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Performance of Chicken Manure, Moringa as an Alternative Fertilizer for Green Pepper *(Capsicum Annuum L.)*

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Abstract

The extensive use of synthetic or inorganic fertilizers in agriculture has been linked to environmental degradation, soil pollution, and groundwater contamination. Organic amendments, such as chicken manure and moringa, have been proposed as sustainable alternatives. Using green pepper as a test crop, the specific objectives were to assess the single and combination of chicken manure and moringa as alternative fertilizers.

The research employed a Randomized Complete Block Design (RCBD) with four treatments: T1 (chicken manure), T2 (moringa), T3 (a combination of chicken manure and moringa), and T4 (a control group) with no fertilizer. Each treatment was replicated three times, resulting in a total of 36 plants across the experimental plots. The study was conducted in the Jack Compound of Lusaka. Data was collected on key growth parameters including plant height, leaf width, number of leaves, and stem diameter and yield parameters, such as days to first flower and fruit, number of flowers and fruits per plant, fruit size, and fruit weight.

The results demonstrated that the combined application of chicken manure and moringa tea (T3) significantly enhanced both vegetative growth and fruit yield compared to the single applications and the control group. Plants receiving the combined treatment exhibited superior overall vigor and productivity, with notable improvements in stem diameter, number of flowers, fruit size, and fruit weight. This indicates that organic amendments like chicken manure and moringa can serve as effective alternatives to artificial fertilizers in green pepper production. Critically, their combined application provided greater agronomic benefits than either treatment alone.

These findings underscore the significant potential of integrating combined organic soil amendments into sustainable farming systems. Adopting such practices can contribute to improved crop performance, a reduced environmental footprint from agriculture, and enhanced food security. The implications of these findings are important for advancing sustainable agriculture. They provide robust evidence that a synergistic combination of chicken manure and moringa is a potent alternative fertilizer to synthetic fertilizers, offering a viable strategy to boost productivity while mitigating environmental harm.

Keywords: Capsicum Annuum, Chicken Manure, Moringa, Soil Fertility, Synthetic Fertilizer, Crop Growth and Yield, Organic Amendments and Sustainable Agriculture

1. Introduction

1.1 Background

Green pepper, often called bell pepper or sweet pepper, is a popular vegetable that belongs to the Solanaceae family. Bittman (2019) [5], revealed that green pepper is loved for its mild, sweet taste and crunchy texture, making it a go-to ingredient in various cuisines worldwide. Green pepper is usually an annual or a short-lived perennial that flourishes in warm climates and well-drained soil. It thrives best in temperatures ranging from 18°C to 30°C and needs plenty of sunlight and moisture to grow well (Patidar *et al*., 2020) [20]. However, finding an alternative fertilizer for improving green pepper production is a key. Nevertheless, moringa extract from leaves and chicken manure have been proposed recently, several new natural biostimulant have been used to improve the growth and productivity of a variety of crops. Moringa leaf extract, obtained from *Moringa oleifera* Lam, is one such alternative plant, and is studied for its effect on the growth and yield of crops like okra. It naturally produces certain bio-stimulants, is easy to grow and has gained attention in the scientific literature. Moringa is a plant in the Moringaceae family and is widely distributed across the tropical and subtropical regions, growing best in warmer environments

(Yuniati *et al*., 2022) [23]. With such a fast and perennial growth habit, moringa produces large biomass; its leaves are documented as being rich in mineral nutrients, protein, vitamins (A and C), amino acids, sugars, fiber, β-carotene, riboflavin, phenolics and free prolines. These organs contain a significant amount of ascorbate and phytohormones, particularly the cytokinin zeatin, auxins and gibberellins. Additionally, moringa leaf extract exhibits high antioxidant activity, as it is a rich source of certain plant secondary metabolites, including osmo-protectants. The balanced composition of phytohormones, antioxidants and mineral nutrients in moringa makes the extract an exceptional natural plant biostimulant. and Lovatt., Native to India, *M. oleifera* is the most widely dispersed and utilized species worldwide compared to the other 12 moringa species making up the Moringaceae family. Moringa is a small, drought-tolerant, strong-growing, and dicotyledonous tree that can reach a height of up to 4 m in a year and 6–15 m at maturity (Basra 2016). According to Tomlison and Diaz (2023) [21] confirmed that poultry manure like chicken manure which comes from chickens is a valuable organic fertilizer that increases crop productivity and soil fertility since it is high in potassium, phosphorus, and nitrogen. In addition to improving soil structure and water-holding capacity, its application influences the biochemical composition and physiological responses of plants. This results in improved water uptake and decreased water stress in plants, which is reflected in firmer and more resilient fruits after harvest (Adekiya *et al*., 2020) [1].

1.2 Statement of the Problem

In Zambia organic farming is increasingly recognized as a sustainable and cost-effective alternative for both smallholder and large-scale farmers in the vegetable industry. As the agricultural sector shifts toward sustainable agricultural practices which are more environmentally friendly. Concerns have emerged regarding the overreliance on chemical fertilizer, which contribute largely to soil degradation and pollution, ground water contamination, increased production costs and possible potential health risks or challenges. According to the study conducted by Goo *et al* (2005) [8], reviewed that excessive use of inorganic fertilizers can negatively impact soil health and agricultural productivity.

Even though various research has been conducted on the effect of chicken manure and moringa extracts on the yield of several horticultural and field crops, there is a pressing challenge on the understanding of the performance of the combination of chicken manure and moringa extracts as an alternative fertilizer. Therefore, there is a need to fill up the enormous knowledge gap, which has remained hanging in order to increase yield in a more sustainable way Mozdzer and Styrczula (2019) [18].

1.3 Objectives

Main Objective

To evaluate the performance of chicken manure, moringa as an alternative fertilizer for green pepper.

Specific Objectives

To explore the influence of chicken manure on the yield parameters such as days to flower and fruit, flower and fruit count, size and weight of fruits of green pepper. To evaluate the effect of moringa on the yield parameters like days to flower and fruit, flower and fruit count, size and weight of fruits of green pepper. To assess the effect of chicken manure and moringa (combined) on the yield parameters like days to flower and fruit, flower and fruit count, size and weight of fruits of green pepper.

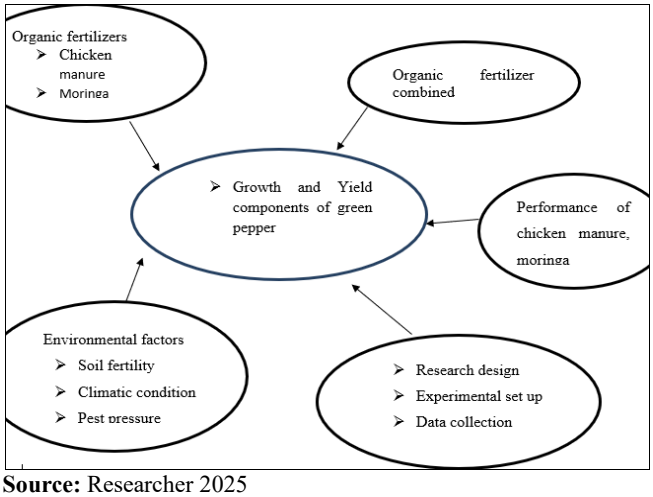
1.4 Hypothesis

H_0: Chicken manure and moringa have no significant effect on the growth and yield of green pepper plants.

H_1: The application of chicken manure and moringa as organic fertilizer significant increases growth and yield of green pepper compared to untreated plants.

1.5 Conceptual Frameworks

The conceptual framework of this study provides a structured approach to understanding the relationship between soil amendments (chicken manure, and moringa) and green pepper growth and yield. The studies from Tomlison and Diaz (2023) [21], Adekiya *et al* (2020) [1], indicates that chicken manure contains macronutrients N=35-60, P=40-60 and K=20-55 and micronutrients such as Ca and Mg respectively varying from fresh to dry manure. However, Moringa leaf extract is composed of calcium, magnesium, phosphorus, potassium, nitrogen, copper, iron and Sulphur. Moringa also packed with the bio-stimulants such as cytokinin and auxin (Yuniati *et al*., 2022) [23]. Effects of chicken manure, moringa leaf extract, it was found that poultry manure affected okra growth (height and leaf size) and yield (pod weight and number of pods per plant) (Adekiya *et al*., 2020) [1]. On moringa part, Basra and Lovatt (2016) [3], present that moringa leaf extract (MLE) foliar spray significantly increased the growth of lateral shoots produced per cherry plants and the plants received root-applied produced the greatest number of flowers (2.2-fold more than control plants). Yuniati *et al* (2022) [23], adds that moringa also affected the weight and size, fruit firmness of the navel orange and the color of plum fruits positively.



Source: Researcher 2025

2. Literature Review

Bekele (2022) [4], reviewed that green pepper, often referred to as bell pepper or sweet pepper, is a type of *Capsicum annuum* that's picked before it fully ripens into its vibrant color and is the world's most important vegetable after tomato used as fresh, dried or processed. Mokshapathy and Yogesh (2013) [17], found that the total production has surpassed 36 million metric tons each year. The top producers of green pepper include China, Mexico, Turkey,

Indonesia, and Spain. Notably, China leads the pack, accounting for about 45% of the world's total output.

Physical factors that impact plant growth are the environmental conditions that play a crucial role in shaping the development, health, and productivity of plants these include light, water, temperature, soil and wind. However, fertilizers that come from natural sources can really boost soil health and provide essential nutrition for plants over time. Chicken manure is a fantastic organic fertilizer, packed with nutrients great for enhancing soil quality. It's a popular choice for improving plant growth, enriching soil structure, and maintaining long-term soil fertility. On the other hand, moringa is one extracted from moringa leaves or any other part of moringa tree and is composed of minerals and bio-stimulants (Ambrosano *et al*., 2003) [2].

Kyakuwaire *et al* (2019) [14], defined that chicken manure is a natural byproduct of poultry farming, primarily derived from the droppings of chickens raised for meat (broilers) or for egg production (layers). Chicken manure typically contains nitrogen levels ranging from 1.1% to 3.0%, phosphorus content in chicken manure ranges from 0.8% to 1.5% and potassium levels between 0.5% and 1.0%, making it a valuable addition to the soil for promoting strong root systems and enhancing crop resilience (Hue and Silva., 2000) [10].

Fadeyi *et al* (2023) [7], shows that the percentage nitrogen in moringa leaves was 4.1 while the carbon to nitrogen ratio (C: N) was 2.6. Other macro nutrients, were potassium (0.32) with phosphorus (0.0087) as the least and micro nutrients calcium (12.93), magnesium (1.3).

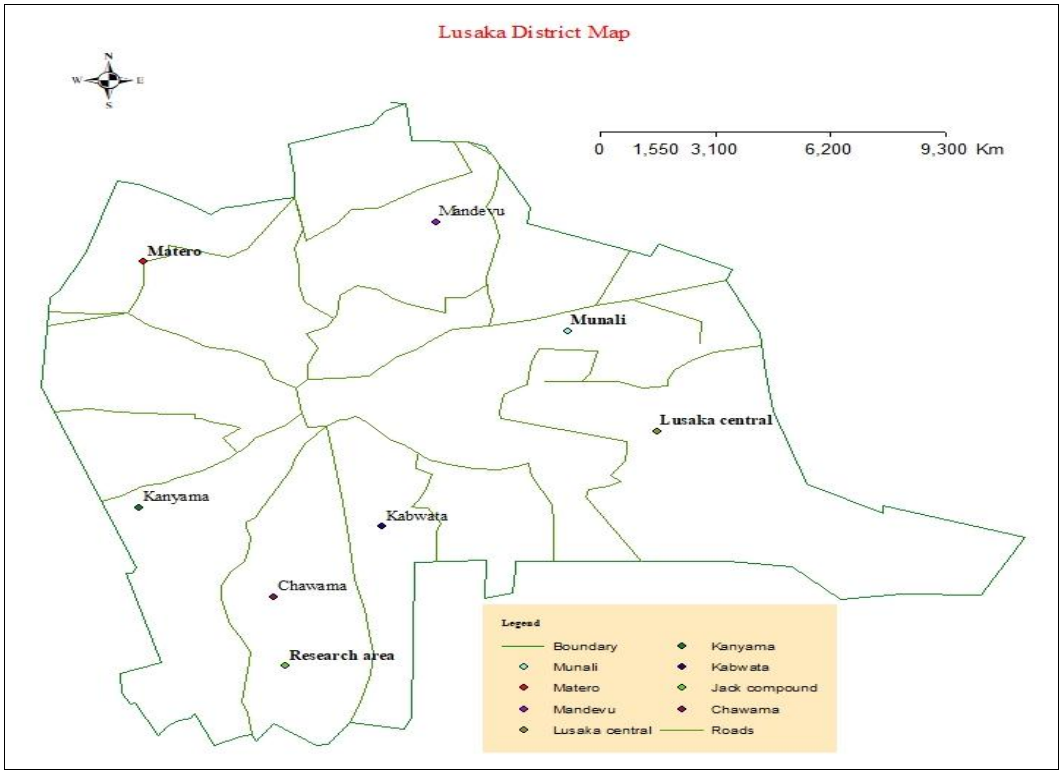
Moring oleifera leaves is composed of macro nutrients (N P K,) and micronutrients (Ca, Mg, Cu, Fe, Mn and Zn). The mineral composition of moringa leaves is dependent on the region where it is grown Grusak (2001).

3. Materials and Methods

Research Location

The study was conducted at farm A in Lusaka district, the farm has a total area of 2500m2 and the research plot was 9m2 in total. This area is located between latitudes 15.43000 S and 28.32280 E. According to agro- ecological conditions based on temperature and moisture supply, the area lies in Region II of Zambia. In this region, the farming systems are characterized by mixed farming, with a strong emphasis on crop and beef production. This region receives a total annual rainfall of between 800 to 1000mm. Temperatures range from about 260 C to 320 C during the hot season and 40 C to 14.90 C in the cold season, (Esser, 2017) [6].

Map of Lusaka showing study area

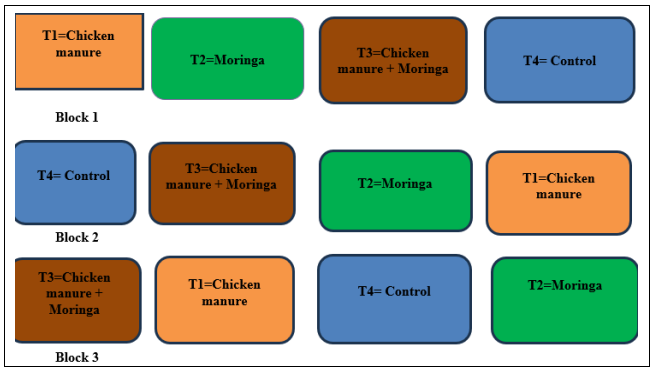


Materials

This research started with the preparation of hoes, rakes, pepper seedling, soil meter for pH, 30 cm rule, measuring tape and portable electronic scale and physical properties inspection of soil aggregates. The suitable variety of green pepper, was acquired from a seedling grower. The measuring tape, and the 30 cm rule were obtained from the local market. Additionally, the plant parameters of fruit weight were measured using a portable electronic scale which is currently at K55 and soil meter for pH which is at K450. Other materials included a note book for raw data entry, string for measuring stem and fruit size and pens for noting down the collected data. Finally, Chicken manure and Moringa leaves were collected from the local farmers. Other materials include garden folk and shovel desirable watering cans and buckets.

Experimental Design

The approach which was used is quantitative. The organic fertilizers which were evaluated are Chicken manure and Moringa leaf extracts. The experiment was laid out according to a Randomized Complete Block Design (RCBD) with three replications.



Land Preparation, Planting and Fertilizer Application

The land was ploughed 2 weeks prior to planting using hand hoe and harrowed for an even seedbed. The field was cleared from any tree stumps and weed residues. Moringa extract was applied at 350Ltr/ha and chicken manure at the rate of 10,000kg/ha as a starter dose two weeks before planting as a source of NPK. However, based on the peace of land which is $9m^2$ we only needed 0.32 liters of Moringa and 9kg of Chicken manure.

Planting rows measuring 4m were made using a hoe and later level the beds with a rake. One seedling per hole was planted maintaining interrow and intra spacing of 50cm and 50cm respectively. In order to uphold an ideal planting density (Hatutale, 2010) [9].

Sampling and Sample size.

The study had 4 treatment groups chicken manure, moringa, chicken manure + moringa(combined) and a control group it's typical in agricultural studies to include at least three replications for each treatment. This helps us account for the natural variability we see in field conditions. A widely accepted approach would be to use a Randomized Complete Block Design (RCBD) with three replicates for each treatment, leading to a total sample size of 12 experimental units (4 treatments × 3 replicates).

Data Collection

Data was collected steadily at various growth stages of the green pepper crop to capture both vegetative and reproductive indicators. The data was collected at vegetative, flowering, fruiting and maturity stages of plant development and growth. Key growth data points which were recorded include plant height, number of leaves, stem diameter, and leaf size at regular intervals, every week to monitor growth trends. In addition, yield-related data such as time to first flowering and fruiting, number of fruits per plant, fruit weight, fruit size, and number of flowers, were collected before and during harvest. This information was obtained from the randomly selected plants out of 4 treatments.

Statistical Analysis

The research experiment on the growth and yield of Capsicum annuum recorded data on plant height, number of leaves, stem diameter, and leaf width; on yield, first to flower and fruit, flower and fruit count, fruit size and weight, which were foremost entered in excel sheet and later data points were used to plot trajectory and bar graphs to observe the trend on growth and yield of green pepper among treatments. Analysis of variance was conducted to confirm the significance of the findings. The data analysis was performed using SPSS software version 20.

The trajectory line graphs assumes that the continuous variables like fruit size and weight can be analyzed using line graph to show trend and pattern over time. Additionally, when using line graph the x-axis represents ordered categories, such as time, days or weeks. Lastly, linear progression happens when the plant increase in height, leaf width is expected to follow a near-linear pattern over time allow to model and compare the treatment effects.

Ethical Considerations

The study on evaluating how green pepper grows and yields when grown in soils treated with chicken manure and moringa, as alternative fertilizers, brings up some important ethical issues. The first ethical issue, the researcher prioritized was environmental ethics by adopting sustainable practices that protect against soil degradation, water pollution, and harm to ecosystems. This means managing manure carefully and preventing fertilizer runoff. Health and safety are also top priorities; the research took it as a must to handle chicken manure safely to prevent the spread of pathogens and ensure that any residues on the produce stay within safe limits. While the research did not involve live animals, sourcing chicken manure ethically still raises concerns about animal welfare standards. It's crucial to maintain transparency and integrity throughout the research process, which includes honest reporting of data and disclosing any potential conflicts of interest. Moreover, the study considered its effects on local communities by honoring indigenous agricultural knowledge, engaging local stakeholders, and sharing findings in ways that are easy for communities to understand. Finally, landowners were fully informed about the purpose, methods, and possible outcomes of the research.

4. Results

Plant height, Leaf count, Stem diameter and Leaf width

Source of variation		Sum of squares	Mean of squares	F-value	P-value
Height	Between groups	681.874	227.291	12.425	0.000
	Within groups	804.925	18.294		
	Total	1486.799			
Leaf count	Between groups	1433.396	477.799	33.025	0.000
	Within groups	636.583	14.468		
	Total	2069.979			
Stem diameter	Between groups	12.238	4.079	9.483	0.000
	Within groups	18.928	0. 430		
	Total	31.167			
Leaf width	Between groups	12.684	4.228	28.237	0.000
	Within groups	6.588	0.150		
	Total	19.273			

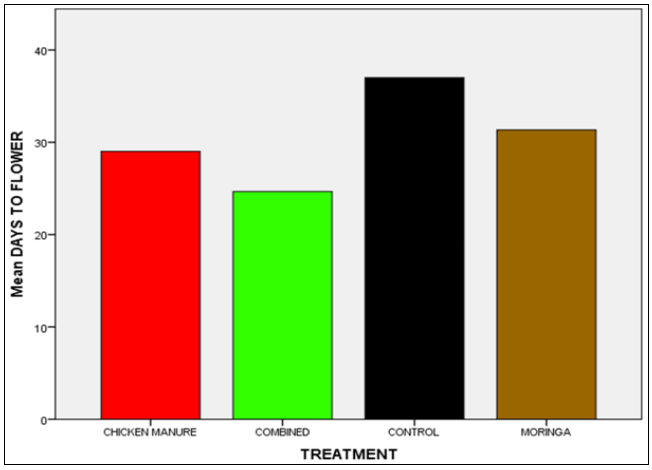
The ANOVA table above was obtained after running the raw data in SPSS 20 at 0.05 level of significance to confirm the significance of the results. Taking a look at P-values < 0.05 shows that the results are statistically significant.

Raw data for Days to flower and fruit

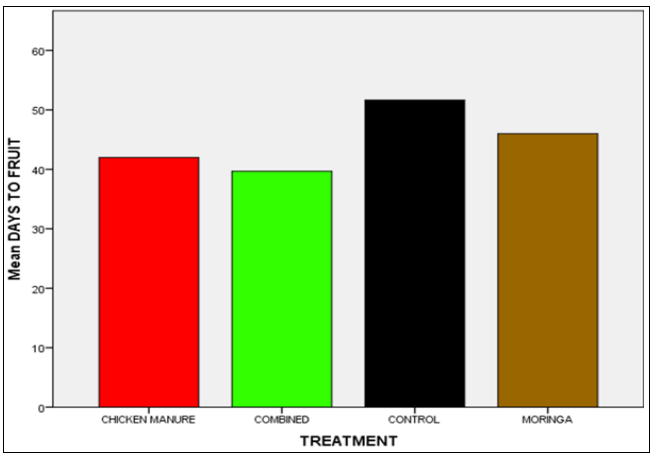
Treatment	Plant ID	Days to Flower	Days to Fruit
Chicken manure	1	30	42
Moringa	2	32	45
Combined	3	25	40
Control	4	38	50
Chicken manure	5	28	41
Moringa	6	30	46
Combined	7	24	39
Control	8	36	52
Chicken manure	9	29	43
Moringa	10	32	47
Combined	11	25	40
Control	12	37	53

The bar graphs below illustrate the superiority of different treatments on the flowering and fruiting period of green pepper. The lower the bar the superior the treatment. The combined treatment in green colour indicates lowest days to flower and fruit.

Days to flower



Days to fruit



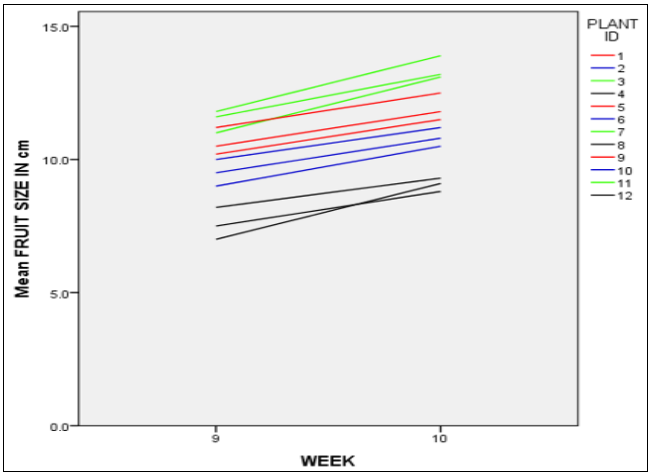
Flower and Fruit count

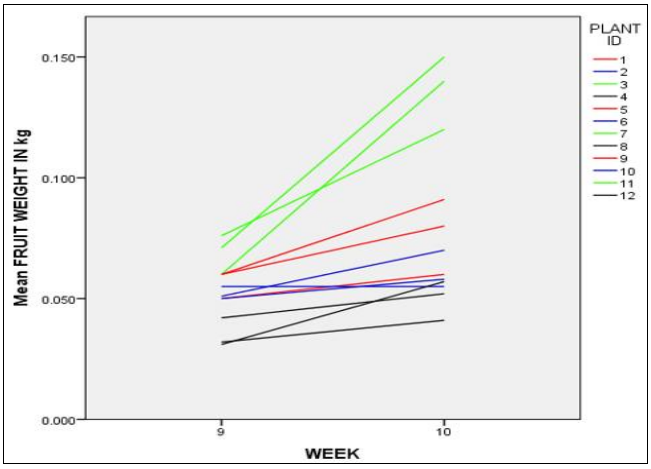
The ANOVA table below shows the sum of squares and mean squares for flower and fruit count. P-value less than (P< 0.05) indicates that the results are statistically significant.

Source of variation		Sum of Squares	Mean Square	F	P-value
FLOWER COUNT	Between Groups	85.833	28.611	7.948	.001
	Within Groups	72.000	3.600		
	Total	157.833			
FRUIT COUNT	Between Groups	47.458	15.819	7.329	.002
	Within Groups	43.167	2.158		
	Total	90.625			

Fruit Size and Weight

The trajectory line graphs below show tendency of the line movement based on the group of treatment over a period of 2 weeks. Plant 1, 5, and 9 were collected from chicken manure, 2, 6, and 10 from moringa, 3, 7, and 11 from combined and 4, 8, and 12 from control respectively. The graphs shows that the combined treatment yielded the largest and heavier fruits.





5. Discussion, Conclusion and Recommedations

Discussion of Key Findings

Effects on growth

The trajectory graphs for plant height, number of leaves, stem diameter, and leaf width consistently revealed a superior upward growth pattern in plants treated with the combination of chicken manure and moringa (T3). The control group's stunted growth underscores the nutrient-

deficient state of the soil. The statistical analysis strongly supports these observations. The ANOVA showed a highly significant treatment effect for plant height ($F=12.43$, $p<0.001$), number of leaves ($F=33.03$, $p<0.001$), stem diameter ($F=9.48$, $p<0.001$), and leaf width ($F=28.24$, $p<0.001$). Afterward Tukey HSD tests indicated that for key parameters like stem diameter, the combined treatment was significantly superior to an untreated ($p<0.05$), validating the visual trends observed in the trajectory graphs.

The exceptional performance of the combined treatment (T3) can be attributed to the complementary mechanisms of action of the two organic amendments, as established in the literature. Chicken manure, as a rich source of macronutrients (Tomlison and Diaz, 2023) [21], provided a steady, slow-release supply of nitrogen (N), which is fundamental for chlorophyll synthesis, protein production, and overall vegetative growth (Karthika *et al*., 2018) [12]. This is evident in the robust plant height and leaf count in T1 and T3. Concurrently, the moringa leaf extract functioned as a powerful biostimulant. As detailed by Yuniati *et al* (2022) [23] and Basra and Lovatt (2016) [3], moringa is rich in phytohormones, particularly auxins and cytokinins. Auxins promote cell elongation, directly influencing stem diameter and plant height, while cytokinins stimulate cell division and delay leaf senescence, contributing to a higher number of leaves and sustained photosynthetic activity.

The combined effect in T3, therefore, created an optimal growth environment: the NPK foundation from the chicken manure ensured the basic building blocks for growth were present, while the hormonal and micronutrient boost from the moringa enhanced the plant's efficiency in utilizing these resources (Kheiry *et al*., 2016) [13]. This aligns perfectly with the (Matar, 2018 and Mufwanzala and Dikinya, 2010 [19]), which suggests that organic amendments promote a diverse microbial community and improve soil structure, leading to enhanced nutrient availability and uptake. The control group's stunted growth underscores the nutrient-deficient state of the soil and confirms the problem statement regarding the limitations of unamended cultivation.

Effects on Yield

The yield data further highlights the power of the organic treatments, particularly the combination. Key findings include earlier flowering and fruiting, a higher number of flowers and fruits, and significantly larger and heavier fruits in the T3 group.

The fewer days to first flower and fruit in the treated groups, especially T3, can be linked to the hormonal influence of moringa and the nutritional support of chicken manure. This acceleration was statistically confirmed, with the combined treatment flowering earlier than control (Mean Difference=12.33 days, $p<0.001$) and chicken manure only (4.33-day, $p<0.001$). Cytokinins in moringa are known to break apical dominance and promote the initiation of lateral buds, which include flower buds (Maryam, 2013) [16]. Furthermore, the abundant phosphorus supplied by the chicken manure is critical for energy transfer (ATP), root development, and is a key driver of flowering and fruiting processes (Karthika *et al*., 2018) [12]. The combination likely triggered a more rapid and synchronized transition from the vegetative to the reproductive stage.

The increased flower and fruit count, as well as the final fruit size and weight, are a direct consequence of improved plant vigor. The LSD test fruit weight showed that the combined treatment produced heavier fruits than control (Mean Difference=0.060kg, $p<0.000$), moringa (Mean Difference=0.046kg, $p<0.001$) and chicken manure (Mean Difference=0.036kg, $p<0.010$). The larger leaf area and healthier canopy as indicated by growth parameters in T3 plants resulted in greater production of photo-assimilates. The role of potassium from chicken manure is central here, as it regulates the translocation of these sugars to the developing fruits (Uchida, 2000) [22]. Moreover, the antioxidants and growth promoters in moringa, as noted by Hussein *et al* (2014) [11], likely improved the plant's resilience to minor environmental stresses, reducing flower abortion and ensuring a higher proportion of flowers set into mature, high-quality fruits. The results for fruit size and weight in T3 were markedly superior, demonstrating that the combined treatment not only increased fruit number but also enhanced the filling and development of each individual fruit.

The null hypothesis (H_0) stated that "Chicken manure and moringa have no significant effect on the growth and yield of green pepper plants."

The results from this study, particularly the significant differences in stem diameter, timing of fruiting, and final fruit size and weight, provide sufficient evidence to reject the null hypothesis. The alternative hypothesis (H_1) that " The application of chicken manure and moringa as organic fertilizer significant increases growth and yield of green pepper compared to untreated plants." is accepted. The effect is most pronounced and statistically significant when the two amendments are used in combination.

Conclusion

In conclusion, this study demonstrates that chicken manure and moringa extract are effective organic fertilizers for green pepper production. While both treatments individually showed improvements over the unfertilized control, their combination yielded the most compelling results. The synergy between the two created a more complete fertilization regime; chicken manure provided the essential macro-nutrients (N, P, K) and improved soil organic matter, while moringa tea supplied growth-stimulating hormones, antioxidants, and micronutrients that enhanced plant vigor, stress tolerance, and reproductive efficiency.

This research validates the use of integrated organic fertilization as a viable strategy for smallholder farmers in Zambia and similar agro-ecologies. It offers a sustainable alternative to costly synthetic fertilizers, aligning with the principles of sustainable agriculture by improving soil health, reducing environmental impact, and potentially increasing farmers' profitability.

Limitations

Despite the valuable insights, this study had several limitations:

Plot size a larger plot size could have provided large sample size which would have led to more robust data and reduced the impact of variability. Environmental Variability the research was conducted in one location over a single growing season. Factors such as unexpected chilly temperatures, as noted in the limitations, may have impacted

plant performance and nutrient uptake, influencing the results. Economic Analysis a cost-benefit analysis comparing the economics of using these organic amendments against conventional synthetic fertilizers was not conducted, which is crucial for farmer adoption. During the study process several significant challenges were encountered such as distance to research site, cost of purchasing all the necessary research equipment. Lastly, human pests posed a great challenge.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

Farmers

Green pepper farmers are encouraged to adopt the integrated use of chicken manure applied at 10,000 kg/ha and moringa applied at 350 L/ha as a basal dose to improve growth, accelerate fruiting, and enhance fruit size and yield. Chicken manure should be well-composted before application to avoid the risk of burning plants and to eliminate potential pathogens and weed seed. Lastly, moringa can be produced locally at a low cost, providing a sustainable and readily available source of plant bio stimulants.

Future Research

Initially, future studies should incorporate a larger sample size and more replications to enhance the statistical reliability of the findings. Furthermore, research should be conducted over multiple seasons and across different agro-ecological zones to verify the consistency of these results. In addition, a detailed soil chemical and biological analysis should be included to scientifically quantify the improvement in soil health parameters. An economic analysis comparing the profitability of this organic strategy versus conventional practices should be undertaken. Lastly, further investigation into the optimal ratios and application frequencies (e.g., split applications of moringa as a foliar spray) of chicken manure and moringa could help refine the recommendations for maximum efficiency.

6. Acknowledgments

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