EFFECT OF ORGANIC AMENDMENTS ON TOMATO GROWTH AND YIELD UNDER FIELD CONDITIONS

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This is to certify this was conducted under our supervision and is now ready for submission.

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DEDICATION

This dissertation is dedicated to my family.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
Ca	Calcium
CAP	Calcium Ammonium Phosphate
CEC	Cation Exchange Capacity
DGM	Decomposed Goat Manure
FPA	Food Processing Africa
GM	Goat Manure
K	Potassium
K2O	Potassium Oxide
Kg	Kilogram
LSD	Least Significant Difference
M	Manure
Mg	Magnesium
Mg/L	Milligrams per Liter
MUARIK	Makerere University Agricultural Research Institute, Kabanyolo
N	Nitrogen

Na	Sodium
NaCRRI	National Crops Resources Research Institute
NPK	Nitrogen (N), Phosphorus (P) and Potassium(K)
P	Phosphorus
pH	Potential of Hydrogen
RCBD	Randomized Complete Block Design
REP	Replication
R-OH	Alcohol Molecule
S	Sulfur
WVC	World Vegetable Centre

ABSTRACT

Tomatoes represent a crucial component of Ugandan agriculture, providing essential nutrients like vitamins A, C, and E, along with antioxidants such as lycopene. However, their growth and yield are often hampered by soil fertility issues, compounded by the limited affordability of conventional fertilizers among smallholder farmers. This study aimed to assess the impact of various organic amendments on tomato growth and yield in Wakiso District, Uganda. Conducted at the National Crops Resources Research Institute (NaCRRI) in Namulonge, Wakiso District, the study investigated the effects of organic amendments—specifically, goat manure, coffee husks, organo-yield fertilizers, and their combination—on key growth parameters and yield metrics. Bi-weekly measurements were taken for plant height, number of branches, number of leaves, fruit count, and fruit weight. Results revealed significant enhancements in plant growth attributes following the application of organic amendments. Notably, treatments with coffee husks (59.0± 1.3) organo yield (70.8±3.3) goat manure (72.6±3.9) and their combination (69.5± 1.5) led to a substantial increase in plant height compared to the control treatment (12.3 ± 0.8) ($P<0.001$). Goat manure) emerged as the most effective treatment for promoting plants height followed by organo yield and the combination treatment. Furthermore, the number of branches and leaves per tomato plant showed significant increase with treatments involving goat manure, organo yield, and their combination compared to the control group ($P<0.01$). The organo yield treatment exhibited the highest number of branches while all three treatments resulted in significantly higher leaf numbers compared to coffee husks and control. In terms of yield, the mean number of fruits harvested from plots treated with goat manure, organo yield, or their combination was statistically similar but significantly higher than those from coffee husks and control ($P<0.01$). Similarly, the mean fruit weight from plots treated with coffee husks was significantly higher than control ($P<0.05$), although similar to plots treated with goat manure, organo yield, or their combination. Moreover, organic amendments positively influenced nutrient uptake by tomato plants, with coffee husks notably enhancing nitrogen, phosphorus, potassium, and calcium uptake compared to other treatments.

CHAPTER ONE: INTRODUCTION

1.1 Background

The tomato (*Lycopersicon esculentum* Mill) is one of the continent's most extensively produced vegetable fruits, especially among small-landholder farmers. Tomatoes are popular among farmers and consumers because of its good taste and contains high levels of lycopene, vitamin C, and beta-carotene which promote good health (Sianju et al., 2003). Worldwide tomato production in 2016 was 4.9 million hectares, yielding 177 million tonnes annually (FAOSTAT, 2017). Africa produces 19.7 million tonnes of tomato on 1.3 million hectares while Uganda produces 38,234 metric tonnes on 6485 hectares (FAOSTAT, 2017). The main tomato production districts in Uganda are Mbarara, Kasese, Kabaale, Mbale, Mubende, Wakiso Kapchorwa, Mpigi and Masaka (Sonko et al., 2005).

Despite the importance of tomato crop, yields per unit area in Uganda remain as low as 4 t ha-1 compared to potential yield of 16 t ha-1 for the East African region. The low tomato yield is mainly attributed to biotic (pests and diseases) and abiotic factors (soil fertility) (Ochilo et al., 2019). The soils in Uganda are heavily degraded by erosion and human pressure due to continuous cropping. Because, of high levels of poverty that has resulted into limited land that is neither fallowed nor crop rotated hence, this has compromised productivity of tomatoes (FAO, 2008). Low production is going to compromise achievement of sustainable development goal, zero hunger and improved wellbeing. Therefore, soil organic amendment techniques

like use coffee husks, organo-yield, goat compost manure and integrated Goat manure should be embraced.

There has been a recent drop in tomato p Production of tomatoes in Uganda increased for a while there, but recently it has dropped due to a biotic issue (low soil fertile). Therefore, soil nutrients pool in some of its hardest hit countries like Uganda is depleted. to 2.5 kgs/plant compared to achievable yield of 5kgs/plant (Abejide et al., 2020). Tomatoes, on the other hand, are a highly stable crop in terms of income and health advantages, including the provision of vitamins A, C, and E and antioxidants such as lycopene. Moreover, they provide food security., and livelihood for smallholder farmers throughout Uganda (Ddamulira et al., 2022).

Peat moss, wood chips, straw, sewage sludge, and sawdust are some of the materials used.as organic soil supplements, although compost and animal manure are the two most recommended options today. Animal manure, municipal bio-solids, green manure and cover crops, industrial waste, and compost are all examples of waste and they are the five broad types of materials available (Adekiya & Agbede, 2019). Over 40,124 metric ton of tomatoes may be harvested from 6,671 hectares of land when the soil is rich in nutrients, as is the case with tomatoes prefer sandy soil but may be grown practically anywhere; to enhance clay soil for tomatoes, add sand organic debris such as peat moss or compost (Ddamulira et al., 2021).

Farmers in both high and low altitude areas have discovered that utilizing decomposed coffee husk as fertilizer on their maize and pineapple fields has increased crop yields (Sonko et al., 2015). The plant nutrients 2.07% N, 0.55% P2O5, and 2.87% K2O are present., which can be present in coffee husk compost, organo-yield, and goat manure, respectively, can alter crop yields. Despite an

increase in land area under cultivation, Ugandan tomato growers have produced less tons of tomatoes due to an overreliance on soil nutrients. However, inorganic fertilizers such as Nitrogen, Phosphorus, and Potassium (NPK), Urea, Single Super Phosphate could increase yield. Yet, their prices are increasing annually and a poor resource farmer cannot afford them. They also alter the ecological parameters of the soil, impacting both macro- and microbes. As they lack carbon molecules and carbon components, it is difficult for microbes to survive. The overuse of inorganic fertilizers degrades soil fertility and is unsustainable (Mukiibi, 2019). Organic fertilizers, on the other hand, such as compost and animal manure, are derived from plant and animal waste (cattle, sheep, goat and poultry).

Organic fertilizers have enabled many tomato farmers to attain high crop yields (Adegbeye etal.,2020). through intensive cultivation, something that was previously only achievable with the use of synthetic fertilizers. In addition, they are sustainable because they improve soil physical, biological, and chemical properties, encourage the multiplication of microorganisms such as earthworm increase the soil's water-holding capacity, and organic matter decomposition releases organic compounds necessary for the improved performance of soil microorganisms such as fungi, earthworms, and bacteria, nematodes and soilborne insects, also provide plant growth hormones such as auxins Hence, the soil quality for plant growth improves (Eid et al., 2021). But they have not been fully exploited for tomato production in areas of abundance due to lack of knowledge. To address this knowledge gap goats' manure, coffee husks and organ-yield should be applied to replenish nutrients and possibly increase production to reduce 1.6 million Ugandans going on bed hungry every day and 9.3 million are not sure of having a daily meal (World Bank, 2017).

Nevertheless, no study has been conducted to investigate the impacts of amending tomato growing performance and yield with goats' compost manure, coffee husks, and organo-yield. Therefore, it was from this observation that the study was conducted to address this knowledge gap as well as erasing the yield gap of tomatoes.

1.2 Statement of the problem

Farmers in Uganda who work on a small-scale face threat to their food security and livelihood despite the importance of tomatoes as a highly predictable horticultural product, a source of revenue as well as a source of vitamins A, C, E, and antioxidants like lycopene (Abejide et al., 2020). Its production is inhibited by low soil fertility in contrast, nutrient-deficient soil restricts root growth, limiting the plant's ability to access essential nutrients leading to stunted growth resulting in decreased yield of tomato (Kumari, 2022). Karuku and Verplancke (2017) reported that there is a high nutrient depletion from 200 million hectares of cultivated land in African countries including Uganda. Hence this has resulted in reduced tomato yield of 2.5 kgs/plant compared to achievable yield of 5kgs/plant (Abejide et al., 2020). Various alternatives have been proposed to improve and sustain tomato yields, including the use of organic in organic fertilizers but the availability in organic fertilizers is limited day due, increase in prices, in organic improper use can lead to environmental pollution and disrupted microbial activity, all of which can reduce tomato yields (Baweja, (2020). There reports that fertilizes suppress biological activities in the soil hence growth and yield are compromised (Mukiibi, 2019). Therefore, use the combination of goat manure, organo-yield, and coffee husks

should be used to increase the yield and growth of tomatoes because approach provides a comprehensive enhancement to soil fertility (Mowa, 2018). Goat manure supplies essential nutrients and improves soil structure Rayne, & Aula (2020). organo-yield products add concentrated nutrients and improve soil texture, while coffee husks enhance organic matter content and stimulate microbial activity (Dawid, 2018). Together, these amendments create a synergistic effect, promoting better nutrient availability, improved soil health, and sustained plant growth, ultimately leading to higher tomato yields of Goat manure and crop residues is a cheap and a better option as it involves use of manure composts which is locally available (Washaya & Washaya, 2023).

There is currently scanty information on effect of amending goats compost manure, coffee husks and organo-yield on growth performance and yield of tomatoes in Wakiso district Yet, Goat manure like goat's compost manure, coffee husks and organo-yield has been reported to significantly improve growth and yield of cucumber, Irish potatoes elsewhere (Nyamadzawo & Chirinda, 2015). This study therefore aimed to determining the effects of organic amendments on tomato growth, nutrient uptake and yield in Wakiso district, Uganda.

1.3 Objectives

1.3.1 General Objective

To assess the effect of organic amendments on tomato growth, yield and nutrient uptake under field conditions.

1.3.2 Specific objectives

(i) To determine the effect of organic amendments on tomato growth characteristics.

(ii) To determine the effect of organic amendments on tomato yield parameters.

(iii) To determine the effect of organic amendments on nutrient uptake by tomatoes.

1.4 Hypotheses

(i) Organic amendments have significant effect on tomato growth characteristics.

(ii) Application of organic amendments to tomato plants has significant effect on tomato yield.

(iii) There is a significant effect of organic amendments on nutrients uptake by tomato.

1.5 Significance of the study

The findings of this study hold great significance for farmers as they contribute to a deeper understanding of the impact of organic amendments on nutrient absorption in tomatoes. By examining and analyzing these effects, farmers can make informed decisions about the types and quantities of organic nutrients they apply to their crops. This knowledge empowers farmers to optimize their nutrient management practices, leading to improved tomato yields and overall crop quality. Consequently, farmers can maximize their agricultural productivity while minimizing the potential negative environmental impacts associated with excessive nutrient application.

Extension agents play a vital role in disseminating knowledge and providing guidance to tomato growers. The findings of this study serve as valuable insights that can be shared by extension agents with farmers. Armed with this information, extension agents can effectively advise tomato growers on the optimal management of organic nutrient additions. By tailoring recommendations based on the specific requirements and conditions of each farm, extension agents can assist farmers in implementing sustainable and efficient practices, thereby enhancing the overall success and profitability of tomato cultivation.

This study serves as a foundational framework for future research endeavors in the field of organic nutrient management for tomatoes. The outcomes and methodologies presented in this study provide a starting point for further investigation and exploration. Researchers can build upon this study's findings to delve deeper into specific aspects such as the long-term effects of organic amendments, the influence of different organic sources, or the interactions between organic nutrients and soil microorganisms. By expanding the body of knowledge through subsequent research, scientists can continually refine and improve organic nutrient management practices for tomatoes, leading to more sustainable and resilient agricultural systems.

The findings of this study contribute to the broader understanding of sustainable agriculture and environmental stewardship. Organic nutrient management is a key component of sustainable farming practices that promote soil health, biodiversity, and the reduction of chemical inputs. By elucidating the effects of organic amendments on nutrient absorption in tomatoes, this study adds to the existing knowledge base on organic farming and its potential benefits. This

information can be utilized by policymakers, environmental organizations, and agricultural stakeholders to support the adoption and promotion of sustainable farming practices that prioritize both productivity and environmental conservation. Beyond the immediate implications for farmers, extension agents, and researchers, the findings of this study have the potential to benefit society at large. As global concerns about food security and environmental sustainability continue to grow, the knowledge gained from this study can contribute to the development of more resilient and resource-efficient agricultural systems. By optimizing nutrient management using organic amendments, farmers can reduce their reliance on synthetic fertilizers, decrease nutrient runoff, and mitigate potential water pollution. Ultimately, these efforts can help foster a more sustainable and secure food supply while minimizing the ecological footprint of agricultural practices, ensuring a healthier and more sustainable future for generations to come.

1.6 Definition of terms

Organic amendments: Compost is a mixture of decomposed organic matter It improves soil fertility.

organo yield: is biochar-based soil enhancer or amendments, are substances added to soil to improve soil.

Goat manure: is used organic fertilizer in composted that can provide essential nutrients to plants.

Coffee husks: composted coffee husks being used as amendments to can contribute soil fertility.

CHAPTER TWO: LITERATURE REVIEW

2.1 Tomato production in Uganda

There are contradictory accounts regarding the date of tomato introduction in Uganda. According to (Osiru et al., 2001), tomatoes were brought to Uganda at the turn of the 19th century from South East Asia via the Indian Ocean. It is however evident that the tomato cultivars that were introduced into the country were not wild relatives. Contrasting further introduced vegetables, tomatoes remained accepted in Uganda, and by the middle of the 1970s, they were one of the most important vegetables exported there. According to Reddy (2018), exports to Kenya and Tanzania totaled 208,972 kilograms and were worth $37,140. 12,539 ha were thought to have been under tomato production in Uganda in 1990, and each has produced an average of 10 tons of tomatoes. Currently, the tomato is planted almost everywhere in Uganda (Dijkxhoorn et al., 2019). Makerere University Agricultural Research Institute, Kabanyolo (MUARIK), farmers were being encouraged to use organic fertilizers since the studied confirmed better performance in tomato yield (Kizito, 2021). The cultivar known as "Money Maker" was chosen as the best producer, and it went on to become the most popular variety in Uganda (Kalibbala, & Bakuneeta ,2011)

The majority of fruit production is currently carried out by smallholders in Uganda. The southern, central, and eastern regions are the primary centers of production. There are very few large-scale fruit growers in Uganda. The majority of tomatoes are bush varieties grown in the open field and can be grown all year round (up to four harvests) with irrigation (Atuhaire et al., 2017).

Uganda's economy depends a lot on tomato production, which also helps feed the people of Uganda. Tomatoes stay as one of the vegetables that small-scale farmers grow for their own use and to sell in their own country. FAOSTAT (2018) reported that the area harvested (in hectares) of tomatoes has been increasing since 2000 (Table 1). According to FAOSTAT (2018), there has been a proportional increase in the total number tons of tomatoes produced over the years. On the other hand, the yield per acre has been decreasing.

Table 1:Tomato production in Uganda

	2000	2005	2010	2015	2016	2017
Area harvested, in hectares	2,100	3,704	5,500	6,178	6,424	6,671
Production, in tonnes	14,000	22,770	31,000	37,176	38,650	40,124
Yield (tonnes per ha)	6.7	6.1	5.6	6.0	6.0	6.0
Yield (tonnes per acre)	2.7	2.5	2.3	2.4	2.4	2.4

Source: FAOSTAT, 2018

2.2. Importance of tomato production

A diet that is both healthy and well-balanced includes tomatoes. Sugars, dietary fibers, minerals, vitamins, and essential amino acids are all abundant in tomatoes. They are packed with nutrients like iron and phosphorus and vitamins B, C, and A. (Thanki et al., 2015). There is a sizable market for processed items like canned and dried tomatoes (Lopez et al., 2020). They are used as a seasoning and eaten fresh all over the world (Plucknet & Smith, 2014).

In Uganda, tomatoes are the most extensively grown and consumed vegetable. Tomatoes, for example, give small hold farmers a lot more money and jobs per hectare than basic crops, and they are also the greatest source of micronutrients (Mugisa, et al., 2017). It is grown in Uganda for cash and food (Reddy, 2018).

2.3. Constraints to tomato production

Despite its significance, several abiotic, biotic, and social economic factors limit both global and local tomato production. The low tomato yield in Uganda is due to a number of constraints which include poor varieties, pests and diseases, drought, as well as low soil fertility (Karungi et al., 2014). According to Belew et al., 2019) pests and diseases are one of the most significant global obstacles to tomato production.

Pests and diseases make it difficult for Ugandan tomato farmers to produce a sufficient number of tomatoes (Ddamulira et al., 2021). The most common important pest observed by growers is whitefly (*Bemisia tabaci*) which transmits the tomato leaf curl viruses. Other pests that affect tomato include caterpillars, thrips and worms. According (Bachwenkizi et al., 2022), the most common and overwhelming pathogens which infect tomatoes in Kenya's North Rift are Phytophthora infectants, which causes late blight and *Alternaria solani*, which creates early blight. According to (Nuwamanya, 2022), the most significant foliar diseases in Uganda are tomato bacterial speck and spot diseases caused about by *Pseudomonas syringae* and *Xanthomonas vesicatoria* respectively the risks associated with tomato production have increased due to resistance to pests, a lack

of awareness of risks, and the availability of low-cost but highly toxic pesticides. According to (Sonko et al., 2015), gender is a crucial consideration that influences farmers' pest management decision-making. Misapplication of pesticides has raised concerns about health risks associated with intoxication, which can lead to deaths, morbidity, and environmental pollution.

Most smallholder farmers in Africa are unable to make profit from the potential of tomato production due to poor postharvest handling (Sibomana et al., 2016). Additional limitations that prevent farmers from attaining possible yields include the use of unadopted varieties, the lack of high-quality seed, low soil fertility and inappropriate cultural practices. (Bwambale, 2015) indicated that one of the primary factors that has hindered tomato production for fifty years is drought.

Climate variation has a significant influence on agricultural production as well as natural ecosystems (Iftikhar et al., 2021). Global warming and other climatic effects have resulted from human- the planet is heated by CO_2 and other gases reaching dangerous levels in the atmosphere over the past century (Chaudhry & Sidhu, 2021). Heat waves, droughts, extreme precipitation, flooding, and freezing pattern shifts are all putting an enormous strain on global farming in addition to the production of food safety (Dempewolf et al., 2014).

Tomato production in Uganda is also challenged by price fluctuations, low prices, high transport costs, post-harvest loss on farm, and poor market access (Ddamulira et al., 2021). These challenges are further compounded by lack market information. Reliable and accessible market information systems can provide producers with up-to-date data on prices, demand, and consumer favorites, good agriculture inputs guidance of and marketing decisions (Ramathani, 2021).

2.4 The effect of organic amendments on the growth attributes of tomatoes

The application of organic amendments like coffee husks, goat manure, organo yields, and inorganic fertilizers typically increases the quantity of organic matter within the soil and enhances environmental, chemical, and physical properties (Basri. et al., 2021; Tzortzakis et al., 2020). These factors increase the height of tomato plants. The organic amendments have the capacity to enhance several the soil's physical characteristics, including capacity to hold water, its porosity, and its reduction in compaction, thereby assisting in the height and root growth of tomato plants (Hariyadi et al., 2019).

Coffee husks and other organic residues can be utilized as growth media to increase tomato plantations' height and length (Atif et al.,2016). demonstrates that the solicitation of 15 tons per hectare of coffee husk compost has increased peanut yield. This is probably because the treatment with 15 tons of organic matter per hectare increased peanut yield. The capacity of the soil for optimal nutrient absorption is enhanced by the application of the coffee husk compost as specified by (Adnan et al., 2021), has the potential to increase soil nutrients, which in turn can assist tomato plantations in growing more leaves. This is in line with what (Adnan et al., 2021), claimed that husk coffee compost might have more phosphorus and potassium, which would make more leaves. Composting can also create conditions in the soil that are favorable to plant growth by boosting the soil's organic matter content and dipping compaction (El-Naggar et al., 2019). These conditions encourage vegetal progression for maximum productivity and growth.

The use of organic compost has been shown to make a big impact on the overall leaf production of tomato plants. Agbede and Kalu (1995) found that tomato crops fertilized with goat manure yielded the uppermost quantity of leaves per plant. Organic fertilizers like Organo-yields, which provide the nutrients necessary for tomato plant growth and are slower-acting than chemical fertilizers, allowing for more leaves to be produced. Organic fertilizers (Simiele et al., 2022) are not immediately absorbed by plants; rather, soil bacteria and fungi must first break them down into forms that plants can absorb. According to Fleming (2012), organic yields are not easily washed away in heavy rainstorms or irrigation sessions, unlike chemical fertilizers. As a result, tomato plants receive growth-promoting nutrients.

Tomato plants fertilized with a high phosphorus fertilizer were significantly taller than those fertilized with a low phosphorus fertilizer due to the combination of goat manure, Organo yields, and coffee husks (Schmidt et al., 2017). The tomato plant grows in height and diameter when organo-mineral fertilizers like goat manure, organo yields, and coffee husks are applied simultaneously (Sibomana et al., 2021)

In general, the application of goat manure, coffee husks, and Organo yields results in the highest values, while the application of coffee husks alone results in a smaller plant diameter (Sibomana et al., 2021). This outcome is a result of biochar's ability to boost soil cation exchange capacity and soil availability of nutrients both of which are very important for the tomato plant's height (Vaccari et al., 2015). High nutrient content and ability to hold on to nutrients improve plant nutritional supply and reduce leaching of nutrients Furthermore, (Mustafa et al., 2010) demonstrated that when compared to applying biochar or fertilizer alone, the application of goat

manure, Organo yields, and coffee husks increased plant height. The combination not only makes the soil more organic, but it also makes it easier to use inorganic fertilizer, which makes the tomato plant grow taller.

In accordance with (Oyinlola et al., 2023) findings, the combination of goat manure, Organo yields, and coffee husks results in increased leaf numbers. who discovered that combining Organo yields, coffee husks, and goat manure results in improved soil properties and increased yields of tomato leaves. This is because each of the three organic amendments has a distinct impact on enhancing soil characteristics favorable to tomato leaf development. The application of goat manure, Organo yields, and coffee husks improves tomato leaf nutrients and resistance to rust disease (Nassar et al., 2000).

2.5. The effect of organic amendments on yield parameters of tomatoes.

The application of organic amendments including organo yields, coffee husks, and goat manure has a substantial impact on the quantity of tomato fruits. In commercial and horticultural agriculture, organic amendments are used to produce high-quality fruits and vegetables with high yields (Rocha et al., 2022). According to Warzukni & Jauharlina, (2022), organo yields, coffee husks, and goat manure improved the physical property of the soil as well as the availability of nutrients, which may have a direct impact on the characteristics of tomato crop growth and yield. For sustainable tomato productivity enhancement, it is more effective to apply both NPK chemical fertilizers and coffee husk compost together than to apply either NPK blended fertilizers or coffee husk compost alone.

organic amendment like goat manure, as stated by (Mowa et al., 2017), has a significant impact on fruit weight because different amounts of nitrate and other nutrients are present tomato plants grown with goat manure weigh less than those grown with other organic amendments. As a result, the nutrients in goat manure have a soluble fiber in them that enables the tomato fruits to form a gel-like substance that serves as a food source for the beneficial gut bacteria and increases the animal's appetite and weight gain.

According to Gore & Sreenivasa (2017), the yield of tomato plants is impacted by the levels of nitrogen in goat manure, with higher nitrogen levels producing more tomatoes. It's reported that the number of nitrates in the goat manure nutrition solution has an effect on fruit weight, with higher nitrate levels producing more fruit (Van Klompenburg et al., 2020). According to (Klompenburg et al,.2020), this could also be due to the fact that the tomato yield was expressively higher in tomato plants grown in a manure nutrient elucidation than in the control, in which tap water was used as the only source of nitrates and other nutrients. Céline Masclaux-Daubresse et al., (2010) indicted that organic fertilizers like goat manure can improve the quality of seed and fruit, leading to increased yields and increased profits. According to (Gichangi et al., 2009), the primary contributor to tomato plant maturity is the phosphorus nutrient found in fertilizers.

Specifically in intensive vegetable producing systems, Mulugeta (2020) explained that tomato growers frequently employ a combination of goat manure, organo yields, and coffee husks as soil additions to boost fertility, quality, and sustained productivity of the soil Composts enhance physical, chemical, and organic

qualities of modified soil can be used to biologically control plant pathogen-caused illnesses. Additionally, they might lessen the severity of illnesses brought on by foliar plant infections. For the best production, tomatoes, like many other plants, need soil with a high organic content and a sufficient nutritional reserve. As a result, organic mineral fertilizer seems to be a trustworthy supply of nitrogen, with amaranths needing a fair quantity of nitrogen to thrive. Studies have shown that using organic fertilizers in conjunction with inorganic fertilizers can result in higher, more sustainable agricultural yields than using only inorganic fertilizers alone (Chemutai et al., 2019)

2.6. The effect of organic amendments on nutrients uptake by tomatoes

Organic amendments are known to influence the ability of tomatoes to absorb nutrients. Use of t goat manure for example, not only improves the structure of the soil, promotes aeration, and promotes healthy root growth, but it also provides all of the nutrients that tomato plants need (Sisay & Sisay, 2019). According to Kirkby (2012), nitrogen (N), potassium (K), phosphorus (P), calcium (Ca), magnesium (Mg), sulfur (S), and other elements are among the most essential for higher plants. The uptake of nutrients from the specialized transporters and channels in the roots ensures soil. According to Giehl & Von Wirén (2014), these transporters and channels are influenced by the soil's water content, metabolism, availability of nutrients, and environmental conditions (Mulugeta, 2020). If one of the aforementioned nutrients is either absent or present in low concentration, the regulatory system will adjust the plant's growth (Cunha et al., 2017). These intricate

signals trigger metabolic as well as morphological changes in the root tissue which enhance nutrient uptake. The responses of the entire plant are controlled by signaling molecules and ion sensors, microRNAs, mobile polypeptides, and phytohormones interlining as indigenous and. long-distance signals (Kiba et al., 2011; Nassar et al., (2000). Previous research has demonstrated that applying goat dung to *Coriandrum Sativum* L plants had progressive effects on nutrients uptake and yield.

Coffee husks tend to contain lignocellulose which is a lot, and helps tomatoes absorb nutrients better and produce higher yields (Keter et al., 2020). Coffee husks can be used to biologically reduce plant pathogen-caused illnesses and improve the biological, chemical, and physical qualities of modified soils. Additionally, they may lessen the severity of foliar plant infections-related illnesses (Rolando, 2019). Coffee husk compost did more to increase phosphorus uptake than any other treatment because it contained tannins and caffeine, both of which have the potential to be toxic and slow the holistic breakdown and mineralization of organic matter. Phosphorus absorption was high due to the conductive effect of mass flow and passive transport, and temperature was raised as a result of the insulating effect of coffee husks. Since some sections of tomato plants are unwooded, the high potassium absorption in coffee husk compost may have been caused by the affinitive need for osmotic potential balancing to improve turgidity of the plant (Ogbomo, 2019).

2.7 Literature summary and gap

The literature on organic amendments such as coffee husks, goat manure, and Organo yields highlights their significant impact on tomato plant growth and yield

parameters. Studies consistently demonstrate that these amendments improve soil physical properties, nutrient availability, and overall plant performance, leading to increased plant height, leaf production, and fruit yield (Basri et al., 2021; Tzortzakis et al., 2020; Atif et al., 2016). However, while existing research emphasizes these agronomic benefits, there is a notable gap in understanding their effects on soil microbiota, soil health, and broader environmental implications.

Few studies delve into how these organic amendments specifically influence soil microbial communities, which are crucial for nutrient cycling and disease suppression, or assess their long-term impacts on soil quality beyond immediate plant productivity. Addressing these gaps is essential for a comprehensive understanding of the sustainable use of organic amendments in tomato cultivation, ensuring both agronomic benefits and environmental stewardship are maximized.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Description of Study Area

The study was carried out at National Crops Resources Research Institute (NaCRRI), located in Wakiso District, northeast of Kampala, at latitudes of 0.52500E and 32.61500N. Wakiso district is the second most populous district in Uganda, with a population of 2,007,700 according to the 2014 census and an area of 2,807.75 square kilometers.

The shallow seasonal or year-round waterlogged or flooded areas that are often supported by hydrophilic vegetation are what define the drainage system of the study area. The district's minimum and highest surface air temperatures are 11.0^0 and 33.3^0 C, respectively, with bimodal rainfall. There are two temperature peaks: one occurs from January through May, and the other occurs from July through September. The month of February typically has the highest temperatures, while the month of July typically has the lowest.

3.3 Organic matter composting processes

Goats manure (800kg) was collected from Nagibugwa's goats' farm 100m away from Namulonge livestock farm in Wakiso district. However, coffee husks were collected from Bweyogerere coffee processing plant and transported to Namulonge for composting. After collection of the organic samples, they were mixed separately to get samples for analyzing the carbon and nitrogen ratio. The samples were separately placed in the Aluminum foil paper to enclose bad smell and transported to Namulonge laboratories. The C:N ratio was determined using the procedures.

QA- Quantity of coffee husks, required to improve compost,

200ibs – quantity of manure used, Nm % of nitrogen in the sample,

C: NT - normal carbon manure,

C: NM -carbon in manure after analysis

NA -% nitrogen in coffee husks,

DMM - % dry matter in manure

DMA- % dry manure in coffee husk

C:NA – normal carbon in coffee husks

C: NT- carbon in coffee husks after analysis.

After calculation 340kgs coffee husks were blended in 800kgs of goat's dung and organized in piles, a long side 600kg of coffee husks watered and composted for 12 weeks under protected roof using wind row methods. In the first four weeks materials under composition were turned twice a day accompanied by watering whenever temperatures could rise beyond 600. This was followed by weekly turning since temperatures were dropping until compost was fully composted. Same compost samples were picked from goat's manure pile and coffee husk pile and taken to the lab for analyzing pH, organic matter, and nitrogen analysis potassium, phosphorus and calcium the balance was packed in sacks of 50kgs then carried to the garden manually for application as treatments.

3.1 Soil characterization and chemical properties

Soil testing was carried out before planting of tomato in the study plots using the transverse approach. A set of twelve soil samples was collected from a depth of (0 to 25 cm). These individual samples were combined thoroughly in a bucket to create

a uniform composite sample. The composite sample was then air-dried at room temperature and passed through a 2mm sieve (Bachmann et al., 2000).

Table 2: Chemical properties of soil before planting

Sample Details	pH	OM/%	N/%	P/ppm	K/%	Ca/%	Mg/%	sandy	clay	silt
First season	6.31	2.6	0.16	2.3	1.3	6.5	0.11	50	44	6.0
Second season	6.34	2.3	0.12	2.1	1.4	5.8	0.31	48	46	6.0

The sand, clay, silt, and texture were analyzed using the Bouyoucos hydrometer technique (Okalabo et al., 2002). The soil's acidity or alkalinity was measured using pH meter and potassium, calcium and magnesium were determined by flame photometer and available phosphorus was extracted by Bray1 extraction method and determined by atomic absorption spectrophotometer AAS calcium and magnesium Nitrogen and organic matter were determined by rapid titration (Walkley, 2017). Results of the analysis of soil chemical properties are presented in Table 2.

Testing of organic amendments such as goat manure, coffee husks, and organo yield before applying them to tomato plots was crucial to know their availability of nutrients such as nitrogen (N), phosphorus (P), potassium (K) (pH) and their level by conducting a comprehensive analysis of nutrient composition, can be informed

decision regarding their appropriateness for optimizing plant growth and yield of the tomatoes. These tests, laterally with necessary modifications based on the results, contributed to supportable practices of tomato (Garcia et al., 2020).

3.2. Field layout and experimental design

The experimental field was laid in Randomized Complete Block Design (RCBD) that was replicated three times (Table 4). The treatments composed of five sources: Goat manure, Organo yield, Coffee husks, Combination (Coffee husks+ Goat manure + organ yield) and Control (no amendments). The field was marked in three blocks (replicates) each block consisted of 5 plots measuring 3.3 m width *3.6 m length separated by 1metre between plots and 1.5meters between blocks to enable easy movement during collection of data and when carrying out agronomic practices. Different treatments were assigned to each plots randomly. Treatments were applied at the rate of:

- Goat manure-(76kg t/ha) (M1)
- Organo yield-(76kg t/ha) (M2)
- Coffee husks- (76kg t/ha) (M3)
- Combination (Coffee husks+ Goat manure + organ yield) - (76 t/ha) (M4)
- Control (no amendments) (M5).

Table 3: Layout of treatments

REP 1	M1	M2	M3	M4	M5
REP 2	M5	M4	M3	M2	M1
REP3	M3	M1	M4	M5	M2

3.3 Raising of tomato seedling and transplanting

After 21 days in the nursery, the tomatoes reached a height of 15 centimeters (6 inches) and had five to six leaves ready to transplanted them, essential and optional soil preparation to optimize sunlight exposure and eliminate soil-borne pests and weeds Once the land was prepared, it was leveled, and organic amendments were incorporated to facilitate the smooth and speedy transplantation process. The 14-days period provided organic Amendments This duration was necessary to ensure that the fertilizers were fully incorporated into the soil to allowed the beneficial nutrients and organic matter present in the amendments to become thoroughly mixed with the soil. Before the seedlings were evacuated, the seedbed was watered to prevent damage to the roots. During the first part of the day, planting was completed, and each establishes received a minimal water supply for upkeep.

3.4. Data Collection Methods

3.4.1. Effect of organic amendments on the growth attributes of tomatoes

Starting with the vegetative stage, data was collected on growth stage until all plants had achieved their physiological maturity and no growth is occurring, by tagging

randomly five sampled plants per plot. After transplantation, data was gathered every two weeks using indicators/ parameters such as plant size, number of leaves, number of branches, fruit production, fruit weight, and newly emerged leaves to gauge health and vitality. The following growth parameters were determined.

Plant height: Following the methods used by Kyebogola (2013), plant height in centimeters (cm) was measured by extending a measuring tool from the soil's surface to a tomato plant leaf's tip.

Number of Leaves per plant: Number of leaves per plant was obtained by direct counting and recording of individual compound leaves borne on individual tagged plant including those compound leaves that were 50% open (Beebe 2008).

Number branches: Number of branches per plant was determined by directly counting and recording of branches on each tagged plant per plot.

3.4.2. The effect of organic amendments on yield of tomatoes

The number of tomatoes produced by each tomato plant and their respective sizes, weights, and shapes were recorded to effect of organic amendments on tomatoes yield attributes after every one week from the onset of fruiting until when the plants had achieved their physiological maturity. The following yields parameters were determined:

Number of fruits per plant: This was worked out by counting and recording of the specific fruits which were borne on each individual plant tagged in the plot as recommended by Kisetu & Heri, (2014).

Number of fruits per plant: This was calculated by gathering ripe fruits from each tagged plant, placing them on a scale with a by (vegetable scale unit) for weight measurement, and recording the results in grams to find out how much fruit each plant produced (Kisetu & Heri, 2014).

3.4.3 Effect of Organic Amendments on Nutrients uptake by tomatoes

This objective aimed to assess how different organic amendments influenced the nutrient uptake efficiency of tomato plants. However, there was a discrepancy in the approach, where nutrient concentration was measured instead of actual nutrient uptake. Additionally, to address this, fresh leaves were collected from the plants two weeks after amendment application and taken to the lab for nutrient uptake testing.

Measurement of Nutrient Uptake: To determine nutrient uptake, both the concentration of nutrients in plant tissues and the biomass of the plant were measured. Samples of tomato plant tissues (leaves, stems, and fruits) were collected at various growth stages. These samples were analyzed for concentrations of key nutrients (N, P, K, Ca) using methods such as atomic absorption spectroscopy or inductively coupled plasma optical emission spectrometry (ICP-OES).

Nitrogen Analysis:

For nitrogen analysis, tools were sterilized with ammonia-free distilled water. A 10 ml aliquot of the digested sample was treated with NaOH in a steam distillation apparatus. The distillate was collected into 50 ml of 1% boric acid with four drops

of mixed indicator and titrated with N/140 HCl until the endpoint was reached (Okalabo et al., 2002).

Phosphorus Extraction:

For phosphorus extraction, 2 grams of the sample were weighed into a 150 ml polythene shaking bottle, and 50 ml of Olsen or Bray 1 extracting solution was added. The mixture was shaken for 30 minutes, filtered through Whatman No. 42 filter paper, and the filtrate was collected. Colorimetric phosphorus estimation was performed by adding 10 ml of the filtrate to 50 ml volumetric flasks, followed by 10 ml of ascorbic acid reagent. The absorbance was measured at 880 nm using a spectrophotometer (Okalabo & Gathua, 2002).

Potassium Analysis:

For potassium analysis, 5 grams of air-dried tomato leaves were extracted with 100 ml of ammonium acetate solution, shaken for 30 minutes, and filtered. The filtrate was read using a flame photometer at a wavelength of 766.5 nm. The potassium concentration was compared against a standard series (Tekalign & Aduayi, 1991).

Calcium Extraction:

Calcium extraction involved 2 grams of air-dried tomato leaves digested with 0.8 ml of concentrated nitric acid (96%) and hydrogen peroxide. The mixture was diluted to 50 ml with distilled water, and the analyte was read using an atomic absorption spectrophotometer (AAS) at the appropriate wavelength. The absorbance was plotted against a standard calibration curve (Okalabo & Gathua, 2002).

Calculation of Nutrient Uptake:

The formula used was: Nutrient Uptake (mg/plant) = Nutrient Concentration (mg/g) × Biomass (g/plant) This calculation provided a comprehensive understanding of the total amount of each nutrient absorbed by the tomato plants.

3.5 Statistical data analysis

Since the season had no discernible impact, data were aggregated and checked for normality and homogeneity. Data was imported into GenStat statistical software (16th Edition) and submitted to analysis of variance after the results demonstrated the normality and homogeneity of the data (ANOVA). The Least Significant Difference (LSD) test was used to equate all significant pairs of treatment means at the 5% level of significance were carried out to determine the relationships between yield and variables linked to yield, such as plant height, branch number, leaf number, fruit number, and fruit weight.

CHAPTER FOUR: RESULTS

4.1. Effect of organic amendments on the growth attributes of tomatoes

4.1.1 Tomato Plant Height

Application of organic amendments considerably improved plant height. Coffee husks, organo yield, goat manure and the combination led to a significant ($P<0.001$) increase in plant height when compared to control treatment (Figure 1). Application of goat manure resulted into the tallest plants, followed by the organo yield treatment, and then the combination treatment in increasing order. The effect of goat manure, organo yield and the combined treatment on plant height was statistically similar.

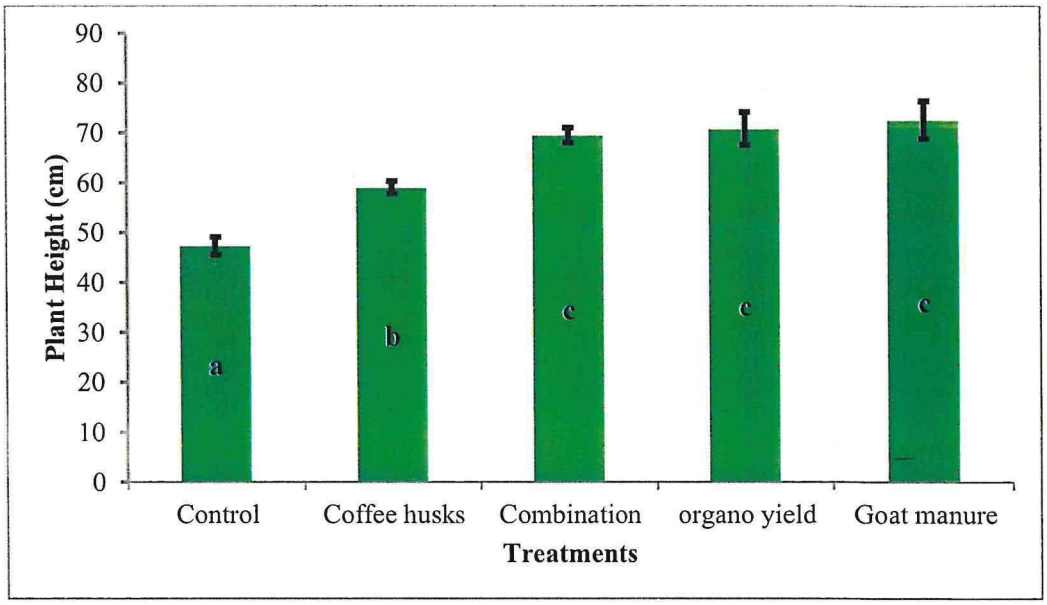

Figure 1: Mean of plant height (cm) of Tomatoes form plots treated with different organic amendments at Namulonge, Wakiso. Means followed by similar letters are not significantly different at P of 0.005 using Least Significant Difference (LSD).

4.1.2 Tomato Number of Branches

Tomatoes treated with goat manure, organo yield and the combination had significantly ($P<0.01$) higher mean number of branches than those from control plots (Figure 2). The application of organo yield resulted in plants with the highest number of branches. The number of branches produced by the coffee husks treatment was comparable to that of the control.

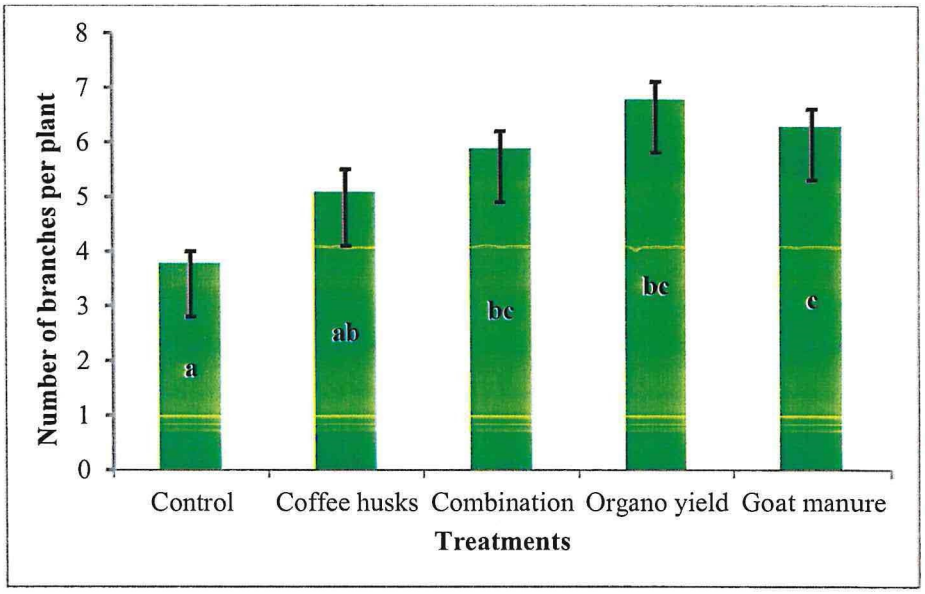

Figure 2: Mean number of branches on tomatoes from plots treated with different organic amendments. Means followed by similar letters are not significantly different at P of 0.005 using Least Significant Difference (LSD).

4.1.3 Number of Tomato Leaves

The number of tomato leaves dramatically increased when compared to the control treatment after organic amendments were applied (Figure 3). The mean number of

leaves per plant following treatment with goat manure was statistically similar to the number of leaves following treatment with organo yield and combination. The three treatments however resulted in significantly higher number of leaves compared to coffee husks and control.

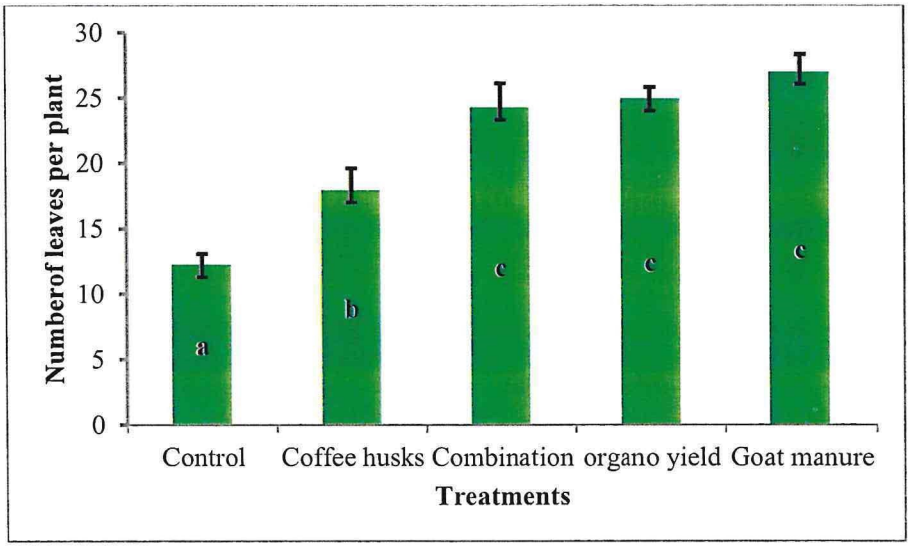

Figure 3: Mean number of tomato leaves from plots treated with different organic amendments. Means followed by similar letters are not significantly different at P of 0.005 using Least Significant Difference (LSD).

4.2 The effect of organic amendments on yield of tomatoes

4.2.1 Mean number of fruits

Fruit yield from tomato plots treated with goat manure, organo yield, or combination were statistically similar but considerably different from those harvested from plots treated with coffee husks and control (Figure 4). The tomato harvest from plots treated with coffee husks were however significantly higher than from control.

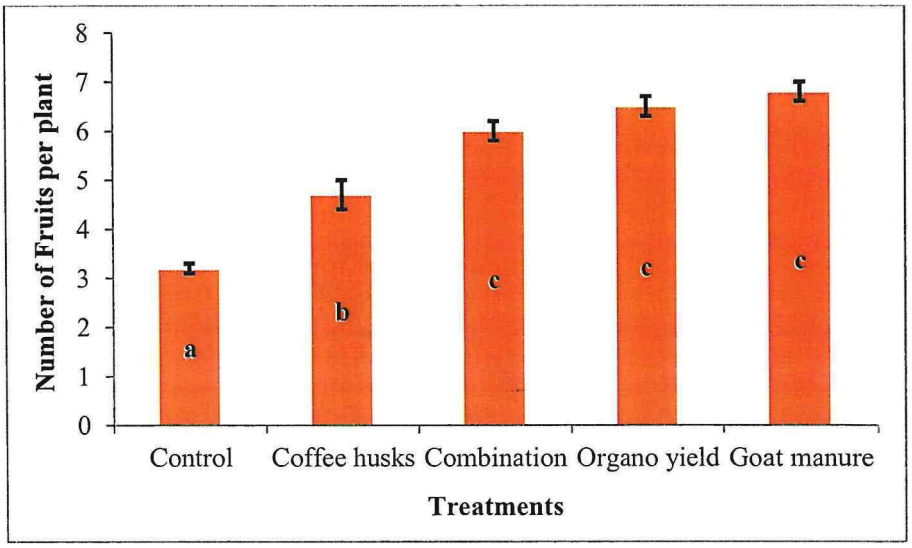

Figure 4: Mean number of tomato fruits from plots treated with different organic amendments. Means followed by similar letters are not significantly different at P of 0.005 using Least Significant Difference (LSD).

4.2.2 Mean Fruit Weight

The mean fruit weight from tomato plots treated with goat manure, organo yield, or combination were statistically similar but considerably different from those harvested from plots treated with coffee husks and control (Figure 5). The tomato means fruit weight from plots treated with coffee husks were however significantly higher ($P<0.05$) than from control.

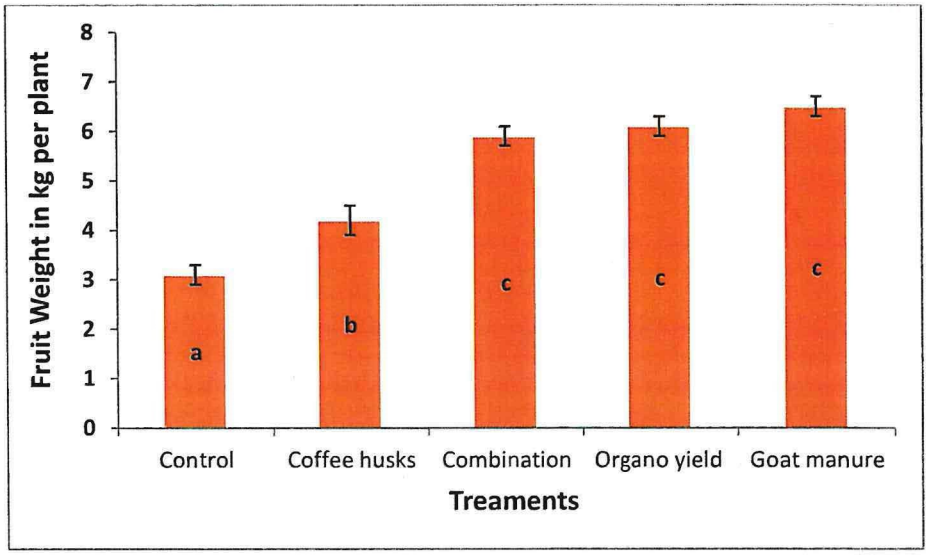

Figure 5: Mean Fruit weight of tomatoes treated with different Organic amendments. Means followed by similar letters are not significantly different at P of 0.005 using Least Significant Difference (LSD).

4.3 Effect of different organic amendments on nutrients uptake by tomatoes

It was observed that tomato plants absorbed nitrogen, potassium, phosphorus and calcium most in plots treated with coffee husk compost as compared to those treated with goat manure, organo-yield, combined goat manure and control (Figure 6).

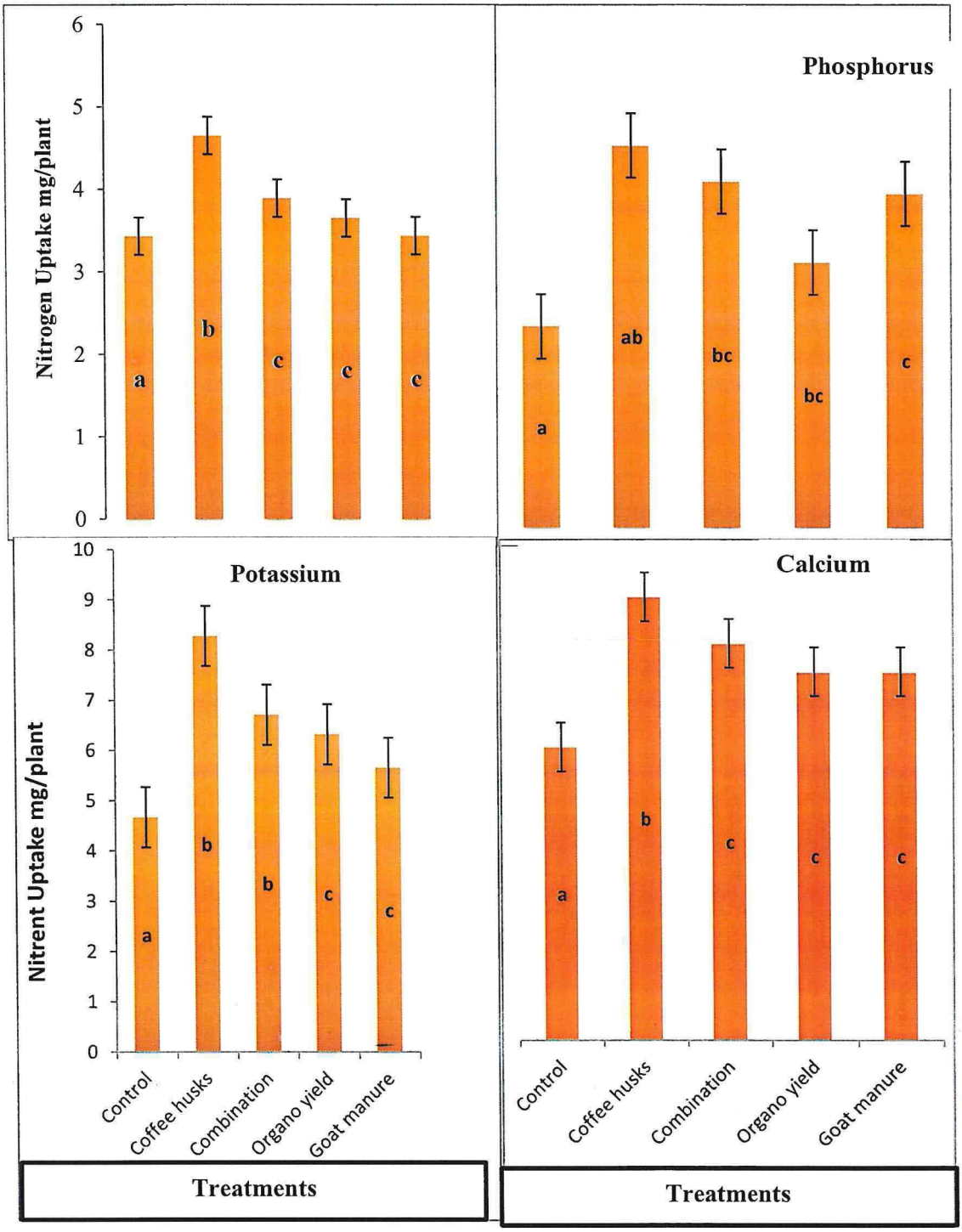
Nitrogen Uptake mg/plant
6
5
4
3
2
1
0
a
b
c
c
c
Phosphorus
a
ab
bc
bc
c
Nitrent Uptake mg/plant
10
9
8
7
6
5
4
3
2
1
0
Potassium
a
b
b
c
c
Calcium
a
b
c
c
c
Control
Coffee husks
Combination
Organo yield
Goat manure
Treatments
Treatments

Figure 6: Effect of organic amendments on uptake of Nitrogen (A) Phosphorus (B) Potassium (C) and Calcium (D). Means followed by similar letters are not significantly different at P of 0.005 using Least Significant Difference (LSD).

Nitrogen nutrient uptake was significantly enhanced by application of coffee husks as compared to other treatments (Figure 6 A). The combination by crop types, with Coffee husks having the greatest impact followed by a combination, Organo yield and goat manure enhanced nitrogen uptake similarly but higher that control. A similar trend was observed with enhanced of potassium uptake and calcium (Figure 6 C-D)

Phosphorus uptake (Figure 6B) was significantly enhanced by application of coffee husks, combination, organo and goat manure as compare as compared to control.

CHAPTER FIVE:

DISCUSSION, SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Effect of organic amendments on the growth attributes of tomatoes

The study found that the application of organic amendments significantly improved all the growth attributes of tomatoes. All organic amendments recorded significantly taller tomato plants compared to the control. Specifically, goat manure resulted in the tallest plants, although not significantly different from the other organic amendments. This may be because goat manure, like other animal manures, is known to be a rich source of nutrients. It contains a good balance of essential plant nutrients, including nitrogen, phosphorus, and potassium, as well as various micronutrients.

The nutrients in goat manure are present in organic forms, which means they are released slowly over time as the organic matter decomposes. This slow release of nutrients allows for a steady and sustained supply of nutrients to the plants, supporting their growth and development over an extended period. On the other hand, other organic amendments used in the study might have different nutrient compositions and release rates. Some organic amendments may contain nutrients that are not as readily available to plants or might release their nutrients more slowly, leading to a less immediate impact on plant growth compared to goat manure.

The finding that goat manure resulted in the tallest tomato plants, although not significantly different from the other organic amendments, suggests that it provided a particularly favorable nutrient supply to the plants, promoting their growth. However, it is important to note that the differences in growth attributes could also be influenced by other factors, such as the initial nutrient status of the soil and the overall soil health.

Goat manure may result in taller tomato plants compared to other organic amendments like coffee husks due to its balanced nutrient composition, higher nutrient availability, moderate decomposition rate, soil conditioning effects, support for beneficial microbial activity, and favorable pH and C:N ratio. These factors collectively contribute to providing a steady and continuous supply of essential nutrients to the plants, promoting their overall growth and development.

This finding aligns with the study conducted by Adnan et al. (2021), who observed that the application of coffee husk compost increased peanut yield, which they attributed to the likely increase in soil nutrient availability, leading to enhanced plant growth. Furthermore, the study revealed that tomato plants treated with goat manure, organo yield, and the combination had a significantly higher number of branches compared to those from the control. Organo-yield resulted in the highest number of branches, whereas coffee husks recorded similar results to the control.

The observed trend of results, where tomato plants treated with goat manure, organo-yield, and the combination showed a significantly higher number of branches compared to the control, while coffee husks had similar results to the

control, could be attributed to differences in nutrient availability and nutrient release rates among the organic amendments. Goat manure and organo-yield likely provided a more favorable and readily available nutrient supply to the tomato plants, supporting branch development. On the other hand, coffee husk compost might have had a slower nutrient release rate or contained nutrient levels that were not as conducive to promoting branching in tomatoes. These findings suggest that the choice of organic amendment can have a significant impact on specific plant growth attributes, such as the number of branches in tomato plants.

5.1.2 The effect of organic amendments on yield of tomatoes

The study aimed at assessing the effect of organic amendments on yield of tomatoes. The yield parameters assessed included number of fruits and fruit weight. The study observed that the application of organic amendments, including goat manure, organo yield, and their combination, led to statistically similar fruit yields in tomatoes. However, these treatments significantly differed from the yields obtained from plots treated with coffee husks and the control.

The tomato harvest from plots treated with coffee husks was notably higher than that from the control plots. Similarly, the mean fruit weight from plots treated with goat manure, organo yield, or the combination was statistically similar but significantly different from that harvested from plots treated with coffee husks and the control. The mean fruit weight from plots treated with coffee husks was significantly higher compared to the control. These results align with Rocha et al (2022) who mentioned that, organic amendments have a substantial impact on the yield of tomato fruits. He mentioned that the application of organic amendments,

such as organo yields, coffee husks, and goat manure, is commonly used in commercial and horticultural agriculture to produce high-quality fruits with higher yields. This is in line with the findings of the study, which showed that the application of organic amendments positively influenced fruit yield in tomatoes.

Furthermore, the literature review suggests that goat manure has a significant impact on fruit weight due to its nutrient content. Mowa et al. (2017) reported that different amounts of nitrate and other nutrients in goat manure can influence the weight of tomato fruits. This aligns with the results of the study, which found that the use of goat manure, organo yield, and their combination led to statistically similar fruit yields, indicating that goat manure contributes to fruit production in tomatoes. The literature review also indicates that the combination of organic amendments, including goat manure, organo yield, and coffee husks, can improve soil fertility, quality, and sustained productivity. Mulugeta (2020) explained that in intensive vegetable producing systems, growers frequently use this combination of organic amendments to enhance soil properties and boost tomato yields. The study's results are consistent with this, showing that the combination of organic amendments had a positive impact on fruit yield in tomatoes.

Considering these consistent results from the literature and the study, it can be concluded that the application of organic amendments, especially goat manure, organo yield, and their combination, is an effective practice to enhance tomato fruit production and overall crop productivity. The use of organic amendments not only boosts nutrient availability but also improves soil health, contributing to better plant

growth and higher yields. Agricultural practices that incorporate these organic amendments can be beneficial for sustainable and high-yielding tomato cultivation.

5.1.3 Effect of different organic amendments on nutrients uptake by tomatoes

The study aimed at assessing the effect of different amendments on nutrients uptake by tomatoes. The nutrients elements examined included; Nitrogen, Phosphorus, Calcium and Potassium by the tomato plant was assessed. The study observed that the application of different organic amendments had varying effects on the nutrient uptake by tomato plants. Tomato plants treated with coffee husk compost exhibited the highest uptake of nitrogen, potassium, phosphorus, and calcium compared to plants treated with goat manure, organo yield, the combination of goat manure, and the control. Specifically, coffee husks significantly enhanced nitrogen uptake, followed by the combination treatment, organo yield, and goat manure. Similarly, coffee husks, combination treatment, organo yield, and goat manure significantly increased phosphorus uptake compared to the control. Moreover, coffee husks had a notable impact on enhancing potassium and calcium uptake, with the combination treatment, organo yield, and goat manure also contributing to increased uptake of these nutrients.

In agreement with the literature review, organic amendments can influence the nutrient uptake by tomato plants. Goat manure, for example, is known to improve soil structure, aeration, and root growth, while providing essential nutrients for tomato plants (Sisay & Sisay, 2019). The uptake of essential nutrients like nitrogen, potassium, phosphorus, and calcium in plants is facilitated by specialized transporters and channels in the roots, which are influenced by soil water content,

nutrient availability, and environmental conditions (Kirkby, 2012; Giehl & Von Wirén, 2014). Nutrient availability and concentration in the soil have a direct impact on the regulatory system that adjusts plant growth and nutrient uptake (Cunha et al., 2017).

The literature review also supports the finding that coffee husks can enhance nutrient uptake and yield in tomatoes. Coffee husks contain lignocellulose, which aids in nutrient absorption and can contribute to higher yields (Keter et al., 2020). Additionally, coffee husks have the potential to improve soil properties and reduce the severity of plant pathogen-caused illnesses (Rolando, 2019). The presence of tannins and caffeine in coffee husk compost can affect nutrient breakdown and mineralization, leading to increased phosphorus uptake. The study's results are consistent with this, as coffee husks significantly increased phosphorus uptake compared to other treatments. Goat manure, for instance, is known to improve soil structure, aeration, and root growth, thereby promoting nutrient availability and uptake by tomato plants. This aligns with the study's findings, as tomato plants treated with goat manure also exhibited increased nutrient uptake compared to the control. The regulatory system that adjusts plant growth and nutrient uptake is influenced by nutrient availability and concentration in the soil, which highlights the importance of organic amendments in promoting nutrient-rich environments for plant growth.

5.2 Summary

The study aimed to assess the effect of organic amendments on the growth, yield, and nutrient uptake of tomatoes. The application of organic amendments significantly improved tomato growth parameters, including plant height, number of branches, and number of leaves, with goat manure resulting in the tallest plants, followed by other organic amendments. All organic amendments showed significantly taller plants compared to the control. In terms of yield, the application of goat manure, organo yield, and their combination led to similar fruit yields, which were significantly higher than those from plots treated with coffee husks and the control. Mean fruit weight was significantly higher in plots treated with coffee husks compared to the control, with other organic amendments showing similar results to each other. Regarding nutrient uptake, different organic amendments affected nutrient absorption in tomato plants, with coffee husk compost leading to the highest uptake of nitrogen, phosphorus, potassium, and calcium, followed by the combination treatment, organo yield, and goat manure. All organic amendments improved nutrient uptake compared to the control.

5.3 Conclusions

The application of organic amendments, including coffee husks, organo yield, and goat manure, significantly improved the growth attributes of tomato plants. Goat manure resulted in the tallest plants, organo yield treatment led to the highest number of branches, and the combination of all three amendments resulted in significantly higher numbers of leaves. These findings demonstrate the potential of organic amendments in enhancing tomato plant height, branching, and leaf

production, contributing to improved plant health and productivity. Organic amendments, such as goat manure, organo yield, and the combination, positively influenced the yield of tomato fruits. Although fruit yield was statistically similar for these treatments, they significantly differed from the yields obtained from plots treated with coffee husks and the control. Coffee husks treatment resulted in significantly higher fruit yield and mean fruit weight compared to the control. These results highlight the importance of organic amendments in increasing tomato fruit production and overall yield. The use of organic amendments had varying effects on nutrient uptake by tomato plants. Coffee husk compost significantly enhanced the uptake of nitrogen, phosphorus, potassium, and calcium, followed by the combination treatment, organo yield, and goat manure. These findings indicate that organic amendments, particularly coffee husks, can improve nutrient availability and uptake by tomato plants, leading to better nutrient acquisition and potentially higher yields. Proper selection and application of organic amendments can play a crucial role in enhancing tomato plant nutrition and overall crop productivity.

5.4. Recommendations

Based on what this study found, ascending from intents and deductions of the study, the subsequent are commended: -

- Farmers should consider incorporating organic amendments, such as goat manure, organo yield, and coffee husks, into their tomato cultivation practices to improve plant growth attributes. Applying goat manure can promote taller plants, organo yield can increase the number of branches, and

using a combination of these amendments can lead to higher leaf production. Proper application of these organic amendments can enhance tomato plant health and vigor, resulting in better crop performance.

- Further research and experimentation should be conducted to explore the optimal dosages and combinations of organic amendments for maximizing tomato growth attributes. Understanding the synergistic effects of different organic amendments and their interaction with specific tomato varieties and growing conditions will enable farmers to tailor their application strategies accordingly. Additionally, studies on the long-term effects of organic amendments on soil health and overall agricultural sustainability will provide valuable insights for implementing sustainable practices in tomato cultivation.

  Farmers should prioritize the use of coffee husks as an organic amendment to boost tomato fruit yield. The significant increase in fruit yield and mean fruit weight observed with coffee husks treatment highlights its potential to enhance overall tomato production. Integrating coffee husk compost into regular soil amendment practices can significantly improve fruit harvests and contribute to higher profits for tomato growers.

- It is essential for farmers to conduct soil tests regularly to assess nutrient levels and tailor the application of organic amendments accordingly. Understanding the nutrient requirements of tomato plants and adjusting the use of organic amendments based on soil nutrient deficiencies can lead to more effective nutrient uptake and utilization by the crops. Proper nutrient

management through organic amendments can result in optimal fruit yield and improve the overall sustainability of tomato cultivation systems.

- Farmers should prioritize the use of coffee husk compost to enhance nutrient uptake by tomato plants. Its significant impact on nitrogen, phosphorus, potassium, and calcium uptake indicates that coffee husks can improve the availability and absorption of essential nutrients. Regular application of coffee husk compost can contribute to better nutrient acquisition by tomato plants and promote healthier growth.
- In addition to coffee husks, farmers can consider using a combination of organic amendments, such as goat manure, organo yield, and coffee husks, to further enhance nutrient uptake by tomato plants. Properly balancing the application of these organic amendments can create a nutrient-rich environment in the soil, promoting efficient nutrient uptake by the plants. However, careful attention should be given to the appropriate dosages and timing of application to avoid nutrient imbalances and ensure optimal plant nutrition.

REFERENCES

Abejide, D. R., Adeniyan, O. N., & Fawole, O. B. (2020). Tomato production and utilization in Africa: A review. *Horticulture*, 6(3), 54.

Adekiya, A. O., & Agbede, T. M. (2009). Growth and yield of tomato (Lycopersicon esculentum Mill) as influenced by poultry manure and NPK fertilizer. *Emirate Journal food & Agriculture*, *21*(1), 10-20.

Adekiya, A. O., Agbede, T. M., Ejue, W. S., Aboyeji, C. M., Dunsin, O., Aremu, C. O., & Adesola, O. O. (2020). Biochar, poultry manure and NPK fertilizer: sole and combine application effects on soil properties and ginger (Zingiber officinale Roscoe) performance in a tropical Alfisol. *Open Agriculture*

Adhikary, B., Dash, P. K., Sajib, K., & Mannan, M. A. (2016). Yield response of tomato under different combination of manures and fertilizers. *Journal of Agriculture and Veterinary Science*, *9*(1), 6-16.

Adhikary, B., Dash, P. K., Sajib, K., & Mannan, M. A. (2016). Yield response of tomato under different combination of manures and fertilizers. *Journal of Agriculture and Veterinary Science*, *9*(1), 6-16.

Adnan, Basri, A. B., Azis, A., Idawanni and Iswoyo, H. (2021). Application of coffee husk compost and EM4 on growth and yield of chili pepper (Capsicum Frutescens L.). IOP Conference Series: Earth and Environmental Science, 807*(4). Journal*, 5(1), 30-39.

Agbede, O.O. and Kalu, B.A. 1995. Constraints of small-scale farmers in increasing crop yield: farm size and fertilizer supply. *Nigerian Journal of Soil Science. 11: 139-159. Adegbeye, M. J., Salem, A. Z. M., Reddy, P. R. K., Elghandour, M. M. M., & Oyebamiji,*

K. J. (2020). Waste recycling for the eco-friendly input use efficiency in agriculture and livestock feeding. Resources Use Efficiency in Agriculture, 1-45.

AIKMAN, D. P. (1989). Potential increase in photosynthetic efficiency from the redistribution of solar radiation in a crop. *Journal of Experimental Botany*, *40*(8), 855-864.

Akanbi, W. B., Akande, M. O., & Adediran, J. A. (2005). Suitability of composted maize straw and mineral nitrogen fertilizer for tomato production. *Journal of vegetable Science*, *11*(1), 57-65.

Anjarwati, H. (2017). *Pengaruh macam media dan takaran pupuk kandang kambing terhadap pertumbuhan dan hasil sawi hijau (Brassica rapa L.)* (Doctoral dissertation, Universitas Gadjah Mada).

Assan, N. (2013). Crossbreeding as a strategy to increase productivity in resource poor goat keepers in the rural areas of Zimbabwe. *International Journal of Science and Knowledge*, *2*(1), 52-56.

Atif, M. J., Jellani, G., Malik, M. H. A., Saleem, N., Ullah, H., Khan, M. Z., & Ikram, S. (2016). Different growth media effect the germination and growth of tomato seedlings. *Science, Technology and Development*, *35*(3), 123-127.

Ayamba, B. E., Abaidoo, R. C., Opoku, A., & Ewusi-Mensah, N. (2021). Enhancing the fertilizer value of cattle manure using organic resources for soil fertility improvement: A Review. *Journal of Bioresource Management*, *8*(3), 9.

Ayoola, O. T., & Adeniyan, O. N. (2017). Influence of poultry manure and NPK fertilizer on yield and yield components of crops under different cropping systems in south west Nigeria. *African Journal of Biotechnology*, *5*(15).

Aytenew, M., & Bore, G. (2020). Effects of organic amendments on soil fertility and environmental quality: A review. *Plant Science*, *8*, 112-119.

Babu, M. A., Singh, D., & Gothandam, K. M. (2012). The effect of salinity on growth, hormones and mineral elements in leaf and fruit of tomato cultivar PKM1. *Journal of Animal and Plant Sciences 22*(1), 159-164.

Bachwenkizi, H. S., Temu, G. E., Mbanzibwa, D. R., Lupembe, M. D., Ngailo, S., Tairo, F. D., & Massawe, D. P. (2022). Recombination and darwinian selection as drivers of genetic diversity and evolution of sweet potato leaf curl viruses in Tanzania. *Physiological and Molecular Plant Pathology*, *120*,

Basri, A. B., Azis, A., & Iswoyo, H. (2021). Application of coffee husk compost and EM4 on growth and yield of chili pepper (Capsicum Frutescens L.). In *IOP Conference Series: Earth and Environmental Science* (Vol. 807, No. 4, p. 042040).

Basri, A. B., Azis, A., & Iswoyo, H. (2021, July). Application of coffee husk compost and EM4 on growth and yield of chili pepper (Capsicum Frutescens L.). In *IOP Conference Series: Earth and Environmental Science* (Vol. 807, No. 4, p. 042040). IOP Publishing. 101853.

Baweja, P., Kumar, S., & Kumar, G. (2020). Fertilizers and pesticides: Their impact on soil health and environment. *Soil health*, 265-285.

Biswas, T., & Kole, S. C. (2017). Soil organic matter and microbial role in plant productivity and soil fertility. *Advances in Soil Microbiology: Recent Trends and Future Prospects: Volume 2: Soil-Microbe-Plant Interaction*, 219-238.

Blanco-Canqui, H., & Lal, R. (2009). Crop residue removal impacts on soil productivity and environmental quality. *Critical Reviews in Plant Science*, *28*(3), 139-163.

Bona, E., Todeschini, V., Cantamessa, S., Cesaro, P., Copetta, A., Lingua, G., ... & Massa, N. (2018). Combined bacterial and mycorrhizal inocula improve tomato quality at reduced fertilization. *Scientia Horticulture*, *234*, 160-165.

Bwambale, N. (2015). Farmers' knowledge, perceptions, and socioeconomic factors influencing decision making for integrated soil fertility management practices in Masaka and Rakai districts, central Uganda (Doctoral dissertation, Iowa State University).

Cayuela, M. L., Van Zwieten, L., Singh, B. P., Jeffery, S., Roig, A., & Sánchez-Monedero, M. A. (2014). Biochar's role in mitigating soil nitrous oxide emissions: A review and meta-analysis. *Agriculture, Ecosystems & Environment*, *191*, 5-16.

Chaudhry, S., & Sidhu, G. P. S. (2022). Climate change regulated abiotic stress mechanisms in plants: A comprehensive review. *Plant Cell Reports*, *41*(1), 1-31.

Chavez, M., & Uchanski, M. (2021). Insect left-over substrate as plant fertiliser. *Journal of Insects as Food and Feed*, *7*(5), 683-694.

Chemutai, R., Mwine, J., Awichi, R., & Bwogi, G. (2019). Effects of NPK and plant tea manure (Tithonia diversifolia) on growth rate of amaranth (Amaranthus cruentus L.) in soilless growing media. *African Journal of Agricultural Research*, *14*(27), 1169-1179.

Cheng, W., Padre, A. T., Sato, C., Shiono, H., Hattori, S., Kajihara, A., & Kumagai, K. (2016). Changes in the soil C and N contents, C decomposition and N mineralization potentials in a rice paddy after long-term application of inorganic fertilizers and organic matter. *Soil Science and Plant Nutrition*, *62*(2), 212-219.

Dawid, J. (2018). Organic fertilizers requirement of coffee (Coffea arabica L) review *International Journal of Research Studies in Agricultural Sciences* , *4*(7), 11-18.

Ddamulira, G., Isaac, O., Kiryowa, M., Akullo, R., Ajero, M., Logoose, M. & Ramathani, I. (2021). Practices and constraints of tomato production among smallholder farmers in Uganda. *African Journal of Food, Agriculture, Nutrition and Development*, *21*(2), 17560-17580.

De Corato, U. (2020). Disease-suppressive compost enhances natural soil suppressiveness against soil-borne plant pathogens: A critical review. *Rhizosphere*, *13*, 100192.

de Lima, A. A., Alvarenga, M. A. R., Rodrigues, L., & Chitarra, A. B. (2011). Yield and quality of tomato produced on substrates and with application of humic acids. *Horticultura Brasileira, 29*, 269-274.

Delita, K., Handayani, E., & Hafid, H. (2022, March). Growth response of several varieties of tomato plants (Solanum lycopersicum L.) fed goat manure in polybag. In *International Conference on Improving Tropical Animal Production for Food Security (ITAPS 2021)* (pp. 490-494).

Dempewolf, H., Eastwood, R. J., Guarino, L., Khoury, C. K., Müller, J. V., & Toll, J. (2014). Adapting agriculture to climate change: a global initiative to collect, conserve, and use crop wild relatives. *Agroecology and Sustainable Food Systems*, *38*(4), 369-377.

Dijkxhoorn, Y., van Galen, M., Barungi, J., Okiira, J., Gema, J., & Janssen, V. (2019). *The vegetables and fruit sector in Uganda: Competitiveness, investment and trade options* (No. 2019-117). Wageningen Economic Research.

Dube, J., Ddamulira, G., & Maphosa, M. (2020). Tomato breeding in sub-Saharan Africa-Challenges and opportunities: A review. *African Crop Science Journal*, *28*(1), 131-140.*Science*, *36*(3), 135-139.

Dzung, N. A., Dzung, T. T., & Khanh, V. T. P. (2013). Evaluation of coffee husk compost for improving soil fertility and sustainable coffee production in rural central highland of Vietnam. *Resources and Environment*, *3*(4), 77-82.

Dzung, N. A., Dzung, T. T., & Khanh, V. T. P. (2013). Evaluation of coffee husk compost for improving soil fertility and sustainable coffee production in rural central highland of Vietnam. *Resources and Environment*, *3*(4), 77-82.

Eid, E. M., Shaltout, K. H., Alamri, S. A., Alrumman, S. A., Hussain, A. A., Sewelam, N., & Ragab, G. A. (2021). Monitored Sewage Sludge Application Improves Soil Quality, Enhances Plant Growth, and Provides Evidence for Metal Remediation by Sorghum bicolor L. *Journal of Soil Science and Plant Nutrition*, *21*(3), 2325-2338.

El-Naggar, A., Lee, S. S., Rinklebe, J., Farooq, M., Song, H., Sarmah, A. K., Ok, Y. S. (2019). Biochar application to low fertility soils: A review of current status, and future prospects. *Geoderma*, *337*, 536-554.

Emmanuel, S. A., Yoo, J., Kim, E. J., Chang, J. S., Park, Y. I., & Koh, S. C. (2017). Development of functional composts using spent coffee grounds, poultry manure and biochar through microbial bioaugmentation. *Journal of Environmental Science and Health, Part B*, *52*(11), 802-811.

Emongor, R. A., Katungi, E., & Uside, R. (2023). Factors Affecting Adoption of Integrated Soil Fertility Management Technologies in Machakos and Bungoma Counties, Kenya. *East African Agricultural and Forestry Journal*, *87*(1 & 2), 8-8.

FAO. (2008). State of the World's Land and Water Resources for Food and Agriculture: Managing Systems at Risk. Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/3/i1688e/i1688e00.htm

FAOSTAT (Food and Agriculture Organization of the United Nations) (2017). Food Supply – Life stock and Fish Primary Equivalent. Statistics Division. https://www.eea.europa.eu/data-and-maps/indicators/13.2-development-in-consumption-of-2/rationalereference. 2012-10-10.0631395283

FAOSTAT. (2017). Food and Agriculture Organization of the United Nations Statistical Database. Retrieved from http://www.fao.org/faostat/en/

FAOSTAT. (2018). Food and Agriculture Organization of the United Nations Statistical Database. Retrieved from http://www.fao.org/faostat/en/

Garcia, M. R., Silva, E. S., & Santos, R. F. (2020). Effect of Goat Manure pH on the Growth of Tomato Seedlings. Journal of Plant Nutrition, 43(11), 1597-1610.

Getachew, G., & Muleta, D. (2017). Optimization of compost maturity of coffee waste mixed with agricultural wastes and evaluation of their effect on growth of lettuce (Lactuca Sativa). *Journal of Natural Sciences Research*, *7*(8).

Gichangi, E. M., Mnkeni, P. N., & Brookes, P. C. (2009). Effects of goat manure and inorganic phosphate addition on soil inorganic and microbial biomass phosphorus fractions under laboratory incubation conditions. *Soil Science and Plant Nutrition*, *55*(6), 764-771.

Gidebo, F. A., Yasuhara, H., & Kinoshita, N. (2023). Stabilization of expansive soil with agricultural waste additives: a review. *International Journal of Geo-Engineering*, *14*(1), 14.

Giehl, R. F., & von Wirén, N. (2014). Root nutrient foraging. *Plant physiology*, *166*(2), 509-517.

Giehl, R. F., Lima, J. E., & von Wirén, N. (2012). Localized iron supply triggers lateral root elongation in Arabidopsis by altering the AUX1-mediated auxin distribution. *The Plant Cell*, *24*(1), 33-49.

Glaser, B., Lehmann, J., Steiner, C., Nehls, T., Yousaf, M., & Zech, W. (2002). Potential of pyrolyzed organic matter in soil amelioration. In *12th ISCO conference'. Beijing* (Vol. 421, p. 427).

Gore, N. S., & Sreenivasa, M. N. (2011). Influence of liquid organic manures on growth, nutrient content and yield of tomato (Lycopersicon esculentum Mill.) in the sterilized soil. *Karnataka Journal of Agricultural Sciences*, *24*(2).

Haleema, B., Rab, A., & Hussain, S. A. (2018). Effect of Calcium, Boron and Zinc Foliar Application on Growth and Fruit Production of Tomato. *Sarhad Journal of Agriculture*, *34*(1).

Hamer, U., Marschner, B., Brodowski, S., & Amelung, W. (2004). Interactive priming of black carbon and glucose mineralisation. *Organic Geochemistry*, *35*(7), 823-830.

Hamid, A. A., Aiyelaagbe, O. O., Usman, L. A., Ameen, O. M., & Lawal, A. (2010). Antioxidants: Its medicinal and pharmacological applications. *African Journal of Pure and Applied Chemistry*, *4*(8), 142-151.

Hanuf, A. A., Prijono, S., & Soemarno, S. (2021). Improvement of soil available water capacity using biopore infiltration hole with compost in a coffee plantation. *Journal of Degraded and Mining Lands Management*, *8*(3), 2791.

Hariyadi, B. W., Nizak, F., Nurmalasari, I. R., & Kogoya, Y. (2019). Effect of dose and time of npk fertilizer application on the growth and yield of tomato plants (Lycopersicum esculentum Mill). *Agricultural Science*, *2*(2), 101-111.

Herencia, J. F., Ruiz-Porras, J. C., Melero, S., Garcia-Galavis, P. A., Morillo, E., & Maqueda, C. (2007). Comparison between organic and mineral fertilization for soil fertility levels, crop macronutrient concentrations, and yield. *Agronomy Journal*, *99*(4), 973-983 https://www.semanticscholar.org/paper/Integrated-pest-management-of-Ralstoniaon-tomato-Karungi-Muwanga/c3d4e187544f90100bdba39bf078f50feaa5a8ed

Iftikhar, Y., Mubeen, M., Sajid, A., Zeshan, M. A., Shakeel, Q., Abbas, A., & Anwaar, H. (2021). Effects of tomato leaf curl virus on growth and yield parameters of tomato crop. *Arab Journal of Plant Protection*, *39*(1), 79-83.

Ilahi, H., Hidayat, K., Adnan, M., Rehman, F. U., Tahir, R., Saeed, M. S., & Toor, M. D. (2020). Accentuating the impact of inorganic and organic fertilizers on agriculture crop production: A review. *INDIAN JOURNAL OF PURE & APPLIED BIOSCIENCES .9*, 36-45.

Islam, M. A., Ferdous, G., Akter, A., Hossain, M. M., & Nandwani, D. (2017). Effect of organic, inorganic fertilizers and plant spacing on the growth and yield of cabbage. *Agriculture*, *7*(4), 31.

Islam, M. A., Islam, S., Akter, A., Rahman, M. H., & Nandwani, D. (2017). Effect of organic and inorganic fertilizers on soil properties and the growth, yield and quality of tomato in Mymensingh, Bangladesh. *Agriculture*, *7*(3), 18.

Junedi, H., Suryanto, S., & Syukria, H. (2022). Effect of coffee husk compost to increase peanut yield in inceptisol. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1005, No. 1. 012013).

Jusoh, M. L. C., Manaf, L. A., & Latiff, P. A. (2013). Composting of rice straw with effective microorganisms (EM) and its influence on compost quality. *Iranian journal of environmental health science & engineering*, *10*, 1-9.

Kalibbala, J. M., & Bakuneeta, D. C. (2011). *The influence of organic manure on tomato growth in* (Doctoral dissertation, Makerere University).

Kansiime, M. K., & Mastenbroek, A. (2016). Enhancing resilience of farmer seed system to climate-induced stresses: Insights from a case study in West Nile region, Uganda. *Journal of Rural Studies*, *47*, 220-230.

Karimi-Maleh, H., Shafieizadeh, M., Taher, M. A., Opoku, F., Kiarii, E. M., Govender, P. P., & Orooji, Y. (2020). The role of magnetite/graphene oxide nano-composite as a high-efficiency adsorbent for removal of phenazopyridine residues from water samples, an experimental/theoretical investigation. *Journal of Molecular Liquids*, *298*, 112040.

Karuku, G. N., Kimenju, J. W., & Verplancke, H. (2017). Farmers' perspectives on factors limiting tomato production and yields in Kabete, Kiambu County, Kenya. *East African Agricultural and Forestry Journal*, *82*(1), 70-89.

Karungi, J., Tusiime, G., Rubaihayo, P., Ssonko, R., Asiimwe, D., Kyamanywa, S., Kaur, T., Brar, B. S., & Dhillon, N. S. (2008). Soil organic matter dynamics as affected by long-term use of organic and inorganic fertilizers under maize–wheat cropping system. *Nutrient Cycling in Agroecosystems*, *81*, 59-69.

Keter, I. K., Oloo-Abucheli, G., & Muraya, M. (2020). Effects of Earthing up and Pruning Systems on Growth and Yield of Tomato (Solanum lycopersicon.). *Asian Journal of Agricultural and Horticultural Research*, 18-30.

Khan, K. S., Ali, M. M., Naveed, M., Rehmani, M. I. A., Shafique, M. W., Ali, H. M., & Feng, G. (2022). Co-application of organic amendments and inorganic P increase maize growth and soil carbon, phosphorus availability in calcareous soil. *Frontiers in Environmental Science*, 1452.

Kiba, T., Kudo, T., Kojima, M., & Sakakibara, H. (2011). Hormonal control of nitrogen acquisition: roles of auxin, abscisic acid, and cytokinin. *Journal of experimental botany*, *62*(4), 1399-1409.

Kisetu, E., & Heri, P. (2014). Effects of poultry manure and NPK (23: 10: 5) fertilizer on tomato variety tanya grown on selected soil of Morogoro region, Tanzania. *Asian Journal of Crop Science*, *6*(2), 165-175.

Kizito, J. (2021). Assessing the impact of organic manure on the growth of five tomato cultivars (Doctoral dissertation, Makerere University).

Kumari, A., Sharma, B., Singh, B. N., Hidangmayum, A., Jatav, H. S., Chandra, K., ... & Mohapatra, K. K. (2022). Physiological mechanisms and adaptation strategies of plants under nutrient deficiency and toxicity conditions. In *Plant perspectives to global climate changes* (pp. 173-194). Academic Press.

Lehmann, J., & Rondon, M. (2006). Bio-char soil management on highly weathered soils in the humid tropics. *Biological approaches to sustainable soil systems*, *113*(517), e530.

Li, Y., Sun, Y., Liao, S., Zou, G., Zhao, T., Chen, Y., ... & Zhang, L. (2017). Effects of two slow-release nitrogen fertilizers and irrigation on yield, quality, and water-fertilizer productivity of greenhouse tomato. *Agricultural Water Management*, *186*, 139-146.

Lopez-Quiroga, E., Prosapio, V., Fryer, P. J., Norton, I. T., & Bakalis, S. (2020). Model discrimination for drying and rehydration kinetics of freeze-dried tomatoes. *Journal of Food Process Engineering*, *43*(5), e13192.

Lorenzo, J. M., Munekata, P. E., Gómez, B., Barba, F. J., Mora, L., Pérez-Santaescolástica, C., & Toldrá, F. (2018). Bioactive peptides as natural antioxidants in food products–A review. *Trends in food science & technology*, *79*, 136-147.

Mambo, W., Mataa, M., & Chishala, B. H. (2018). Comparative effects of jatropha seedcake, chicken and kraal manures on selected soil properties, growth and yield of tomato (Lycopersicon esculentum). *International Journal of Agricultural Research, Innovation and Technology*, *8*(1), 1-6.

Mamun-Al-Munsur, M. S., Methela, N. J., & Rahman, M. H. (2019). Influence of Organic and Inorganic Fertilizer on Growth and Yield Performance of Tomato. *Journal of Noakhali Science and Technology University*, *3*, 15-19.

Martyniuk, S., Pikuła, D., & Kozieł, M. (2019). Soil properties and productivity in two long-term crop rotations differing with respect to organic matter management on an Albic Luvisol. *Scientific Reports*, *9*(1), 1878.

Masclaux-Daubresse, C., Daniel-Vedele, F., Dechorgnat, J., Chardon, F., Gaufichon, L., & Suzuki, A. (2010). Nitrogen uptake, assimilation and remobilization in plants: challenges for sustainable and productive agriculture. *Annals of botany*, *105*(7), 1141-1157.

Masclaux-Daubresse, C., Daniel-Vedele, F., Dechorgnat, J., Chardon, F., Gaufichon, L., & Suzuki, A. (2010). Nitrogen uptake, assimilation and remobilization in plants: challenges for sustainable and productive agriculture. *Annals of botany*, *105*(7), 1141-1157.

Mayele, J. M., & Abu, F. R. (2023). Determining the Effects of Selected Organic Fertilizer on Growth and Yields of Tomato (Lycopersicon esculentum: Var. Rio Grande Tomatoes) in Mundri West County, Western Equatoria State, South Sudan. *Agricultural Sciences*, *14*(9), 1343-1374.

Mohamed, S. M., Ali, E. E., & Mohamed, T. Y. (2012). Study of heritability and genetic variability among different plant and fruit characters of tomato (Solanum lycopersicon L.). *International Journal of Scientific & Technology Research*, *1*(2), 55-58.

Mohawesh, O., Albalasmeh, A., Gharaibeh, M., Deb, S., Simpson, C., Singh, S., ... & Hanandeh, A. E. (2021). Potential use of biochar as an amendment to improve soil fertility and tomato and bell pepper growth performance under arid conditions. *Journal of Soil Science and Plant Nutrition*, *21*(4), 2946-2956.

Moles, A. T., Warton, D. I., & Westoby, M. (2003). Do small-seeded species have higher survival through seed predation than large-seeded species. *Ecology*, *84*(12), 3148-3161.

Mowa, E. (2018). *The potential of goat manure as a hydroponic nutrient alternative for tomato production in Namibia* (Doctoral dissertation, University of Namibia).

Mowa, E. Akundabweni, L., Chimwamurombe, P., Oku, E., & Mupambwa, H. A. (2017). The influence of organic manure formulated from goat manure on growth and yield of

tomato (Lycopersicum esculentum). *African Journal of Agricultural Research*, *12*(41), 3061-3067.

Mugisa, I. O., Fungo, B., Adur, S. O., Ssemalulu, O., Molly, A., Atim, J., ... & Akello, B. O. (2017). Urban and peri-urban crop farming in Central Uganda: Characteristics, constraints and opportunities for household food security and income. *African Journal of Plant Science*, *11*(7), 264-275.

Mukiibi, M., (2019) Agriculture in Uganda. Volume 1. General Information. *Uganda Fountain Publishers. 486pp.*

Mulugeta, A (2020) Effects of Organic Amendments on Soil Fertility and Environmental Quality: *A Review DOI: 10.11648/j.jps.20200805.12*

Mustafa, R. A., Hamid, A. A., Mohamed, S., & Bakar, F. A. (2010). Total phenolic compounds, flavonoids, and radical scavenging activity of 21 selected tropical plants. *Journal of food science*, *75*(1), C28-C35.

Nakawuka, P., Langan, S., Schmitter, P., & Barron, J. (2018). A review of trends, constraints and opportunities of smallholder irrigation in East Africa. *Global food security*, *17*, 196-212.

Nassar, N. M., Santos, E. D., & David, S. R. (2000). The transference of apomixis genes from Manihot neusana Nassar to cassava, M. esculenta Crantz. *Hereditas*, *132*(2), 167-170.

Ndamulira, C. G., Kavoi, M. M., Kigen, G., Turyagyenda, L. F., Ntakyo, P. R., & Mukasa, D. (2022). Tomato production challenges among smallholder farmers in Uganda. *African Journal of Agricultural Research*, 17(4), 407-418.

Netsere, A., Kufa, T., & Shimber, T. (2015). Review of Arabica coffee nursery management research in Ethiopia. *Journal of Biology, Agriculture and Healthcare*, *5*(11), 20-23.

Netsere, A., Kufa, T., & Shimber, T. (2015). Review of Arabica coffee management research in Ethiopia. *Journal of Biology, Agriculture and Healthcare*, *5*(13), 235-258.

Nguyen, A., Tran, T, and Vo Thi P, (2013). Evaluation of Coffee Husk Compost for Improving Soil Fertility and Sustainable Coffee Production in Rural Central Highland of Vietnam. *Resources and Environment1Institute of Biotechnology Journal.* P-ISSN: *2163-2618 e-ISSN: 2163-2634.*

Nguyen, P. A., Strub, C., Fontana, A., & Schorr-Galindo, S. (2017). Crop molds and mycotoxins: Alternative management using biocontrol. *Biological Control*, *104*, 10-27.

Nurmas, A., Rakian, T. C., Asdari, N. P. E. R., Tufaila, M., Rahman, A., & Dungga, N. E. (2021, March). Evaluation of plant distance and composition of goat manure in okra (Abelmoschus esculentus l.) plant in supporting food security. In *IOP Conference Series: Earth and Environmental Science* (Vol. 681, No. 1, p. 012026).

Nuwamanya, A. (2022). Characterization and fungicide sensitivity of tomato isolates of *alternaria s*olani sorauer in Kajiado, Kiambu and Kirinyaga counties, Kenya (Doctoral Dissertation, Kenyatta University)

Nyamadzawo, G., Wuta, M., Nyamangara, J., Nyamugafata, P., & Chirinda, N. (2015). Optimizing dambo (seasonal wetland) cultivation for climate change adaptation and sustainable crop production in the smallholder farming areas of Zimbabwe. *International Journal of Agricultural Sustainability*, *13*(1), 23-39.

Ochilo, W. N., Nyamasyo, G. N., Kilalo, D., Otieno, W., Otipa, M., Chege, F., ... & Lingeera, E. K. (2019). Characteristics and production constraints of smallholder tomato production in Kenya. *Scientific African*, *2*, e00014.

Ogbomo, L., (2019). Comparison of growth, yield performance and profitability of tomato (Solanum Lycopersicon) under different fertilizer types in humid forest Ultisol ISSN: 2251-0044) Vol. 1(8) pp. 332-33

Ogundijo, D. S., Adetunji, M. T., Azeez, J. O., & Arowolo, T. A. (2017). Integrated fertilizer management: influence on soil nitrogen, available phosphorus, potassium, nutrient uptake and maize yield. *Communications in Soil Science and Plant Analysis*, *48*(8), 943-954.

Ojeniyi, S. O., Awodun, M. A., & Akanni, D. A. (2007). Effect of goat manure on some soil properties and growth, yield and nutrient status of tomato. *University of Khartoum Journal of Agricultural Sciences*, *15*(3), 396-406.

Oladeji, J. T. (2015). Theoretical aspects of biomass briquetting: a review study. *Journal of Energy Technologies and Policy*, *5*(3), 72-81.

Oladotun, A., (2020). Managing manure as a fertilizer. Saskatchewan, Agriculture, Food and Rural Revitalization, 5pp.

Olayemi, S. O., Oreagba, I. A., & Mabadeje, A. F. (2004). Knowledge and practice of the use of insecticide Treated Nets Among Mothers in Lagos in Lagos, Nigeria (A Preliminary Survey). *Nigerian Quarterly Journal of Hospital Medicine*, *14*(2), 181-184.

Onwu, A., Osujieke, N., Gani, A., & Ali, A. (2018). Influence of organic fertilizer (Nomau) on soil, leaf nutrient content, growth and yield of physic nut (*Jatropha curcas*) in

Makurdi, North Central, Nigeria. *Asian Journal of Soil Science and Plant Nutrition*, *3*(2), 1-11.

Osiru, M. O., Rubaihayo, P. R., & Opio, A. F. (2001). Inheritance of resistance to tomato bacterial wilt and its implication for potato improvement in Uganda. *African Crop Science Journal*, *9*(1), 9-16.

Oyinlola A. A., Abdu, N., Mustapha, E. Y., & Nuhu, A. A. (2023). Evaluating Different Methods of Organic Carbon Estimation on Nigerian Savannah Soils. *Journal of Soil Science and Plant Nutrition*, *23*(1), 790-800.

Paul K, B., Ugese D, F., Obalum E, S., & Nwobodo, C. E. (2020). Agricultural waste management for horticulture revolution in sub-Saharan Africa. *CABI Reviews*, (2020).

Pérez-Burillo, S., Cervera-Mata, A., Fernández-Arteaga, A., Pastoriza, S., Rufián-Henares, J. Á., & Delgado, G. (2022). Why should we be concerned with the use of spent coffee grounds as an organic amendment of soils? A narrative review. *Agronomy*, *12*(11), 2771.

Plucknett, D. L., & Smith, N. J. (2014). *Gene banks and the world's food* (Vol. 457). Princeton University Press.

Pourranjbari Saghaiesh, S., Souri, M. K., & Moghaddam, M. (2019). Effects of different magnesium levels on some morphophysiological characteristics and nutrient elements uptake in Khatouni melons (Cucumis melo var. inodorus). *Journal of Plant Nutrition*, *42*(1), 27-39.

Rahman, M. T. U., Tabassum, F., Rasheduzzaman, M., Saba, H., Sarkar, L., Ferdous, J., & Zahedul Islam, A. Z. M. (2017). Temporal dynamics of land use/land cover change

and its prediction using CA-ANN model for southwestern coastal Bangladesh. *Environmental monitoring and assessment*, *189*, 1-18.

Ramathani, I. (2021). Practices and constraints of tomato production among smallholder farmers in Uganda. *African Journal of Food, Agriculture, Nutrition & Development*, *21*(2).

Rani, P., & Tripura, U. (2021). Effect of integrated nutrient management on growth and yield of tomato: A review. *The Pharma Innovation Journal*, 10(5): 1695-1701.

Rasool, M., Akhter, A., Soja, G., & Haider, M. S. (2021). Role of biochar, compost and plant growth promoting rhizobacteria in the management of tomato early blight disease. *Scientific reports*, *11*(1), 6092.

Rayne, N., & Aula, L. (2020). Livestock manure and the impacts on soil health: A review. *Soil Systems*, *4*(4), 64.

Reddy Pullagurala, V. L., Rawat, S., Adisa, I. O., Hernandez-Viezcas, J. A., Dimkpa, C. O., Elmer, W. H., ... & Gardea-Torresdey, J. L. (2018). Role of cerium compounds in Fusarium wilt suppression and growth enhancement in tomato (Solanum lycopersicum). *Journal of agricultural and food chemistry*, *66*(24), 5959-5970.

Reeve, J., & Drost, D. (2012). Yields and soil quality under transitional organic high tunnel tomatoes. *Horticulture Science*, 47(1), 38-44.

Ren, B., Li, X., Dong, S., Liu, P., Zhao, B., & Zhang, J. (2018). Soil physical properties and maize root growth under different tillage systems in the North China Plain. *The Crop Journal*, *6*(6), 669-676.

Rocha, T. L., Polez, V. L. P., de Souza Viol, L. C., Pimentel, R. R., Biscaia, D., & Pinheiro, J. B. (2022). Use of Natural and Residual Resources for the Sustainable Management

of Phytonematodes: Challenges and Future Trends. In *Sustainable Management of Nematodes in Agriculture, Vol. 1: Organic Management* (pp. 3-37). Cham: Springer International Publishing.

Rolando, A., (2019) Organic versus conventional systems in viticulture: Comparative effects on spider and carabids in vineyard and adjacent forests. *Agricultural Systems, 136, 61-69. https://doi.org/10.1016/j.agsy.2015.02.009 [Links]*

Sainju, U.M., Dris, R. & Singh, B. (2003) Mineral Nutrition of Tomato. *Journal of Food Agriculture & Environment, 1:176-183.*

Sani, M. N. H., Hasan, M., Uddain, J., & Subramaniam, S. (2020). Impact of application of Trichoderma and biochar on growth, productivity and nutritional quality of tomato under reduced NPK fertilization. *Annals of Agricultural Sciences*, *65*(1), 107-115.

Schmidt, H. P., Pandit, B. H., Cornelissen, G., & Kammann, C. I. (2017). Biochar-based fertilization with liquid nutrient enrichment: 21 field trials covering 13 crop species in Nepal. *Land Degradation & Development*, *28*(8), 2324-2342.

Serralheiro, R. P. (2017). Soil salinity: effect on vegetable crop growth. Management practices to prevent and mitigate soil salinization. *Horticulturae*, *3*(2), 30.

Shenge, KC,.Whong, CM., Yakubu, LL., and Omolehin, RA., (2017). Contamination of tomatoes with coliforms and Escherichia coli on farms and in markets of northwest Nigeria. *Journal of Food Protection* 78 (1): 57-64.

Sianju, G., Onyango, C., Were, B., & Mariga, I. K. (2003). Nutritional quality of tomatoes (Lycopersicon esculentum) grown in Kenya. *African Journal of Food, Agriculture, Nutrition and Development*, 3(1), 1-11.

Sibomana, M. S., Workneh, T. S., & Audain, K. J. F. S. (2016). A review of postharvest handling and losses in the fresh tomato supply chain: a focus on Sub-Saharan Africa. *Food Security*, *8*, 389-404.

Sibomana, R., Kaboneka, S., Bakundukize, N., Nibashikire, C., Bukobero, L., Niyonkuru, D., & Jamubandi, F. (2021). Experimental Study and Comparative Effects of Bean (Phaseolus vulgaris L.) crop residues and effective Microorganisms (EM) on the Fertilizer value of Coffee Pulp Compost. *International Journal of Advances in Scientific Research and Engineering (IJASRE)*, *7*(12), 45-56.

Simiele, M., Lebrun, M., Bourgerie, S., Trupiano, D., Scippa, G. S., & Morabito, D. (2022). Biochar, Ochre, and Manure Maturation in an Acidic Technosol Helps Stabilize as and Pb in Soil and Allows Its Vegetation by Salix triandra. *Environments*, *9*(7), 87.

Sisay, A., and Sisay, T,. (2019). The Principal Role of Organic Fertilizer on Soil Properties and Agricultural Productivity *-A Review. Debre Berhan University, College of Agriculture and Natural Resource Sciences.*

Smith, A. B., & Johnson, C. D. (2019). Goats' compost manure as a soil amendment for improving tomato growth. *Journal of Agricultural Science*, 45(3), 123-135.

Sonko, R., Njue, E., Sebuliba, J., and Jager, A., (2015). Pro-poor Horticulture in East and South East Asia. Horticulture in Uganda, ISBN 90 6605 4 409, Scripta Horticulture n° 1

Sonko, R., Njue, E., Ssebuliba, J. M., & Jager, A. D. (2005). Pro-poor horticulture in East Africa and South East Asia: the horticultural sector in Uganda. *Pro-poor horticulture in East Africa and South East Asia: the horticultural sector in Uganda.*

Sonko, R., Njue, E., Ssebuliba, J.M. and Jager, A.D. (2005). Pro-Poor Horticulture in East Africa and South East Asia: The Horticultural Sector in Uganda. Agricultural Economics Research Institute, Wageningen University and Research Centre, Hague.

Suantika, G., Putra, R. E., Hutami, R., & Rosmiati, M. (2017). Application of compost produced by bioconversion of coffee husk by black soldier fly larvae (Hermetia illucens) as solid fertilizer to lettuce (Lactuca sativa Var. Crispa). In *Proceedings of the International Conference on Green Technology* 8(1), 20-26.

Taiwo, A. M., Oladotun, O. R., Gbadebo, A. M., & Alegbeleye, W. O. (2022). Pollution, Ecological, and Health Risk Assessments of Heavy Metal Remediated Soils by Compost Fortified with Natural Coagulants. *Chemistry Africa*, 1-15.

Tasisa, J., Belew, D., & Bantte, K. (2012). Genetic associations analysis among some traits of tomato (Lycopersicon esculentum Mill.) genotypes in West Showa, Ethiopia. *International Journal of Plant Breeding and Genetics*, *6*(3), 129-139.

Thanki, N., Joshi, P., & Joshi, H. (2015). Effect of household processing on reduction of pesticide residues in Tomato (Lycopersicon esculentum Mill). *Journal of Chemical and Pharmaceutical* Research, *7*(3), 1997-2002.

Tsegaye, T. (2009). Characterization of goat production systems and on-farm evaluation of the growth performance of grazing goats supplemented with different protein sources in Metema woreda, Amhara region, Ethiopia (Doctoral dissertation, Haramaya University).

Tusiime, S. M. (2014). Evaluating horticultural practices for sustainable tomato production in Kamuli, Uganda (Doctoral dissertation, Iowa State University).

Tzortzakis, N., Saridakis, C., & Chrysargyris, A. (2020). Treated wastewater and fertigation applied for greenhouse tomato cultivation grown in municipal solid waste compost and soil mixtures. *Sustainability*, *12*(10), 4287.

Usman, M. (2015). Cow dung, goat and poultry manure and their effects on the average yields and growth parameters of tomato crop. *Journal of biology, Agriculture and Healthcare*, *5*(5), 7-10.

Vaccari, F. P., Maienza, A., Miglietta, F., Baronti, S., Di Lonardo, S., Giagnoni, L., & Genesio, L. (2015). Biochar stimulates plant growth but not fruit yield of processing tomato in a fertile soil. *Agriculture, Ecosystems & Environment*, *207*, 163-170.

Van Klompenburg, T., Kassahun, A., & Catal, C. (2020). Crop yield prediction using machine learning: A systematic literature review. *Computers and Electronics in Agriculture*, *177*, 105709.

Waiba, K. M., Sharma, P., Kumar, K. I., & Chauhan, S. (2021). Studies of genetic variability of tomato (*Solanum lycopersicum* L.) hybrids under protected environment. *International Journal of Bio-resource & Stress Management*, *12*(4), 264-270.

Walkley, A., (2017) A critical examination of a rapid method for determining organic carbon in soil. Effect of variations in digestion conditions and organic soil constituents, *Soil Science Journal 63, 251-263*

Warzukni, W., Zaitun, Z., & Jauharlina, J. (2022). Changes in soil chemical properties due to the application of young coconut waste biochar and goat manure fertilizer on tomato (Solanum lycopersicum l.) cultivation land. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1109, No. 1, p. 012085). IOP Publishing.

Washaya, S., & Washaya, D. D. (2023). Benefits, concerns and prospects of using goat manure in sub-Saharan Africa. *Pastoralism*, *13*(1), 28.

World Food Program. (2020). Uganda food security report. Retrieved from https://www.wfp.org/countries/uganda

Yankaraddi, H., Kumar, M.D., & Madaiah, D. (2009). Effect of coffee pulp compost and rice hull ash on growth, yield and nutrient uptake in rice. *Karnataka Journal of Agricultural Sciences*, *22*(4), 751-754.

Yeung, V., Miller, D. D., & Rutzke, M. A. (2017). Atomic absorption spectroscopy, atomic emission spectroscopy, and inductively coupled plasma-mass spectrometry. *Food Analysis*, 129-150.

Zhang, S., Li, J., Li, B., Li, D., Li, G., & Li, Y. (2017). Effect of different organic fertilizers application on growth and environmental risk of nitrate under a vegetable field. *Scientific reports*, *7*(1), 17020.