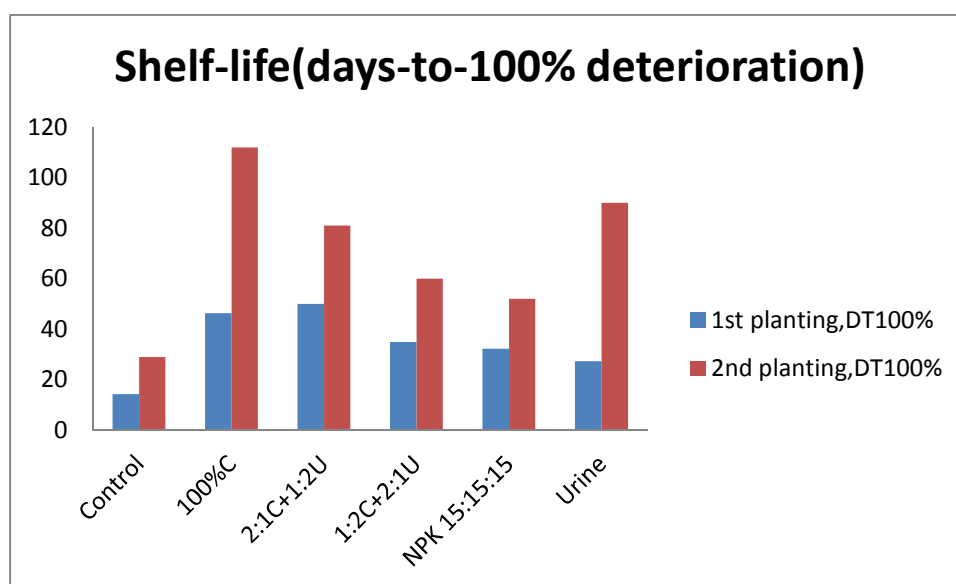


Fig. 5 Effects of the treatments on the shelf-life of tomato fruits after harvest

Discussion

Generally, the compost and 1:2 compost + 2:1 urine fertilizer treatments showed better residual soil fertility status compared to other treatments used in this experiment. The better fertility status of most of the soils treated with compost and 1:2 compost + 2:1 urine could be due to benefits of organic matter in the soil [30]. This was mostly evident with the results of organic

carbon and nitrogen contents of the soils, Although, the pH of all the soils at the end of the first planting period **was** within the safe range of 5.5 - 7.0 [18]-, however, this was not the same at the end of the second planting period. The average pH of the soil at this planting period was basic; especially with the compost and its urine mixtures. This could be the strength of these organic fertilizers to buffer soil pH during tropical raining season, when soil could be acidic, due to leaching of bases.

The result of this study indicate that the application of the 1:2 compost+ 2:1 urine resulted in the better dry weight of fruits.[BF28] Although the yields during the second planting were generally low, due to disease attack and bad weather, the 1:2 compost+ 2:1 urine treatment still resulted into best yields (fresh and dry). This result could be attributed to the fact that nutrients in this treatment contributed to plants nutrients uptake. [BF29] This result is in consonance with AdeOluwa *et al.*, [1] who stated that nutrients in human urine are as readily available as those in mineral fertilizers. Similarly, this fruit yield (13.2 t ha⁻¹) **from the 1:2 compost+ 2:1 urine treated plots** at[BF30] the first planting was higher compared to **that of** NPK (8.25 t ha⁻¹) and the average yield of tomatoes (10 t ha⁻¹) [6] in the southwest, Nigeria. The better performance of urine and urine-compost mixtures compared to mineral fertilizer is in agreement with the findings of Nansabuga, [BF31][20] and AdeOluwa and Cofie [2], who reported that human urine increased yield of some crops more than mineral fertilizers and also in Finland [7], where cabbage grown with human urine performed better than those from conventional plots. This result also corroborates previous experiments carried out by AdeOluwa and Sobamowo [3], **who reported that urine improved the yield of Celosia argentia more than that of NPK 15-15-15.**

The better influence of the compost and 2:1 compost + 1:2 urine fertilizers generally improved[BF32] shelf-life (days-50%-to-deterioration) of fresh tomato fruits compared to ?. This could be due to better dry matter accumulation effects of the fertilizer treatments [BF33] on the tomato fruits[27]. Similarly, this could be due to better bioavailability nutrient [BF34] supplied by the organic fertilizers compared to ?[31].

In summary, the results of this study revealed that compost and urine-compost mixtures are excellent materials for improving soil fertility, yield of tomatoes and its shelf-life. ~~Moreover, it has been established that treated urine is safe for crop production [29][BF35]-.~~

Conclusion

The results of this experiment reveal that human urine could be a good fertilizer for producing tomatoes in terms of soil fertility improvement, ~~yield~~ increase and improvement in shelf-life. Moreover, if the compost is combined with urine, the effects are better. Consistently, the compost and urine-compost (either 2:1 or 1:2 ratios) mixtures performed better than the ~~commonly used~~ NPK (1:1:1) mineral fertilizer. This is an indication that if human urine is properly harvested and treated, it ~~could be a valuable fertiliser~~ might no longer be a menace in many communities. Thus, the use of compost or compost + urine mixture, especially at 1:2 ratio is recommended for production of tomatoes. Urine alone could also be used when there is no compost to mix it.

References

1. AdeOluwa, O.O., Adeoye, G. O., and Yusuff, S. A., 2009. Effects of organic nitrogen fortifiers on some growth parameters of green amaranths (*Amaranthus caudatus* L.). *Renewable Agriculture and Food Systems* 24(4): 245–250.
2. AdeOluwa, O. O., and Cofie, O., 2012. Urine as an alternative fertilizer in agriculture: Effects in amaranthus (*Amaranthus caudatus*) production. *Renewable Agriculture and Food Systems*. 27(4): 287 - 294.
3. AdeOluwa, O. O., and Sobamowo, J. O., 2008. Growth and yield response of *Celosia argentea* L. to evaluation of human urine, compost and their fortifications as organic fertilizer sources. In proceedings of 1st West African Summit on Organic Agriculture, 17-21 November, 2008 at University of Agriculture, Abeokuta, Nigeria. Pp. 228-232.
4. Adewole, A. T., Oyekale, A. S., AdeOluwa, O. O., and Cofie, O., 2013. Farmer's perception on the use of urine for growing vegetable in Ibadan. *Journal of Human Ecology*. 41(1): 19 - 23.
5. Akibu, Y., 2014. Tomato production in Nigeria-Prospects of a bright future. www.belvynaglobal.com (retrieved on 17th Feb., 2015).
6. Alofe, C. O., and Somide, O., 1982. Influence of spacing on the performance of three cultivars of Tomato. *Nigeria Journal of Science*. 16: 119 - 127.
7. American Chemical Society (ACS) 2007. Human urine as a safe, inexpensive fertilizer for food crops. *Science Daily*, October 8. Available at website <http://www.sciencedaily.com/releases/2007/10/101071008093.htm> (accessed July, 27, 2014).
8. Andersson, J., Zehnder, A. J. B., Rockström, J., and Yang, H., 2011. Potentials impact of

- waste water harvesting and ecological sanitation on crop yield, evaporation and river flow regimes in the Thukela River basin, South Africa. *Agriculture and Water Management*. 98 (11), Pp. 1113 – 1124.
9. Bouyoucos, G. J., A., 1962. Recalibration of the Hydrometer Method for Making Mechanical analysis of soils. *Agronomy journal*, 43: 434-438
 10. Bray R.H and Kurtz, L.T., 1945. Determination of total organic and available forms of Phosphorus. *Soil Science* 59:45-49.
 11. Cofie, O., AdeOluwa, O. O., and Phillip, A., 2010. Introducing urine as an alternative fertilizer source for urban agriculture: case study from Nigeria and Ghana. *Urban Agricultural Magazine* No. 23: 49
 12. Food and Agriculture Organization of the United Nation. 2013. 01 de marco. FAOSTAT. FAO statistics Division. Disponível em: <<http://faostat.org/home/index.html>. Accessed 2 January, 2015.
 13. Gendebien, A. H. R., Ferguson, J., Brist, H., Horth, M., and Sullivan, R. Davis, 2001. Survey of Wastes spread on land-draft final report European commission Director General for Environment study contracts. ec.europa.eu/environment/waste/studies/pdf/rdf.pdf. Accessed 1 January, 2015.
 14. Guzha, E. N., Hapi, I., and Rockström, J., 2005. An assessment of the effect of human faeces and urine on Maize production and water productivity. *Physics and Chemistry of the Earth*. 30: 840 - 845.
 15. Hallman, E., 2012. The influence of organic and convectional cultivation systems on the nutritional value and content of bioactive compounds on selected tomato types. *Journal Science Food Agriculture*, Nov. 92 (14): 2840 – 2848.
 16. Jackson, M. L., 1967. *Soil Chemical Analysis* Prentice, Hall of India Private Limited, New Delhi. Pp. 498. Jackson, M. L., 1967. *Soil Chemical Analysis* Prentice, Hall of India Private Limited, New Delhi. Pp. 498.
 17. Jönsson, H., Stizing, A. R., Vinnerås, B., and Salomon. E., 2004. Guidelines on the Use of Urine and Faeces in Crop Production- Report 2004-2. *Journal American Society Horticultural Science*. 121: 164 - 168.
 18. LSU, Ag Centre. Commercial Growing of Greenhouse Tomatoes <http://www.lsuagcenter.com/NR/rdonlyres/A9C8B225-338E-48F1-A5F5-9D02963B8AB5/10421/pub1808greenhousetomatoes1.pdf> (accessed 27 June, 2015).
 19. Mondal, M. F., 2000. Production and storage of fruits (in Bangla). Published by Mrs. Afia, B.A.U Campus, Mymensingh. Pp 202 - 312.

20. Nansabuga, P., 2008. Uganda: Human urine safe as fertilizer. The monitor, February 27, 2008. Available at <http://allAfrican.com> (accessed 20 February, 2015)
21. Ngobi, R. M., 2007. Sanitation of urine: Attitude towards urine diverting toilet and reuse of Nutrients in peri-urban areas of Kampala, Uganda. www.sciencedirect.com/science
22. Peech, M. 1965. Hydrogen-ion activity in methods of soil analysis. (A, Blanc Ed. Pp. 914- 926
23. Pradhan, S. K., Holopainen, J. K., Weisell, J., and H. Tanski. 2010. Human urine and wood ash as plant nutrient for red Beet (*Beta vulgaris*) cultivation: impacts on yield quality. *Journal of Agriculture and Food Chemistry*. 58 (2010), Pp.2034 – 2039.
24. Semalulu, M., Azuba, P., and Makhosi, S. Lwada, 2011. Potential for Reuse of Human urine in peri-urban Farming. Innovation as key to the Green Revolution in Africa. Pp. 651 – 660.
25. Steel, R. G. D., Torrie, J. H., and Dickey, D. A., 1997. Principles and procedures of statistics: A biometrical approach. McGraw Hill Book Co. Inc. New York. Pp. 666.
26. Tel A, Hargerty M 1984. Soil and Plant analyses study guide for agricultural Gueloh laboratory directors and technologies working in tropical regions IITA and University of p. 227.
27. Tonfack, L. B. , E. Youmbi and A. Amougou. 2013. Effect of Organic/Inorganic - Cation Balanced Fertilizers on Yield and Temporal Nutrient Allocation of Tomato Fruits under Andosol Soil Conditions in Sub-Saharan Africa. *International Journal of Agricultural and Food Research*. ISSN 1929-0969 | Vol. 2 No. 2, pp. 27-37.
28. Walkey, A and C.A Black 1934. An examination of the Degtjereff for determining soil organic matter and a proposed modification of chromic acid titration method, *Soil science*.37:29-38.
29. World Health Organization, 2006. WHO Guidelines for the Safe Use of Wastewater, Excreta and Grey Water. WHO, Geneva. Pp. 95.
30. Wolgast, M., 1993. “Rena vatten. Om tankar ikretslopp”. Uppsala. Pp.186.
31. Zhai, Z, 2009. Organic Fertilizers for Greenhouse Tomatoes: Productivity and Substrate

331
332 |

Microbiology. HORTSCIENCE 44(3):800–809.