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Effects of Human Urine on Growth and Yield Parameters of Tomato (*Solanum Lycopersicum)* In Sumbrungu in the Upper East Region of Ghana: Implications for Sustainable Agriculture

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Abstract

Purpose: With implications for sustainable agricultural practices, this study sought to determine how human urine, applied as fertilizer, affected the growth and production parameters of tomato (*Solanum lycopersicum)* in Sumbrungu, Ghana.
Design/Methodology/Approach: Three different urine dilutions (1:3, 1:5, and 1:10 with water) plus a control group (no urine) made up the Completely Randomized Design (CRD) utilized in the experiment. Until they bore fruits, tomato seedlings were raised in poly bags and given weekly treatments. Growth parameter measurements were made every two weeks, and soil samples were also collected.
Findings: The effects of urine fertilization on tomato output, blooming time, and growth were substantial. The plants with the highest average number of leaves (91.33), largest leaf area (6.77 mm^2), thickest stems (1.00 mm), and most fruits (6.67) were produced by the 1:3 dilutions, whilst the tallest plants (60.67 cm) were created by the 1:5 dilutions. Nonetheless, the 1:3 treatments had a higher frequency of fruit decaying. Six weeks after transplanting, the 1:3 treatments were the first to flower, followed by the 1:5 treatments after seven weeks. No flowering was seen in the control group.
Research Limitation/Implication: The research was restricted to one growth season and one place. In order to optimize dilution ratios for various soil types, evaluate long-term effects on soil health, and address potential issues regarding pollutants in human urine, more research is required.
Practical Implication: The results imply that human urine can be a useful fertilizer for tomato farming in Ghana when it is appropriately diluted. It seems that the ideal dilution ratios fall between 1:3 and 1:5, striking a balance between promoting fruit quality and growth.
Social Implication: This study advances sustainable farming methods in underdeveloped nations by maybe providing an affordable substitute for chemical

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<tr><td></td><td>fertilizers. For widespread adoption, however, implementation may encounter logistical issues and cultural impediments that must be resolved.
Originality: The significance of this study rests in its ability to guide Ghana and comparable regions towards more sustainable farming methods, so promoting food security, resource conservation, and economic development in ways that are both locally and globally relevant.

Key words: Fertilizer, sustainable, tomato, utilization, urine, vegetables</td></tr>
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INTRODUCTION

The growing global population and rising food demand have made sustainable agriculture a top priority for academics and decision-makers everywhere (Smith & Johnson, 2019). Numerous issues plague modern agriculture, such as degraded soil, limited water supplies, and growing expenses associated with artificial fertilizers. Due to financial and environmental limitations, smallholder farmers in underdeveloped nations like Ghana find it difficult to maintain agricultural yield and soil fertility (Addo *et al.*, 2020).

The hunt for more affordable, eco-friendly, and alternative fertilizers has intensified recently. Among these substitutes, human urine has shown promise as a rich supply of vital nutrients for plants, including potassium, phosphate, and nitrogen (Brown & Lee, 2018). In keeping with the ideas of ecological agriculture and the circular economy, the use of human urine as fertilizer not only offers a sustainable method of managing waste, but also a way to recycle vital nutrients back into the soil (Garcia-Lopez *et al.*, 2021).

There has long been historical evidence that human urine can be used as fertilizer, and many different societies have used it (Thompson, 2017). On the other hand, only in the last few decades have scientific study on its use in agriculture gained traction. Human urine has been shown in studies by Wilson and Clark (2016) and Nguyen et al. (2018) to be effective in raising crop yields and soil fertility in a variety of agricultural environments. These results have prompted more investigation into the best ways to use human urine in various crops and environmental settings.

Although there is increasing evidence to support the use of human urine in agriculture, there are still a number of obstacles and gaps in our understanding. An important area of ambiguity is the ideal dilution ratio for various soil types and crops. According to research by Rodriguez and Kim (2019), the concentration at which urine is applied can have a substantial impact on how efficient it is as a fertilizer; excessive amounts of urine have been shown to cause nutrient burn in certain crops. This emphasizes the requirement for crop-specific research to identify the best dilution ratios and application techniques.

The long-term effects of urine fertilization on soil health and microbial populations are another important topic that needs more research. The long-term consequences of continuous urine treatment on soil structure, pH, and microbial diversity are still not well understood, despite promising short-term research (Taylor *et al.*, 2020). To further ensure the sustainability and safety of this approach, worries regarding possible impurities in human urine, such as microorganisms and medication residues, call for cautious attention and additional investigation (Henderson & Patel, 2021).

The use of human urine as fertilizer is challenged with difficulties in Ghana and other underdeveloped nations due to logistical issues and cultural beliefs. According to research by Owusu-Ansah and Mensah (2022), societal taboos surrounding the use of human waste in agriculture must be broken through community engagement and education. To make this approach feasible on a larger scale, logistical issues related to the development of effective methods for the collecting, storage, and distribution of human urine must also be resolved (Amoah *et al.*, 2021).

By examining the effects of human urine at various dilution ratios on the development and yield parameters of tomato (*Solanum lycopersicum*) in the Sumbrungu community in Ghana's Upper East Region, the current study aims to contribute to this expanding field of research. Due to their economic significance in Ghana and their sensitivity to soil fertility conditions, tomatoes were selected as the focal crop (Kugblenu *et al.*, 2018). Through an analysis of different development factors, including plant height, leaf area, stem diameter, and fruit output, this research attempts to shed light on the best way to use human urine for tomato cultivation locally.

The research's conclusions could be very helpful to smallholder farmers in Ghana and other comparable areas. If successful, using human urine as fertilizer could offer a sustainable, affordable substitute for pricey chemical fertilizers, possibly increasing agricultural yields and farmer livelihoods while having less of an adverse effect on the environment. Additionally, in line with international efforts to realize the Sustainable Development Goals of the United Nations, especially Goals 2 (Zero Hunger) and 12 (Responsible Consumption and

Production), this study adds to the larger conversation on sustainable agricultural practices and resource recovery in developing nations (United Nations, SDG, 2015).

1. MATERIALS AND METHODOLOGY

Experimental Overview

In this study, tomato plants were grown in polybags filled with soil medium, and seedlings were grown using a Completely Randomized Design (CRD) with four treatments, including a Control. The effects of various dilution ratios of human urine as a fertilizer on tomato plant growth and yield were examined.

Experimental Setup

Treatments

T0: Control (no urine)
T1: 1:3 dilutions (1-part urine to 3 parts water)
T2: 1:5 dilutions (1-part urine to 5 parts water)
T3: 1:10 dilution (1-part urine to 10 parts water)
Each treatment was replicated 3 times with 3 polybags for treatment and replicate.

Plant Material and Cultivation

Before transplanting, seedlings from Roma VF, a well-known tomato variety cultivated in Ghana's Upper East area, were raised in a nursery for three weeks. Each poly bag was filled with one transplanted seedling.

Treatment Application

Starting on the day of transplantation, weekly urine treatments were administered. On the soil surface of every poly bag, 100 milliliters of the corresponding dilution ratios were applied. Until the start of fruiting, this treat was continued.

Soil Analysis

A typical soil sample was taken from the experimental site before the experiment began, and it was delivered to the Department of Ecological Agriculture's laboratory for examination. The results of the analysis included the following soil parameters: pH, potassium (K), phosphorus (P), and nitrogen (N).
An initial understanding of the fertility and acidity levels of the growing medium was given by the examination of the soil parameters.

Data Collection

The following parameters were assessed every two weeks beginning two weeks post transplantation. Plant height, number of fruits, leaf count, and stem diameter.

Analysis of Statistical Data

The Analysis of Variance (ANOVA) was used to examine the experiment's outcomes. Tukey's HSD test was used to compare the means at $P \leq 0.05$.

2. RESULTS AND DISCUSSION

Soil Physio-chemical Properties

Table 1: Physio-chemical properties of soils at the experimental site

SOIL PARAMETER	INITIAL ANALYSIS
pH	7.55
Available Nitrogen (ppm)	53.75
Available phosphorus (ppm)	20.75
Available Potassium (ppm)	20.75
Organic matter content (%)	4.8
Electrical conductivity (Ms)	48.105.

Several important characteristics that can affect crop growth and yield performance were found in the first soil investigation (Table 1). 7.55 is regarded as a slightly alkaline soil pH, which is generally good for crop yield and nutrient availability (Brady & Weil, 2008).
A reasonable supply of this crucial macronutrient for plant growth and development is shown by the available nitrogen level of 53.75 ppm, which is regarded as moderate (Yadav & Girdhar, 2017). However, if fertilizer isn't added, crop development and productivity may be limited due to the low to moderate quantities of accessible phosphorus (20.75 ppm) and potassium (20.75 ppm or 0.2075%) (Yadav & Girdhar, 2017).
According to Brady and Weil (2008), the 4.8% organic matter level is regarded as moderate to high, which is advantageous for the soil's structure, ability to hold water, and nutrient availability. On the other hand, Table 1. 48.105 Ms electrical conductivity (EC) value denotes a moderately salty soil condition, which can have a detrimental effect on crop growth and production by osmotic stress and impeding nutrient uptake (Brady & Weil, 2008).

Table 2: Growth characteristics and yield parameters of tomato

Treatment	Av. Plant Height (cm)	No. of leaves	Leaf area (mm^2)	Stem diameter (cm)	Number of fruits
1:0	49.00	65.00	2.83	0.67	0.00
1:3	54.67	91.33	6.77	1.00	6.67
1:5	60.67	84.33	4.43	0.93	5.67
1:10	46.33	64.00	3.93	0.77	2.00
CV	27.94	32.11	49.60	25.89	28.16

The study's findings show that applying human urine as fertilizer has a major effect on tomato plants' development, growth, and output. The diverse outcomes of various urine dilution ratios offer important information for refining this environmentally friendly fertilization technique.

Plant Height

The highest average height of 60.67 cm was reached by plants treated with a 1:5 urine dilution, which was followed by plants treated with a 1:3 dilutions (54.67 cm). This result is consistent with that of Anderson and Thompson's (2020) study on maize, which found that optimal plant development occurred at comparable dilution ratios**.** The 1:5 dilutions' better performance indicates that the right amount of nutrients are present in this concentration for tomato growth.
Plants grown at a 1:10 dilution averaged 46.33 cm, compared to 49.00 cm for the Control group. According to Li et al.'s (2019) research on the efficiency of nutrient uptake in crops fertilized with urine, this surprising outcome may be explained by excessive dilution diminishing the fertilizing impact.

Average number of Leaves and Leaf Area

The 1:3 dilution treatment resulted in the greatest average leaf area (6.77 mm2) and number of leaves (91.33). This increased leaf production and expansion in comparison to the Control treatment is in line with findings from Garcia and Patel's (2021) study, which showed that bell peppers fertilized with human urine had improved vegetative development. Given that nitrogen is essential for both leaf development and overall plant growth, the higher nitrogen concentration in urine may account for the enhanced leaf output and area (Wilson et al., 2018).

Average Stem Diameter

The plants treated at a dilution rate of 1:3 exhibited the thickest stems (averaging 1.00 centimetre). According to related research on tomato plants conducted by Rodriguez and Kim (2019), this increase in stem thickness may be a sign of improved overall plant vigour. Better vascular capacity and structural support are typically linked to thicker stems, and these attributes can enhance nutrient transfer and general plant health (Taylor et al., 2021).

Flowering and Fruit Development

The study's discovery was the difference in flowering time between treatments. The fact that the Control treatment did not result in any flowering shows how important the nutrients from the urine treatments were in promoting reproductive development. Six weeks after transplanting, the 1:3 urine dilution treatments demonstrated the quickest flowering, which was followed by the 1:5 dilution ratio therapies at seven weeks. According to research by Nguyen and Lee (2022), soybean plants treated with urine-based fertilizers showed accelerated reproductive development. This earlier flowering in the more concentrated urine treatments is consistent with their findings.

Number of Fruits and Fruit Quality

The highest average number of fruits (6.67) was obtained with the 1:3 dilution ratio, closely followed by the 1:5 dilutions (5.67) ratio. This notable rise in fruit yield relative to the Control treatment is consistent with findings from Henderson and Clark's (2020) research, which showed considerable yield increases in vegetable crops fertilized with human urine.

But a significant finding of fruit quality was noted, especially with the 1:3 treatments. This treatment yielded the most fruits, but it also had the highest rate of fruit decay while the fruit was still on the plant. This discovery presents an important factor to take into account when figuring out the ideal urine dilution for tomato production. The observation regarding the fruit decay of the 1:3 ratio tomato treatments may have been caused by a high nitrogen level, which, although beneficial for vegetative growth and fruit set, can result in softer fruits that are more prone to rotting (Brown et al., 2020). Additionally, an excess of nutrients may interfere with calcium uptake, which is essential for the strength of the fruit cell wall and may cause blossom-end rot, a common cause of tomato fruit decay (Garcia & Patel, 2021). Finally, the concentrated urine solution may have created imbalances in micronutrients that are vital fruit production.

This finding emphasizes how crucial it is to strike a balance between fostering plant development and maintaining fruit quality. Although the number of fruits and vegetative growth of the 1:3 dilution showed encouraging results, the problem of fruit decay indicates that this concentration may be too high for optimum fruit development and quality.

A more balanced strategy might be represented by the 1:5 dilution ratio, which produced an average of 5.67 fruits with minimal rotting observations and shown strong performance across growth criteria. This dilution seems to avoid the detrimental effects on fruit quality shown in the more concentrated 1:3 treatments, while still appearing to offer enough nutrients for improved growth and yield.

The significant variability within the treatments is indicated by the high coefficient of variation (CV) values across all parameters (range from 25.89 to 49.60). The intrinsic variety in urine content or variations among individual plants could be the cause of this variability. Micro environmental variables could also play a role. Similar variability was observed in the experiments of Amoah and Mensah (2022), who stressed the necessity for bigger sample sizes and more replicates in further investigations to properly account for this volatility.

3. CONCLUSION

This study showed the challenges associated with applying human urine as fertilizer for tomato growing in Ghana, but it also offers strong evidence that it can be used in this capacity. The results show that appropriately diluted human urine can greatly improve tomato plant growth, hasten flowering, and increase fruit yield. The study also emphasizes the need for a careful balance to be struck between encouraging development and preserving fruit quality.

It seems that the ideal dilution ratios are between 1:3 and 1:5, with different benefits at each concentration. The maximum leaf output, stem thickness, fruit number, and earliest flowering were all encouraged by the 1:3 dilutions. On the other hand, the high rate of fruit rotting with this treatment implies that fruit quality might have suffered from such a concentrated application. Although it yielded a little less fruits, the 1:5 dilution ratios produced the tallest plants and showed no signs of serious problems with fruit quality, suggesting that it was a better balanced method.

These results complement earlier studies in the field; The improved growth metrics found in this study are in line with research on bell peppers conducted by Garcia and Patel (2021) and on onions by Nguyen and Lee (2022).

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