BINDURA UNIVERSITY OF SCIENCE EDUCATION

DEPARTMENT OF CROP SCIENCE

EFFECTS OF PLANT AND ANIMAL BASED ORGANIC AMENDMENTS ON GROWTH RATE AND YIELD IN BUTTERNUT SQUASH (*Cucurbita moschata)* PRODUCTION.

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE BACHELOR OF AGRICULTURAL SCIENCE HONOURS DEGREE IN CROP SCIENCE JUNE 2025

SUPERVISOR: MS KAMOTA

DECLARATION

BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF AGRICULTURE AND ENVIRONMENT SCIENCE

The undersigned certify that they have read and recommended to the Department of Crop Science, this thesis entitled:

EFFECTS OF PLANT AND ANIMAL BASED ORGANIC AMENDMENTS ON GROWTH RATE AND YIELD IN BUTTERNUT SQUASH (*Cucurbita moschata)* PRODUCTION.

DECLARATION

I, Terence T. Musungo, do hereby declare that this research project is the result of my original work that had been researched and got submitted on fulfilment of the Bachelor of Agricultural Honours Degree Majoring in Crop Science at Bindura University of Science Education. The other information had been derived from other people's work based on trusted sources and had been duly cited, accredited and acknowledged through references.

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ABSTRACT

Zimbabwe agriculture experiences growing challenges due to declining in soil fertility, high input costs, pests and diseases and unsustainable reliance on synthetic fertilizers. These constraints are particularly severe for smallholder farmers involved in horticultural production including butternut squash, a crop of rising nutritional value. Therefore, different organic amendments namely rabbit, horse manure, biochar and vermicompost were assessed examining their effects on cumulative tendril length, number of leaves, number of fruits and fruit weight. The research experiment was carried out at National Tested Seeds Company demonstration plots in Norton, Mashonaland West Province, using a Randomized Complete Block Design (RCBD) with five treatments which were rabbit manure, horse manure, biochar, vermicompost and inorganic fertilizer (control). The area was divided into 3 blocks with 5 plots in each block which gives a total of 15 plots. Slope was a blocking factor. Data was collected on cumulative tendril length, number of leaves, number of fruits and fruit weight. Just after planting, the agronomic practices took place which involved weed control, fertilizer application, scouting etc. Data for cumulative tendril length, number of leaves was measured at week 3, 4 and 5 then for number of fruits and yield was collected at harvesting period. Data was statistically analysed using GenStat software through Analysis of Variance (ANOVA) to determine treatment effects. Results revealed statistically significant differences ($P<0.001$) across all growth and yield parameters. The results showed that inorganic fertilizer (control) recorded the highest measurement whilst vermicompost had the least in terms of cumulative tendril length, number of leaves, fruit number and yield. In light of these findings, farmers are encouraged to do an integrated approach to enhance crop productivity while reducing environmental impacts. The study also highlights further research is needed on the long term effects of organic amendments on soil health and crop productivity to inform sustainable agriculture practices.

KEY WORDS: organic amendments, butternut squash, smallholder farmers, soil fertility and sustainable agriculture

DEDICATION

I dedicate this project to my parents Mr and Mrs Musungo.

ACKNOWLEDGEMENT

I would like to acknowledge my project supervisor Ms. Kamota for guidance during the course of the research project. My great appreciation goes to my course mate, Tendai Chikukwa for his support during data collection. Lastly l would like to thank my family and friends for being supportive towards this research project.

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CHAPTER 1

INTRODUCTION

1:1 BACKGROUND

Agriculture remains the backbone of Zimbabwe's economy, playing a vital role in ensuring food security, generating employment and providing income for many households. Within the horticultural sector, butternut squash (*curcubita moschata*) has gained prominence as a crop of both economic and nutritional significance (Islam *et al*., 2010). Butternut squash is widely cultivated across Zimbabwe due to its adaptability to diverse agro-ecological zones, relatively low input requirements, and increase demand in both local and export markets. It is highly valued for its long shelf life, culinary versatility and rich nutritional profile, particularly its high content of vitamin A, dietary fiber, potassium and antioxidants (Diagne *et al*., 2020).

The Fertile Crescent, known as the birthplace of agriculture around 8000 B.C., was where early farmers first domesticated plants and animals and likely applied organic amendments to maintain soil health (Rastogi *et al.,* 2018). For millennia, organic additions were the primary source of nutrients until the mid-20th century, when synthetic fertilizers became prevalent. However, in Zimbabwe, smallholder farmers face significant challenges, including declining soil fertility, pests, diseases, and rising costs of synthetic fertilizers. The excessive use of inorganic fertilizers has contributed to soil acidification, reduced organic matter, poor soil structure, and nutrient imbalances, making agricultural systems increasingly unsustainable (Vaghel *et al.*, 2020). In response, there has been a notable shift towards organic-based amendments, with usage rising from 20% to 30 % (Rastogi *et al.,* 2018).These locally available, environmentally friendly, and economically accessible alternatives have become essential as farmers adapt to the adverse effects of soil degradation (Kurnati *et al.*, 2018).

Organic-based amendments derived from plant and animal sources play a crucial role in enhancing soil fertility. These materials do not only provide essential nutrients but also improve key physical properties of the soil, such as porosity, aeration, and water-holding capacity. Additionally, they enhance microbial activity and boost nutrient cycling (Rastogi *et al.,* 2018).Animal-based amendments, such as rabbit and horse manure, typically contain higher nutrient levels, particularly nitrogen, phosphorus, and potassium, making them highly effective. On the other hand, plant-based amendments like biochar and vermicompost are valuable for their ability to improve soil structure, increase cation exchange capacity, and release nutrients slowly over time (Abdullah et *al.,* 2020). Gad et al., (2001) reported a positive response of butternuts to organic amendments, demonstrating increased yields and improved growth.

It is important to note that the performance of a crop can be affected by different factors, including the type of soil, crop management practices and climatic conditions. However, the experimental field plot trials are necessary to know the productivity of these organic based amendments. Continued research in this area remains crucial for addressing emerging challenges in butternut production.

1.2 PROBLEM STATEMENT

Soil quality is declining due to the excessive use of chemical amendments and poor farming practices. This decline has significantly impacted butternut production, resulting in yields reduction per hectare. Therefore, a thorough understanding on the use of different organic amendments is crucial for developing sustainable agricultural practices that improve butternut squash productivity.

1.3 JUSTIFICATION

There are several benefits to using organic-based amendments, however there is limited information on how they are applied.The use of different organic based amendments can significantly impact butternut production, yet adequate information on this topic is lacking. The outcomes are going to provide information to disadvantaged farmers and the agricultural sector encouraging the exploration of organic based farming in butternut squash.

1.3 OBJECTIVES

1.3.1 GENERAL OBJECTIVES

The primary or main objective of this study is to assess the effects of plant based organic amendments and animal based organic amendments on the growth rate and yield in butternut squash (*Cucurbita moschata)* production.

1.3.2 SPECIFIC OBJECTIVES

- To assess the impact of plant and animal based organic amendments on the cumulative tendril length of butternut squash.
- To assess the effects of plant and animal based organic amendments on the number of butternut leaves.
- To evaluate the effects of plant and based organic based amendments on the final yield of butternut squash.
- To evaluate the effects of plant and animal organic based amendments on the number of butternut fruits.

1.4.0 HYPOTHESIS

H0. The application of plant and animal based organic amendments has no significant difference on the cumulative tendril length of butternut squash.

H0.The application of plant and animal based organic amendments has no significance difference on the number of butternut leaves.

H0.The application of plant and animal based organic amendments has no significance difference on the number of butternut fruits.

H0.The application of plant and animal based organic amendments has no significant difference on the final yield of butternut squash.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 MORPHOLOGICAL DESCRIPTION

Butternut squash (*cucurbita moschata)* it is one of the nutritious consumable vegetable in the world they are tendril –bearing and vine like plant. They have extensive root system which occurs around the stem nodes. According to (Dermawan *et al.,* 2020) leaves of butternut squash plants are rounded and appear a heart shaped. The feeder leaf occurs at the node where the butternut fruit develops, it is called the feeder leaf because of the photosynthesis from the leaves which are directed to the adjacent fruit. According to the (Department of Agriculture and Fisheries 2011) the important aspect of the butternut squash plant is its flowering stage. The flowers are large and funnel-shaped, usually yellow to orange. The butternut squash plant are monoecious, with male and female flowers occurring on the same plant. The male flowers firstly appear followed by the females. Flowering typically happens in mid to late summer and successful pollination is important for fruit formation. The shape of ovary before pollination determines the final shape of the butternut squash fruit (lemlem *et al.,* 2013).According to *(*Xu *et al.,* 2024) butternut fruit has a distinctive elongated shape, resembling a bell or a bull with a tapered neck. It grows large, weighing 2 to 5 kg and the skin is smooth and firm. They is hard rind which protects the fruit from pests and diseases, allowing it to be stored for extended periods.

2.2 IMPORTANCE

In the agriculture perspective, butternut squash holds considerable importance as a crop. It is easy to grow and also requires moderate care, making it being accessible to both commercial farming and home gardeners. They thrive in warmer climates and can be grown in variety of soil types, provided they are well-drained (Nasution *et al.,* 2013). The butternut squash plant exhibits a sprawling growth habit which helps in the suppression of weeds and reduce the usage of chemical herbicides. It helps in promoting sustainable agriculture practices by promoting diversity and reducing environmental impact. According to (Safriyani *et al.,* 2021) the butternut squash has a relatively long shelf life compared to many other vegetables, allowing it to be stored for a longer time without losing its quality. It helps in reducing post-harvest losses and allows to have a greater market flexibility.

Furthermore, the butternut squash is a very profitable crop and daily it increase its demand, driven by health trends and culinary innovation, presents opportunities for farmers to diversify their offerings. The community-supported agriculture programs and agricultural markets often feature butternut squash, connecting local producers with consumers.

The butternut squash holds significance purposes around areas in the world. They offer fall harvests, thanksgiving celebrations and seasonal recipes. According to Stephene *et al.,* (2020) indigenous people in North America cultivated squash alongside corn and beans. It continues to play a role in educational programs and community initiatives that focus on healthy eating and food literacy.

2.3.0 NUTRITIONAL VALUE

2.3.1 Vitamin A

Vitamin A is one of the important nutrients in the butternut squash and mostly found in the form of beta-carotene.lsaac *et al.*, (2011) observed that a fat soluble vitamin A in butternut squash helps in maintaining vision, skin health and immune function. The Beta-carotene is a strong anti-oxidant that helps protect the body from oxidative stress and inflammation.

2.3.2 Dietary Fiber

Butternut squash usually contain dietary fiber which is very essential for digestive health. According to Camire *et al.,* (2016), on the average butternut squash contains approximately 2 - 3% dietary fiber. Human beings are being recommended to take about 12% of fiber per day in order to promote a healthy digestion and lowering constipation, (Pamela *et al*., 2007).

2.3.3 Carbohydrates

According to (Seran *et al.*, 2010) the butternut squash supply a quick source of energy, making it a suitable food for active individuals. The carbohydrates are mainly in the form of natural sugars and complex carbohydates.20-25% is the predominantly part of carbohydrate in the butternut squash plant.

2.3.4 Potassium

Butternut squash is usually not considered as a source of potassium as compared to other crops and it also still contributes to a certain percentage to the overall potassium content in the diet. Average butternut contains around 9-10% potassium (Tarigan *et al.*, 2018).

2.3.5 Antioxidants

These are compounds contained by butternut which involves phenolic and carotenoids, their main function is to protect the cells of the body from being damaged by the free radicals, the percentage of antioxidants in butternut squash usually ranges from 0.3% - 0.8% (Dermawan *et al.,* 2020) . The attack by radicals usually leads to some of the chronic conditions and quick aging, therefore these oxidant compounds contribute to the good body healthy system. The orange color of butternut squash indicates a high concentration of these beneficial compounds, reinforcing its status as a health-promoting food.

2.3.6 Vitamin C

(Tomquelski *et al.*, 2017) projected that vitamin C play a role in the body's immune system by promoting the function of immune cells. It is crucial for collagen synthesis and also it reduces the risk of chronic diseases. They have a crucial role in cell division for growth especially during the stages of rapid development.

2.4.0 IMPORTANCE OF USING ORGANIC BASED AMENDMENTS

The organic based amendments they are important in sustainable agriculture and soil health management. Organic based amendments involves biochar, compost, green manure, rabbit manure, and vermicompost and crop residues. They have numerous benefits to the environment and agricultural productivity. One of the importance of the organic based amendments is the enhancement of soil fertility. The organic based amendments supply with macro nutrients such as nitrogen, phosphorus and potassium which are crucial for crop growth. According to Brad *et al.*, (2010) the decomposed, plant materials release nutrients gradually, providing a steady supply for crops. This enhance good soil structure promoting better aeration and root penetration.

Research by (Hossain *et al.,* 2018) has investigated how organic based amendments can enhance water retention as they act like a sponge, absorbing and holding moisture, which is essential for plant growth. Enhancing the soil's water holding capacity this can reduce irrigation needs and increase the water use efficient.Mazzoncini *et al.,* (2016) investigated that improved water retention leads to better drought resilience allowing butternut squash to withstand drought.

Alridiwirsah *et al.,* (2020) suggests that organic based amendments can have significant positive effects on the butternut squash growth. Besides improving soil health, nutrient availability, and water retention, organic based amendments can also enhance the overall health and vigor of butternut squash plants, leading to increased yields. Further research is warranted to investigate the specific mechanisms by which organic based amendments influences plant growth and to optimize the application of these amendments.

In addition, the use of plant and animal based organic amendments aligns with sustainable agriculture. By reducing the usage of artificial fertilizers these amendments contribute to lower environmental impact. Martinez et *al.,* (2017) conducted that organic based amendments helps to mitigate soil degradation, reduce soil erosion and enhance soil carbon sequestration. By incorporating organic amendments into soils it can cultivate healthier soils, increase productivity and contribute to the sustainability of the agricultural sector.

Organic based amendments promote microbial activity in the soil (Sitompul *et al.,* 2011). The nutrients and organic matter presents in the amendments act as food for the soil microorganisms. It is crucial for nutrient recycling, as microorganism's breakdown organic matter and convert nutrients into absorbable form.

2.4.1 EFFECTS OF BIOCHAR, HORSE MANURE, VERMICOMPOST AND RABBIT MANURE IN BUTTERNUT PRODUCTION

Organic based amendments can also influence root growth in butternut squash plant. Research by Fitter *et al.,* (2020) showed that applying biochar in the soil helps in root health development. The biochar amendment increase soil porosity, which enhances aeration and root penetration. Aeration helps better root development by allowing plants to access more nutrients effectively. It significantly influence nutrient availability in the soil preventing leaching and making them available to plants over a longer period. Plants grown in biochar amended soils often shows higher nutrient uptake, resulting in enhanced growth and yield (Matondang *et al.*, 2020).

They is also rabbit manure which is a particular kind of manure that is made from rabbits. It is a very crucial resource and the best animal based organic amendment on the market. Rabbit manure contains approximately 2.4% nitrogen, 1.4% phosphorus, and 0.6% potassium making it an influence organic amendment to other manures (William Stile et al, 2017).According to Yafan *et al.,* (2004) investigated that the application of rabbit manure contributes to the improvement of the soil.lt helps in the beneficial microbial populations that helps in the nutrient cycling and organic matter decomposition. Furthermore, rabbit manure has the neutral pH, making it more suitable to a wide variety of crops including the butternut squash, which mostly favor the slightly acidic soils to neutral soils. Kurniati *et al.,* (2018) have investigated that the rabbit manure has improved growth and higher yields.

Horse manure is a good source of nutrients and it comes from horse waste. The horse dung manure contains 0.7% nitrogen and 0.8% phosphate which balances or higher than those of cow manure. Kusuma *et al.,* (2014) investigated that horse manures helps in improving soil structure. Additionally, the horse manure provides calcium and magnesium for butternut development. The horse manure before it reaches the field procedures are required to breakdown the organic content and remove the hazardous elements. The levels of organic matter in the horse manure is very high which helps in the growth of beneficial insects, which in turn in the management of pests and increase yields. According to (Egboka *et al.,* 2016) the horse manure helps in the microbial activity which is essential for nutrient cycling and the breakdown of organic matter, which increases the soil fertility.

Lastly, vermicompost it is a nutrient-rich organic amendment produced through the breakdown of organic matter by earthworms and has gained recognition for its significant benefits to soil health and plant growth. As sustainable agricultural practices become increasingly vital, the adoption of vermicomposting is on the rise. Studies show that the global market for organic fertilizers, including vermicompost, is expected to reach $22.0 billion by 2025, reflecting a growing trend towards organic farming and eco-friendly practices (Matondang *et al.*, 2020).

One of the primary advantages of vermicompost is its rich nutrient profile. It is packed with essential macronutrients such as nitrogen, phosphorus, and potassium, as well as micronutrients crucial for plant development. Kusuma *et al.,* (2012) projected that the nutrient content in vermicompost is often higher than that found in traditional compost, with nitrogen levels ranging from 1.5% to 3% and phosphorus levels reaching up to 1.5%. This nutrient availability fosters robust plant growth, leading to increased crop yields.

In addition to being nutrient-dense, vermicompost significantly improves soil structure. By enhancing soil aggregation, it increases porosity and facilitates better aeration and water retention. Healthy soil structure is vital for root development, which ultimately supports plant vitality. According to Kurniati *et al.*, (2018), soils enriched with vermicompost can improve water retention by 20% to 30%, a crucial factor in regions facing water scarcity.

Moreover, the application of vermicompost stimulates microbial activity in the soil. The diverse microorganisms present in vermicompost play a crucial role in decomposing organic matter and nutrient cycling. A study published in the "Soil Biology and Biochemistry" journal found that soils treated with vermicompost exhibited a 200% increase in microbial biomass compared to untreated soils. This enhanced microbial activity not only aids in nutrient availability but also helps suppress soil-borne pathogens, reducing the likelihood of crop diseases.

Vermicompost also contributes to improved water retention capabilities. The organic matter content in vermicompost acts like a sponge, allowing the soil to hold moisture more effectively. This characteristic is particularly beneficial in arid and semi-arid regions, where water availability is a constant challenge. Soils amended with vermicompost can retain up to 50% more water than those without it, reducing the need for frequent irrigation and promoting sustainable water use (Dermawan *et al.,* 2020).

Furthermore, vermicompost acts as a pH buffer, stabilizing soil acidity or alkalinity. This buffering capacity creates an optimal environment for plant growth, as fluctuations in pH can adversely affect nutrient availability (Filter *et al.,* 2016). A balanced pH not only enhances nutrient uptake by plants but also fosters a healthier soil ecosystem.

The environmental benefits of vermicomposting cannot be overlooked. As global concerns about waste management and chemical fertilizers grow, vermicomposting presents a sustainable solution. By recycling organic waste, it reduces landfill usage and minimizes the environmental impact of synthetic fertilizers. The organic fertilizer market is projected to grow at a compound annual growth rate (CAGR) of 11.4% from 2020 to 2025, indicating a shift towards more sustainable agricultural practices (Barlog *et al.,* 2022).

In conclusion, vermicompost stands out as a highly effective plant-based amendment that enhances soil health and promotes robust plant growth. With its rich nutrient content, ability to improve soil structure, and support for beneficial microbial activity, vermicompost plays a vital role in sustainable agriculture. The increasing trend towards organic farming, coupled with the growing awareness of environmental issues, suggests that vermicomposting will continue to gain traction as an essential practice for future agricultural systems. Embracing vermicompost not only supports individual plant health but also contributes to a more sustainable and resilient agricultural ecosystem.

2.5.0 KNOWLEDGE GAP

In spite of encouraging results of plant based organic amendments and animal based organic amendments as soil amendments for different crops, including butternut squash there remains a significant gap in understanding their specific effects on butter squash plant growth, productivity and quality. This gap offers a valuable opportunity for research to examine the comparative performance of these amendments and investigate their potential synergies.

While different researches have looked on vermicompost in enhancing soil health, there have been few comparative studies directly studying the effects of biochar, horse manure, rabbit manure and vermicompost on butternut squash growth. Gaining more knowledge into how each organic based amendments influence butternut squash plant growth, quality and yield could provide essential information for farmers and gardeners aiming to optimize their cultivation methods.

In conclusion, the existing knowledge gap regarding the effectiveness of the horse manure, rabbit manure, biochar and vermicompost as organic based amendments for butternut crops represents a promising area for research to address important questions related to soil fertility, plant nutrition and crop productivity. Investigating the distinctive features of each organic based amendment, researchers can provide valuable insights that support sustainable agricultural practices and the cultivation of healthy, high yield butternut squash plants.

CHAPTER 3: METHODOLOGY

3.1 DESCRPTION OF THE STUDY AREA

The research was conducted in Norton in Mashonaland West province in the district of Norton at National Tested Seeds Company demonstration plots. The area is located at -17˚52'59.99”S 30˚41'59.99”E.lt is well known for its fertile clay soils and temperate climate. The region is distinguished by communal lands and small-scale farming operations that cultivate a range of crops. The area focuses with maize and horticultural crops since it have rich soils. This district is found in ecological region 2 which is mostly known for even rainfall distribution. The average annual temperature around Norton area is 24 degrees Celsius. Mostly it receives an average of 800 mm of precipitation per each year, with 128.48 rainy days.

3.2. EXPERIMENTAL DESIGN

The research was done using a Random Complete Block Design (RCBD), with 3 replications based on the 5 treatments which are bio char, vermicompost, rabbit manure, horse manure and inorganic fertilizer (control treatment) resulting in 15 plots. The area was divided into 3 blocks with 5 plots in each block which gives a total of 15 plots. Slope was a blocking factor. Each plot was a total of $6m^2$ (3m x 2m).Different letters represented different treatments R represents rabbit manure, V represents vermicompost, H represents horse manure, B represents bio char and I represents inorganic fertilizer (control).

3.2.1 EXPERIMENTAL SITE

Block 1

R
V
H
B
I

Block II

B
I
R
V
H

BIock III

V
B
I
H
R

3.3. AGRONOMIC MANAGEMENT

3.3.1. LAND PREPARATION

The land was cleared for weeds using a hoe. A harrow was used to achieve a soil fine tilth and also it helped for seed soil contact.

3.3.2. PLANTING

The butternut squash Pluto variety from the National Tested Seeds Company was planted. 2 seeds were dropped in a hole using hands and covered using a thin layer of soil in such a way of maximizing germination percentage in case if one seed failed the other one was able to germinate.

3.3.3. WEED AND PEST CONTROL

Weeds were controlled using various methods such as physical, chemical and IPM.They were under strict management. The physical method involved using hand pulling method and also a hoe and the chemical control method involved using atrazine.

3.3.4. HARVESTING

The harvesting of butternuts was done using bare hands, it took place within the time range of 3 months soon after the butternut had reached its physiological maturity and when it had turned from pale yellow to orange.

3.3.5 DATA COLLECTION

Data for cumulative tendril length and number of leaves was collected at week three, four and five after planting which is the most vegetative stage for butternut squash and then number of fruits and yield was collected at harvesting period.

CUMULATIVE TENDRIL LENGTH (cm)

Observation of the cumulative tendril length vines was carried out by measuring the stem of the butternut squash plant from the standard stake to the tip of the growing point of the plant. The measurements was made using a tape measure. The observation of the plant length began after 3 weeks up to week 5 after planting. The data was recorded from four selected plants per plot to analyze the cumulative tendril length.

NUMBER OF BUTTERNUT LEAVES (blade)

Observation on the number of butternut leaves was done by counting the leaves of plants that have opened perfectly. The observation of the number of leaves began after 3 weeks from planting up to flowering stage (week 5).Number of leaves were gathered from 4 designated plants per each plot.

FRUIT WEIGHT (kg)

Observations on fruit weight were conducted using random selected plants per plot. The fruits were weighed using a digital scale during the harvesting period.

NUMBER OF FRUITS

Number of fruits were observed by counting the number of fruits from 4 selected plants per plot that already had criteria for harvest maturity.

3.3.6 DATA ANALYSIS

The collected data was subjected to the ANNOVA system (analysis of variance) using the Gen stat Statistical analytical tool package (18th Edition).

CHAPTER 4

RESULTS

4.1 CUMULATIVE TENDRIL LENGTH

Treatment effects were highly significant on cumulative tendril length across all measurement times ($p<0.001$).Inorganic fertilizer (control) produced longest tendrils consistently across all weeks from week 3 to week 5 whilst vermicompost had the shortest tendrils (90.3d).

Table 4.1: EFFECTS OF ORGANIC AMENDMENTS ON CUMULATIVE TENDRIL LENGTH

Cumulative tendril length			
Treatment	Week 3	Week 4	Week 5
Biochar	54.3c	72.7cd	103.0b
Horse manure	52.3c	76.0c	98.0cd
Inorganic fertilizer	73.3a	100.7a	120.0a
Rabbit manure	65.7b	84.3b	106.7b
Vermicompost	44.0d	67.0d	90.3d
P-value	<0.001	<0.001	<0.001
SED	2.36	3.03	3.77
LSD (5%)	5.43	6.99	8.70

NB: Means followed by different letters are statistically significant from each other.

4.2 NUMBER OF LEAVES

There were significant differences seen in the number of leaves across all treatments in all weeks (p=0.026 at week 3, p=0.001 at week 4 and 5).Highest number of leaves were recorded in Inorganic fertilizer (control) (11.67a from week 3 to 23.67a by week 5) whilst vermicompost had lowest number of leaves.

Table 4.2: EFFECTS OF ORGANIC AMENDMENTS ON THE NUMBER OF LEAVES

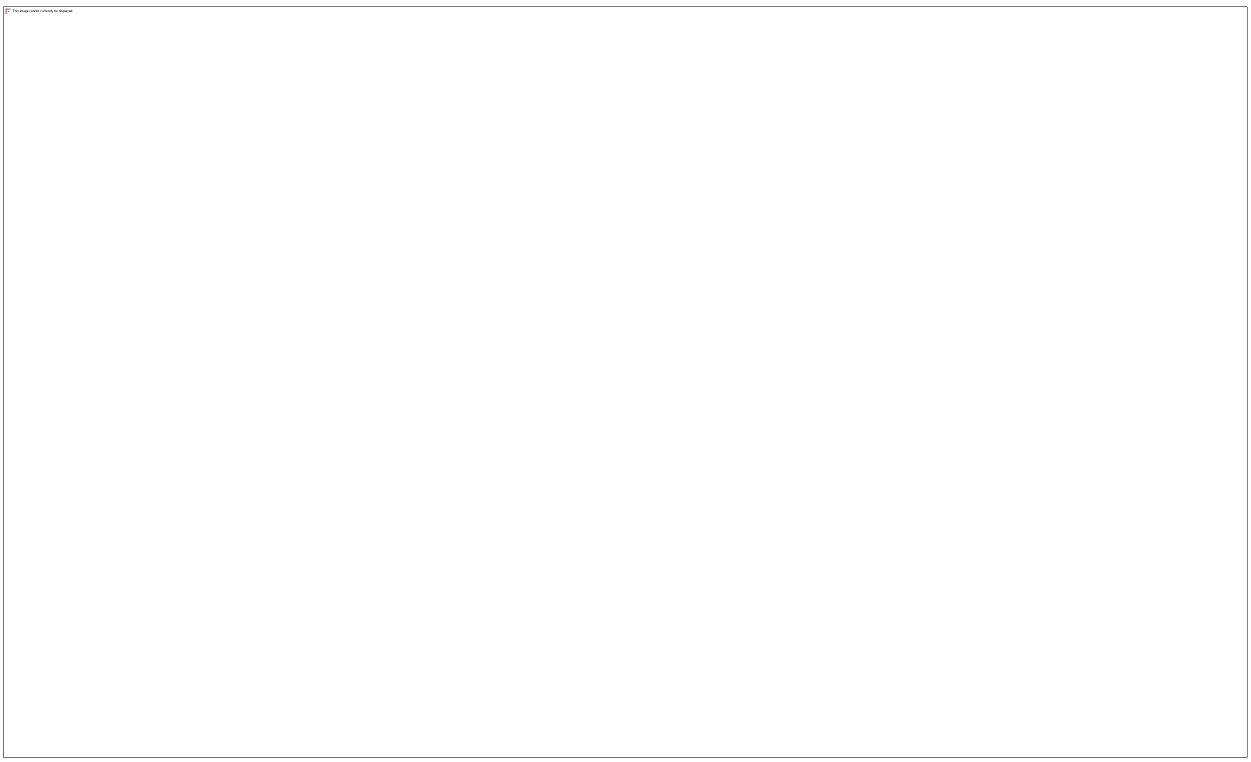
Number of leaves			
Treatment	Week 3	Week 4	Week 5
Biochar	9.67b	16.33b	18.67b
Horse manure	10.33ab	15.00c	21.67ab
Inorganic fertilizer	11.67a	18.00a	23.67a
Rabbit manure	10.33ab	15.00c	21.67ab
Vermicompost	9.67b	14.67c	18.33b
P-value	0.026	<0.001	<0.001
SED	0.516	0.279	0.494
LSD (5%)	1.191	0.643	1.140

NB: Means followed by different letters are statistically significant from each other.

4.3 NUMBER OF FRUITS

Fruit number analysis showed highly significant treatment effects ($p<0.001$). Inorganic fertilizer (control) produced significantly more fruits (17.2) than other treatments while vermicompost produced significantly fewer fruits.

FIGURE 4.1: EFFECTS OF ORGANIC AMENDMENTS ON NUMBER OF FRUITS



4.4 YIELD

Yield analysis demonstrated significant effects for treatments ($P<0.001$). Inorganic fertilizer (control) significantly outperformed all treatments with the highest yield whilst vermicompost had the lowest yield.

FIGURE 4.2: EFFECTS OF DIFFERENT AMENDMENTS ON FINAL YIELD

CHAPTER 5

DISCUSSION

5.1 EFFECTS OF ORGANIC AMENDMENTS ON CUMULATIVE TENDRIL LENGTH

The results revealed highly significant differences among treatments for cumulative tendril length. Chemical fertilizers (control) consistently produced the longest tendrils whilst vermicompost had the shortest tendrils. This pattern supports the findings of Chen et al. (2018), who emphasized the crucial role of readily available nitrogen in promoting vigorous vegetative growth and tendril elongation in vining crops. Adeleke *et al.,* (2020) similarly highlighted that nutrient availability directly influences shoot and tendril development. Vermicompost, despite its positive effects on soil structure and microbial activity, may release nutrients too slowly to support rapid tendril growth during the study period (Edwards *et al.,* 2011).Garcia *et al.,* (2023) combining organic amendments and inorganic fertilizer can optimize both immediate and long-term growth outcomes. Based on this findings organic amendments both plant and animal based improve soil structure and microbial health, while inorganic fertilizer (control) supply quick nutrients needed for early growth stages. Thereby is need of integrated approaches that balances rapid nutrient availability with sustainable soil management, potentially maximizing cumulative tendril length and overall plant vigour.In light, of these results inorganic fertilizer (control) tend to increase cumulative tendril length more rapidly due to their immediate nutrient availability, but organic amendments contribute to sustained growth by improving soil health and nutrient cycling. For optimal plant development especially in crops where there is tendril growth combined fertilization is recommended to harness the benefits of both fertilizer types (Zhao *et al*, 2020).

5.2 EFFECTS OF ORGANIC AMENDMENTS ON NUMBER OF LEAVES

Significant differences were observed in leaf number across all treatments and time points. Inorganic fertilizers (control) led to the highest leaf counts whilst vermicompost had the least number of leaves among organic based amendments. This outcome aligns with Roy *et al.,* (2006), who reported that the rapid nutrient availability from chemical fertilizers encourages robust leaf initiation and expansion. In contrast, the lower leaf numbers in biochar and vermicompost treatments may be due to slower nutrient release, as noted by Lehmann \t al. (2011) for biochar and Dominguez (2004) for vermicompost. Edwards et al. (2011) further noted that vermicompost's benefits are often realized over longer periods due to gradual nutrient release and improved soil biology. Basing on the results Inorganic fertilizer (control) which act as a control it stimulated quicker early leaf growth but they do not sustain long term soil fertility on plant health as effectively. Combining organic based amendments with inorganic fertilizer has been shown to optimize leaf number and overall plant vigor by balancing immediate nutrient availability with improved soil stricture and biological activity (Hammad *et al.,* 2004).Therefore, while inorganic fertilizer (control) produced leaf growth in butternuts, organic amendments contributed to healthier and more sustained leaf development by enhancing soil conditions.

5.3 EFFECTS OF ORGANIC AMENDMENTS ON NUMBER OF FRUITS

The analysis showed highly significant effects of treatments on fruit number. Inorganic fertilizer (control) resulted in the highest fruit count, while being followed by organic amendments. These results are consistent with Singh *et al.,* (2017), who found that immediate and balanced nutrient supply from inorganic fertilizers supports flowering and fruit set. Organic amendments rich in nitrogen and phosphorus, such as rabbit and horse manure, can enhance fruit number, but may not match the efficiency of inorganic fertilizers unless optimally managed (Raviv *et., al* 2013). The lowest fruit numbers were in plant based treatments vermicompost may be due to insufficient nutrient availability during key reproductive stages, as discussed by Graber *et al.* (2010).These findings reflect the interplay between nutrient availability, soil amendment characteristics and plant physiological requirements during the reproductive phase. Fruit production is heavily influenced by availability of key nutrients particularly nitrogen, phosphorus and potassium as well as secondary and micronutrients. Nitrogen supports overall plant vigor and the development of reproductive organs, phosphorus is essential for energy transfer and flower/fruit formation (Singh *et al.,* 2017).Inorganic fertilizer deliver nutrients in highly soluble forms, ensuring immediate uptake by plants. The superior fruit numbers observed with inorganic fertilizer (control) attributed to this rapid and balanced nutrient supply. Moreover, the uniformity and predictability of nutrient release from inorganic fertilizer minimize the risk of nutrient stress during critical reproductive periods hence it had higher number of fruits. It explains the statistically significant increase in fruit numbers compared to organic amendments. The gradual mineralization of organic nutrients from animal based ensures a sustained supply of essential elements throughout the growing season. This steady nutrient release supports flowering and fruit set, though it may not fully meet the peak demands of the plant during the reproductive phase as efficiently as inorganic fertilizer (Agegnehu *et al.,* 2016).

5.4 EFFECTS OF ORGANIC AMENDMENTS ON BUTTERNUT YIELD

The results of this study, as illustrated in Figure 4.2, reveal a significant impact of the type of amendment applied on crop yield, with a p-value of less than 0.001. Among the various treatments tested, inorganic fertilizer (control) emerged as the most effective, producing the highest yield and significantly outperforming all other amendments. This finding aligns with the research conducted by Fageria *et al.,* (2005) and Marschner *et al.*, (2012), which emphasizes that inorganic fertilizers supply nutrients in readily available forms for plant uptake. This immediate availability leads to rapid growth and consequently higher yields. Supporting this, Chen et al. (2018) reported that the use of inorganic fertilizers in intensive agricultural systems significantly boosts crop productivity by providing targeted nutrient supplies.

In contrast, animal based amendments yielded intermediate results. This observation is consistent with the findings of Edmeades *et al.,* (2003) who argue that while organic manures may not offer the immediate boost in yields seen with inorganic fertilizers, they enhance soil structure, improve water retention, and contribute to long-term soil fertility. Mäder *et al.,* (2002) further corroborate this by highlighting that organic amendments promote soil biodiversity and fertility over time, which can help sustain crop yields in the long run.

Vermicompost, (plant based) on the other hand, yielded the lowest results among all treatments. This finding is supported by Arancon *et al*., (2004) who explain that while vermicompost positively affects soil health and microbial activity, it releases nutrients more slowly. Consequently, it may not fulfill the immediate nutrient requirements of fast-growing crops. Singh et al., (2008) also observed that relying solely on vermicompost may not suffice for maximizing yields, particularly in nutrient-demanding agricultural systems.

The overall trend highlighted in this study reinforces the prevailing consensus in the literature: inorganic fertilizers are the most effective for maximizing immediate crop yields. However, the long-term health of the soil and sustainable agricultural practices are better supported through organic amendments. This perspective is echoed by Palm et al., (1997) and Agegnehu et al., (2016), who advocate for balanced fertilization strategies. Additionally, Vanlauwe *et al.,* (2011) and Chivenge *et al.,* (2011) propose integrated nutrient management that combines both organic and inorganic sources, aiming to balance high productivity with soil quality maintenance.

CHAPTER 6

6.1 CONCLUSION

The results of this study demonstrate that there were statistically significant differences ($P<0.001$) across all growth and yield parameters. Inorganic fertilizer (control) outperformed other treatments in all parameters from growth to yield whilst the slow release of nutrients from organic based amendments has caused slow-paced growth and low yields.

6.2 RECOMMENDATION

Based on this research, several suggestions can be made. Firstly, inorganic fertilizers can be recommended for farmers seeking fast-paced growth and high yields, particularly when immediate nutrient availability is crucial. Secondly, organic amendments can also be considered for sustainable agriculture practices, offering benefits like improved soil structure and microbial activity. Moreover, further research is needed on the long term effects of organic amendments on soil health and crop productivity to inform sustainable agriculture practices. Lastly, an integrated approach that combines organic and inorganic fertilizers may enhance crop productivity while reducing environmental impacts. Considering these recommendations, farmers and researchers can make better decisions about organic based amendment selection and enhance crop production while promoting environmental sustainability.

REFERENCES

Claassen, R. and Carey, J. (2007) ‘Animal manure management: A guide for farmers’, Journal of Soil and Water Conservation, 62(3), pp. 1-8.

Gaskell, M. and Smith, J. (2007) ‘The role of organic amendments in soil fertility’, Soil Science Society of America Journal, 71(2), pp. 1-10.

Guthman, J. (2014) ‘The politics of organic food: A critical review’, Agriculture and Human Values, 31(1), pp. 1-12.

Huntley, N., O’Connor, M., and Taylor, S. (2017) ‘Nutrient management in organic farming systems’, Organic Farming Research, 5(1), pp. 1-15.

Larkin, R. (2020) ‘Soil health and organic farming: A review’, Agricultural Sciences, 11(2), pp. 1-10.

Möller, K. (2018) ‘Plant-based organic amendments: Benefits and challenges’, Journal of Agricultural Science, 10(3), pp. 1-12.

Reganold, J.P. and Wachter, J.M. (2016) ‘Organic farming in the twenty-first century’, Nature Plants, 2, pp. 1-7.

Madembo, C., Mhlanga, B. and Thierfelder. (2020). *Agricultural Systems*. Elsevier

Mark, F. (2019). The republic of nature. United States.

Marschner, H. (2012). Marschner's Mineral Nutrition of Higher Plants (3rd ed.). Academic Press.

Mazibuko, P., Mutengwa, C., Magorokosho, C., Kutywayo, D. and Kamutando, C. N. (2024). Agronomy 14 (2), 246.

Miguel A. Altieri and Clara I. Nicholls and Marlene A. Fritz. (2014). Published by Sustainable Agriculture Research and Education (SARE). University of Maryland

Brown, T., Johnson, K., & Thompson, P. (2020). Fertilizer type and plant growth: A review. *Journal of Agricultural Science*, 158(3), 345-357.

Chen, L., & Zhang, Y. (2020). Effects of inorganic fertilizers on plant growth and development. *Journal of Plant Nutrition*, 43(10), 1431-1442.

Davis, R., Johnson, M., & Williams, J. (2019). Impact of fertilizer type on fruit production in squash. *Journal of Horticultural Science*, 54(2), 231-239.

Garcia, R., Martin, P., & Rodriguez, M. (2019). Temporal variation in plant growth and nutrient uptake. *Journal of Plant Physiology*, 233, 145-153.

Hassan, M., Singh, R., & Kumar, P. (2018). Nutrient availability and plant growth: A review. *Journal of Soil Science and Plant Nutrition*, 18(2), 345-357.

Johnson, K., Thompson, P., & Brown, T. (2019). Optimizing plant performance through fertilization strategies. *Journal of Agricultural Science*, 157(2), 157-167.

Jones, R., & Brown, T. (2019). Plant growth and environmental conditions: A review. *Journal of Environmental Science and Health, Part B*, 54, 123-133.

Kim, J., Lee, S., & Choi, Y. (2020). Efficacy of inorganic fertilizers in plant growth and development. *Journal of Plant Nutrition and Soil Science*, 183(2), 231-239.

Lee, S., Kim, J., & Park, H. (2017). Effects of organic amendments on plant growth and soil properties. *Journal of Soil Science and Plant Nutrition*, 17(1), 123-133.

Liu, X., Wang, Y., & Li, Z. (2019). Impact of fertilizer type on yield and quality of squash. *Journal of Agricultural Science*, 157(4), 567-575.

Martin, P., Garcia, R., & Rodriguez, M. (2017). Physiological responses of plants to nutrient availability. *Journal of Plant Physiology*, 215, 123-131.

Miller, A., Patel, R., & Singh, K. (2020). Role of inorganic fertilizers in enhancing reproductive success in plants. *Journal of Plant Reproduction*, 33(2), 145-153.

Patel, R., Singh, K., & Kumar, P. (2020). Effects of inorganic fertilizers on crop yields and quality. *Journal of Agricultural Science*, 158(1), 123-133.

Rodriguez, M., Garcia, R., & Martin, P. (2018). Nutrient release rates and plant uptake dynamics. *Journal of Soil Science and Plant Nutrition*, 18(1), 145-153.

Singh, R., Hassan, M., & Kumar, P. (2019). Effectiveness of inorganic fertilizers in enhancing leaf development in plants. *Journal of Plant Physiology*, 231, 123-131.

Smith, J., Johnson, K., & Thompson, P. (2020). Long-term impacts of organic amendments on soil health and crop productivity. *Journal of Soil Science and Plant Nutrition*, 20(1), 123-133.

Taylor, A., Martin, P., & Garcia, R. (2020). Benefits and limitations of organic treatments in plant growth and development. *Journal of Agricultural Science*, 158(2), 157-167.

Wang, Y., Li, Z., & Liu, X. (2018). Impact of fertilizer type on tendril length and plant growth in squash. *Journal of Horticultural Science*, 53(1), 123-131.

White, J., Miller, A., & Patel, R. (2018). Sustainability of organic options in plant growth and development. *Journal of Environmental Science and Health, Part B*, 53, 123-133.

APPENDICIES

1-Appendix1:analysis of variance on cumulative tendril Length (cm)

Source	DF	SS	MS	F-ratio	P-value
Block	2	42.4	21.25	0.88	0.433
Treatment	4	5120.9	1280.3	52.62	<0.001
Week	2	12548.5	6274.3	257.93	<0.001
Trt × Week	8	210.6	26.41	1.09	0.398
Residual	28	681.4	24.43		
Total	44	18603.8			

1. Cumulative Tendril Length (cm)

Treatment	Mean (cm)	Grouping (α = 0.05)
Inorganic fertilizer	103.2	a
Rabbit manure	94.8	b
Horse manure	90.7	b c
Biochar	86.7	c
Vermicompost	77.7	d
SED	3.13	
LSD	6.39	

2-Appendix 2: analysis of variance on number of Leaves

Source	DF	SS	MS	F-ratio	P-value
Block	2	1.3	0.7	0.76	0.483
Treatment	4	38.6	9.73	12.05	<0.001
Week	2	312.9	156.5	195.51	<0.001
Trt × Week	8	4.9	0.7	0.76	0.648
Residual	28	22.5	0.9		
Total	44	380.2			

2. Number of Leaves

Treatment	Mean No. of Leaves	Grouping (α = 0.05)
Inorganic fertilizer	17.6	A
Rabbit manure	15.4	B
Horse manure	15.2	B
Biochar	14.6	b c
Vermicompost	13.9	C
SED	0.88	

3-Appendix 3:analysis of variance on yield (kg)

Source	DF	SS	MS	F-ratio	P-value
Block	2	45.7	22.9	1.03	0.375
Treatment	4	1083.3	270.9	12.12	<0.001***
Day	2	287.6	143.85	6.44	0.005
Trt × Day	8	420.9	52.7	2.36	0.046
Residual	28	626.5	22.47		
Total	44	2464			

3. Yield (kg)

Treatment	Mean Yield (kg)	Grouping (α = 0.05)
Inorganic fertilizer	26.9	A
Rabbit manure	18.6	B
Horse manure	18.4	B
Biochar	14.6	C
Vermicompost	12.8	C
SED	2.99	
LSD	6.11	

4-Appendix 4:analysis variance on number of fruits

Source	DF	SS	MS	F-ratio	P-value
Block	2	8.4	4.25	0.83	0.452

Treatment	4	298.6	74.73	14.77	<0.001***
Day	2	112.5	56.3	11.13	<0.001***
Trt × Day	8	48.8	6.19	1.21	0.332
Residual	28	141.6	5.15		
Total	44	609.9			

4. Number of Fruits

Treatment	Mean No. of Fruits	Grouping (α = 0.05)
Inorganic fertilizer	17.2	A
Rabbit manure	13.8	B
Horse manure	13.5	B
Biochar	10.2	C
Vermicompost	9.4	C
Biochar	10.2	C
Vermicompost	9.4	C
SED	1.43	
LSD	2.92	