INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 19, No. 6, p. 11-21, 2021

RESEARCH PAPER OPEN ACCESS

Sustainable agriculture for food security: An assessment on the influence of human urine on maize (*Zea mays*) productivity as a top dressing fertilizer

Douglas Marowa*

Amrita School for Sustainable Development, Amritapuri, Amrita Vishwa Vidyapeetham, India

Article published on December 28, 2021

Key words: Human urine, Biological fertiliser, Maize productivity, Food security, Sustainable agriculture

Abstract

The world's agriculture and food systems are not presently delivering desirable outcomes on food security, hence threatening attainment of second sustainable development goal, which has a commitment to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture' by 2030. The research sought to assess the influence of Human Urine on maize productivity as a top dressing fertilizer and remove sceptical view on the use of Human Urine. An experimental research was carried out at a homestead in Marange communal area. Randomize complete block design of three treatments; Human Urine, Ammonium Nitrate and Untreated were replicated three times. The Spearmen's Rank Correlation Coefficient method was used. Results revealed that the Human Urine treatment had a high incremental growth rate and 3.7 tonnes per hectare at harvesting, which was a good yield for a household in the rural area and would have enough maize grain for the year. The research concur with the reviewed literature that human urine would influence the growth rate and the productivity of crops. It revealed that there was a positive relationship between plant growth and the plant productivity. The researcher concluded that Human Urine has influence on the maize productivity and if promoted could improve food security in the study area. The promotion of biological fertilizer like Human Urine would increase crop production and household food security in the country of Zimbabwe. Further research on the influence of the human urine as a top dressing fertiliser on other cereal crops in Zimbabwe.

* **Corresponding Author:** Douglas Marowa ✉ dmarowa1975 @gmail.com

Introduction

The world's agriculture and food systems are not presently delivering desirable outcomes on food security and nutrition (Edmundo *et al.*, 2020). In 2015, the Sustainable Development Goals (SDGs) were adopted, with SDG2 committing to 'end hunger, achieve food security and improved nutrition, and promote sustainable agriculture' by 2030 (Edmundo *et al.*, 2020). The SDGs recognized, well beyond previous global goals, the strong interconnectivity among development goals. Thus, issues of hunger and malnutrition are linked to issues of equity, justice and employment, along with environmental sustainability hence the need for holistic approaches. Maize production in Zimbabwe has been generally on the decline especially in the recent past years, which has been influenced by the global and economic climate. FAO (2010) reviewed that globally about 925 million people remained food insecure in 2010. FAO (2019) revealed that the average maize production in Zimbabwe has been going down, averaging 1,313,000 tonnes in the years 1996/97 to 2017, 2018 the yield was 970,000 tonnes, 2019 the yield was 830, 000, then 2020 was estimated to go down further to 777,000 tonnes. As the economy continue to dwindle, rural farmers had not been able to purchase fertilizers due to their ever escalating prizes and this has subsequently witnessed the reduction on maize yield. Mashingaidze (2004) indicated that the fertilizer manufacturers have been operating below capacity since the mid-1990s due to general shortage of foreign currency, which subsequently caused fertilizers to be a rare commodity to be assessed by especially smallholder farmers due to its prohibitive costs, caused by the high cost of foreign exchange sourced in the black market.

Maize production in Zimbabwe has been generally on the decline especially in the recent past years, which has been influenced by the global and economic climate. FAO (2010) reviewed that globally about 925 million people remained food insecure in 2010. FAO (2019) revealed that the average maize production in Zimbabwe has been going down, averaging 1,313,000 tonnes in the years 1996/97 to 2017, 2018 the yield was 970,000 tonnes, 2019 the yield was 830, 000, then 2020 was estimated to go down further to 777,000 tonnes. As the economy continue to dwindle, rural farmers had not been able to purchase fertilizers due to their ever escalating prizes and this has subsequently witnessed the reduction on maize yield. Mashingaidze (2004) indicated that the fertilizer manufacturers have been operating below capacity since the mid-1990s due to general shortage of foreign currency, which subsequently caused fertilizers to be a rare commodity to be assessed by especially smallholder farmers due to its prohibitive costs, caused by the high cost of foreign exchange sourced in the black market. The green revolution in agriculture led many people to forget about basic ecological rules in agriculture that include the use of animal waste to fertilize their crops. In a balanced ecosystems urine fertilizes the soil and thus helps plants to grow, hence the need to harness human urine in particular to boost maize production as some farmers may not alternatively have animals especially cattle to tap the urine. Human Urine as a biological fertiliser, according to Kirchmann and Petterson (1994) studies have shown that stored human urine has pH values of 8.9, nitrogen was mainly (> 90%) present as ammoniacal nitrogen, with ammonium bicarbonate being the dominant compound. Urea and urate decomposed during storage. Heavy metal concentrations in urine samples were low compared with other organic fertilizers, but copper, mercury, nickel and zinc were 10-500 times higher in urine than in precipitation and surface waters (Kirchmann and Petterson, 1994). In a pot experiment with ^{15}N labelled human urine, higher gaseous losses and lower crop uptake (barley) of urine N than of labelled ammonium nitrate were found. Phosphorus present in urine was utilized at a higher rate than soluble phosphate, showing that urine P is at least as available to crops as soluble P fertilizers (Kirchmann and Petterson, 1994).

However, despite these positive and importance facts about human urine, its uses is relatively rare because of lack of promotion of biological fertilisers, inadequate knowledge and the public still skeptical. This research proposed to test human urine on maize, being the target species as the staple diet of the people of Zimbabwe.

Steinfeld (2004) revealed that Human urine is one of the fastest-acting, excellent sources of nitrogen, phosphorous, potassium and trace elements for plants, delivered in a form that is perfect for assimilation.

Not only that, there is a constant, year round supply of it and it is free. Most of the arable lands in Zimbabwe are characterized by highly degraded areas and infertile soils hence low production in maize yield. The cost of buying inorganic fertilizers has just become unbearable. Maize crop yields have continued to deteriorate mainly due to the above-cited challenges. Hence, the need to research on the use of Human Urine in order to address the problem low production, poor soil fertility and reduce production cost as farmers would avoid purchasing expensive inorganic fertilizer like ammonium nitrate.

Mashingaidze (2004) reviewed that despite the government having been subsidizing fertilizers through input schemes in the past, it has never been enough for most of the farmers in the country, especially in the smallholder farming sectors. The questions remain, "Can farmers use human urine as fertilizer in maize production? Is urine good for the maize plant? Will urine kill the plants? Is urine good for the soil? "The research sought to assess the influence of Human Urine on maize productivity as a top dressing fertilizer. This was done so as to recommend its suitability as sustainable agriculture input that is found locallly, cheap and affordable top dressing fertilizer to farmers in the study area. It will also help to remove the skeptical view on the use of Human Urine by farmers.

Materials and methods

Research questions

i. What is the yield rate obtained from the use of Human urine in maize production as compared to AN and untreated plots?
ii. What is the growth rate obtained from the use of Human Urine in maize production as compared to the use of AN and untreated plots?
iii. Is Human Urine suitable and sustainable top dressing fertilizer for maize production.

Specific objectives of the study

i. To determine the yield potential of human urine top-dressed maize.
ii. To compare growth rate of maize in response to human urine.
iii. To recommend to farmers the whether human urine can be used as a top dressing fertilizer for maize.

Hypothesis

H0: The application of Human Urine as a top dressing fertiliser does not influence maize productivity and does not promotes food security.

H1: The application of Human Urine as a top dressing fertiliser influence maize productivity and promotes food security.

Study Area

The experimental research was carried out at a homestead in Mutare District, in Marange communal area, Nyachitu village. The site is in natural farming region V of Zimbabwe's Agro-ecological zones, receives an average annual rainfall of 350 -450mm per year, and normally accompanied by severe dry spells and droughts.

The mean minimum temperatures in this area range from 11-20̊ c and the mean average temperature ranges 18-34̊C, rainfall distribution has recently reduced to 100-450mm per year. The altitude is 900m above sea level and has sandy loom soils with patches of red and black soils. Farmers grow maize drought tolerant crops like sorghum, millets groundnuts and roundnuts, and practice extensive livestock production. Nyikanda (2005) indicated that frequent dry spells during summer have caused droughts leading to food shortage in the area.

Research Design

An experimental design was used in the research through treatments of the maize plants using Human Urine, AN and untreated soil. The experiment consisted of three treatments that were replicated three times.

- Treatment 1 -Human Urine
- Treatment 2 -Ammonium Nitrate
- Treatment 3 -Untreated (Negative control)

Layout of the plots

Table 1. Design layout using randomized complete block design (RCBD).

Block	Plot Treatments		
Block 1	Treatment 1	Treatment 2	Treatment 3
Block 2	Treatment 3	Treatment 1	Treatment 2
Block 3	Treatment 2	Treatment 3	Treatment 1

Experimental Design

In this study, the randomized complete block design (RCBD) was used, this design groups the experimental units into blocks such that variability among the units in the blocks was reduced. The research adopted RCBD because it has the ability to keep the experimental error within each block as low as possible. Spearmen's Rank Correlation Coefficient method was used to determine the relationship between Human Urine (HU) and the influence it has on the yield of the maize cob. In this case, 10 plants from the Human Urine top dressed were randomly selected. The grains from each cob was measured and recorded in grams.

The total area of the field was 42,84m² composed of 9 plots each with an area 3m² each to give a total of 27 m². A difference of 12,84m² was designated for some pathways between plots by a width of 0,6cm.The experiment had 3 blocks of equal size, each having all the 3 treatments. The in row spacing in each plot was 30cm and the inter row spacing was 60cm with 20cm from the edge of the plot.

Collection, treatment and storage of Human Urine

Fifteen (15) liters of urine was collected by one family members (three sons aged 9, 12 and 14) respectively.

The urine was collected from overnight urinations for a period of one week and stored for 3 months (September to November 2020) in an air tight containers to allow for anaerobic fermentation to take place.

The product after anaerobic formation was now Ammonium Nitrate ready to be applied as top dressing fertilizer in December 2020. According to Dugue (2010) if urine is allowed for anaerobic formation to take place, for a period of 3-4 months, urea would have been broken down to Ammonium Nitrate.

Plate 1. Human Urine collected during overnight urinations for a period of one week.

Maize seed used for the experiment

A certified maize hybrid seed SC 403 (tsoko) from a seed company was selected for its suitability in the area, mainly being drought resistant and a very early maturing variety. This variety was suitable for the experiment and for the study area, since it is a drought tolerant variety as the area sometimes experience some dry spells.

Agronomy practices

The experimental site ploughed using an ox drawn moldboard plough and harrowed to bring the soil to a fine tilth. Later on, hoes were used to make raised beds, demarcating the twelve plots of 3m² each by path ways 0,6cm wide.

Plate 2. Land preparation of the experimental site.

Planting was done during the very first effective rains which were received by mid-November 2020.The in row spacing of each plant. Rain planting was adopted since the land was prepared before the first rains and ready to plant soon as conditions are suitable i.e. when the soil is sufficiently moist to germinate all

viable seed, whether further rain occurs in the near future or not. The seeds were hand planted in already holed land in advance of the first expected planting rains. The researcher planted the seed at 50mm depth at the same time applying basal fertilizer (compound D) not in contact with the seed, placing them side by side to avoid seed burn at a rate of 150g/3m².

Plate 3. Pot holing at the experimental site.

The researcher used mechanical weed control after germination at 2 weeks using a hoe. Weeding was done for the second time before tussling and second application of treatments. Composite manure was applied per each planting spot at 20cm depth after ploughing and before fertilizer application. The good fertilizer management is based on the fertilizer type, rates, timing and placement. Under reasonable conditions, nitrogen is mainly the limiting factor and thus dramatic increases of yields on a wide range of soil results from supplying nitrogen to the crop. The standard fertilizer recommendation for maize consists of 150kg/ha, NPK 14-23-14 and 50kg/ha urea (Dugue, 2010).

On a research conducted on fertilizer recommendations for maize production in the South Sudan and Sudano-Guinean zones of Benin, Dugue (2010) highlighted that 50ml liquid fertiliser in the form of human urine can be applied per plant.

The above literature was then used as a standard in the research in Marange whereby 50ml of Human Urine was applied per plant. However for the basil fertiliser, the research site being of poor nutrient status, the rate of 160kg/ha was used. Applying of both fertilisers, Human urine and Ammonium Nitrate was done at knee height and second application at tussling (split to reduce leaching especially with sands.)

Harvesting

On drying, harvesting was done by hand. Cobbs were removed from the plants and placed in the shed to dry to reduce the moisture content to 12,5% accepted for marketing. Maize yield was measured using a scale and calculated into tonnes per hectare to compare yields between the treatments.

Data Collection

Comparing growth rates from the three treatments was one of the objectives which signified the importance of this research. Plant height was measured with a meter rule graduated in centimeters. Three measurements were done as follows, the maize plants were first measured and recorded from knee height level (6 weeks) when the first application of treatments was done.

The second measurement of growth was done after 3 weeks from the initial application of treatment and another thereafter the final after tussling (third measurement). Ten days later the first ear initiated marking the development of the cob.

Recording yield from the harvested crop, yield from each of the nine plots was measured and recorded, thereafter yield for plots of the same treatment were added together.

Data Presentation and Analysis

Mathematical calculation using Microsoft excel was used to calculate the average yield per hectare of the maize production from Human Urine, Ammonium Nitrate and untreated plots. The data was presented in tables and photos taken from field observation.

Results

Growth rate of maize in response to human urine as compared to AN and Untreated

The germination percentage was very good as shown by the 91.7% germination rate. This then shows that the selected seed SC 403 (tsoko) was suitable for the study area. Plant targeted population was (16 planting position x 3 treatments x 3 replication) = 144 plants. Total germinated was 132 (for Block 1= 42 + Block 2 = 47 + Block 3 = 43). Therefore 132/144x100 = 91.7%

Table 2. Germination performance.

Block	Seeds Planted	Seeds Germinated	Percentage (%)
Block (1)	48	42	87.5
Block (2)	48	47	97.9
Block (3)	48	43	89.58
Total	144	132	91.7

The table below shows the maize growth rate for the treatments, indication were that the Human Urine treatment had a high average incremental growth rate as shown by an average of 0.85 meters at maturity stage of the crop. This concludes that the research agrees with the fact that human urine would influence the growth rate of maize crops.

The average growth rate for the maize crop were as follows; for treatment (1) were Human Urine was applied, the trend of the growth rate was at knee height (6) weeks average height was 0.43m, then (3) weeks after fertilization the average height was 1.19m then at the maturity the final measurement the average height was 2.04m. This gave an average growth rate of 0.76m and 0.85m respectively.

Table 3. Maize growth rate for the treatments.

Treatments	Average height (m) Growth rate			Average incremental height (m) Growth rate	
	At 6 weeks	At 9 weeks	At maturity	At 9 weeks	At maturity
Human Urine - (T1)	0.43	1.19	2.04	0.76	0.85
Ammonium Nitrate - (T2) Positive control	0.44	0.98	1.80	0.54	0.82
Untreated - (T3) Negative control	0.46	0.88	1.58	0.42	0.70

Then for treatment (2) were Ammonium Nitrate was applied, the trend of the growth rate was at knee height (6) weeks average height was 0.44m, then (3) weeks after fertilization the average height was 0.98m then at the maturity the final measurement the average height was 1.80m. This gave an average growth rate of 0.54m and 0.82m respectively.

Then for treatment (3) untreated, were there was nothing applied, the trend of the growth rate was at knee height (6) weeks average height was 0.46m, then (3) weeks after fertilization the average height was 0.88m then at the maturity the final measurement the average height was 1.58m. This gave an average growth rate of 0.42m and 0.70m respectively.

Plate 4. The maize crop growth rate at 9 weeks and at second measurements.

The above plate is showing the maize crop at second measurement and first ear initiated marking the development of the cob for the crop.

The yield potential of human urine as top-dressed maize as compared to AN and Untreated.

The table below shows that the total yield from the 3 plots of the Human Urine produced high yield of 3.3kgs, whereas the Ammonuim Nitrate and Untreated plots produced 2.1kgs and 1.5kgs respectively.

Table 4. The maize potential yield from the research.

Block	Yield (kgs) per Treatments			
Yield (kgs)	1.2	0.8	0.6	
Block (1)	T1	T2	T3	
Yield (kgs)	0.5	1.0	0.7	
Block (2)	T3	T1	T2	
Yield (kgs)	0.6	0.4	1.1	
Block (3)	T2	T3	T1	
Treatments Total yield	Total Yield Actual (kgs)	Area (m2) Plots total size	Yield per (Ha) Estimated (kgs)	Yield per (Ha) Estimated (ton)
Human Urine (T1)	3.3	9	3667	3.7
Ammonium Nitrate (T2)	2.1	9	2333	2.3
Untreated (T3)	1.5	9	1667	1.7

It can be safely estimated that a yield of 3.7 tonnes per hectare of maize yield can be produced from the use of Human Urine in the study area.

Plate 5. Green maize crop with cob ready for consumption as fresh.

Recommendations on the use of human urine as a top dressing fertilizer for maize.

According to the results, the researcher recommends that Human Urine is suitable as one of the local, cheap and affordable top dressing fertilizer to farmers in the study area as human urine can be a good top dressing fertilizer at a very low cost. This was revealed by high growth rate and high yield of maize from where human urine was applied. These are the characteristic of a good soil, the crops will grow well and the production yield is high.

The research has also helped to remove the skeptical view on the use of Human Urine by farmers, the researcher had to use the Human Urine without facing an healthy challenges. The researcher also recommends that the farmers must understand that human urine can be safely used as a fertilizer. In addressing skeptical views on safety and hygiene during handling of the human urine, the experiment used human urine from family members and no signs of healthy challenges were experienced.

Testing the Hypothesis

Ho: The application of Human Urine as a top dressing fertiliser does not influence maize productivity and does not promotes food security.

H1: The application of Human Urine as a top dressing fertiliser influence maize productivity and promotes food security.

Spearmen's Rank Correlation Coefficient method was used to determine the relationship between Human Urine (HU) and the influence it has on the yield of the maize cob. In this case, 10 plants from the Human Urine top dressed were randomly selected. The grains from each cob was measured and recorded in grams.

Table 5. Growth of crops applied HU and the yield from the plant cobs.

Plants	Growth (m) HU Fertilised (x)	Yield from the plant Cobs (gs) (y)	Rank (x)	Rank (y)	Diff. between ranks (x-y)	Squared differences (d^2)
1	1.66	230	10	10	0	0
2	1.72	254	9	8	+1	1
3	1.78	243	8	9	-1	1
4	1.84	288	7	5	+2	4
5	1.88	274	6	6	0	0
6	1.91	268	5	7	-2	4
7	1.95	300	4	2.5	+1.5	2.25
8	1.98	298	2.5	4	-1.5	2.25
9	1.98	312	2.5	1	+1.5	2.25
10	2.04	300	1	2.5	-1.5	2.25
						$\sum d^2 = 19$

$P = 1 - 6\sum d^2/n\,(n^2-1)$

$P = 1 - 6 \times 19 /10\,(10^2 -1)$

$P = 1 - 114 / 990$

$P = 1- 0.1152$

$P = +0.88$

It can therefore, be concluded that there is a positive relationship between growth (height) in meters and the maize productivity. The conclusion that can be drawn is thus, plants applied with Human Urine that have a high growth (height) are more productive than those of short in height. The alternative hypothesis that the application of Human Urine as a top dressing fertiliser influence maize productivity and promotes food security is thus accepted.

Discussion

Growth rate of maize in response to human urine as compared to AN and Untreated

The germination percentage was very good as shown by the 91.7% germination rate. The results revealed that Human Urine treatment had a high average incremental growth rate as shown by an average of 0.85 meters at maturity stage of the crop.

The above observation concur with the literature reviewed whereby according to Egigu *et al.* (2014), as for crops and vegetables, trees and liana seem to benefit from human supplementation 50ml of water with 1/3 urine every 3 days. In this tropical area the treated seedlings grow faster and develop more leaves (Egigu *et al.*, 2014). Heinnonen-Tanski and van Wijk-Sijbesms (2005) also indicated that it was much hoped and anticipated that human urine positively affect growth rate and subsequently yield.

The yield potential of human urine as top-dressed maize as compared to AN and Untreated.

The results revealed that the total yield from the 3 plots of the Human Urine produced high yield of 3.3kgs, whereas the Ammonium Nitrate and Untreated plots produced 2.1kgs and 1.5kgs respectively. This was against an average area of 9m² for each treatment. Basing on mathematical calculations using Microsoft excel, the estimated yield for each treatment was 3667kgs per hectare for the Human Urine top dressed maize crop, 2333kgs per hectare for the Ammonium Nitrate top dressed maize crop and 1667kgs per hectare for the Untreated soil with the maize crop. Further analysis revealed that this can be estimated to 3.7 tonnes per hectare, 2.3 tonnes per hectare and 1.7 tonnes per hectare respectively. It can be safely estimated that a yield of 3.7 tonnes per hectare of maize yield can be produced from the use of Human Urine in the study area. And concluded that Human Urine has influence on the maize productivity.

In general, the observed maize cob, grain and stover yields of the different treatments were significantly different. There were signs of yield incremental right from the untreated plots, Ammonium Nitrate treated plots and Human Urine treated plots respectively. The Human urine treated plots had high yield than any other treatments. This was supported but the fact given by other authors who indicated that use of top dressing fertiliers like human urine increased soil fertility. According to Saidou *et al.* (2012) and Balogoun *et al.* (2013) the main causes of the low soil fertility are low organic matter content, the low use of fertilizer, poor soil fertility management practices and monocropping. This is as well followed by typical that the maize yields will be low about 800kg/ha (Saidou *et al.*, 2003) and generally without fertilizer application. This was the situation on the results as the untreated block in the research had very low yield.

Recommendation to farmers on the use of human urine as a top dressing fertilizer for maize.

According to the results and the literature reviewed, the researcher recommends that Human Urine a suitable and safe top dressing fertilizer to farmers in the study area. Dugue (2010) who indicated that if urine is allowed for anaerobic formation to take place urea would have been broken down to Ammonium Nitrate. After this period, the urine will be ready to use as a fertilizer, it can be sanitized by applying 2 capfuls of dettol to destroy an available pathogens for hygienic purpose and safe handling. This was supported by to Saidou *et al.* (2012) who indicated that the general rule for home garden use, dilute fresh urine with water 3 or 4 parts to one, mixing only as much as use that day. This was confirmed by the research as the research used the as dilution and applied 50ml per plant as per the general rule and the yield and growth rate were positive.

Peter (2004) suggested that Human urine provides an excellent source of nitrogen, phosphorous, potassium and trace elements for plants, and can be delivered in a form that's perfect for assimilation. With a constant, year-round and free supply of this resource available, more and more farmers and gardeners are making use of it. According to Gayton and Hall (2006) Urine is 95% water, the other 5% consists of urea (around 2.5%), and a mixture of minerals, salts, hormones and enzymes. It is a blood byproduct, but despite containing some bodily waste, it is non-toxic.

The average urine from a healthy adult will release 11g nitrogen/urea, 1g phosphorus/super-phosphate and 2.5g potassium. The normal range for a 24-hour urine output is 800 to 2000 milliliters (ml) per day with a normal fluid intake of about 2 liters per day. Only when it is older than 24 hours, the urea turns into ammonia, which is what causes the distinctive smell. Antibiotics, vitamin supplements, and other medications will end up in people's urine, but in such minute quantities as to be negligible, especially when diluted with water (Gayton and Hall, 2006).

Fig. 1. The chemical composition of Urine, source: Gayton and Hall (2006).

Young *et al.* (2014) suggested that Urine can be used in a number of ways, such as a solution that is applied to plants to provide a quick, short-term boost in growth or as a nitrogen additive to the carbon-based material, facilitating the composting process. The most preferred system is to use urine for compost building or biomass production as there will be long-term fertility solutions preferable to quick fixes. It can be used as plant feed solution, however it is too strong to be used neat on most plants and should be diluted. Dilute one part fresh urine to 10-15 parts water for application on plants in the growth stage. Dilute one part fresh urine to 30-50 parts water for use on pot plants, which are much more sensitive to fertilisers of any kind (Young *et al*., 2014).

To address skeptical views on safety and hygiene during handling of the human urine. Can people drink human urine, according to Beaune (2018) and the research results, it was revealed that a healthy person's urine is about 95 percent water and sterile, so in the short term it's safe to drink and does replenish lost water. But the other 5 percent of urine comprises a diverse collection of waste products, including nitrogen, potassium, and calcium and drinking too much of these can cause problems (Beaune (2018).

Plate 6. The final maize yield produced from the Human Urine treatment block.

Decision basing on the results of the tested Hypothesis

There is a positive relationship between growth (height) in meters and the maize productivity. The conclusion that can be drawn is thus, plants applied with Human Urine that have a high growth (height) are more productive than those of short in height. The alternative hypothesis that the application of Human Urine as a top dressing fertiliser influence maize productivity and promotes food security is thus accepted.

The results of the hypothesis were concurred with the literature reviewed as Egigu *et al.* (2014) suggested that Human urine is composed of nitrogen (Urea and ammonium), inorganic potassium, phosphorus, calcium, sulphur and magnesium, directly absorbable by plants, similarly to commercial fertilizers which a major nutrients for maize groth and prodcutivity. Pradham *et al.* (2007) highlighted that human urine is as efficient as commercial fertilizers without pathogen risk, low NH_3 emissions, no flavor effect, and has been tested positively on different plant orders and families including tomatoes, cabbages, Beans, corns, etc. (Nagy and Zseni, 2017), and these plants have shown high growth rate and high productivity.

The above crops were said to have gain grow and produced high yield after the use of human urine as supplementary top fertiliser. Now, as the hypothesis proved that Human Urine can improve growth of maize and produce high yield, countries can now promote this biological fertiliser so as the reduce the threats of hindering the attainment of the second sustainable development goal. The farmers continue to use the top dressing fertisiler as a sustainable agriculture input in their respective countries. In order to meet SDG2, there is an urgent need for transformative change, understood here as a profound transformation of human activity across multiple dimensions and at multiple scales towards adaptation of sustainable agriculture practices for sustainable food security (Edmundo *et al*., 2020). With continually increasing demand for food accompanied by the constraints of climate change and the availability and quality of soil and water, the world's farmers are challenged to produce more food per hectare with less water, and with fewer agrochemical inputs if possible (Prabhakar *et al*., 2017).

Table 6. Plants showing positive results of growing and productivity with urine supplementation.

Order	Family	Plant Name	Species Name	Reference
Brassicales	Brassicaceae	Cabbage	*Brassica oleracea*	Pradin *et al.* (2007)
Brassicales	Caricaceae	papaya	*Carica papaya*	Beaune (2018)
Caryophyllales	Amaranthaceae	Beet	*Beta vulguris*	Egigu *et al.* (2014)
Cucurbitales	Cucurbitaceae	Cucumber	*Cucumis Sativus*	Heinonen -Tanski *et al.* (2007)
Cucurbitales	Cucurbitaceae	pumpkin	*Cucurbita maxima*	(Pradan *et al.* 2008)
Fabales	Fabaceae	Beans	*Phaseolusvulgaris*	Ranasinghe *et al.* (2016)
Fabales	Fabaceae	Faifai	*Seanthes myriadenia*	Beaune (2018)
Malpighiales	Passifloraceae	Passion fruit	*Passiflora edulis*	Beaune (2018)
Malvales	Malvaceae	Okra	*Abelmoschus esculentus*	Akpan-Idiok *et al.* (2012)
Malvales	Malvaceae	Hibiscus	*Hibiscus tiliaceus*	Beaune (2018)
Poales	Poaceae	maize	*Zea mays*	Guzha *et al.* (2005)
Poales	Poaceae	Barley	*Hordeum vulgare*	Heinomen-Tansiki *et al.* (2007)
Poales	Poaceae	wheat	*Triticum sp*	Tidaker *et al.* (2007)
Solanales	Solanaceae	tomatoe	*Solanum lycopersicum*	Egigu *et al.* (2014), Mnkeni *et al.* (2008), Pradhan *et al.* (2009)

Conclusion

The researcher concluded that, biological fertilizer especially human urine use, would influence maize productivity.

Hence there is need for the use of this fertiliser to be promoted to intensify crop production and increase household food security in the country of Zimbabwe.

Acknowledgements

I would like to thank the Almighty God for guiding me throughout the entire study. My profound gratitude to the family that supplied land and Human Urine. I would also want to acknowledge the Agriculture extension service department, village head and community for the much needed encouragement and support during the study.

Acknowledgement to Amrita Vishwa Vidyapeetham

This article has been funded by the E4LIFE International PhD Fellowship Program offered by Amrita Vishwa Vidyapeetham. I extend my gratitude to the Amrita Live-in-Labs® academic program for providing all the support.

References

Achor C Gayton, John Edward Hall. 2006. "25" Textbook of Medical physical (11 ed) Elsevier Saunders.

Balogoun I, Saidou A, Ahoton LE, Adjanohoun A, Amadji GL, Ezui G, Youl S, Mando A, Igue AM, Sinsin BA. 2013. Détermination des formules d'engrais et des périodes desemis pour une meilleure production du maïs (*Zea mays* L.) au Sud et au Centre Bénin. Bulletin de la Recherche Agronomique du Bénin (BRAB) Numéro Spécial Fertilité du maïs-Janvier pp 1-11

Beaune D. 2018 International Journal of Forestry and Horticulture (IJFH). Vol 14. Issue **1,** 24-28

Dugue P. 2010. Etude d'évaluation environnementale et du développement de systèmes deproduction durables dans le cadre des projets de soutien à la production vivrière (Benin, Togo, Ghana). FARM CIRAD, Ghana p 135

Edmundo Barrios, Barbara Gemmill-Herren, Abram Bicksler, Emma Siliprandi, Ronnie Brathwaite and Soren Moller. 2020. The 10 Elements of Agroecology: enabling transitions towards sustainable agriculture and food systems through visual narratives. Pages 230-247: Published online: https://doi.org/10.1080/26395916. 2020.

Egigu MC, Melak B, Kebede A, Muthusavomy M. 2014 Use of Human Urine as a fertiliser for vegetable cultivation, Methods.

FAO. 2010. The State of Food Insecurity in the World (SOFI): Addressing food insecurity in protracted crises. Rome.

FAO. 2019. GIEWS Country Cereal Balance Sheet

Guzha E, Nhapi I, Rockston J. 2005. Physics and Chemistry of Earth Parts, Elseier

Heinnonen-Tanski H, van Wijk-Sijbesms C. 2005. Human excreta for plant production. Bioscience Technology **96(4),** 403-411

Kirchmann H, Pettersson S. 1994. Fertilizer research volume **40,** 149-154

Mashingaidze AB. 2004. Improving Weed Management and Crop Productivity in Maize Systems in Zimbabwe. PhD Dissertation, Wageningen University, Wageningen.

Morgen Peter. 2004. The usefulness of urine, an ecological approach to sanitation in Africa. A compilation of experiences, Harare, Zimbabwe.

Nagy J, Zseni A. 2017 Human urine as an efficient fertiliser product in Agriculture, Agronomy Research **15(2)** 490-500

Prabhakar Adhikari, Hailu Araya, Gerald Aruna, Arun Balamatti, Soumik Banerjee, Baskaran P. 2017. System of crop intensification for more productive, resource conserving, climate-resilient, and sustainable agriculture: experience with diverse crops in varying agroecologies. Pages 1-28 https://doi.org/10.1080/14735903.2017.1402504

Pradham SK, Nerg AM, Sjoblom A, Holopainera JK, Heinnonen-Tanski H. 2007. Use of Human Urine fertiliser in cultivation of cabbage (*Brassica oleracea*) - Impacts on chemical, microbial and flavor quality: Journal of agricultural and food chemistry **55 (21),** 8675-8663

Saidou A, Janssen B, Temminghoff EJM. 2003. Effects of soil properties, mulch and NPK fertiliser on maize yields and nutrient budgets on ferralitic soils in southern Benin. Agric Ecol Environ **100,** 265-273

Saidou A, Kossou D, Acakpo C, Richards P, Kuyper WT. 2012. Effects of farmers' practices of fertilizer application and land use types on subsequent maize yield and nutrient uptake in central Bénin. Int J Biol Chem Sci **6(1),** 365-378

Steinfeld Carol. 2004. Liquid Gold; the love and logic of using urine to grow plants. Ecowater books

Young PJ, Phom J, Choo J, Ha DL. 2014. Duration of urination does not change with body size. Proceeding of the national academy of science.