

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 study 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 study had six treatments: urine, compost, compost: urine, 1:2 and 2:1, 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 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⁻¹) at the end of the first growth cycle. At the end of the second growth 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) 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. Compounds such as nitrogen dioxide (NO₂) and ammonia (NH₃) in this waste contaminates the environment and aquatic bodies, causing eutrophication and bad odours. 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 [1; 14; 21]. According to Wolgast [30], the annual amount of human urine 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. Human urine was successfully used to raise some crops like amaranths, celosia, lettuce, carrot, etc [2; 3; 11].

Positive impact was also reported with maize [8; 23; 24]. Adewole *et al.*, [4] elucidate that acceptability of urine as a fertilizer is a way of increasing farmers' gross margins.

Organic fertilizers are sourced from organic wastes which contain large organic matter and have advantages compared to mineral fertilizers [13]. Examples of organic fertilizers are compost, green manure, animal manure, other agricultural wastes, plant and human waste (excreta, and urine), etc. There is an increasing research interest in the fertilizer value of human waste with studies focused mainly on the yield potentials [24]. Thus, there was the need to evaluate the effects of human urine on tomato.

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]. 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.

Materials and methods

The study was 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 past six years prior to this experiment and planting was done twice. The soil was loamy sand based on USDA definition (www.ncrs.usda.gov/.../class), slightly acidic to slightly alkaline, low in nitrogen, moderate in organic carbon and potassium. The materials for the study included: tomatoes seeds (Roma VF), compost, NPK 15:15:15, 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 as a Randomized Completely Block Design (RCBD) with four replicates.

Table 1: Primary macronutrient composition of fertilizer treatments

Fertilizer Source	Nutrient composition (g kg ⁻¹)		
	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 September, 2012 and June to October, 2013 during the raining seasons (7th and 8th year of the study). Land clearing was done manually and this was followed by seedbed preparation. Each experimental plot was 2 m by 1 m with 0.5 m spacing in between the plots. There was a total of 24 experimental plots and land area of 79.75 m² (14.4 mX5.5 m), transplanting of tomato seedlings was done at four weeks after sowing, at 60cmX40cm spacing with twelve plants per plot. The fertilizer treatments were applied at the rate of 90 kg K ha⁻¹ split using spot application. 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 application (45 kg K ha⁻¹) was done at the on-set of flowering of tomatoes, that is, two weeks after transplanting. Weeding was done manually as at when due with cutlass. Data were collected at 2, 4 weeks after transplanting. Composite soil samples of six per plot were collected with soil auger at 0-15 cm depths for chemical and physical soil analysis. The soil samples were air-dried and sieved using 2mm for routine analysis. Particle size distribution was determined by hydrometer [9], as cited by Tel and Hargarty [26], using sodium hexametaphosphate (calgon) as the dispersing agent. Soil pH was determined using pH meter in water (1:1). 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 determined by the method of Bray and Kurtz[10] and determined colourimetrically using Molybdenum blue Method, while K, Ca, and Mg were first extracted using neutral normal (NH₄OAc), thereafter K was determined by flame photometry, and Ca by spectrophotometry, using the atomic absorption spectrophotometer. Micronutrients (Mn, Fe and Cu) were extracted with Mehlich 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 using 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 and the effects of applied treatments on post-planting soil nutrients

The pre-planting chemical properties of the soil revealed that at the first growth cycle, the pH of the plots were slightly acidic to slightly alkaline: control (7.1), 100% compost (7.4), 2:1 compost + 1:2 urine (7.3), 1:2 compost + 2:1 urine (6.3), NPK 15:15:15 (7.2) and urine (7.1). At the end of the first growth cycle, all the plots had their pH increased respectively. At the end of second growth cycle, the pH of all the plots was reduced except the control. Moreover, the plots treated with 100% compost, 2:1 compost + 1:2 urine and 1:2 compost + 2:1 urine had higher margins in their reduction than others. (Tables 1, 2)

The organic carbon of the experimental plots at the first growth cycle ranged from medium to high ($15\text{--}23.22 \text{ g kg}^{-1}$), with the control plot having the highest value (23.2 g kg^{-1}), closely followed by 100% compost plot (22 g kg^{-1}) and the lowest value (15 g kg^{-1}) was obtained from NPK plot. All the treated plots were high in organic carbon except the NPK plot, which was medium. At the end of first growth cycle, all the treated plots had their soil organic matter reduced respectively; the least reduced plots were 100% compost (14 g kg^{-1}) and 2:1 compost + 1:2 urine (13 g kg^{-1}). At the commencement of the second growth cycle, the values of organic carbon ranged between $0.4\text{--}2.1 \text{ g kg}^{-1}$, with 100% compost plot having the highest value (2.1 g kg^{-1}) and followed by the urine plot (1.7 g kg^{-1}). At the end of the second growth cycle, the plots treated with urine, 1:2 compost + 2:1 urine and NPK had their soil organic matter increased from 1.7 g kg^{-1} to 3.1 g kg^{-1} , 0.4 g kg^{-1} to 1.1 g kg^{-1} and 0.4 g kg^{-1} to 1.3 g kg^{-1} respectively. (Tables 1, 2)

Similarly, the total nitrogen values of the plots at the commencement of the first growth cycle range from $0.4\text{--}1.4 \text{ g kg}^{-1}$. The 2:1 compost + 1:2 urine plot had the highest total nitrogen value (1.4 g kg^{-1}) and the lowest values in NPK plot (0.4 g kg^{-1}) (Table 1). At the end of the first

growth cycle, all the plots had their total nitrogen increased respectively with the 1:2 compost + 2:1 urine plot having the highest total nitrogen value (2.8 g kg^{-1}) which is above the critical range of $1.5 - 2.0 \text{ g kg}^{-1}$ [13]. Moreover, at the commencement of the second growth cycle, all the plots had low total nitrogen values ($0.1 - 0.2 \text{ g kg}^{-1}$). However, at the end the second growth cycle, the 1:2 compost + 2:1 urine plot had its total nitrogen value increased from 0.1 g kg^{-1} to 0.2 g kg^{-1} .

The exchangeable K values of the plots at the first growth cycle ranged from medium to high ($0.3 - 0.9 \text{ cmol kg}^{-1}$). All the treated plots had high exchangeable K values except 1:2 compost+2:1 urine (0.4 cmol kg^{-1}) plot and the control (0.3 cmol kg^{-1}) which were medium in exchangeable K. At the end of first growth cycle, all the treated plots were medium in exchangeable K except NPK plot (0.5 cmol kg^{-1}) which had high exchangeable K value. At the commencement of the second growth cycle, all the treated plots were low in exchangeable K. At the end of second growth cycle, the plot treated with 100% compost (0.5 cmol kg^{-1}) was high in exchangeable K while 2:1 compost+1:2 urine (0.3 cmol kg^{-1}) and 1:2 compost+2:1 urine (0.4 cmol kg^{-1}) plots had medium exchangeable K values respectively.

At the first growth cycle, extractible Fe in the experimental plots was at medium range with values $60-105 \text{ mg kg}^{-1}$. The plot treated with 100% compost had the highest Fe value (105 mg kg^{-1}) followed by the 2:1 compost+1:2 urine plot (98 mg kg^{-1}) while 1:2 compost+2:1 urine plot had the lowest extractible Fe values (60 mg kg^{-1}). At the end of the first growth cycle 100% compost had the highest extractible Fe value (706 mg kg^{-1}) followed by the 2:1 compost+1:2 urine plot (698 mg kg^{-1}) while the urine plot (545 mg kg^{-1}) had the lowest extractible Fe value. At the commencement of the second growth cycle, the extractible Fe values range between $72-105 \text{ mg kg}^{-1}$ with the urine plot having the highest value (105 mg kg^{-1}) and 2:1 compost+1:2 urine plot having the lowest value (72 mg kg^{-1}). At the end of the second growth cycle, NPK plot (242 mg kg^{-1}) had the highest extractible Fe value while the control plot (100 mg kg^{-1}) was the lowest.

At the commencement of the first growth cycle, extractible Mn content of the experimental plots ranged within low to medium ($58 - 104 \text{ mg kg}^{-1}$). The control plot had the highest extractible Mn value (104 mg kg^{-1}), while 1:2 compost+ 2:1 urine plot had the lowest extractible Mn value (58 mg kg^{-1}). At the end of the first growth cycle, 100% compost (578 mg kg^{-1}) had the highest extractible Mn value while 1:2 compost+ 2:1 urine plot had the lowest extractible Mn value (379

143 mg kg⁻¹). At the commencement of the second growth cycle, 1:2 compost+ 2:1 urine plot (84 m
 144 mg kg⁻¹) had the highest extractible Mn value and the control plot the lowest extractible Mn
 145 value (71 mg kg⁻¹).

146 Table: 2. Pre-planting chemical properties of the soil during 2012 and 2013 growth cycles

Treatments		O.C	N	P	K	Ca	Fe	Mn	Cu
		g kg ⁻¹		mgkg ⁻¹		cmolkg ⁻¹		mgkg ⁻¹	
	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	2
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

148 **SD: standard deviation**

149 **Legend:**

150 C=Compost

151 2:1C+1:2U= 2:1 compost + 1:2 urine

152 1:2C+2:1U= 1:2 compost + 2:1 urine

153 U= urine

154

155 Table: 3. Post-Planting chemical properties of the soil during 2012 and 2013 growth cycles

Treatment		O.C	N	P	K	Ca	Fe	Mn	Cu
		gkg^{-1}		mgkg^{-1}		cmol kg^{-1}		mgkg^{-1}	
	pH								
1st 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
2nd 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 the organic fertilizers than the mineral fertilizer (NPK). At the end of the first growth cycle, the urine

produced significantly higher ($P<0.05$) number of fruits (16.50/plant) than NPK and the control plots while the lowest number of fruits (3.25/plant) was recorded in the control treatment, however, it was not significantly lower than NPK plot. At the end of the second growth cycle, 2:1 compost + 1:2 urine plot had significantly higher number of fruits (17.4/plant) than others while the lowest number of fruits (3.07/plant) was recorded in the control treatment, however, this was not significantly higher than NPK and the control plots (Figure 1).

Similarly, at the end of the first growth cycle, the 2:1 urine + 1:2 compost treatment resulted in the significantly higher ($P<0.05$) mean dry weight (834 kg ha^{-1}) than others while the control plot (no soil additive applied) recorded the lowest mean dry weight (149 kg ha^{-1}) however, this was not significantly higher than NPK (377 kg ha^{-1}), urine (203 kg ha^{-1}) and 100% compost (274 kg ha^{-1}) plots. At the end of second growth cycle, urine treated plot had significantly higher ($P<0.05$) mean dry fruit weight (142 kg ha^{-1}) than others except 2:1 urine + 1:2 compost plot (119 kg ha^{-1}) while the lowest was recorded by NPK plot (25 kg ha^{-1}) and this was significantly lower than other treated plots (figure 3).

At the end of the first growth cycle, 2:1 compost + 1:2 urine treated plot had significantly higher ($P<0.05$) mean fresh weight 246 g/fruit (13 t ha^{-1}) than others however this was not significantly higher than 2:1 urine + 1:2 compost plot (12 t ha^{-1}). At the end of the second growth cycle 1:2 compost + 2:1 urine treated plot had significantly higher fresh fruit weight 85 g/fruit (1.76 t ha^{-1}) than others while the lowest mean fresh fruit weight was recorded by NPK 26 g/fruit (0.5 t ha^{-1}) however this was not significantly higher than urine 27 g/fruit (0.6 t ha^{-1}) (figure 2).

The results of the effects of fertilizer treatments on shelf-life of tomato fruits is shown in figure 5. At days-to-50% deterioration, the treatments with 100 % compost and 2:1 compost + 1:2 urine (37.3 days) treatment performed better than NPK (13.3 days) treatment and the control (11 days) at the first growth cycle (figure 4). A similar trend was recorded at the second growth cycle (figure 5).

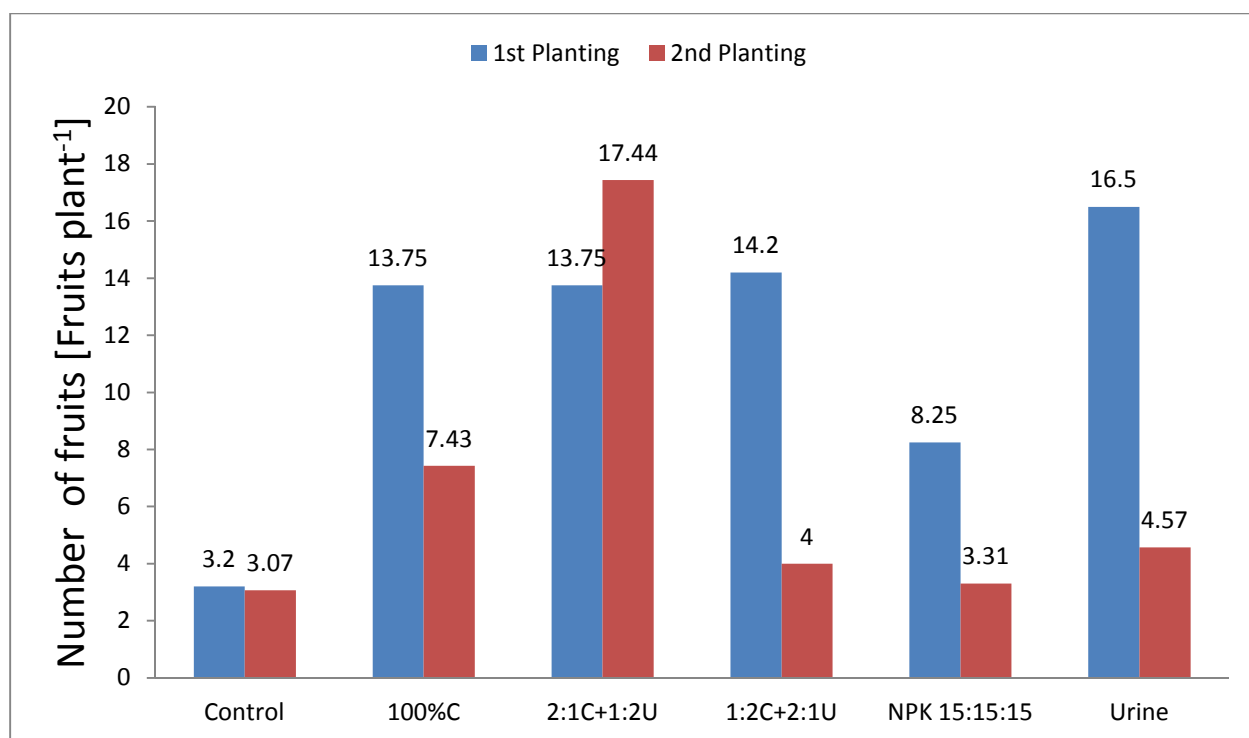


Fig. 1 Effects of the treatments on number of fruits.

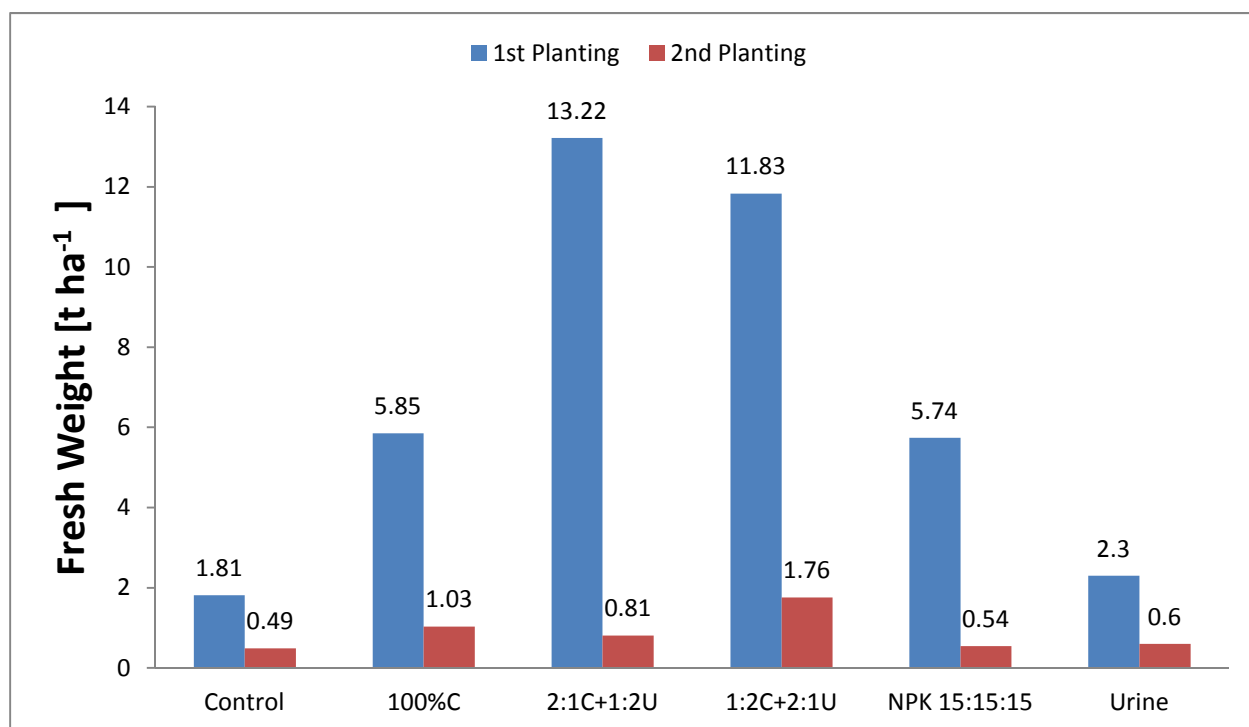
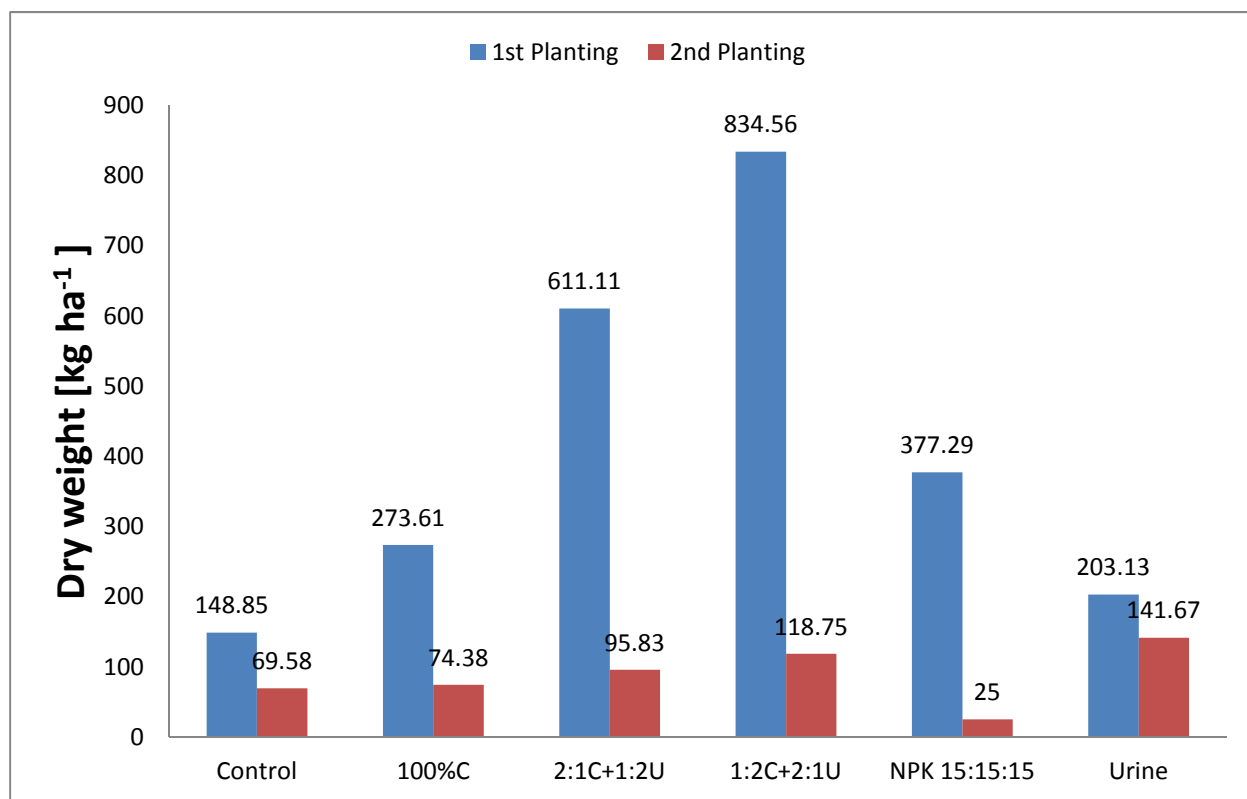


Fig. 2 Effect of the treatments on fresh weight of tomatoes

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

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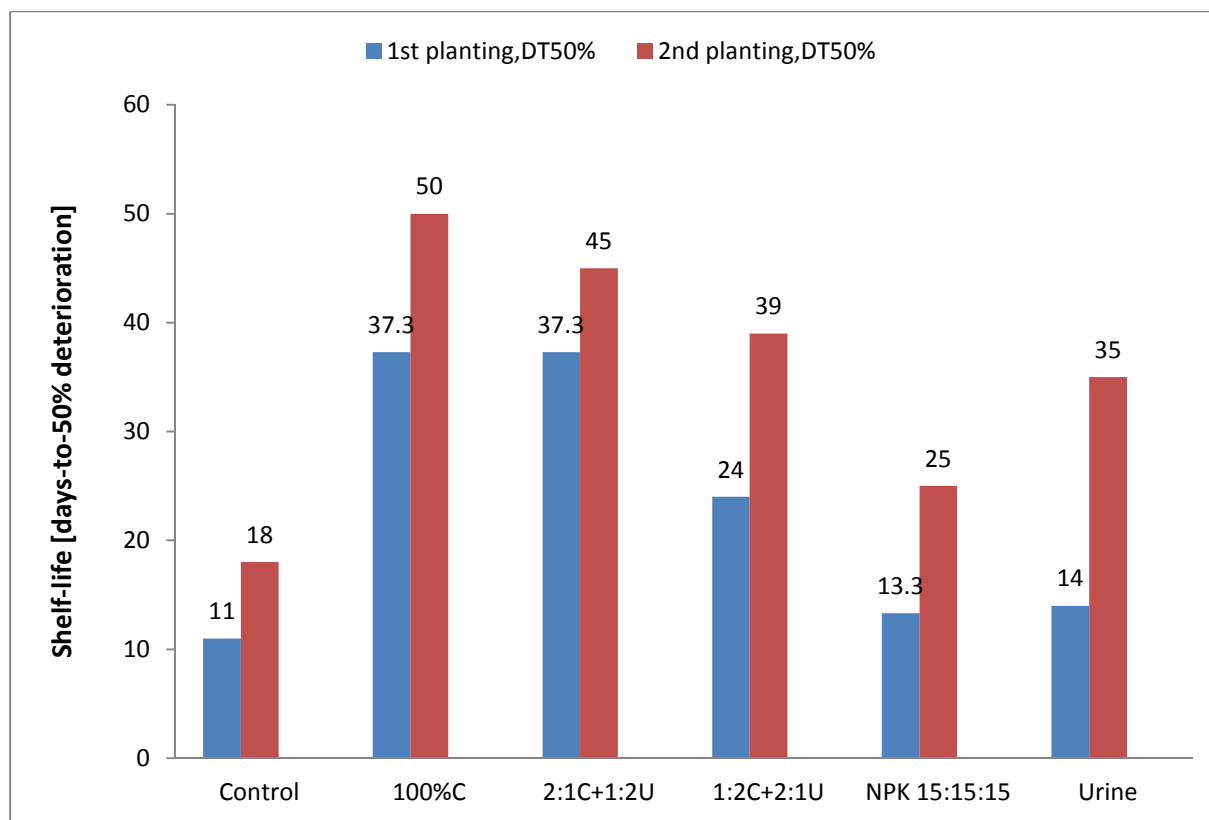


Fig. 4 Effects of the treatments on the shelf-life of tomato fruits after harvest

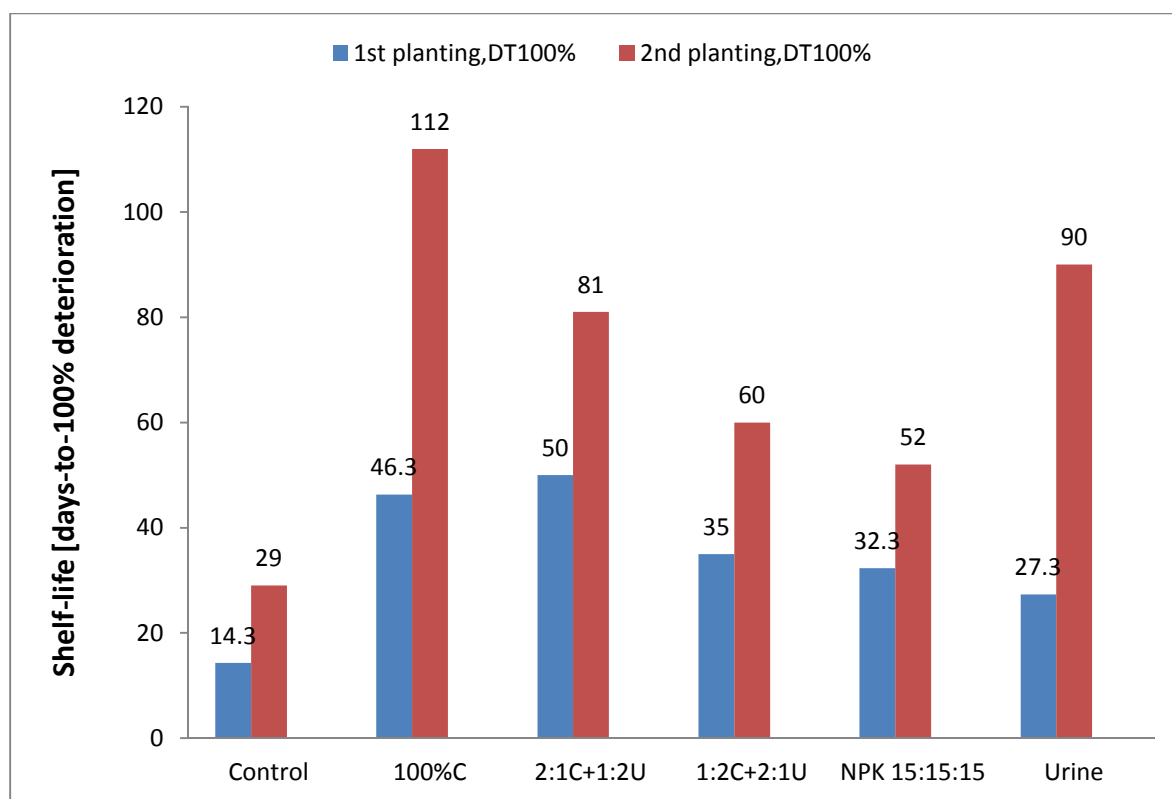


Fig. 5 Effects of the treatments on the shelf-life of tomato fruits after harvest

Discussion

Generally, the compost and 1:2 compost + 2:1 urine fertilizer treatments showed better residual soil fertility status compared to other treatments based on the soil chemical status analysed in this research. This better fertility status could be due to the gradual decomposing effect of the compost and its ability to improve soil fertility over a period of time as is the general case with organic matter [30]. The result is also an indication that compost could serve as a storehouse for nutrients essential to crop growth. Moreover, the experimental plots have been given similar treatments for the past six years and this could result in organic matter build up over the years. Similarly, there was an increase in organic carbon and nitrogen of the soil which in many cases are associated with the increase in microbial activities usually found in fields where organic fertilizers are used [32]. Although, the pH of all the soils were at the end of the first growth cycle within the safe range of 5.5 - 7.0 [18], however, this was not the case at the end of the second growth cycle, the average pH of the soil at this growing period was basic; especially with the compost and its urine mixtures. This could be due to the strength of these organic fertilizers to

buffer soil pH during tropical raining season, when the soil could be more acidic, due to leaching of bases.

Our results are indicating that the application of the 1:2 compost+ 2:1 urine resulted in the better dry weight of fruits in the first growth cycle. Although, the yields during the second growth cycle were generally low, due to bad weather (too much rain) and disease attack (powdery mildew) however, 1:2 compost+ 2:1 urine treatments resulted into better fresh weight of fruits during this growth cycle. This result is in agreement with the result of research findings of Nansabuga, [20] and AdeOluwa and Cofie [2] who reported that human urine has 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. Similarly, the fruit yield (13.2 t ha^{-1}) at the first growth cycle was higher than 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 corroborates previous experiments carried out by AdeOluwa and Sobamowo [3]. This indicates that the use of compost-urine mixtures as fertilizers can improve crop productivity.

Similarly, the compost and 2:1 compost + 1:2 urine treatments had better influence on the shelf-life (days-50%-to-deterioration) of the fresh tomato fruits compared to NPK (15:15:15). This result could be due to better dry matter accumulation effect on the tomato fruits [27]. Similarly, this could be due to better bio-availability nutrient supplied by the organic fertilizers [31] compared to NPK (15:15:15). Usually nitrogen in organic fertilizers is less bio-available compared to mineral fertilizers. However, if you have much rain during the growing season, bio-available nutrients can be washed out before the plants take them up. Therefore, it is more advantageous to add less bio-available nutrients, which will only become available later in the growing season

In summary, the results of this research revealed that compost and urine-compost mixtures are excellent materials for improving soil fertility, yield of tomatoes and its shelf-life.

Conclusion

The results of this experiment revealed that human urine could be a good fertilizer for producing tomatoes in terms of soil fertility and shelf-life improvement. Moreover, if the compost is

combined with urine nitrogen, the effects are better. Consistently, the compost and urine-compost mixtures performed better than the NPK (15:15:15) mineral fertilizer. This is an indication that if human urine is properly harvested and treated, it could be a valuable fertilizer. Thus, the use of compost + urine or compost + urine N mixture is recommended for production of tomatoes. Urine alone could also be used when there is no compost to mix it.

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