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Use of Human Urine as Fertilizer for Vegetable Cultivation

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Abstract – **Human urine contains high amount of Nitrogen (N) and is comparable to synthetic chemical fertilizer in terms of the nature of N content. This paper reports the fertilizer value of human urine for tomato and beetroot cultivations under greenhouse conditions. Both vegetables were grown in a pot filled with agricultural soils treated with synthetic chemical fertilizer (SCF) or Human urine (HU). Fertilizers were applied at a rate of 135kgN/ha of SCF, HU and their double dose for tomato, and at a rate of 133kgN/ha of SCF and HU and their double dose for red beet root cultivation. In both cases controls were neither fertilized by SCF nor HU. The microbial quality of the cultivated tomato fruits and beetroot samples was also assessed. Results show that the yield and other measured agronomic parameters of both vegetables fertilized with urine were found to be higher than that of unfertilized vegetables. However, the effect of urine fertilization was found to be similar with that of SCF in most of the variables measured. There was no significant difference between treatments in hygienic quality of the edible portions of both vegetables. This suggests that urine can be used to fertilize tomato and red beet root with no negative impact on human health.**

Keywords – **Beetroot, Tomato, Fertilizer, Microorganisms, Nitrogen, Human Urine.**

I. Introduction

Human urine is a waste released into the environment by every household. It is estimated that 1-1.5L of urine will be released by an adult person per day, though its chemical composition varies with feeding and drinking habits, physical activities, body size and other environmental factors [1]. Pure urine from a healthy person contains very few enteric microorganisms unless there is fecal contamination [2]. Human urine contains high amount of Nitrogen (N) and adequate amounts of Phosphorous (P) and Potassium (K) [3]. Human urine and artificial chemical fertilizer (ACF) are comparable in terms of the nature of N content. In both cases, 90-100% of N is either in the form of urea or ammonium [1]. In human urine, about 75-90% of N is excreted as urea while the rest is in ammonium form. Urea in human urine will rapidly degrade into ammonium and water, and elevates the pH value up to 9. This rise in pH negatively affects the survival of most harmful bacterial populations making urine safer for use as fertilizer [4]. The P and K contents of urine are almost (95-100%) in an inorganic form that are directly plant-available. For instance, the phosphate plant availability from urine has been demonstrated to be as good as that of artificial phosphate [5].

In developing countries, particularly sub-Saharan Africa, most agricultural lands are over-utilized and poor in plant nutrients. The poor soil nutrient content coupled with recurrent drought rendered these countries to be less productive. As a result, millions of people in these countries are exposed to food shortage and diseases due to malnutrition. To curb these problems, soils need to be fertilized highly, and in most cases, fertilization is dependent on synthetic chemical fertilizer (SCF). Nowadays, the demand for SCF has been increasing with increasing demand for food to support high population size of developing countries. However, synthetic chemical fertilizers are so expensive and may not be affordable to the poor people [5]. Thus, other cheap and safer fertilizer source must be sought. In this regard, stored pure human urine, which is known to be rich in primary plant macro nutrients, particularly N, and harbors less microbial contaminants, can be a good alternative to cultivate crops/vegetables. Storing human urine for a few weeks greatly reduces the number of enteric microbes, and makes it safer fertilizer than animal manure, which needs more than 6 months for decomposition [6]. Some researchers have demonstrated fertilizer value of stored human urine for cultivation of barley [1]; maize [7]; wheat [8] and cucumber [2]. Apart from its fertilizer value, the use of human urine as fertilizer will also help to sanitize the environment as people are no more urinating openly everywhere. In Ethiopia, people are not aware of the fertilizer value of urine, which otherwise could have been used to boost agricultural products. Especially, urine can be effectively used to fertilize vegetables that can be cultivated in small scale in home gardens or back yards. Thus, local people can easily fulfill their daily nutritional requirements and support their economy through the sale of vegetables. This study was therefore conducted to evaluate the fertilizer value of pure human urine for the cultivation of vegetables commonly grown in East Hararge, Ethiopia.

II. Materials and Methods

A. Plant material and urine collection

Seeds of tomato (*Solanum lycopersicun* L. variety chali) were obtained from Melkassa Agricultural Research Center, Ethiopia. Red beet root (*Beta vulgaris*) seeds were purchased from local seed sellers. Human urine was collected from students of Haramaya University, Ethiopia in a jerrycan and stored for 8 weeks before chemical analysis. Nitrogen content of urine was determined using Kjeldhal method and found to contain 9.3gN/L of urine.

B. Cultivation experiments and experimental Design

The selected tomato variety and red beet root were separately planted in pots (one seed/pot) of 380cm^2 (surface area) in greenhouse. After germination, seedlings were randomly assigned to 4 fertilizer treatments, namely, no N supplementation (control), supplementation of N in a form of synthetic chemical fertilizer (urea) at a recommended rate (135kg/ha) for tomato and 133kgN/ha for red beet root, supplementation of N in a form of urine at a rate of 135kg/ha and 133kgN/ha for tomato and red beet root (urine fertilization 1x), respectively, and supplementation of N in a form of urine at a rate of 270 kg/ha and 266kgN/ha for tomato and red beet root (urine fertilization 2x), respectively. After well establishment of the seedlings, fertilizers were added into the soil around the root distributing over 5 periods of application to achieve the amount to be applied for each treatment group. Plants were regularly irrigated with tap water to keep soil always moist.

C. Microbial analyses

The presence and levels of microbes that serve as indicator for fecal contamination and selected microbial pathogens (Total coliforms, Faecal coliforms, *Staphylococcus* spp., *Salmonella* spp., Enterococci and Clostridia) were determined to evaluate the hygienic condition and safety of vegetable samples using standard methods [9]-[12].

D. Data Analysis

Statistical analyses were conducted with the statistical packages SPSS for Windows 16.0 (SPSS; Chicago, IL, USA). Data were first checked for normality of distribution and logarithmically transformed as necessary. One-way ANOVA was used to analyze greenhouse agronomic data and laboratory microbial quality data. The differences between means were considered to be statistically significant at $P < 0.05$.

III. Results

A. Agronomic traits of tomato (Solanum lycopersicum L. variety Challi) grown under greenhouse condition

The different agronomic traits and yield responses of tomato under greenhouse condition are shown in Table 1. Compared to the control, plant height was significantly higher when fertilized with synthetic chemical fertilizer or urine fertilizer. However, there was no significant difference between synthetic chemical fertilized and urine fertilized plants. Number of branch per plant was significantly higher when fertilized with synthetic chemical fertilizer or urine at a double dose (2x), but no difference was seen between control and urine fertilization at a recommended dose (1x).

Urine and synthetic chemical fertilizers enhanced more leaf formation than the control. However, difference was not seen between urine and synthetic chemical fertilizer in terms of number of leaves when applied at a recommended dose (i.e., 135kgN/ha), though there was a slight difference between double dose urine fertilizer and recommended dose of synthetic chemical fertilizer. Unfertilized plants took longer time to produce flowers than the fertilized ones. However, there was no difference between unfertilized and fertilized plants in terms of the number of flowers produced. Compared to the control, fertilization increased the number of fruits produced per plant, and no difference was seen between chemical fertilizer and urine fertilizer (1x) or urine fertilizer (2x). However, number of fruits per plant was slightly lower when fertilized with urine (1x) than urine (2x) fertilizer. Both synthetic chemical fertilizer and urine fertilizer significantly increased fruit yield of tomato when compared with unfertilized ones. However no variation was seen between urine and synthetic chemical fertilizer in terms of fruit yield. Compared to control, total fresh plant biomass (fresh shoot + root + fruit) was significantly higher under synthetic chemical fertilizer and urine fertilizer. No significant difference was observed between synthetic chemical fertilizer and urine (1x), and between synthetic chemical fertilizer and urine (2x). Shoot dry weight was significantly higher under all types of fertilization than control, but its value under urine (2x) was higher than both synthetic chemical fertilizer and urine (1x), though no difference was seen between synthetic chemical fertilizer and urine (1x). Likewise, root dry weight was significantly increased under all types of fertilization, but no significant difference was seen between synthetic chemical fertilizer, urine (1x) and urine (2x) with respect to root dry weight.

B. Agronomic traits of red beet root (Beta vulgaris L.) grown under greenhouse condition

Compared to the control plant, all measured parameters (plant height at harvest, number of leaves per plant, root fresh weight and fresh total biomass) were significantly higher when fertilized by synthetic chemical fertilizer or urine. However there were no significant differences between synthetic chemical fertilizer and both doses of urine fertilization in all of the parameters measured (Fig.1).

C. Analysis of microbial quality and assessment of visible leaf injury

Edible portions of both vegetables were analyzed for the presence of some pathogenic and indicator microorganisms. The results showed that enterococci, staphylococcus and salmonella were not detected in both vegetables cultivated using urine and synthetic chemical fertilizer. Moreover, there was no significant difference between vegetables of the different fertilizer treatments with respect to total coliforms, fecal coliforms and clostridia (Tables 2 and 3). In both vegetables, we continuously inspected if urine fertilization induces any visible leaf injury such as necrotic and chlorotic spots. However, we did not find any difference between the treatments.

IV. Discussion

Results of greenhouse experiment showed that supplementation of nitrogen at a rate of 135kgN/ha through human urine fertilization increased number of fruits/plant, number of leaves/plant, total fresh biomass, shoot and root dry weight of tomato at least by twofold when compared with that of control. Average tomato fruit weight and plant height at harvest each were also increased by about 40%. Likewise, supplementation of nitrogen through synthetic chemical fertilizer and human urine significantly increased plant height at harvest, number of leaves per plant, root fresh weight (commercial yield) and total fresh biomass of red beet root when compared with unfertilized ones. Commercial yields and nearly all other measured agronomic traits of both vegetables cultivated using urine fertilizer at a rate of 135kgN/ha (for tomato) and 133kgN/ha (for red beet root) were the same as synthetic chemical fertilizer applied at the same dose. This result suggests that human urine, which is released into the environment as waste can serve as an alternative to an expensive commercial fertilizer to cultivate both vegetables. From their experiment on other tomato variety [4]. reported that human urine and commercial fertilizer result in the same amount of tomato yield. Fertilizer value of human urine has also been reported for other crops such as cucumber [2], maize [7], cabbage [4], wheat [8].

The Nitrogen in human urine is largely (75-90%) in a form of urea and the rest exists as ammonium [4]. Upon application to the soil, the urea will rapidly decompose into ammonia and carbon dioxide. Ammonia is prone to rapid loss into the atmosphere by volatilization unless appropriate management is taken. Apart from the necessary management taken, we also doubled to compensate for any loss of ammonia from urine and compared the two doses of urine fertilizer. Except number of fruits/plant, total fresh biomass and shoot dry weight of tomato, all other agronomic traits did not significantly vary between normal and double dose application of urine, suggesting less loss of nitrogen from the soil in this experiment. The fact that no much significant differences were observed between double dose and recommended dose of urine fertilization may also show that plants take up that amount of nutrients needed to support their growth, and the remaining nitrogen of double dose fertilized soils might have remained in the soil. In both vegetables, we continuously inspected if urine fertilization induces any visible leaf injury such as necrotic and chlorotic spots or bruises commercial yield. However, we did not find any difference between the treatments.

The microbial analysis showed no *Enterococcus*, *Staphylococcus* and *Salmonella* spp. in any of the samples (detection level = 10 CFU/g) indicating that using proper application and storing the urine for some time reduces the probability of contamination of vegetables by pathogenic microorganisms and makes the urine safe for use as a fertilizer. This result is in line with earlier reports of Schonning [13], [14] that indicate urine fertilization does not introduce pathological contamination to agricultural fields if used properly; The result of this study also accords with that of [15]. who used stored human urine in pumpkin cultivation. [16].reported that storage of urine increases the pH to the alkaline state (pH 9) and results in significant reduction of the numbers of enteric microbes. However, it is always important to note that application of urine should be done with great care not to directly contact with any part of the plant, since besides the risk of microbial contamination; urine may also cause physical damage to plants [15].

V. Conclusion

In conclusion this study revealed that human urine, when applied to provide nitrogen nutrient at a recommended rate for both vegetables, can result in more yield than the unfertilized ones, and the same yield as that of synthetic commercial fertilizer. The hygienic quality of urine fertilized, synthetic chemical fertilizer fertilized and unfertilized vegetables showed no difference, suggesting urine can be used as an alternative fertilizer to cultivate both vegetables. However, great care must be taken with urine fertilization not to directly contact with plant parts to minimize contamination and avoid salt build up in the soil.

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Table 1: Agronomic responses of tomato (*Solanum lycopersicum* var. Chali) to nitrogen supplementation through synthetic chemical fertilizer (SCF) and recommended dose (1x) of human urine fertilizer at a rate of 135Nkg/ha and double dose (2x) of human urine fertilizer at a rate of 270KgN/ha.

Agronomic responses	Control	SCF	Urine fertilizer 1x	Urine fertilizer 2x	*F*-Value	*P*-value
Plant height at harvest (cm)	48.57±3.29 b	65.85±2.99 a	68.57±4.69 a	71.57±2.26 a	10.66	<0.01
Number of branch/plant	5.43±0.20c	8.71±0.84a	7.14±0.26bc	8.00±0.22ab	8.98	<0.01
Number of leaves/plant	20.00±2.05c	41.86±2.65 b	47.57±2.58ab	56.57±5.58 a	20.62	<0.01
Days to flower	52.71±0.42a	46.57±0.20 c	48.28± 0.18b	46.43±0.20c	148.82	<0.01
Number of flower	3.14±0.26 a	3.29±0.42 a	3.71±0.52 a	3.29±0.57 a	0.28	>0.05
Number of fruits/plant	2.00±0.38 c	5.29±0.53ab	4.29±0.43 b	5.57±0.48 a	14.47	<0.01
Fruit weight (g)	34.44±3.95 b	50.46±1.42 a	46.53±2.31 a	50.10±0.98 a	7.81	<0.01
Total plant freshbiomass (g)	97.80±15.74 c	335.96±30.46ab	279.21±20.76 b	383.15±31.86 a	32.12	<0.01
Shoot dry weight	5.05±0.82c	9.35±1.64b	10.63±1.60b	16.63±1.70a	12.23	<0.01
Root dry weight	1.06±0.13 b	2.04±0.29 a	2.19±0.27a	2.10±0.20a	7.12	<0.01

Values are mean ± SE, n=7. Values with different letters in a row are significantly different at $P<0.05$ (one-way ANOVA) while those with the same letters are not significantly different.

Table 2: Quantification of some pathogenic and indicator microorganisms per one gram of tomato fruit. (Values are $\log_{10}$ mean ± SE, n=3).

	Fertilization treatments			
Microorganisms	Unfertilized	SCF	Urine fertilizer 1x	Urine fertilizer 2x
Total colifotms	3.18 ± 0.06^{a}	3.32 ± 0.12^{a}	3.32 ± 0.12^{a}	3.36 ± 0.24^{a}
Fecal coliforms	6.14 ± 0.11^{a}	5.82 ± 0.74^{a}	6.15 ± 0.13^{a}	6.07 ± 0.08^{a}
Clostridia	5.84 ± 0.75^{a}	5.75 ± 0.10^{a}	5.79 ± 0.07^{a}	5.83 ± 0.37^{a}
Entrococci	Ldl	Ldl	Ldl	Ldl
Salmonella	Ldl	Ldl	Ldl	Ldl
Staphyloccus spp.	Ldl	Ldl	Ldl	Ldl

The samples were analyzed from each pot. Ldl= less than detection level, detection level = 10 CFU/g (Colony forming unit per gram). Values with the same letter within a row are not significantly different at $p<0.05$ (one-way ANOVA).

Table 3: Quantification of some pathogenic and indicator microorganisms per one gram of red beet root. (Values are $\log_{10}$ mean ± SE, n=3).

	Fertilization treatments			
Microorganisms	Unfertilized	SCF	Urine fertilizer 1x	Urine fertilizer 2x
Total colifotms	4.04 ± 0.07^{a}	4.32 ± 0.09^{a}	4.36 ± 0.05^{a}	4.32 ± 0.09^{a}
Fecal coliforms	5.86±0.16a	6.12±0.13a	6.00±0.01a	6.05±0.64a
Clostridia	6.05±0.05a	6.11±0.01a	6.05±0.03a	6.15±0.04a
Entrococci	Ldl	Ldl	Ldl	Ldl
Salmonella	Ldl	Ldl	Ldl	Ldl
Staphyloccus spp.	Ldl	Ldl	Ldl	Ldl

The samples were analyzed from each pot. Ldl= less than detection level, detection level = 10 CFU/g (Colony forming unit per gram). The means indicated with the same letter within a row do not differ statistically significantly ($P < 0.05$). Values with the same letter within a row are not significantly different at $p<0.05$ (one-way ANOVA).

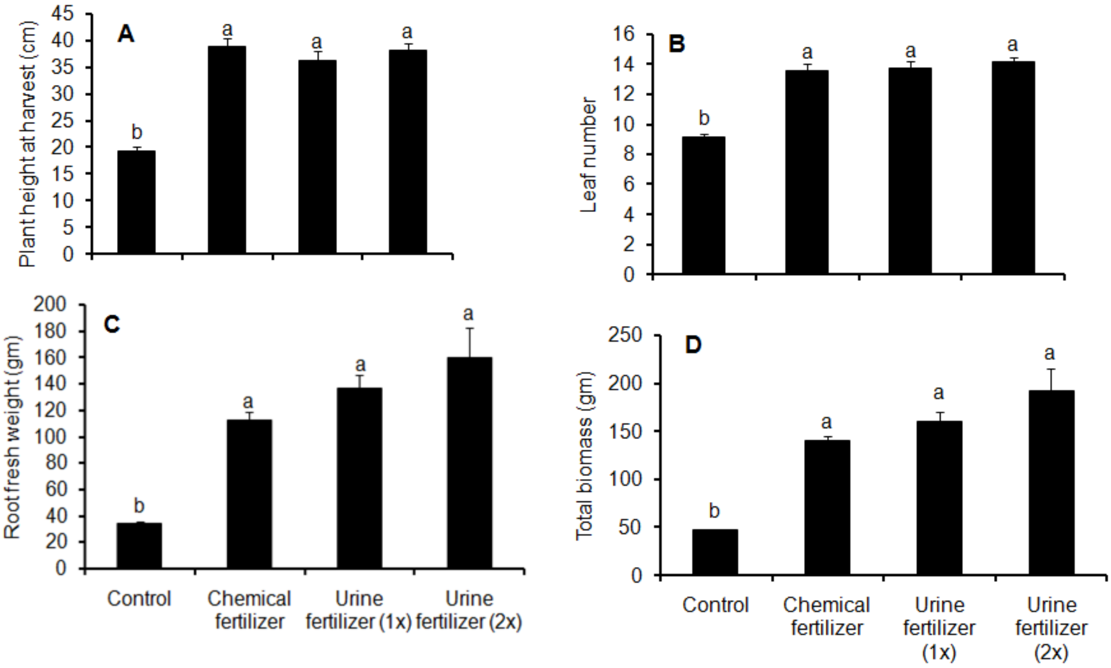

Fig.1. Agronomic responses of beetroot to different levels of nitrogen fertilization. Plant height at harvest (A), Leaf number at harvest (B), Root fresh weight(C) and Total fresh biomass. Values are mean ± SE, n=7.Error bars with different letters are significantly different at $p<0.5$ while those with the same letters are not significantly different. Note: Chemical fertilizer and urine fertilizer (1x) are supplementation of nitrogen at a rate of 133kg/ha. Urine fertilizer (2x) is double of urine fertilizer (1x).