BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULT OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

DEPARTMENT OF CROP SCIENCE

THE EFFICACY OF HUMAN URINE AS TOP DRESSING FERTILIZER ON A MEDIUM SEASON MATURITY WHITE MAIZE (*Zea mays*) VARIETY SC 637

VINCENT MARICHAMA

B192622B

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS

OF THE BACHELOR HONOURS DEGREE IN CROP SCIENCE

Supervisors: Miss Kamota and Mr Mutsengi

Approval form

The undersigned certified that they have supervised and recommended to Bindura University of Science Education for acceptance of dissertation entitled **The Efficacy of Human Urine as Top Dressing Fertilizer on a medium season maturity white maize variety SC637** submitted in the partial fulfillment of requirements of Bachelor Honours Degree in Crop Science.

Supervisor 1……………………………………………………………………………….

Supervisor 2………………………………………………………………………………

Date…………………………………………………

DEDICATIONS

I dedicate this research project to my mother Rosemary Muzanenhamo.

ACKNOWLEDGEMENTS

First of all l want to give thanks to my supervisors Miss Kamota and Mr Mutsengi for their assistance from the beginning of the research work till the end. My deepest appreciation goes to Mrs Muputa my high school Crop Science teacher for her assistance with resources and advices. Not forgetting my class mates their advice and logistics to ensure the research was accomplished, since the list is endless many thanks is given to all the people either directly or indirectly during experiment field activities data collection, analyses and interpretation God bless you all.

ABSTRACT

The efficacy of using human urine fertilizer as top dressing on a medium season maturity white maize variety SC637. The research was carried out at Alheiht High School in Masvingo Province Gutu in Zimbabwe in agro-ecological region V. The research comprised of three treatments which were human urine, synthetic urea fertilizer the positive control and the negative control that had no top dressing fertilizer. The experimental blocks were replicated four times according to each treatment respectively. Urine was applied using spit application method, 0.5liters per plant of urine was applied 14 days after emergence then another 0.5liters per plant was applied 35 days after emergence. Urea fertilizer was applied under spit application also, 0.5g per plant was applied 14 days after emergence, and then 0.5g per plant was applied 35 days after emergence. Compound D was applied in all experiments as basal fertilizer planting at rate of 5 grams per plant to all the plants. The following parameters were measured; dry biomass, stem height and yield of a medium maturity white maize variety. Maize growth rate was measured after every two weeks and the yield and dry biomass was weighed at the end and the results were recorded and analyzed. The results showed that urine had a significant effect on growth rate ($P<0.05$), dry biomass ($P<0.05$) and yield ($P<0.05$). The findings concluded that Human urine is a rich source of nitrogen and it can be recommended to farmers to use it as a top dressing fertilizer in maize just like any other synthetic nitrogen fertilizers like urea and ammonium nitrate, taking into account appropriate application rates based on the nitrogen content of the urine.

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ABBREVIATIONS

ANOVA	Analysis of variance
RCBD	Random complete block design
FAO	Food and Agriculture Organisation
LSD	Least Square Difference
T/ha	Tonnes per hectares
NPK	Nitrogen, Potassium, Phosphorus
cm	centimetres

CHAPTER 1

1.1 INTRODUCTION

Maize plays a crucial role in the Zimbabwean economy as it guarantees food security and serves as a primary source of raw material for agro-industrial activities. The country consumes around 2.1 million metric tons of maize per year, which accounts for approximately 14% of its agricultural gross domestic product. (Makate, *et al*., 2015). According to a report by the Food and Agriculture Organization (FAO), maize is a vital food crop in Zimbabwe, serving as a staple for over 50 percent of the population, which is estimated to be around 17.1 million people. The crop is not only consumed as a whole grain, but it is also processed into maize meal and used to produce various products and by-products, such as flour, oil, maputi, samp, grit that is used in making snacks, and starch (Nyasha, *et al.,* 2019). As such, maize production is highlighted for priority investment owing to its strategic role as a food security commodity (Mashingaidze, *et al.,* 2018).

Maize plays a crucial role in the animal feed industry, serving as the main source of energy in animal feed. It constitutes 47 to 75 percent of feed, supporting the production of millions of livestock, including broilers, laying birds, pigs, and dairy cows, which depend on manufactured feed. Maize is grown by more than 90 percent of farming households in Zimbabwe, covering over 60 percent of the total annual cropped area or 80 to 90 percent of the total land area under cereal production. The crop consumes more than half of the fertilizer and other agricultural inputs used in the country, according to a study by (Charles, *et al., 2014*) and a report by (Moyo, *et al*., 2021).

There is thus an urgent need for the promotion alternative cheaper sources of fertilizers in Zimbabwe in order to maximise maize production among small holder famers. In order to replace the expensive industrial fertilizer, the use of urine as an alternative input for agriculture is a cheap option and encourages waste recycling (Rana and Chopra, *et al*., 2013).Urine is the major product of ecological sanitation toilets such as urine diversion dry toilets and its utilization as an agricultural input is a current challenge in developing countries. The use of urine in agriculture has become a new phenomenon in some countries in recent years but it is not understood and not accepted in developing countries. Urine contains plant nutrients that may supplement or replace commercial fertilizers for crop production (Jöhnsson, *et al*., 2010).

Developed countries have shown increasing interest in using urine as a fertilizer in recent years. For instance, Sweden has been promoting the use of urine as an environmentally friendly replacement for conventional fertilizers. This is according to a study by BJ Zimmerman, A Bandura, and others (2010). In Switzerland, there is a project known as "Pee Power" that aims to investigate the potential of urine as a source of both energy and fertilizer. This information is based on a report by (De Paepe, *et al*., 2021).

To effectively promote the reuse of nutrients, it is important to not only understand the feasibility of implementing such systems in specific contexts but also to consider the perceptions of farmers towards using human waste in food production (Johnsson, *et al.*, 2019). This can help determine how farmers evaluate and adopt such practices. In a research project conducted by E Andersson and others (2015), a collaborative process was used to experiment with urine fertilizer in maize production within a smallholder farmer community in Gutu. The aim was to explore the perceptions of farmers towards using urine fertilizer and to evaluate its potential as a solution to soil productivity problems, including its impact on yield and farmer perceptions.

Human urine can be utilized as a nitrogen fertilizer that is well-balanced and can replace chemical fertilizers in crop production without affecting yields, according to a report by (Szekely and Jijakli, *et al*., 2022). Field research in Burkina Faso has shown that urine-fertilized crops yielded the same as mineral-fertilized crops, as reported by (Wilde, *et al.* 2019). The amount of urine produced by one person in a year can fertilize a crop area of 300-400 m2 to a level of about 50-100 kg N/ha, according to a study by Nascimento, Kiperstok, and others (2018). Urine should be stored in closed tanks or containers and applied directly onto the soil, not on the plants, in doses equivalent to urea and ammonium fertilizers. For small-scale applications, plastic watering cans can be used, while larger-scale applications may require spreaders for animal slurry. To avoid ammonia losses, air contact should be minimized, and the urine should be incorporated into the soil as soon as possible.

There is a growing interest in exploring the potential fertilizer value of human waste, as evidenced by increasing research efforts. Previous studies have focused on various aspects of this topic, including its potential to enhance crop yield, potential health risks, and technical considerations related to collection and storage (Mnkeni, *et al.,* 2008, Semalulu, *et al.,* 2011). However, most of these studies have been conducted off-farm, with limited participation from farmers. Additionally, the cultural and social factors that may influence the adoption of human waste as a fertilizer have not been fully explored. These factors include norms, attitudes, and perceptions that are often identified as barriers to the use of human waste in food production, as discussed in a report by Karak and Bhattacharyya and others (2011).

1.2 PROBLEM STATEMET

The effectiveness of human urine as top dressing fertilizer on maize remains a question among most farmers in Zimbabwe its precise effect on the maize growth rate, dry biomass and yield is still unknown.

1.3 Justification

There is great potential for human urine to be used as a valuable fertilizer worldwide, particularly in developing countries where high fertilizer costs and poor crop yields are significant challenges that require immediate attention. According to (Karak and Bhattacharyya, *et al*., 2011), using urine as a fertilizer can help increase crop yields and provide a viable alternative to chemical fertilizers. Using human urine for agricultural purposes is a more practical approach not only due to the damaging effects caused by synthetic fertilizers but also because the raw materials used to make artificial fertilizers will eventually be depleted.

1.4 Main objective

To determine the effectiveness human urine as a top dressing fertilizer on medium season maturity white maize with regards to growth rate, dry biomass and yield of maize.

1.4.1Specific objective

To determine the effectiveness of top dressing with human urine on the height of maize CS637

To determine the effectiveness of top dressing human urine on the plant dry biomass of maize SC637 To the determine the effectiveness of top dressing human urine on the yield of maize SC637

1.5 Hypothesis

H1: Human urine has a significant effect on stem height

: Human urine has a significant effect on maize dry biomass

: Human urine has a significant effect on maize yield

CHAPTER 2

2.1 LITERATURE REVIEW

2.1.1 Nutritional significance of maize

Maize is the most important cereal crop in Zimbabwe, both in terms of production and consumption. It is a staple food for the majority of the population and plays a significant role in the country's food security. Maize is also an important source of nutrition, providing a range of essential nutrients that are important for human health. Maize is a good source of complex carbohydrates, which provide energy for the body. It is also a good source of dietary fibre, which is important for digestive health. Maize is also relatively low in fat, making it a healthy food choice for people who are trying to maintain a healthy weight (Katia, *et al*., 2019)

In addition to providing energy and fibre, maize also contains a range of vitamins and minerals that are important for human health. These include, vitamin B-complex that constitute of thiamine, niacin, and folate which are found in the contents of 0.1mg per 100g, 5mg per 100g and 50µg per 100g of maize respectively. These vitamins are important for energy metabolism and the proper functioning of the nervous system (Mango, Makate, *et al.,* 2015). Maize is also a good source of beta-carotene, which the body can convert into vitamin A. Vitamin A is important for the immune system, vision, and skin health, it also contains iron, which is important for the production of red blood cells and the prevention of anaemia. Maize is a good source of zinc, which is important for immune function, wound healing, and the proper growth and development of children (Nyasha. K *et al.,* 2019).

However, it is important to note that maize is not a complete source of nutrition on its own and should be consumed as part of a balanced diet that includes a variety of other foods. (Mango, *et al.,* 2015). In Zimbabwe, where maize is a staple food, it is often consumed with other foods such as beans, vegetables, and meat or dairy products, which can help to provide a more balanced and complete source of nutrition (Katia, *et al.,* 2019).

Overall, maize is an important crop in Zimbabwe both for its role in food security and its nutritional significance. Its importance in the country's diet highlights the need for continued efforts to improve maize production and distribution, as well as to promote the consumption of a diverse range of foods to ensure adequate nutrition for all Zimbabweans (Nyasha. *et al.*, 2019).

2.1.2 Maize fertilizer requirements

To achieve good yields in maize production, it is essential to apply fertilizer based on the 4Rs of fertilizer management, which involves using the right source, rate, timing, and placement of fertilizer. In order to optimize fertilizer practices for maize production, it is crucial to understand the nutrients that are required in large quantities and their role in crop growth. A report by Adu, Abdulai, and others (2014) states that three essential nutrients are crucial for maize plant growth and yield.

Nitrogen is required for strong and healthy growth, producing large cobs full of grain. Phosphorus supports good crop establishment by promoting healthy root growth, while potassium ensures healthy plants with strong stems that can withstand drought periods and resist pests and diseases. Nitrogen is needed during early and mid-crop growth,

Phosphorus is mainly required during early stages, and potassium is necessary throughout the crop's growth stages. It is recommended to apply the entire potassium requirement at planting or soon after germination since it is not easily lost from the soil.

Potassium is an essential nutrient for maize plants that promotes strong and healthy growth, helps plants resist pests and diseases, and enables them to withstand drought periods. It is required during both the early and later stages of crop growth. According to a report by Adu, Abdulai, and others (2014), it is recommended to supply the entire potassium requirement at planting or soon after germination because the applied potassium is not easily lost from the soil.

2.1.3 Basal dressing

To ensure optimal maize production, it is recommended to use compound fertilizers that provide all primary macronutrients (nitrogen, phosphorus, and potassium) either during or immediately after planting. Examples of such fertilizers are NPK 15:15:15 and NPK 25:10:10. Additionally, multinutrient fertilizers that contain secondary macronutrients (like sulfur, calcium, and magnesium) and micronutrients (such as zinc and boron) along with NPK are also beneficial to use during or after planting. An instance of such fertilizer is NPK 11:22:21 + 5 S, 0.72 Zn, 0.5 B, which provides crops with S, Zn, and B. According to a study by Sharma et al. (2017), the use of multinutrient fertilizers that also supply secondary and micronutrients has resulted in the highest maize yields in Northern Ghana.

Basal dressing can be done by broadcasting the fertilizer over the soil surface before planting, or by using a banding or placement technique to apply the fertilizer closer to the seed. The choice of application method depends on the fertilizer type, soil conditions, and equipment availability (Osman, *et al.*, 2013). Maize plants should be monitored regularly after planting to ensure that they are responding appropriately to the fertilizer. This may include visual observation of plant growth and development, as well as soil testing to assess nutrient availability (Sharma, *et al.*, 2017).

2.1.4 Top dressing

For optimal growth and grain development, maize plants require a large amount of nitrogen during topdressing. Straight fertilizers that are high in nitrogen, such asu rea, are the recommended source for topdressing, according to a report by (Mahboob, Yang, *et al.*, 2023). The first top dressing should be done when the maize plants have about four to six leaves, and the second top dressing should be done when the plants have about eight to ten leaves. This timing ensures that the plants receive the nitrogen when they need it most, and when they are most responsive to the additional nutrient (Kitchen, *et al.*, 2010).

The application rate of nitrogen fertilizer for top dressing should be based on soil test results, crop needs, and environmental considerations. Excessive use of nitrogen can cause environmental issues like nutrient leaching and greenhouse gas emissions, whereas insufficient use can lead to decreased crop yield and quality

Nitrogen fertilizer can be broadcast over the soil surface or applied closer to the maize plants using a banding or side dressing technique. The choice of application method depends on the soil conditions, the nitrogen source, and the equipment availability (Momesso, *et al.*, 2021). Maize plants should be monitored regularly after top dressing with nitrogen fertilizers to ensure that they are responding appropriately to the additional nutrient. This may include visual observation of plant growth and development, as well as soil testing to assess nutrient availability and potential environmental impacts.

2.1.5 Nitrogen significance in maize

Plants need a significant quantity of nitrogen as it is an essential nutrient for their growth. It is ironically the mostly frequently deficient nutrient in crop production yet its ultimate source, nitrogen gas. Plants absorb both NH4 + and NO3 (Gonsalves, et *al.,* 2016). Nitrates generally occur in higher concentrations than NH4 + and freely move to roots by mass flow and diffusion.

Nitrogen is a crucial nutrient for maize as it performs various vital functions in the plant's growth and development. According to Wang et al. (2014), nitrogen is a vital component of amino acids, which are the building blocks of proteins. It is necessary for the synthesis of proteins that maize needs for growth and development. Additionally, nitrogen is a critical constituent of chlorophyll, the pigment responsible for photosynthesis. Insufficient nitrogen can result in reduced chlorophyll levels, which can impair the plant's ability to produce energy through photosynthesis, as stated by (Fageria *et al.,* 2014).

Nitrogen is important for promoting growth and increasing yield in maize (Cui, *et al.,* 2010). Adequate nitrogen supply can increase the number of cobs on a maize plant, as well as the size and weight of individual ears. Nitrogen also help maize plants tolerate stress, such as drought and disease. A sufficient supply of nitrogen can help maize plants maintain their growth and yield even under adverse conditions (Aslam, *et al.,* 2012). Nitrogen is crucial for root expansion and distribution in maize also it promotes the growth of lateral roots, which can help the plant absorb water and nutrients from the soil more efficiently (Zhang, *et al.,* 2020)

While nitrogen is an essential nutrient for maize, too much of it can lead to various problems. Maize plants that receive too much nitrogen may develop an abundance of leaves and stems at the expense of reproductive structures such as ears, this can reduce yield and quality. Excessive nitrogen can delay the maturity of maize plants, which can result in a longer growing season and increased risk of frost damage (Osman, et *al.,* 2013)

Excessive nitrogen can cause maize plants to become weak and succulent resulting in lodging, which can reduce yield and quality (Coetzee, *et al.,* 2013). Maize plants that receive too much nitrogen may be more susceptible to pests and diseases, as the excess nitrogen can make the plant tissue more succulent and attractive to insects and pathogens. Excess nitrogen can leach from the soil and contaminate groundwater and surface water, leading to eutrophication (Fageria, *et al.,* 2016).

Maize plants that receive insufficient nitrogen may exhibit stunted growth, as nitrogen is essential for cell division and expansion. Nitrogen deficiency can cause maize leaves to turn yellow or pale green, particularly in older leaves (Anas, *et al.,* 2020). This is due to reduced chlorophyll production, which can impact photosynthesis and energy production. Nitrogen deficiency can reduce maize yield, as it can lead to smaller ears and fewer kernels per ear. Nitrogen deficiency can delay maize maturity, as the plant may divert its limited resources to vegetative growth rather than reproductive structures. Nitrogen deficiency can make maize plants more susceptible to stress, such as drought and disease, as they may not have the resources to cope with adverse conditions (Arp, *et al.*, 2017).

2.1.6 Impacts of high fertilizer prices to small holder farmers

Zimbabwe has been experiencing high inflation rates for several years, with the rate of inflation reaching unprecedented levels in recent years. In September 2021, the inflation rate in Zimbabwe remained high, with estimates ranging from 50% to over 100% (ReliefWeb, *et al.,* 2021) this has had a significant impact on the country's economy, including the agricultural sector and smallholder farmers.

The high inflation rates in Zimbabwe have led to an increase in the cost of inputs such as seeds, fertilizers, and pesticides, making it more difficult for smallholder farmers to afford the necessary inputs to maintain crop yields. Additionally, the high inflation rates have led to a decline in the value of the Zimbabwean dollar, reducing the purchasing power of smallholder farmers and making it more difficult for them to afford basic necessities such as food and healthcare (Voice of America, *et al.,* 2021).

Higher fertilizer prices had a significant impact on small-scale maize farmers in Zimbabwe, as maize is one of the most important crops for both subsistence and commercial farming in the country. (Rukuni, et al., 2006). These exorbitant price high have landed a huge blow on the small scale farmers and has resulted in catastrophic effects which include reduced crop yields, higher fertilizer prices have made it more difficult for small-scale maize farmers to afford the necessary inputs to maintain crop yields. This has led to lower maize yields, reducing the amount of food produced and the income generated for small-scale farmers (Reuters, *et al.,* 2021)

Higher fertilizer prices have increase production costs for small-scale maize farmers, as they may need to spend more money on inputs to maintain their crop yields. This has reduced the profitability of maize farming and make it more difficult for small-scale maize farmers to invest in their farms (Saunders, *et al.,* 2014)

These high fertilizer prices have reduced the competitiveness of Zimbabwe's maize sector, making it more difficult for small-scale maize farmers to compete in global markets. This can lead to a decline in exports and a loss of income for small-scale maize farmers (Xinhua, et al., 2021)

Small-scale maize farmers in Zimbabwe often rely on credit to purchase expensive inputs such as fertilizers. Higher fertilizer prices can make it more difficult for farmers to access credit, as lenders may be less willing to provide loans for inputs that are perceived as high risk (Xinhua *et al.,* 2021)

Higher fertilizer prices has reduce food security among small-scale maize farmers and their families, as they are not be able to afford enough food to meet their basic needs. This has led to malnutrition and poor health outcomes, particularly among vulnerable populations such as children and the elderly (Richert, *et al.,* 2010).

2.1.7 Potential of human urine

The use of human urine as fertilizer is practiced in various parts of the world, although it is more common in some regions than others. In rural areas of developing countries, such as India, China, and parts of Africa, urine is often collected and used as a fertilizer for crops and gardens. In these areas, where access to synthetic fertilizers may be limited, urine is seen as a valuable resource for improving soil fertility and increasing crop yields (Udert, *et al.,* 2019).

In 2017, J. Nagy and A. Zseni conducted research on the utilization of urine for agricultural purposes. They found that urine is a suitable fertilizer because it contains most of the nutrients found in human excreta, and these nutrients are readily available to plants. The research revealed that between 75 percent to percent of the nitrogen present in urine is in the form of urea, which converts into ammonium ions in an aqueous solution with a pH close to neutral. This ammonium can be transformed into nitrate through a biochemical process in the presence of oxygen, as stated by (Jonsson *et al,* 2004).

In Europe, the adoption of human urine as a fertilizer was more widespread in the past, but it declined with the advent of synthetic fertilizers. However, there has been renewed interest in recent years in using urine as a sustainable alternative to synthetic fertilizers. In countries like Sweden, Germany, and Switzerland, there are initiatives to collect and process urine from households and public toilets and use it as a fertilizer for agriculture and horticulture (Rich Earth Institute, *et al.,* 2021)

For instance, in Vermont, a non-profit organization called Rich Earth Institute collects urine from households and uses it as a fertilizer for hay fields and pastures. Similarly, in British Columbia, Canada, a project called "Urine the

Money" collects urine from public events and uses it to fertilize community gardens. (Rich Earth Institute, *et al.*, 2021)

According to (Jonsson *et al,*. 2004), the urine from a single person could provide sufficient nutrients to fertilize a crop area of 300-400 square meters per year. The World Health Organization (WHO) has recognized the potential benefits of utilizing recycled excreta nutrients, as stated in their report (2006). These benefits include improved household food security and increased nutritional variety, which can help reduce malnutrition. Additionally, the use of excreta and grey water for agriculture may enable year-round crop cultivation in some areas, leading to increased income from the sale of surplus crops. Furthermore, using excreta as fertilizer can save money that would otherwise be spent on commercial fertilizers, allowing those resources to be directed towards other productive uses.

2.1.8 Problems associated with the utilization of Urine as fertilizer

The utilization of urine as a fertilizer is not without problems, and three main issues are applicable regardless of the community's social situation. These present challenges are probable toxicity to plants, the volatility of nitrogen, and the potential presence of pathogens.

An issue to consider is the potential toxicity of plants resulting from excessive fertilization, which can lead to the accumulation of harmful levels of nutrients in the soil and damage the plants. High nitrogen content in urine fertilizer is a primary concern in this regard. However, the toxic level of nitrogen is relatively high, which provides a considerable margin of safety. According to (Jonsson, *et al.*, 2004). The level of nitrogen that becomes toxic is approximately four times higher than the standard fertilization rate. Therefore, if the nitrogen level is kept at an appropriate level, the other nutrients present in urine are expected to remain at acceptable levels as well, except in rare cases.

The volatility of nitrogen in urine is another concern when using it as a fertilizer. According to Jonsson *et al.,* (2004), the high pH and ammonium concentration in urine increase the risk of nitrogen loss in the form of ammonia through volatilization in the presence of ventilated air. This process occurs rapidly, and the loss of valuable nitrogen to the atmosphere increases with rising temperatures. Additionally, when urine comes into contact with the air, it emits bad smells that may discourage individuals from using it as a fertilizer (WHO, *et al., 2006*). While the odour of urine does not affect its usefulness as a fertilizer, it can be a deterrent to its adoption. To preserve nitrogen and minimize bad smells, it is recommended to collect urine fertilizer and apply it with minimal exposure to the atmosphere." Nitrogen is an essential nutrient for plant growth, and human urine is a valuable source of nitrogen. According to

R.D.H. et al. (2014), nitrogen plays a significant role in the development of plant height, as it is a crucial element in the formation of amino acids, which are the building blocks of proteins, as well as cell division and elongation. When maize plants are provided with sufficient nitrogen, they typically grow taller and healthier. Conversely, (NARC, *et al.,* 2013) observed that maize plants that were not supplied with nitrogen showed clear signs of stunted growth and chlorosis, indicating the importance of nitrogen in plant development. Schistosomiasis is a disease that is not highly transmissible in tropical areas due to its life cycle. However, the main risk of contracting the disease from excreta is through the faecal fraction rather than the urine fraction. Thus, it is crucial to implement measures to prevent faecal cross-contamination of the urine fraction in order to control and prevent the spread of the disease.

The risk of disease transmission through urine is minimal, except under two conditions, as stated in the World Health Organization's report (2006: 34-36). These conditions are the risk of schistosomiasis transfer and the risk of faecal contamination. Provided that these hazards are reduced to a minimum, it is possible to regard urine as a safe option for utilization as a fertilizer. Precautions can be taken in areas where schistosomiasis is a concern to prevent disease transmission, although the risk is low. For instance, it is possible to deactivate the schist parasite by storing urine in a sealed container for 48 hours. Moreover, measures can be incorporated into systems to decrease the likelihood of contamination by faecal matter, or urine can be treated to neutralize faecal pathogens (CDC, et al., 2008). Nevertheless, even if the risks are low, all designs should take into account the potential presence of disease and strive to minimize the risk to the lowest possible degree.

2.1.9 Urine Collection

To make urine fertilizer collection and application sustainable, any system used must address the challenges associated with its use, including plant toxicity, volatility, and the possible presence of diseases, as noted by (Anna Richert *et al.,* 2010). Furthermore, the design of the system should account for behavioural obstacles within the community or individual using it. For smallholder farming communities, the urine collector system should be cost-effective, easy to use, and made from locally available materials. Additionally, these systems should be compatible with existing latrines, as emphasized by Jonsson *et al.,* (2004).

2.1.10 Urine Application

The optimal application of nutrients to a plant depends on the plant species and the stage of its life cycle. Researchers typically use the nitrogen concentration as a benchmark for plant nutrient application. The reason for this is that urine contains a greater amount of nitrogen, compared to other nutrients, and nitrogen is the nutrient that is required by plants in the largest quantity as noted by Jonsson *et al.,* (2004). Therefore, nitrogen is a crucial nutrient to consider when applying urine as a fertilizer.

According to (Jonsson *et al.,* 2004), the amount of urine produced by one person in a day (around 1.5 L/day) can be utilized to fertilize a single crop during the typical three-month cropping season in Mali. This means that 0.25 litters of undiluted urine can be applied to every square meter of the crop every two weeks. CREPA suggests a suitable range of 30-80 kg of nitrogen per hectare for cereal crops.

In order to decrease the risk of transmitting diseases, the World Health Organization recommends that urine-based fertilizers should not be used on crops that will be harvested for consumption during the month prior to harvesting (WHO, *et al.,* 2006). Although the risk of disease transmission through urine is minimal, the one-month gap allows ample time for any potential pathogens in the urine to be deactivated to a safe level. This extra precautionary measure further reduces the risk of disease transmission (WHO, *et al.,* 2006).

To avoid the excessive loss of nitrogen to the atmosphere, the application of urine fertilizer should focus on integrating the urine into the soil with as little air exposure as possible. One way to attain this is to form shallow trenches close to the crops, add the urine, and then cover the trench, as recommended by Hakan Jonsson and others (2004).

CHAPTER 3

3.1 METHODS AND INSTRUMENTS

3.1.2 Area of study

The experiment was carried out at Alheit High School in Agricultural Region V Masvingo Gutu, located in the south-eastern part of the country. During the study, the area experienced an annual precipitation ranging between 450-650 mm, with temperatures varying between 20 to 30 degrees Celsius. The soil types present in the study area were deep loam and sandy loam soils, and the altitude of the location was 1100m above sea level. The latitude and longitude of the area were -19.6667° S and 30.9167° E, respectively. These climatic and geological characteristics provide important context for the study, and help to inform the interpretation of the results obtained.

3.1.4 EXPERIMENTAL DESIGN

The experiment was laid out in a randomised complete block design with 3 treatments that were replicated 4 times. In the laying out the experiment the block factor was slope. Each block measured 4x1 meters (4 square meters) for all 12 blocks which were replicated Treatment 1 was human urine, treatment 2 was the positive control having urea fertilizer and treatment 3 was the negative control without top dressing fertilizer.

3.2Agronomic practices

3.2.1 Land preparation

In October 2021 soil samples were taken for soil laboratory analysis at Department of Research and Specialist Services (DR&SS) in Masvingo and the results were as follows pH: 6.2, organic matter: 2.1%, nitrogen 40 ppm, phosphorus: 12 ppm, potassium 220 ppm, calcium 1,500 ppm, magnesium 250ppm, sulphur 20 ppm, iron 6 ppm, manganese: 2 ppm, zinc 1 ppm, copper 0.5 ppm, boron 0.2 ppm which helped also in nitrogen application rate, in this case low soil nitrogen content was addressed by applying nitrogen fertilizer at rate of 250kg/h

The first step of conventional tillage was ploughing using an ox drawn plough to turn over the soil and break up any existing vegetation and plant residue. After ploughing, the soil was disked using a disk harrow to break up any large clods of soil and incorporate any plant residue that was not completely broken up during ploughing. Once the soil was ploughed and disked, it was levelled to create a smooth surface for planting. This was done using a drag harrow or other levelling equipment.

3.2.2 Making plots

Plots were marked using pegs, tap measure and garden line and they measured 4mx1m with 1m path separating blocks. A hand harrow was used to level the interior of the blocks potholes were marked using a marking stick at 75cm inter raw and 35cm inter row spacing with blocks covered with 15cm crop residues and left to trap maximum rain before planting. The maize seed were sown per plant station and later thinned giving plant population of 44 000 plants/ha.

3.2.3 Urine collection

Twenty school students with age range of 17 to 18 years were selected and their diet was monitored for a period in a period of 1 week and they were made to consume 70g of protein food which was beans and egg each day. Urine was collected from these students who brought the urine in bottles and each student produced an average of 1liter of urine per day.

3.2.4 Urine storage and treatment

To monitor the urine level in the container, translucent jugs were used. The collector was designed to be airtight, preventing nitrogen loss and unpleasant odours. The urine was stored for three days to eliminate bacteria and pathogens present in the urine and to increase the urine's pH from acidic to neutral or higher, which helps to kill any harmful pathogens (CREPA, *et al.*, 2006).

3.2.5 Nutrient analysis of urine

FAO has developed a method that allows for the estimation of nutrient outputs in human excrement based on the nutrients consumed in food. The organization also provides per capita protein consumption

data for different countries. The formulas given by (Jonsson, et al., 2004) can be utilized to forecast the nitrogen output.
Nitrogen = 0.13 x Total Food Protein

Each student consumed an average of 70grams of protein food per capita per day and produced an average of 1 liter of urine per day

In excreta

Nitrogen = 0.13 x 70g/day = 9.1g nitrogen per day in excreta

70 percent of nitrogen in human excreta is found in urine (Jonsson et al,. 2004)

70% x 9.1g nitrogen per day = 6.37g/day in urine

Each student produced average of 1L urine per day

6.37g nitrogen per day ÷ 1 litter per day = 6.37g nitrogen per litter

The urine contained 6.37grams of nitrogen per 1liter of urine and the CS 637 medium maize variety requires average 5g nitrogen per plant according to SeedCo an average of 1 liter of urine was applied per plant with a clearance of 1.37g of nitrogen that can be possibly lost through volatilisation and leaching.

3.2.6 Fertilization application

A basal application of 300kg/ha compound D fertilizer (14:28:14) was applied to all the plots at planting. Before planting and 5g of compound D was applied to each plant station at planting. Two weeks after emergence urea fertilizer was applied as a positive control at rate of 250kg/ha. It was applied under split application with 2.5g applied per plant two weeks after emergence and another applied when the maize reached the knee level.

3.2.7 Urine application

The application rate of urine was 1liter of urine per plant and the urine was applied under split application also with the first application applied two weeks after emergence and another done when the maize plants reached knee level with 0.5L applied first and another 0.5 applied secondly. Urine was diluted with water at ratio of 1:1 before application to reduce the salinity effect on soil.

A furrow 4cm deep was dug along maize the line and diluted urine was applied using a plastic watering cane because urine is highly corrosive then it was covered afterwards. Application was done at don and on a less windy day to avoid the volatilisation of nitrogen. After application the plots were irrigated to improve the nutrient mobility and plant nutrient uptake.

3.2.8 Irrigation

In general SC637 requires about 450 to 550 mm of water thought its growing season. Supplementary weekly irrigation was done using a watering cane at an average weekly water requirement of about 11 to 14 mm using a watering cane.

3.2.9 Weed and pest control

To manage two types of weeds, chemical control and manual weeding methods were employed. A blend of Atrizine and metalachlor was administered immediately after planting. Additionally, Femvelaret was utilized to control pests such as cutworms, with a rate of 2 liters per hectare, and a sticker was used at a rate of 300 milliliters per hectare. These herbicides were mixed with 100 liters of water and sprayed over the surface after sowing, utilizing a knapsack sprayer. To manage the maize stalk borer, which includes Busseola fusca and chilo, Dipterex 2.5% granules were utilized.

3.3 Data collection

3.3.1 Measuring of growth parameters

3.3.2 Plant height (cm)

Representative plants that will be measured for plant height were randomly selected and tagged, 10 plants were selected in each plot. A measuring tape or ruler to measure the height of each maize plants in centimetres after every two weeks from the soil level to the tip of the highest leaf or tassel while standing next to the plant. The plant height measurements were recorded on a recording sheet

3.3.3 Measurements of yield

Once the maize plants reached the stage of maturity, plants were randomly chosen and ten maize plants were selected from each plot. The plants were then cut at ground level, and any leaves or other plant material not considered part of the above-ground biomass were eliminated. The harvested maize plants were oven dried to reduce the moisture content to a consistent level. The dried maize plants were dried using a Pascale's scale to determine their dry biomass. The biomass measurements for each experimental unit were recorded in a data sheet

3.3.4 Measuring dry biomass

At physiological maturity the ears or cobs from all plots were harvested. The husks were removed by hand and it was shelled using a hand held sheller after shelling the maize was packed in bags that were weighed individually per plot using an electronic scale. The data was recorded a calculated on a recording scale. The following formula was used to calculate yield per hectare

Yield per hectare (in kg/ha) = (Total harvested weight / Total harvested area) x 10,000

3.4 Data analysis

The data collected was analysed using GenStat 19th Edition statistical software to obtain ANOVA tables at a significance level of 5%.

CHAPTER 4

Results

4.1 Effects of urine on plant height at week 6 after planting

Human urine had a significant effect on the maize plant height after six weeks at ($P<0.05$) compared to the negative control which had the lowest height of 63.32cm, however there was no significant difference between urine and urea ($P>0.05$), which they recorded a height of 83.32cm and 83.35cm respectively

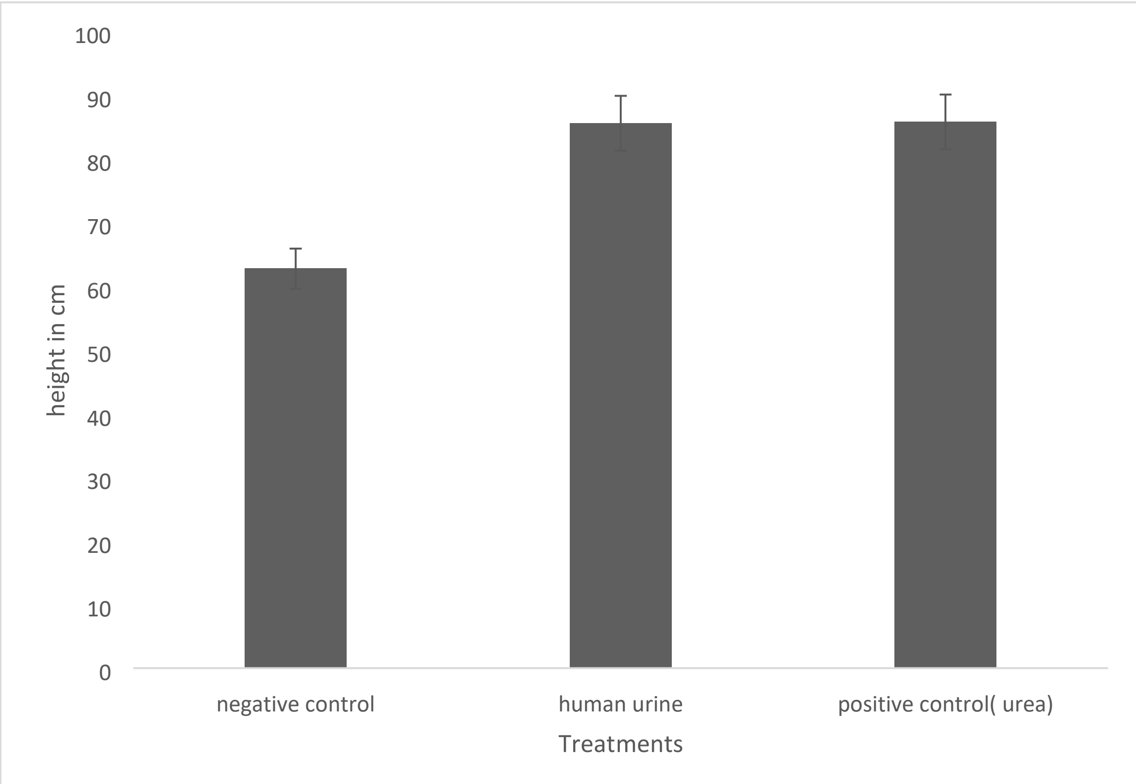

Fig 4.1 maize plant height in 6 weeks

4.2 Effects of urine on plant at height week 8 after planting

Human urine and area were statistically similar and had a significant effect on maize height at $P<0.05$ 8 weeks after planting recording 119.07cm and 119.07cm respectively, which was higher than the control which had no top dressing (85.45cm)

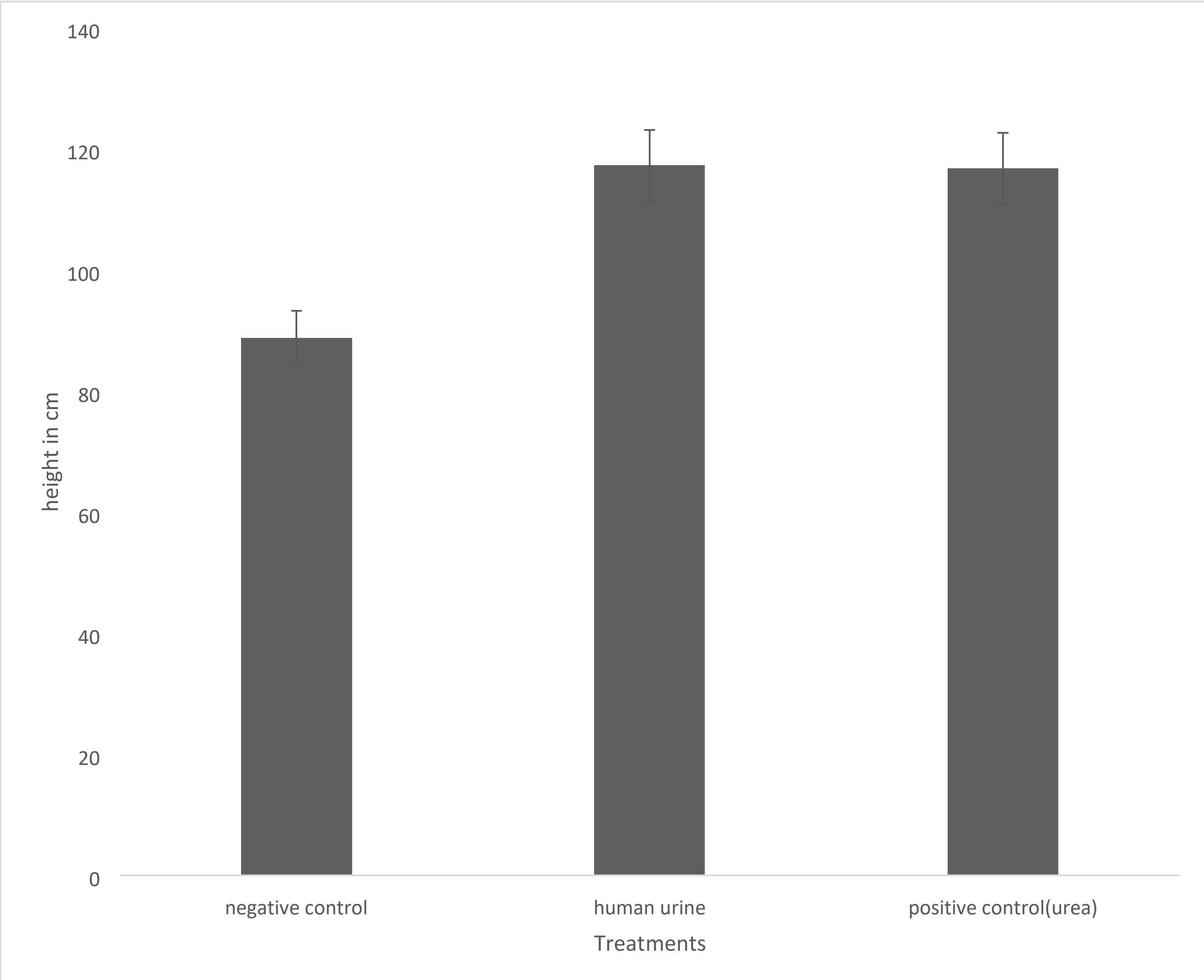

Fig 4.2 plant height in week 8

4.3 Effects of urine on plant height at week 14 after planting

Human urine and urea fertilizer had a significant effect on the maize plant height at fourteen weeks after planting at P<0.05 recording 203.04cm and 203.06cm respectively compared to the negative control which had no top dressing which recorded 143.87cm.

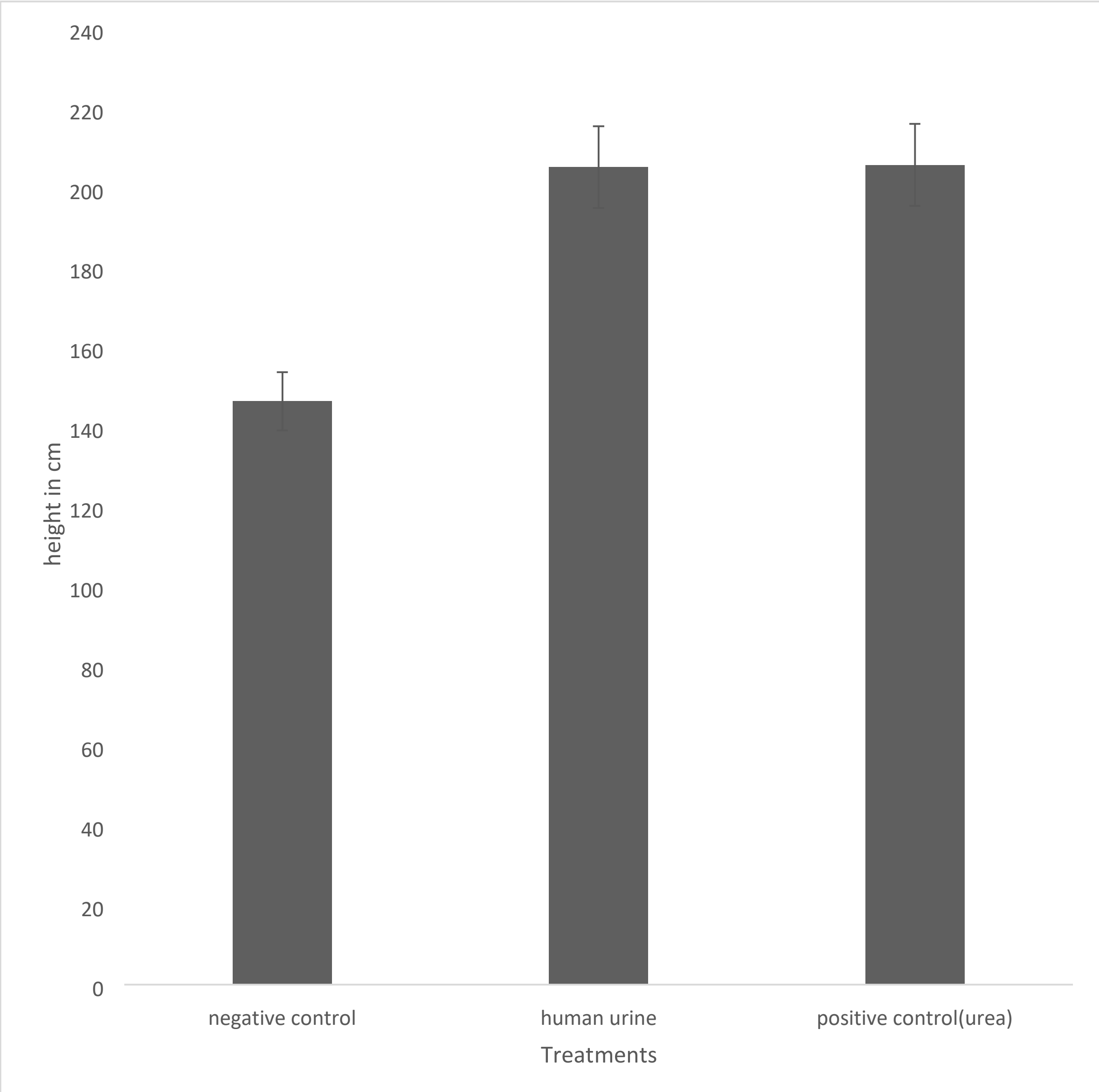

Fig 4.3 maize plant height in week 14

4.4 Effects of urine on plant dry biomass

Human urine and urea had a significant effect on the maize plant dry biomass at (P<0.05) recording 173.93g and 173.96g respectively compared to that with of the negative control which had no top dressing fertilizer which recorded a low dry biomass of 146.45g.

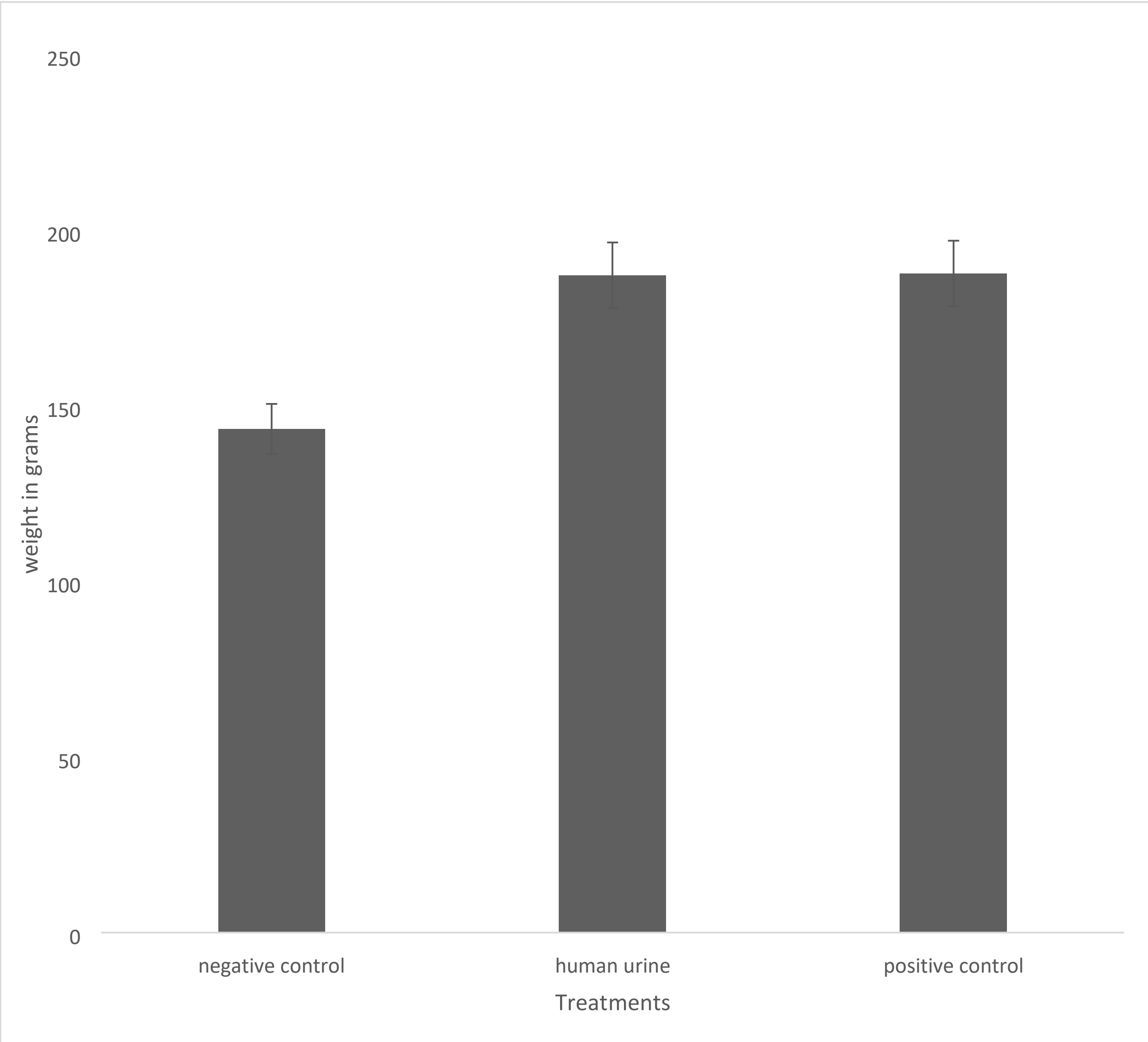

Fig 4.4 maize dry biomass

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4.5 Effects of urine on maize grain yield

Human urine and urea had a significant effect on the maize yield at ($P<0.05$), recording 2750.64g and 2750.68g respectively compared to the negative control which had a relatively low yield of 1004,98g.

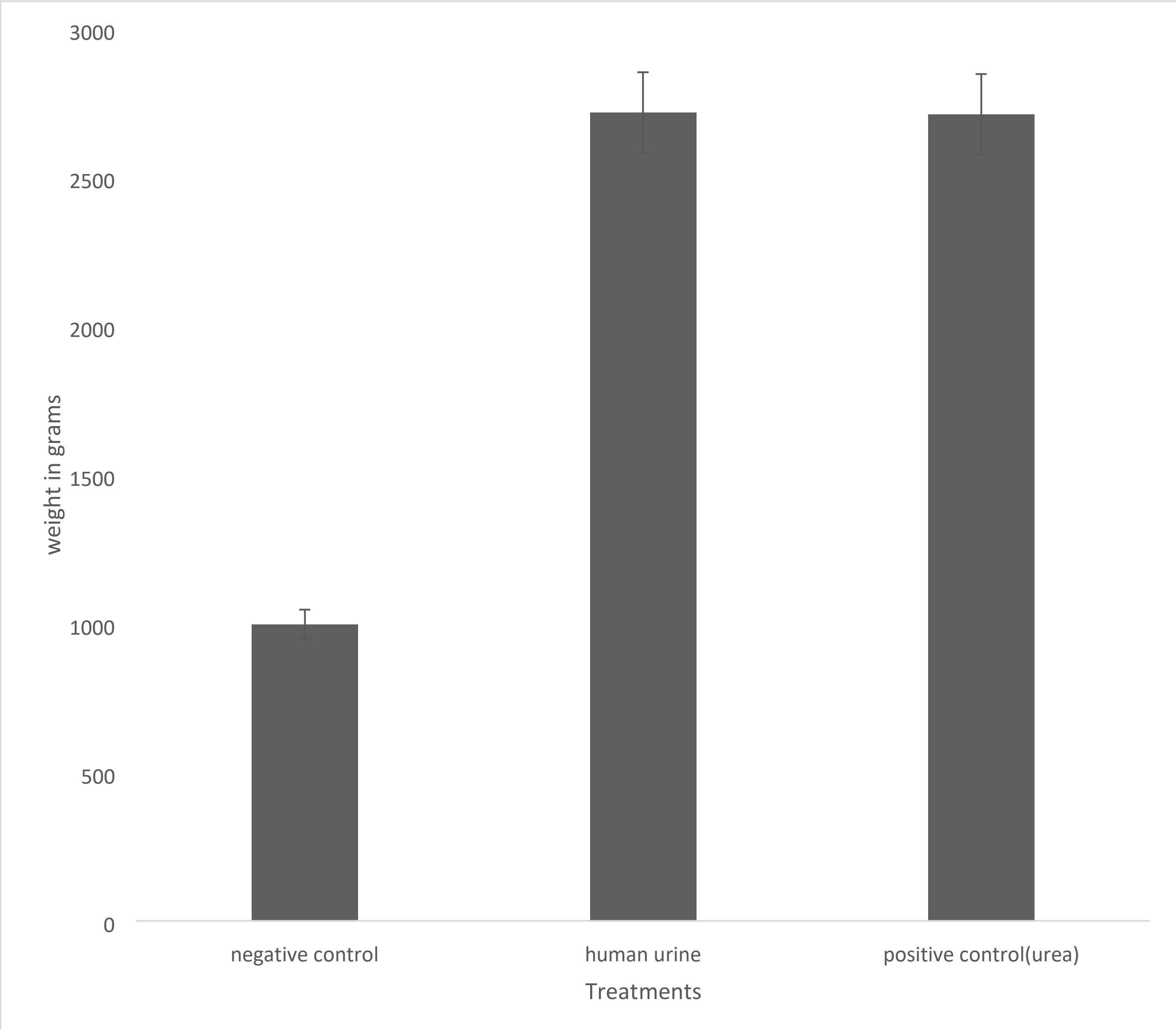

Fig 4.5 maize yield

Fig: 4.6 showing plots of maize with top dressing (left) and maize top dressed with urine (right) **CHAPTER 5**

5.1 DISCUSSION

5.1.1 Effects on plants height

Human urine showed a significant effect on the maize plant height throughout its growth stages proving that human urine is indeed a nitrogen rich fertilizer. Nitrogen is an essential nutrient for plant growth, and human urine is a valuable source of nitrogen. According to (R.D.H., *et al.*, 2014), nitrogen plays a significant role in the development of plant height, as it is a crucial element in the formation of amino acids, which are the building blocks of proteins, as well as cell division and elongation. When maize plants are provided with sufficient nitrogen, they typically grow taller and healthier. (Conversely, et *al.*, 2013). The negative control that was not top dressed recorded shorter maize plant height throughout the growth stages this is because the maize plants suffered from nitrogen deficiency resulting in stunted growth.

5.1.2 Effects on plant dry biomass

Dry biomass refers to the amount of plant material produced by the plant after all the water has been removed from them. Maize plants that were not top dressed recorded the lowest dry biomass results because they lacked an essential element which is nitrogen. Human urine and urea fertilizer being rich sources of nitrogen, the maize plants top dressed with it accumulated more biomass throughout their growing stage. Nitrogen promotes metabolic proses in the plant like photosynthesis and protein synthesis which produces amino acids used to build up protein chains. Proteins are essential for plant growth and development, and they play a critical role in the formation of plant tissues, such as leaves and stems (Young, *et al.*, 2019)

5.1.3 Effect on maize yield

Human urine and urea fertilizer showed a significant impact on the maize grain yield this is because they are both nitrogen rich fertilizers. Nitrogen promotes the cell division and the process of photosynthesis were plants make their own from sunlight. When maize plants have sufficient nitrogen, they are able to produce more carbohydrates and proteins, which are used to fuel the grain filling process (Udert, et *al.*, 2019). This leads to an increase in kernel size, weight, and ultimately, yield. The negative control which was not top dressed recorded a relatively low and poor grain yield this is because there was insufficient supply of nitrogen. Nitrogen deficiency during grain filling can result in reduced kernel size, weight, and yield, as well as lower protein content, poor grain quality, and increased susceptibility to pests and diseases. (Udert, et *al.*, 2019).

CHAPTER 6

6.1 CONCLUSION

From the research it can be concluded that human urine is indeed a rich source of nitrogen and it can have significant impact on the maize plant height, dry biomass and yield. It can also be derived from the study that urine nitrogen content can be affected by a person's diet specifically the amount of protein food a person consumes. From the research work conducted it can also be concluded that human urine can be used as a liquid fertilizer and can be a supplement to fertilizers.

6.2 Recommendations

Based on the results of the study, it has been shown that human urine is a rich source of nitrogen so farmers can utilize it as an alternative top dressing fertilizer in maize but taking into account application rates which are determined by maize variety nitrogen requirement and human urine nitrogen content which can be estimated based on a person's protein food consumption and amount of urine produced by a person per day.

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APENDICES

Appendix 1 ANOVA for maize dry biomass

Variate: biomass_weight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	29.667	9.889	5.48	
block.*Units* stratum					
treatments	2	4829.167	2414.583	1337.31	<.001
Residual	6	10.833	1.806		

Total	11	4869.667

Appendix 2 ANOVA for maize grain yield

Variate: grain_yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	128807.	42936.	2.64	
block.*Units* stratum					
treatments	2	7863932.	3931966.	241.86	<.001
Residual	6	97542.	16257.		
Total	11	8090282.			

Appendix 3 ANOVA for maize plant height at week 2

Analysis of variance

Variate: hieght_wk_2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	2.9625	0.9875	1.12	
block.*Units* stratum					
treatments	2	0.6317	0.3158	0.36	0.712
Residual	6	5.2750	0.8792		
Total	11	8.8692			

Appendix 4 ANOVA for plant height at week 4

Variate: hieght_wk_4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	0.729	0.243	0.13	
block.*Units* stratum					
treatments	2	201.292	100.646	53.88	<.001
Residual	6	11.208	1.868		
Total	11	213.229			

Appendix 5 ANOVA for maize plant height at week 6

Analysis of variance

Variate: hieght_wk_6

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	4.220	1.407	0.70	
block.*Units* stratum					
treatments	2	1407.682	703.841	350.02	<.001
Residual	6	12.065	2.011		
Total	11	1423.967			

Appendix 6 ANOVA for maize plant height at week 8

Analysis of variance

Variate: hieght_wk8

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	1.807	0.602	0.36	
block.*Units* stratum					
treatments	2	2128.572	1064.286	631.73	<.001
Residual	6	10.108	1.685		

Total	11	2140.487			

Appendix 7 ANOVA for maize plant height at week 10

Variate: hieght_wk_10

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	6.376	2.125	0.78	
block.*Units* stratum					
treatments	2	3212.527	1606.263	590.30	<.001
Residual	6	16.327	2.721		
Total	11	3235.229			

Appendix 8 ANOVA of maize plant height at week 12

Variate: hieght_wk_12

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	19.897	6.632	1.43	
block.*Units* stratum					
treatments	2	7677.147	3838.573	828.07	<.001
Residual	6	27.813	4.636		
Total	11	7724.857			

Appendix 9 ANOVA for maize plant height at week 14

Variate: hieght_wk_14

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	8.949	2.983	1.98	

block.*Units* stratum

treatments	2	9302.895	4651.448	3087.81	<.001
Residual	6	9.038	1.506		
Total	11	9320.883			