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COLLEGE OF ENGINEERING

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EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON TOMATO PRODUCTION

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DECLARATION

We Frimpong Elvis and Quaicoe Anthony hereby declare that this thesis is our own work towards BSc. Agricultural Engineering and that to the best of our knowledge it contains no material published by another person or material which has been accepted in another university for any degree except where due acknowledgement has been made in the test.

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DEDICATION

We would like to dedicate this work to our parents, friends, and other family members for their support throughout this project.

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We are most grateful to the Lord Most High for the strength, guidance, knowledge, and understanding given to us throughout this project and for bringing it to a successful ending.

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ABSTRACT

The agricultural domain has maintained its significance within the Republic of Ghana over time. Over time, a significant number of individuals in Ghana have become involved in agriculture. The operational methods of small-scale farmers align closely with their distinctive production traits, encompassing factors such as limited access to extension services, constrained land holdings due to tenure stipulations, insufficiency in storage amenities, and modest levels of inventive practices. These factors have resulted in escalated prices of tomatoes and prevailing nutritional uncertainties. Among the most-consumed vegetables in Ghana and other African nations is *Solanum lycopersicum*. The study was executed within the Department of Agricultural and Biosystems Engineering at the Kwame Nkrumah University of Science and Technology. A comprehensive randomized block design was employed, featuring 6 repetitions and 4 distinct treatments, including organic fertilizers (poultry manure) and inorganic fertilizer (NPK 20-10-10), a balanced combination of 50% organic (poultry manure) and 50% inorganic (NPK), alongside a control group. The tomato plants were transplanted into 12L containers, and data on growth were meticulously gathered every week. Harvesting activities took place between the 10th and 12th weeks, at which point yield assessments were conducted. Distinct variations were observed in terms of plant height, leaf count, stem girth, and tomato yield in comparison to the control group. Notably, the application of poultry manure displayed the most pronounced growth and yield outcomes, followed by the 50% organic and 50% inorganic blend. Subsequently, the NPK 20-10-10 treatment exhibited favorable growth and yield statistics, while the control group demonstrated the least yield.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Tomatoes stand as one of the most extensively consumed vegetables across the globe, contributing significantly to diets owing to their rich nutritional content. Their cultivation has spread across diverse regions and serves as a pivotal crop for numerous farmers. According to AVDRC 2009 report, the tomato production sector in Ghana holds substantial economic importance, a key player in the nation's agricultural landscape. Small-scale farmers who constitute the primary workforce behind tomato cultivation characterize the domain. Tomatoes were chosen because they are valued by different communities for their taste, nutritional qualities, medicinal and culinary properties. Nonetheless, the endeavour of cultivating tomatoes poses its set of challenges, including the presence of pests, diseases, and suboptimal soil conditions.

In response to these challenges, farmers frequently resort to the application of fertilizers to enhance soil fertility and augment crop yields according to AVDRC 2009 report. Fertilizers can be broadly classified into two categories: organic and inorganic. Organic variants are derived from natural sources like animal manure, compost, and plant residues, while inorganic types are synthetically manufactured from chemical compounds.

Numerous studies have delved into the impact of organic and inorganic fertilizers on tomato cultivation. Some researchers have documented those organic fertilizers, such as compost or manure, hold the potential to bolster soil quality by enhancing soil organic matter and nutrient levels, consequently leading to amplified tomato yields (Li *et al*., 2017; Yadav *et al*., 2021). Moreover, organic fertilizers can play a role in sustaining soil fertility over the long term and enhancing the health of the soil's microbiome (Abbasi *et al*., 2017).

Inorganic fertilizers are often more readily accessible to plants, supplying nutrients in optimal proportions that foster growth and yield optimization. Research comparing the effects of organic and inorganic manure on tomato production has yielded diverse findings. Some studies suggest that organic manure enhances tomato yield, quality, and nutritional content due to improved soil structure and microbial activity (Nardi et al., 2004). Conversely, others report comparable or even superior yields when using inorganic fertilizers (Benincasa and Tei, 2011).

It is crucial to recognize that the influence of organic and inorganic fertilizers can be influenced by factors including soil type, climatic conditions, crop variety, and management practices. Therefore, these factors should be taken into consideration when determining the appropriate fertilizer type for tomato cultivation.

Nonetheless, the quest for determining the optimal quantity and type of fertilizer for tomato cultivation persists, necessitating further research. Additionally, the impact of fertilizers on the nutritional quality and flavour of tomatoes requires exploration. Hence, the objective of this study is to scrutinize the ramifications of organic and inorganic fertilizers on tomato cultivation, encompassing aspects of yield and quality. This endeavour aspires to offer insights into selecting the optimal fertilizer type and quantity for tomato production, contributing to the ongoing dialogue surrounding the choice between organic and inorganic fertilizers.

1.2 Problem Statement

Tomato is one of the most widely cultivated and consumed vegetables globally, with its importance in human diets due to its high nutritional value and culinary versatility (Foolad, 2007). To meet the increasing demand for tomatoes, farmers employ various agricultural practices, including the use of fertilizers, such as organic and inorganic manure, to enhance crop productivity. Among the challenges impeding the optimal tomato production in Ghana, the decline in soil nutrients has emerged as a significant contributor to reduced output. Inadequate agronomic techniques, coupled with pest infestations and diseases, contribute to the deficit in tomato supply relative to demand according to AVDRC 1990 training manual. Consequently, there has been an escalated adoption of both organic and inorganic fertilizers by cultivators to amplify crop yield. The application of fertilizers for tomato cultivation results in varied growth reactions and alterations in plant composition, which might potentially have adverse impacts on the plant itself or consumers. The use of organic manure is often associated with several benefits, including improved soil structure, enhanced water retention, and the gradual release of nutrients, resulting in reduced nutrient leaching and lower risk of soil degradation (Shaji *et al., 2021*). These factors contribute to sustainable tomato production by reducing environmental impacts and promoting long-term soil health. However, the use of organic manure may present challenges, including variability in nutrient content and slow nutrient release rates (Mikkelsen, 2008).

Inorganic manure, often referred to as chemical or synthetic fertilizers, is manufactured to provide specific nutrients required by plants (Drinkwater *et al.,* 1998). Inorganic fertilizers are particularly appealing to commercial tomato growers seeking maximum production efficiency. However, the overreliance on inorganic manure may lead to adverse environmental consequences, such as nutrient runoff, soil acidification, and groundwater contamination (Crews and Peoples, 2005). Furthermore, excessive use of inorganic fertilizers can result in imbalanced nutrient ratios in the soil, which may negatively affect tomato plant health (Fageria *et al.,* 2008). However, the specific consequences of using organic and inorganic fertilizers on tomato consumption in Ghana have yet to be fully explored. Further research is needed to explore the specific conditions under which organic or inorganic manure may be more beneficial for tomato production, as well as strategies to mitigate their respective drawbacks.

1.3 Research Questions

The study will attempt to answer the following questions:

1. What kinds of fertilizers do tomato cultivators in Ghana utilize, and what are the challenges linked to cultivating vegetables or tomatoes in this area?
2. What fertilizer types or combinations offer the best potential for enhancing tomato growth and maximizing yields?
3. Could the use of poultry manure and NPK fertilizer influence tomato yields?

To answer the above questions, the following objectives were studied:

1.4 Aim and Objectives

The overall objective of this study was to evaluate the effects of poultry manure and NPK 2010-10 on the cultivation of tomatoes.

The specific objectives were;

i. To evaluate the growth rate of tomato plants under different fertilizer treatments.
ii. To determine the yield of tomato fruits under different fertilizer treatments.

1.5 Significance of the Study

The majority of research regarding fertilizer use in Ghana has been primarily centered on crop yield, with limited exploration into correlating these crop responses to the diverse applications of various organic and inorganic fertilizers. Law-ogbomo and Ajayi (2009) highlighted the influence of cultural practices such as spacing and planting densities on tomato growth in Nigeria. However, investigations into the effects of fertilizers on the growth and yield of tomatoes in Ghana remain scarce. The central objective of this study is to ascertain the impact of organic manure (specifically poultry manure) and NPK 20-10-10 on tomato growth. Given the escalating demand for this crop, it is imperative to employ fertilization techniques that heighten vegetative attributes such as leaf count, plant height, stem circumference, and tomato weight. Comparing diverse fertilizer types under comparable field conditions is essential for developing informed fertilizer recommendations. Consequently, the study aims to provide tomato cultivators with insights into the optimal application levels of poultry manure in conjunction with NPK 20-10-10 to achieve peak tomato yields.

Furthermore, the study's projections encompass the following:

- This study will help us understand the growth rate of tomato plants under different fertilizer treatments.
- This study will help us understand the effect of fertilizer on tomato production.
- This study will help suggest which type of fertilizer is more effective in increasing tomato yield.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Botany and Ecology of Cultivated Species

According to the Cronquist system of classification, *Solanum lycopersicum* can be classified as follows:

2.1.1 Botanical Classification and Description of Tomatoes

Kingdom:	Plantae
Phylum:	Tracheobionia
Class:	Magnoliophyta
Sub-class:	Asteridae
Order:	Solanales
Family:	Solanaceae
Genus:	Solanum
Species:	lycopersicum
Binomial name:	*Solanum lycopersicum*
Common name:	Tomato

2.1.2 Growth and Development

Tomato seeds start to grow within 5-7 days of planting. They grow quickly during the rainy season and can reach a height of 40-50cm in only 4 weeks. This fast growth is helped by the soil being wet and rich, which affects things like how tall the plants get and the size of their leaves (Mavi *et al., 2006)*.

2.1.3 Harvesting and Post-Harvest Handling

Harvesting of tomatoes is done from the 8^{th} -10^{th} week (to be verified) after transplanting. Cutting the shoots at 15 cm from ground level helps new shoots grow and increases how many times you can harvest (Schippers, 2008). The harvested bulbs (tomato-fruit) are kept in the shade and spread on the floor to stop them from spoiling and keep their value (Schippers, 2000).

2.1.4 Insect Pests and Diseases of Tomatoes

Agricultural issues can be divided into major and minor problems based on how much they harm crops. Major pests are the ones that can ruin plants or significantly lower their yield, while minor pests do not harm plants as much. Some pests are specific to certain plants, while others can affect many plants.

Insects that are pests often eat leaves and tender stems, and a few others, usually found in the soil, eat roots. Some of these insects can also spread diseases that commonly affect vegetables like tomatoes.

The main disease that affects tomatoes shows up as yellow patterns on the leaves (vein banding). This happens because of a group of viruses known as Poly-viruses. This can deform the leaves and reduce their value. Fusarium sp has also been found to kill these plants. People have tried using wood ash to control pests like ants and aphids in Ghana (Ngundam *et al*., 1997). Farmers also use chemicals to deal with these pests, but sometimes they do not know how to use them properly (Schippers, 2000).

2.2. The Effects of Fertilizers on the Growth of Tomatoes and Vegetables

Both organic and inorganic fertilizers have been utilized to enhance the growth of numerous crops, including tomatoes and vegetables. Fertilizers play a pivotal role in the cultivation process. The nutrient composition required by different vegetables varies, influenced by the specific crop and its stage of development. Firoz (2009) conducted a study on the impact of Nitrogen and Phosphorus fertilizers on Okra (*ABELMOSCHUS esculenta*) growth and yield, revealing that both types of fertilizers significantly boosted okra's growth and yield. The most favourable yield was achieved with an application rate of 100 kg/ha. A similar trend emerged when cabbage was fertilized with poultry manure. Increasing levels of poultry manure led to notable improvements in headcount, head diameter, and chlorophyll content (Ouda and Mahadeen, 2008).

The effects of combining these manures with crop residues yielded comparable outcomes in terms of plant growth characteristics. Ojeniyi *et al*. (2007) observed a similar pattern in their study on tomatoes. Furthermore, Tagoe *et al*. (2010) explored the impact of carbonized chicken manure on legumes' growth and nodulation.

The application of poultry manure was also found to increase biomass and total phosphorus content in seeds. The strategic combination of organic manures and mineral fertilizers has proven effective for managing soil fertility in vegetable production. Wambani *et al*. (2007) discovered that when farm manure was combined with inorganic fertilizers at a rate of 100 t/ha, it led to higher leaf numbers, increased leaf area, and greater dry weight in Brassica oleracea compared to using farm manure alone. Correspondingly, Hailu *et al*. (2008) reported similar results. They examined the combined application of "orga," an organic fertilizer, with urea at various rates, leading to improvements in leaf number, root diameter, plant height, and other vital agronomic characteristics in carrot plants.

2.3 The Effects of Fertilization on Plant Nutrient Concentration.

Nutrient update and concentration in many plant species are highly responsive to both organic and inorganic fertilizers. Plant nutrients are classified into macro and micronutrients. Macronutrients are elements, which is needed in large amounts by the plant. They include N, P, K, Mg, and Ca while micronutrients also known as trace elements are those needed in small amounts by the plant. They include Fe, Mn, Cu, Al, and Cl. They are involved in the various metabolic processes occurring in the plant. When absent, the plant exhibits deficiency symptoms which affect plant growth its development. There is a strong relationship between soil nutrient content and plant nutrient content. The variation of nutrients in the soil depends not only on the fertilization system but also on the plant variety and the potential productivity of the crops. Castro *et al.,* (2008) studied the effects of poultry manure on N uptake of pine seedlings and found that the percentage of Nitrogen derived from poultry manure increased steadily with increasing poultry manure dose. Ouda and Mahadeen (2008) found that both macro and micronutrients in Brassica oleracea increased with fertilizer application. This is in line with the findings of Selvamani and Manivannan (2009) on the effects of organic manures on the nutrient concentration of Musa spp. They found that leaf N, K, Mg, and Mn increased with increased fertilizer application. The concentration of nutrients in a plant or plant part also depends on the developmental stage of that plant e.g., leaf concentration of nutrients during vegetative growth is different from that during flowering and harvesting (Selvamani and Manivannan, 2009). This is because of the active transport of these nutrients from the leaves to the flowers and young buds during flowering.

2.4 Organic Manure

Poultry manure is an important organic waste derived from bird droppings. Most production of these droppings is by litter system where fowls are kept in large pens, 7-10 fowls/m^2 on the floor covered with litter. Depending on the production system used, the litter material can include sawdust, straw, and plant shavings (Suhail *et al*., 2009). The litter serves as bedding for the fowls and accumulates droppings for several weeks before collection. The period of litter accumulation depends on the management practices used. The age of litter depends on the type of fowl (broilers or hens). A survey on poultry manure management practices in Georgia revealed that droppings from broilers are left to accumulate for a longer time than that from hens (Perkins *et al.,* 1969). This manure is known to contain many essential elements needed for plant growth (Ouda and Mahadeen, 2008) but the nutrient content of these manures depends on the digestibility of the ration, kind of feed, type of bedding or litter type, and climatic conditions and temperature.

In Ghana, chicken manure can generate about 1.5 million tons of fresh droppings annually (Ekue *et al.,* 2001). The production system used here is the deep litter system where fowls are kept in large pens, 7-10fowls/m^2 on a floor covered with sawdust up to a depth of about 20-30cm. In Limbe, droppings are left to accumulate for at least 12 weeks during which they appear like cake and are removed by a shovel and put in bags for commercialization (Kang, 2006).

A study conducted by Karami *et al*., (2017) investigated the effects of organic and inorganic fertilizers on tomato nutritional content. The results showed that the application of organic fertilizers led to a significant increase in the levels of antioxidants and other beneficial compounds in tomatoes.

2.5 Inorganic Fertilizer

Inorganic fertilizers are synthetic or manufactured fertilizers that are typically derived from non-living sources such as rocks, minerals, and chemicals. They are commonly used in modern agriculture to provide crops with essential nutrients such as nitrogen, phosphorus, and potassium. Several studies have investigated the effects of inorganic fertilizers on tomato production. Here is a literature review of some of their key findings:

In a study conducted in Nigeria, researchers found that the use of inorganic fertilizers significantly increased tomato yield compared to non-fertilized plants.

The highest yield was obtained from plants treated with NPK (20-10-10) fertilizer at the rate of 150kg/ha (Ayeni *et al*., 2017).

A study conducted in China found that the application of inorganic fertilizers significantly increased tomato yield and quality. The highest yield was obtained from plants treated with a combination of urea, triple superphosphate, and potassium sulfate (Chen *et al*., 2020).

In a study conducted, researchers found that the application of inorganic fertilizers significantly increased the growth and yield of tomato plants. The highest yield was obtained from plants treated with a combination of urea, single superphosphate, and muriate of potash (Ahmad *et al.,* 1999).

A study conducted in Italy found that the application of inorganic fertilizers significantly increased tomato yield and quality. The highest yield was obtained from plants treated with a combination of urea, triple superphosphate, and potassium sulfate (Quattrucci *et al*., 2011).

A study conducted in India found that the application of inorganic fertilizers significantly increased plant yield, but also resulted in an increase in soil acidity and a decrease in soil organic matter content. The study suggested that the use of organic fertilizers might be a better option for sustainable production (Bhatt *et al*., 2018).

Overall, these studies suggest that the use of inorganic fertilizers can increase tomato yield and quality, but the type and rate of fertilizer application should be carefully considered to avoid negative impacts on soil health and the environment.

2.6 Nutritional Value and Uses of Tomatoes

Tomatoes are parts of plants that people eat either entirely or in portions, whether raw or cooked as part of a main course or salad. They offer an affordable and sustainable source of vitamins, trace elements, and other beneficial compounds (Bouis, 2003). Consumption of tomatoes has long been associated with heart health. Both fresh tomatoes and extracts have demonstrated the ability to reduce overall cholesterol, LDL cholesterol, and triglyceride levels. Moreover, tomato extracts are recognized for their capacity to hinder the undesirable aggregation of platelet cells in the blood—a crucial factor in diminishing the risk of heart-related issues such as atherosclerosis. In a recent South American study involving 26 vegetables, tomatoes and green beans exhibited notable anti-aggregation properties. However, only recently have scientists begun to uncover the uncommon phytonutrients present in tomatoes that contribute to these protective effects on the heart. Among these phytonutrients are nucleoside A, a glycoside, as well as chalconaringenin, a flavonoid, and 9-oxo-octadecadienoic acid, a fatty acid-like molecule. As our understanding of these distinctive tomato phytonutrients grows, we are likely to gain further insights into the distinctive role tomatoes play in promoting heart health. Tomatoes are poised to ascend higher and higher on the list of heart-healthy foods.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Site

3.1.1 Geographic location

The Kwame Nkrumah University of Science and Technology is situated in Ghana within the category of university locations. Its geographical coordinates are 6° 40' 23.4300" N and 1° 33' 55.5228" W. This study took place in the Lath house near the Department of Agricultural and Biosystems Engineering in Kwame Nkrumah University of Science and Technology.

Figure 1: A picture of the Lath house

3.2 Source of Seed and Seedling Production

Seeds of tomato were collected from the Council for Scientific and Industrial Research (CSIR). The variety of tomato seeds planted was *power reno.* 12L buckets were filled with topsoil collected from the experimental field. The seeds were sown in a bowl in the shade constructed at the study site. Seedlings were watered daily using a hand spray and no organic or inorganic fertilizer was used to nurse these seedlings. Seedlings were transplanted at 4 weeks after sowing.

3.2.1 Source of Poultry Manure and Inorganic Fertilizer

Poultry manure was collected from Department of Animal Science poultry farm. The poultry manure was produced by the deep litter system where fowls are kept in large pens on a floor covered with sawdust up to a depth of about 20 cm. The inorganic fertilizer was bought from the market.

3.3 Treatment Allocation

A randomized plot design was used to allocate different treatments. Treatments used were poultry manure, NPK, 50% poultry manure, and 50% NPK. Each treatment had six replicates.

3.4 Production Procedure

3.4.1 Nursing of Tomato Seeds

Tomato seeds were nursed in a bowl for two weeks.

Figure 2: Nursed tomato seedlings

3.4.2 Transplanting of Seedlings

Transplanting was done in the evening hours of the day between 4-6 pm. Seedlings were transplanted at an average height of 8 cm with about 4-6 leaves.

Figure 3: Transplanted tomato seedlings

3.4.2 Irrigation

The plants were irrigated with a watering can every 24 hours. The amount of water used per plant for irrigation was 1 litre.

Figure 4: Irrigation of tomato seedlings

3.4.3 Fertilizer Application

Fertilizers were applied a week before transplanting of seedlings and four weeks after transplanting. Poultry manure was applied at a depth of 10cm as described by Ouda and Mahadeen (2008). This was to allow the organic manure to decompose thus preventing the scorching of the seedlings by the CO_2 released during the decomposition of organic manure.

NPK 20-10-10 application was done by side dressing method according to the treatment allocation in Table 1.

Table 1: The quantity of treatment per plant

Treatment	Application
1	Poultry manure at 41.4g
2	NPK at 5g
3	Poultry manure at 20.7 and NPK at 2.5g
4	Control (no fertilizer)

Figure 5: Fertilizer application

3.4.4 Weed Control

Weed control was carried out by hand.

3.4.5 Harvesting

Harvesting was done by handpicking from the 10th to 12th week after transplanting.

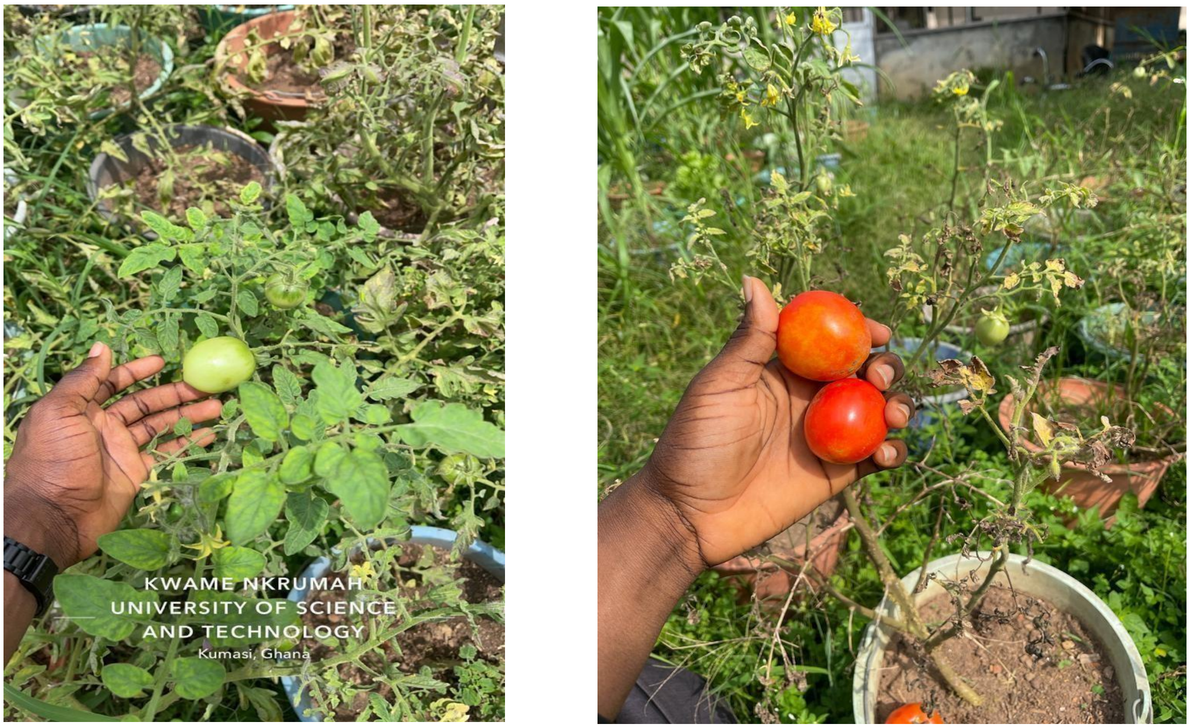

Figure 6: Pictures of tomato fruits

3.5 Data Collection

3.5.1 Growth Data

Plant Height: Using a meter rule, the height of the tomato plant was measured and recorded in centimeters (cm) from the top of the soil to the apex of the shoot.

Leaf Number per plant: This was determined by counting the total number of fully opened leaves of the tomato plants.

Stem girth: This was measured using a vernier calliper and its values were recorded in centimeters (cm).

The Flowers: This was determined by counting the total number of flowers per plant.

3.5.2 Yield Data

The Fruits: This was measured by counting the total number of fruits yielded per stem of the plants.

Fruit weight: The harvested fruits were weighed using a measuring scale and their values were recorded in grams (g).

Figures 7: Pictures of data collection

3.6 Data Analysis

The data was subjected to analysis of variance (ANOVA) to determine the differences in treatment.

The difference among the mean of the treatment was separated using the Least Significance Difference (LSD) at a 5% level of probability.

The efficiency of water usage during the experiment was calculated using the crop water productivity formula

$$\text{CWP} = \frac{Yield\ (\frac{kg}{ha})}{Amount\ of\ water\ used\ for\ irrigation\ (m^3)}$$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Effect of fertilizers on plant growth

All fertilizers used had a positive effect on the growth of tomatoes. The growth rate was very remarkable and distinct from the control in all three fertilizers. There was a progressive increase in plant height, leaf numbers, and stem girth.

4.1.1 Plant height

Maximum plant height was recorded by the use of Poultry manure (71.20cm) as it is mainly for foliage development of plants, while the least was recorded by the control (50.90cm). Tomatoes fertilized by 50% organic and 50% inorganic (61.40cm) of plant height, while NPK has 60.20cm, closely followed by this.

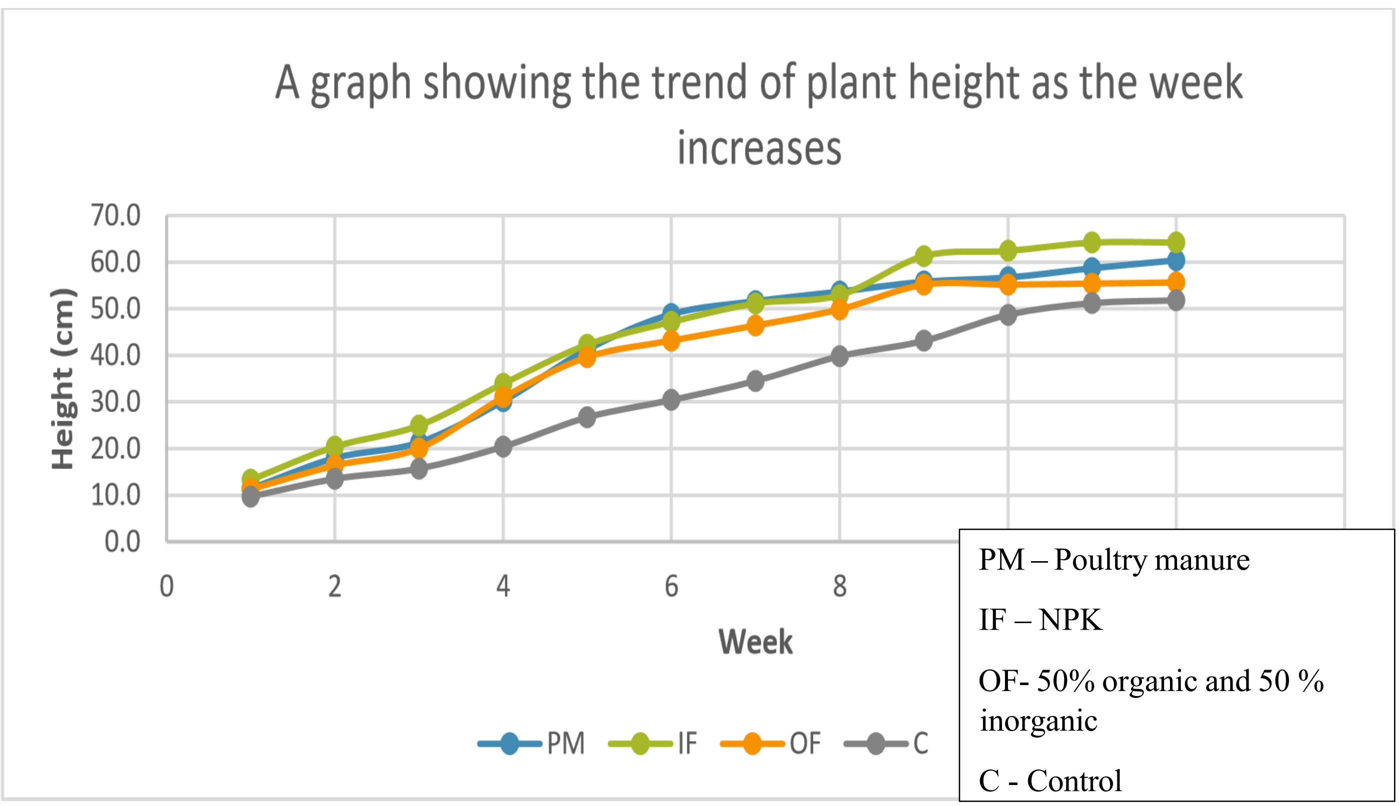

Figure 8: A graph showing the trend in plant height

The graph illustrates the progression of plant height throughout the experiment. Initially, there was substantial growth in plant height after transplantation, peaking in the 10th week. During the 10^{th} to 12^{th} weeks, the plants' height remained unchanged.

It is noteworthy that plants treated with NPK fertilizer displayed the tallest height. Nitrogen, a key nutrient, plays a crucial role in influencing plant height. NPK, being a concentrated source of this nutrient, exerts a stronger impact on plants compared to other fertilizers. NPK delivers nutrients promptly and in a concentrated manner, fostering rapid and notable early growth that can lead to increased plant height. This is in contrast to organic fertilizers that release nutrients gradually over time. Poultry manure and a combination of 50% organic and 50% inorganic fertilizer demonstrated notable plant height increases, following the trend set by the NPK-treated plants. In contrast, the control group, which received no fertilizer application, exhibited the lowest plant height.

The highest height exhibited by plants treated with NPK might have been due to the presence of the primary nutrient nitrogen. This is in line with the studies of (Law-Ogbomo *et al.*, 2009).

4.1.1 Leaf number

There was a progressive increase in the number of leaves of plants under different fertilizer applications, including the control. Inorganic fertilizer (NPK) had the highest leaf number, followed by 50% organic and 50% inorganic fertilizer, and Poultry manure, while the control recorded the least number of leaves.

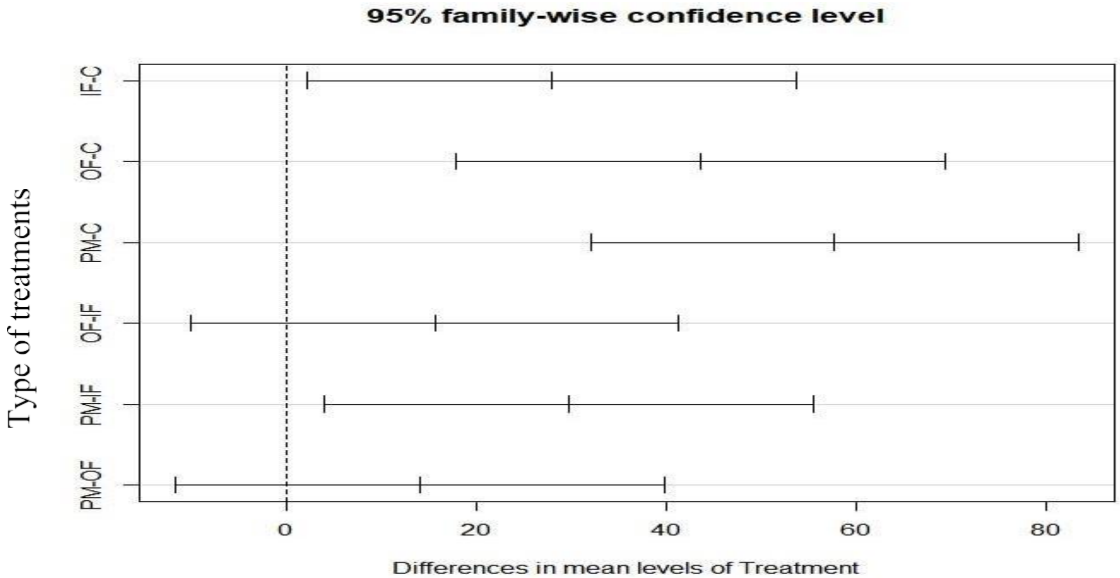

Figure 9: A plot for the number of leaves

When the zero axis intersects the confidence interval of a pair, it indicates that the difference between the pairs is not significant. Conversely, if the zero axis doesn't intersect the confidence interval, it suggests a significant difference between the pairs.

If the confidence interval of a pair lies to the right of the zero axis (positive side) without being cut, it means that the first variable had a positive or stronger impact on the plant compared to the second variable in the pair. On the other hand, if the confidence interval is on the left side of the zero axis (negative side) without being cut, it implies that the first variable had a negative or weaker impact on the plant compared to the second variable.

Looking at the plot, there were significant differences between all the treatments and the control group. All the treatments showed a positive effect on the plant compared to the control. Furthermore, there was a significant difference between poultry manure and NPK. The plot suggests that poultry manure had a more favourable impact on the number of leaves of the tomato plants compared to NPK.

Poultry manure contains organic matter and helpful microorganisms that improve both water retention and nutrient accessibility. Organic manure releases nutrients slowly and therefore are not easily leached away (Oyedele *et al.,* 2006). This encourages strong plant growth, leading to an increased leaf count, even though the nutrients are released gradually.

No significant differences were observed between the other pairs in terms of their effects.

4.1.2 Stem Girth

Maximum stem girth was found in tomatoes fertilized with NPK (1.3 cm), poultry manure

(cm), and 50% organic and 50% inorganic (1.3 cm), while the least was found in the control (1.0). All treatment means were significantly different from the control. There was no significant difference between OF & IF, PM & IF, and PM & OF. The highest stem girth exhibited by plants treated with NPK might have been due to the presence of the primary nutrient nitrogen. This is in line with the studies of (Meng *et al*., 2018).

4.1.3 Tomato Yield

The poultry manure application had the highest yield followed by inorganic fertilizer, 50% organic and 50% inorganic while the control had the least.

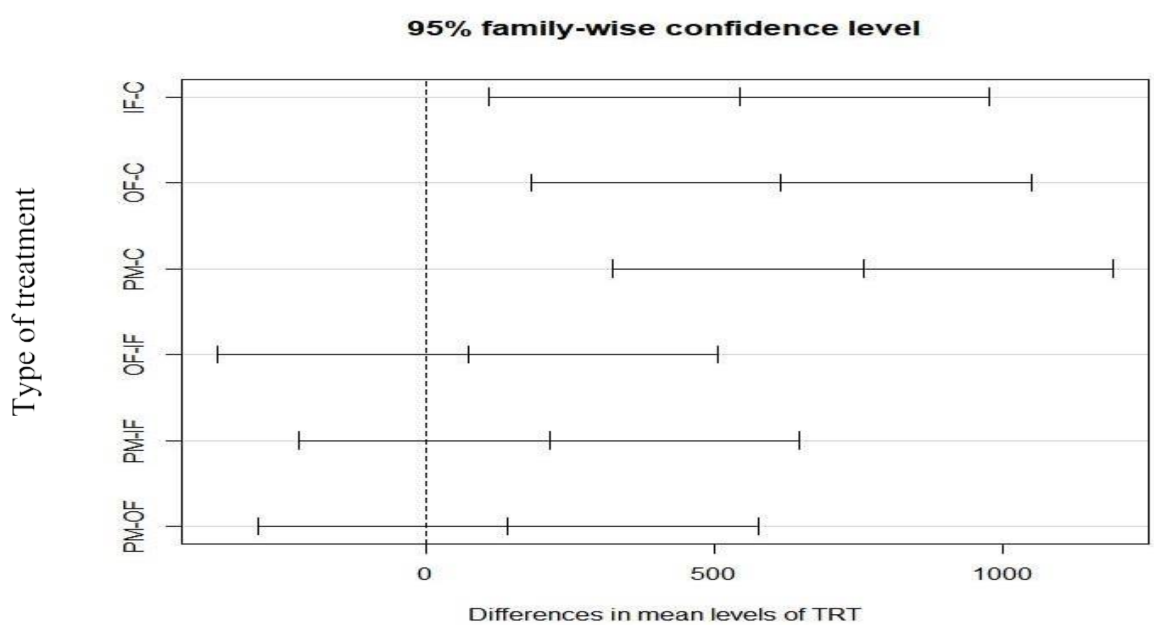

Figure 10: A plot for the plant yield

Reviewing the plot, there were significant differences between all the treatments and the control group in terms of the plant's yield. Each treatment exhibited a positive effect on the plant's yield when compared to the control. No significant differences were identified between the other pairs of treatments.

Upon analyzing the plot, you will notice that the zero axis intersects the confidence interval of different treatment pairs. However, pay attention to the position of the center of these confidence intervals about the zero axis. The closer the center is to the positive axis, the stronger the influence of the first treatment compared to the second.

From this, we can deduce that among the treatment pairs, poultry manure had a more pronounced impact on the plants compared to both NPK and the 50% poultry manure and 50% NPK blend. This could be attributed to the gradual nutrient release of organic manures, which prevents quick leaching and results in a prolonged residual effect in the soil, distinguishing it from the other treatments. The plot indicates that the effect of using 50% poultry manure and 50% NPK is quite similar to using pure poultry manure, followed by the NPK treatment.

Based on this insight, it is reasonable to consider substituting pure poultry manure with 50% poultry manure and 50% NPK blend, with NPK being the next preferable option. These results follow the findings of (Ouda and Mahadeen, 2008).

4.2 Crop Water Productivity (CWP)

Table 2: Crop water productivity for each treatment

Treatment	CWP (kgm^{-3})
Poultry manure	2.72
NPK	1.43
50% organic and 50% inorganic	1.88
Control	0.22

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The tallest plants were observed in plants with 41.4g of poultry manure followed by those with NPK. The untreated plants (the control) were the shortest as they had to depend mainly on the intrinsic soil fertility. The height of the plant is an important growth parameter directly linked with the production potential of a plant.

Leaf number and stem girth tended to increase by increasing the dose of organic manure (poultry manure) but the highest growth in terms of the parameters measured was attained by treatments with NPK: 20-10-10

Generally, increasing levels of application of the organic manure (poultry manure) increased plant growth.

Treatments with poultry manure showed a significantly higher number of leaves, taller plants with higher stem girth, and yield of tomato fruits. These results follow the findings of Ouda and Mahadeen (2008), Thomas *et al*., (2012), Ogboghodo *et al*., 2005 and Ayoola and Makinde (2009). This suggests that the production of larger and numerous leaves as well as the yield of tomatoes are characteristics with economic value. This might be because organic manures release nutrients slowly and therefore are not easily leached thereby producing a long residual effect in the soil which when complemented with the easily absorbed nutrients in NPK promotes high and luxuriant growth. In addition, organic manures have a large humus content that improves the soil's water-holding capacity and soil texture. These promote better root development and prevent the desiccation of the roots in the soil.

Plants in the control were significantly different from all treatments in all the parameters measured. They were shorter, had fewer leaves, and smaller stem girth, produced fewer tomatoes with smaller sizes, and had the lowest fresh weights. Since tomatoes grow very fast and produce much biomass in a short time, their nutrient uptake rate will be high so the plants in the control relied on the intrinsic level of nutrients in the soil. The observed differences in biomass accumulation by the plants in the different treatments could be explained by the fact that the plants treated with fertilizers had larger relative leaf areas and more numerous leaves that intercept more light required during photosynthesis thus favouring the yield of tomatoes.

Tomato gardeners in Ghana use different kinds of fertilizers in the cultivation of tomatoes with NPK (20-10-10) being the most preferred. Poultry manure could be a very attractive fertilizer alternative, particularly for annual crops with short growth cycles such as tomatoes. Organic (poultry manure), 50% organic and 50% inorganic, and NPK (20-10-10) manures enhanced the growth and yield of *Solanum lycopersicum*, hence the production of large, numerous leaves and greater yield of tomatoes which are the characteristics with economic value. Comparatively poultry manure and 50% organic and 50% inorganic is more effective in enhancing the growth, and yield of *Solanum lycopersicum* as compared to the NPK. Poultry manure is then more suitable because it is not only cost-effective but also, provides excellent nutrient content for plants promoting healthy growth and enhancing soil fertility.

5.2 Recommendations

Farmers in Ghana should use poultry manure as their main source of fertilizer because it is inexpensive and it increases the yield of tomatoes.

Integrated Fertilization Approach: Consider adopting an integrated fertilization approach that combines both organic and inorganic fertilizers. This approach can enhance soil fertility and improve nutrient availability to the plants. Organic fertilizers can provide essential micronutrients, improve soil structure, and support beneficial microbial activity, while inorganic fertilizers can offer a quick supply of primary nutrients. A balanced combination of both types can optimize tomato yield and quality.

Extension on-farm studies should be carried out in Ghana to determine the long-term effects of the use of fertilizers on soil characteristics of tomato cultivation.

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