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Growth, Yield and Protein Content of Cowpea (*Vigna unguiculata*) Applied with Organic Fertilizers

Rocelyn J. Bagsao*[1], Prof. Lucila V. Rocha[2]
[1, 2] Isabela State University, Main Campus, Echague Isabela, Philippines
*Corresponding Author e-mail: *bagsaorocelyn@gmail.com*

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Abstract
Aim: This study aimed to explore the effects of organic and inorganic fertilizer combinations on soil properties, growth, yield, and protein content of cowpea (*Vigna unguiculata*) from November 2024 to February 2025 in Barangay Ipil, Bulanao, Tabuk City, Kalinga. Using a Randomized Complete Block Design with three replications, treatments included vermicompost, cow manure, and Black Soldier Fly (BSF) frass at 3 tons/ha, applied alone or with recommended inorganic fertilizer rates. Results showed no significant differences in plant height, pod number, and pod weight across treatments. However, organic fertilizers at 3 tons/ha yielded comparably to full inorganic rates. The combination of half the recommended inorganic rate with 3 tons/ha BSF frass produced the highest pod yield and the best return on investment (77.15%). This suggests that combining reduced inorganic fertilizer with organic amendments can sustain cowpea productivity while lowering input costs.
Methodology: The study was conducted from November 2024 to February 2025 at Barangay Ipil, Bulanao, Tabuk City, Kalinga, using a 459 m² field arranged in a Randomized Complete Block Design (RCBD) with seven treatments and three replications. Treatments included the recommended rate of inorganic fertilizer (30-40-45 kg NPK ha^{-1}), organic fertilizers (vermicompost, cow manure, and Black Soldier Fly frass) applied at 3 tons per hectare, and combinations of organic fertilizers with half the recommended rate of inorganic fertilizer. Cowpea seeds were directly sown at 20 cm × 50 cm spacing after applying organic fertilizers ten days before planting, followed by basal and side-dress application of inorganic fertilizers. Standard crop management practices including manual weeding, irrigation, and pest monitoring were employed. Soil samples were collected before and after treatment for analysis of pH, organic matter, cation exchange capacity (CEC), and bulk density at the Cagayan Valley Integrated Agricultural Laboratory (CVIAL). Data gathered included plant height, pod length, number of pods, pod weight, yield per plot, and seed protein content. Cost and return analysis was also computed to determine the economic viability of treatments. All quantitative data were analyzed using ANOVA appropriate for RCBD, with mean differences compared using Tukey's Honestly Significant Difference (HSD) test at 5% significance level.
Results: The combination of BSF frass with half the recommended rate of inorganic fertilizer resulted in the highest cowpea yield, performing similarly to the full inorganic rate. Though differences were not statistically significant, this approach shows promise as a cost-effective and sustainable fertilization strategy. Further research is recommended across different soil types, climates, and seasons to validate its long-term impact on yield and soil health.
Conclusion: Cowpea plants treated with 3 tons/ha of organic fertilizers showed pod yields comparable to the full inorganic rate. The highest yield and ROI (77.15%) were recorded from the treatment combining half the inorganic rate with BSF frass, suggesting its potential as a sustainable alternative to full inorganic fertilization.
Keywords: *Black Soldier Fly Frass, protein content, cowpea, vermicompost, pods*

INTRODUCTION

Cowpea (*Vigna unguiculata* L.), a member of the *Fabaceae* family, is among the most important legumes widely grown worldwide, as a protein source for food and feed. Nutritionally, cowpea can serve as an alternative to meat. This versatile legume thrives in any diverse climatic conditions, providing a reliable source of nutrition and income. Rich in protein, vitamins, and minerals, cowpeas enhance the local diet, contributing to improved health and

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food security. Moreover, the nitrogen-fixing ability of cowpea improves soil fertility, supporting sustainable farming practices and increasing crop yields. Additionally, cowpea cultivation can reduce the need for chemical fertilizers, lowering costs for farmers and promoting eco-friendly agriculture. Thus, considering these advantages, cowpea has the potential to be a valuable source of income in Tabuk City, Kalinga.

While inorganic fertilizers can provide immediate nutrient availability, their long-term effects on soil health, such as nutrient depletion, soil acidity, and reduced organic matter, are not well understood. One of the most important factors affecting the yield of the cowpea is grown is the useful macro and micronutrients in the soil.Nutrient management tailored with integrated use of organic and inorganic sources may be a viable option to improve legumes yield and quality. Organic matter promotes the introduction of micro-organisms which support soil biological activity and extract nutrients for plant uptake When properly handled, organic amendments prevent soil-borne diseases without the need for chemicals (Tejada et al., 2006).

Cowpea production can play a significant role in achieving several Sustainable Development Goals (SDGs), particularly SDG # Number 1 that no poverty will be removed when farmers input cost reduced and income increased by production, SDG goal number 2 zero hunger and SDG goal number 3 good health and well-being by organic farming which can drive progress toward these global goals while fostering resilience in agriculture.

To address the challenges mentioned above, this study was conducted to evaluate the effect of different combination of organic fertilizer and inorganic fertilizer on the productivity and quality of cowpea.

Objectives

This study was conducted to determine the effect of various combinations of organic and inorganic fertilizers on soil properties as well as the growth and yield and protein content of cowpea.

Specifically, it aimed to:

1. assess the effect of different organic and inorganic fertilizer combinations on soil physical and chemical properties such as bulk density, organic matter and pH, before and after the conduct of the study;
2. evaluate the influence of different fertilizer combinations on the vegetative growth and pod yield of cowpea;
3. determine the increase in terms of protein content of cowpea seeds after using the treatment combinations; and
4. determine which among the treatments gives the highest return of investment.

Review of Related Literature and Studies

Cowpea Varieties and their Characteristics

Cowpea (*Vigna unguiculata*) is a vital legume crop grown primarily in tropical and subtropical regions. It is valued for its high protein content and adaptability to various environmental conditions (Boukar et al., 2019). Research has identified significant variability among cowpea varieties in terms of growth rate, yield potential, and resistance to pests and diseases (Agbicodo et al., 2009). Recent studies have continued to explore the genetic diversity within cowpea varieties, aiming to improve traits such as drought tolerance and nutrient use efficiency (Boukar et al., 2021).

Cowpea production is affected by various biotic and abiotic stresses. The nature of inheritance of qualitative and quantitative characters has been studied intensively for genetic enhancement of cowpea. Resistant genotypes have been developed for drought, heat stress, aluminum toxicity tolerance, high seed protein content and resistance to aphids, flower thrips, pod borer, bruchids and disease resistance against cercospora leaf spot, bacterial blight, bean common mosaic virus and parasitic weeds. Several genetic markers associated with quantitative trait loci (QTL) related to drought response, maturity, pod characters, resistance to bacterial blight, leaf's spot, thrips and striga have been reported. Numerous high yielding varieties have been released with desirable plant type, seed coat color and nutritional value for the betterment of farming community (Narayana & Angamuthu et al., (2021).

Organic Fertilizers and Their Benefits

Organic fertilizers are derived from natural sources and include compost, manure, green manures, biochar, and vermicompost. They improve soil fertility by enhancing organic matter content and providing essential nutrients (Liu et al., 2024). The benefits of organic fertilizers over synthetic ones include improved soil structure, enhanced microbial activity, and reduced environmental impact (Singh et al., 2024).

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Compost improves soil structure and nutrient content, leading to better plant growth and yield. A study by Qasim et al. (2018) demonstrated that compost application significantly increased cowpea yield and improved soil health.

Animal manure, rich in nitrogen, phosphorus, and potassium, has been shown to enhance cowpea growth. Fagbola et al. (2020) found that cowpea plants fertilized with poultry manure had higher biomass and yield compared to those treated with chemical fertilizers.

Green manures, such as leguminous cover crops, improve soil fertility by adding organic matter and fixing nitrogen. According to Muñoz et al. (2016) highlighted the positive effects of cowpea as green manure on soil fertility and nitrogen requirements in sugarcane production.

Vermicompost, produced by the decomposition of organic waste by earthworms, is rich in nutrients and beneficial microorganisms. An investigation by Davoodi et al. (2020) showed that vermicompost significantly improved cowpea growth parameters and yield.

Response of Cowpea to Organic Fertilizers

Low soil fertility is a major challenge to food security and agricultural productivity in smallholder farming systems. This degradation of soil is largely caused by factors such as soil disturbance, unsustainable erosion rates (Schillaci et al.), compaction, secondary salinization, nutrient runoff, and the depletion of stable soil organic matter (Babur et al.; Mafongoya et al.). Addressing the decline in soil fertility is essential and improving soil health through innovative approaches is crucial (Bationo & Waswa; Diatta et al.). One method involves recycling organic waste into nutrient-rich soil amendments. While inorganic fertilizers supply nutrients, they do not restore organic matter lost during cultivation or contribute to long-term soil health. Many smallholder farmers rarely use inorganic fertilizers due to high costs and inconsistent yields (Diatta et al.; Mbow et al.; Vieira Junior et al.).

Organic fertilizers play a critical role in enhancing soil fertility, sequestering carbon, reducing greenhouse gas (GHG) emissions, and improving crop yields. Although mineral fertilizers quickly boost soil fertility due to their concentrated nutrient content, organic matter is key to sustainable agriculture. The success of sustainable farming hinges on the availability of affordable, high-quality organic fertilizers. These fertilizers improve soil oxygen levels, support root development, enhance water retention, and mitigate salinization, all while boosting crop nutrition and yields. Additionally, they protect and improve soil health, serving as a rich source of essential macro and micronutrients through the process of mineralization. Organic fertilizers also activate soil microbial biomass, further enhancing soil fertility and structure.

Organic fertilizers encompass a variety of types, such as compost (including village, town, water hyacinth, and vermicompost), farmyard manure (from cattle, sheep, and poultry), green manures (from leguminous and non-leguminous plants), and biofertilizers (such as algal, fungal, bacterial biofertilizers, and plant-growth-promoting rhizobacteria). These organic fertilizers are essential for preserving soil health, preventing environmental pollution, and enhancing both crop yield and quality. They provide relatively available nutrients crucial for plant growth and soil improvement and serve as a vital source of humus, carrying both macro and microelements. For crops like cowpeas, the residual organic matter after harvest further enriches the soil. However, cowpeas, especially early in the growing cycle, benefit from additional fertilization to meet their nitrogen, phosphorus, potassium, and micronutrient needs. Fertilization during these critical periods supports plant growth and improves soil conditions for future planting.

According to Atugwu et al. (2023), the effects of compost and poultry manure on different cowpea accessions were compared. The results showed that both organic fertilizers improved growth and yield, although the response varied among the accessions. Investigated the impact of vermicompost on cowpea and found that it significantly enhanced growth parameters such as plant height, leaf area, and pod yield across several cowpea varieties (Khan et al., 2016).

According to Okpara et al. (2021) showed that green manures improved soil fertility and increased the yield of cowpea varieties, with significant differences in response among the varieties tested.

Cowpea is a leguminous crop, possesses the remarkable ability to fix atmospheric nitrogen, which is crucial for its early vegetative growth and development. Prior to the initiation of nitrogen fixation in these legumes, especially those growing on poor organic matter soils, nitrogen fertilizer is typically provided during planting (Gautam et al., 2024).

Synthesis

The effect of organic fertilizer cited in the review of literatures highlights that the combination of organic and inorganic fertilizers as well as its sole application promotes crop sustainability, productivity, and economic

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efficiency. The utilization not only enhances the yield of various crops like cowpea but more specifically decreased soil pH and acidity.

The combination to inorganic fertilizer or sole application of organic sources may be a valuable tool for sustainable agriculture as these amendments stimulate the microbial activity which provides the nutrients (N, P) and organic carbon to the soil. The use of organic fertilizers may be helpful in the development of a low-cost technology and ideal solution for ecologically-friendly agriculture.

METHODS

Procurement of Seeds

The seeds of cowpea (Black eye pea) were procured from Valencia's Agricultural Supply at Bulanao Centro, Tabuk City, Kalinga, an accredited seed dealer in the area.

Collection of Soil Sample and Analysis

The experimental area was subjected to soil analysis as part of the treatment. The soil was collected from ten different sites by digging at random. Using the shovel, it was dug by pushing down the shovel to a depth of 15 cm it will be sliced two cm thick and 5 cm wide, and it was placed in a container. The soil sample was air-dried and pulverized. After air drying, it was sent to the Cagayan Valley Integrated Agricultural Laboratory (CVIAL) at Carig Sur, Tuguegarao City, for soil analysis.

Determination of Bulk Density

Using the appropriate tools (soil auger and core sampler), an undisturbed flat horizontal surface in the soil was prepared with a spade to a depth of up to 30 centimeters. The auger was pushed or the steel ring was gently hammered into the soil. The soil was excavated around the ring without disturbing or loosening the soil it contains, and the ring was carefully removed with the soil intact. Excess soil was trimmed from outside the ring, and any plants or roots was cut off at the soil surface with scissors. The was poured into a plastic bag, the bag was sealed, and the date and location of the sample was marked. The same procedure was conducted after the study to determine the change in bulk density following the application of organic fertilizers.

Soil Chemical Properties

The soil pH (acidity or alkalinity) of the soil as well as the organic matter content and the cation exchange capacity (CEC) was recorded before and after the study.

Land Preparation

Before cultivation, the area was cleared using a bolo and a grass cutter. Manual cultivation was done using a shovel, grab hoe and rake; after cultivation, pulverization was done. The study was consisting of twenty-one (21) equal plots for the allocation of treatments, each with three replications. Alleyways was provided between blocks and plots. In accordance with the recommended planting distance for cowpeas, space the seeds 20 cm by 40 cm apart. The cowpea seeds were directly sown in the soil. Every hill with missing plants was replaced right away.

Fertilizer Application

Applying vermicompost, cow manure and black soldier fly frass was done 10 days before planting. The inorganic fertilizer was applied as basal and the second application was applied 30 days after planting.

Experimental design and treatment

The study used a Randomized Complete Block Design (RCBD) and utilized area of 459 square meter. It has seven (7) treatments and replicated three times. The area had a measurement of 4 m x 4 m (16 m^2) per plot with an alley of 1m between plots and 1 m between blocks. The different treatments will be used are as follows;

T_1 – Recommended Rate of Inorganic Fertilizer (30-40-45 kg NPK ha^{-1})
T_2 – Recommended Rate of Organic Fertilizer (3 Tons Vermicompost ha^{-1})
T_3 – ½ RR Inorganic Fertilizer + 3 Tons Vermicompost ha^{-1}
T_4– ½ RR Inorganic Fertilizer + 3 Tons Cow Manure ha^{-1}
T_5– ½ RR Inorganic Fertilizer + 3 Tons Black Soldier Fly Frass ha^{-1}

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T_6– 3 Tons Black Soldier Fly Frass ha^{-1}
T_7– 3 Tons Cow Manure ha^{-1}

Sowing of Seeds

Two weeks after applying fertilizer, the seeds were directly sown in their corresponding plot and planting intervals with 2-3 seeds per hill. The seed was sown at a depth of 2.5 to 5 cm from the soil surface of the ground and immediately irrigated with light irrigation. The distance of planting followed the recommended distance of planting of 50 centimeters (furrows) and 20 centimeters (hills).

Water Management

Watering was done early in the morning and late in the afternoon to maintain sufficient soil moisture for the proper growth and development of the crop whenever necessary.

Weeding and Cultivation

The area was monitored to control the occurrence of the weeds in every plots. Fifteen (15) days after the seed emergence, cultivation was done on the surrounding of the cowpea to provide aeration to the plant. Cultivation and weeding were done simultaneously.

Pest Management

Close monitoring was carried out to make sure that insects and illnesses do not infect the experimental plant. Throughout the experimental period, potential insect pest and disease outbreaks was monitored and noted. In cases of pest or disease occurrences, cultural practices were applied as preventive measures. In the event of a serious disease infestation, applying pesticides was last choice.

Harvesting

Series of harvesting was done whenever the pods are in marketable stage like the pods should be well-developed, firm, have a vibrant green color and should have uniform pod size and color within a specific batch. This was done per plot to avoid intermixing harvest with other treatments. The number of priming was done three times. These harvested fruits were counted, weighed, and recorded immediately after harvesting.

Data Gathered

1. **Plant Height (cm).** The plant height of the 10 sample plants was measured at 30, 60 and 90 days after planting. It will be measured from the base of the plants up to the tip of the youngest leaf using meter stick.
2. **Length of Pods (cm).** The pods from ten representative samples were collected and measured using a ruler. The total pod lengths were then be summed and divided by ten to determine the average length per pod.
3. **Average Number of Pod.** This was determined by counting all the pods produced by ten (10) sample plants manually. The total number of pods of the ten sample plants were divided by ten to get the average.
4. **Weight of Pods per Sample Plant (g).** The pod weights of the ten sample plants from each plot were measured. The total weight of the pods from all the sample plants were then divided by ten to calculate the average weight.
5. **Yield per plot (kg).** The pods of plants per plot were harvested and weighed. The weight of the pods per plot including the sample plant was weighed using the digital weighing balance.
6. **Protein Content of the Seeds per Treatment.** Samples of dry seeds of cowpea per treatment was harvested and brought to the Cagayan Valley Integrated Agricultural Laboratory (CVIAL) at Carig Sur, Tuguegarao City, to determine the crude protein after the application of the different treatments.

7. Cost and Return Analysis. All the expenses spent during the conduct of the study was recorded. The cost of production was based on the prevailing price of farm inputs and labor. The gross income was determined based on the prevailing price of cowpea. The net income is equal to the gross income minus the cost of production and the return of investment was computed by dividing the net income with the cost of production multiplied by 100.

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$$\text{Return of investment} = \frac{\text{Net income}}{\text{Total expenses}} \times 100$$

8. Protein Content of the Seeds. The protein content of the cowpea seeds per treatment was brought to the laboratory to determine the change after the application of different organic fertilizer and those treatments combined to inorganic fertilizer.

Statistical Analysis

All the data gathered were tabulated and analyzed statistically using ANOVA in Randomized Complete Block Design (RCBD). Comparison among means was computed through the use of Tukey's Honestly Significant Difference test.

RESULTS and DISCUSSION

Table 1. Plant Height at Maturity (cm)

TREATMENTS	MEAN
T_1 - 30-40-45 kg NPK ha^{-1} (RR)	45.40
T_2 – 3 Tons Vermicompost ha^{-1}	43.60
T_3 – 15-20-22.50 kg NPK ha^{-1} + 3 Tons Vermicompost ha^{-1}	51.93
T_4 - 15-20-22.50 kg NPK ha^{-1} + 3 Tons Cow Manure ha^{-1}	45.80
T_5 - 15-20-22.50 kg NPK ha^{-1} + 3 Tons Black Soldier Fly Frass ha^{-1}	50.31
T_6 -3 Tons Black Soldier Fly Frass ha^{-1}	46.73
T_7 -3 Tons Cow Manure ha^{-1}	45.27
F- RESULTS	ns
C. V. (%)	11.31

ns-not significant

Plant Height at Maturity (cm). The data on the plant height of cowpea as presented in Table 1 did not show any significant differences between treatments. Regardless of the fertilizer combination, the plant heights remained relatively similar with means ranging from 43.60 cm to 51.93 cm. It shows that despite these similar heights, plants treated with ½ RR In Organic Fertilizer + 3 Tons of Vermicompost per hectare exhibited slightly better growth across all treatments.

This result emphasizes the potential beneficial effect of vermicompost in combination to the half of inorganic fertilizer on plant growth even though the overall differences were not statistically significant. This can be attributed to the readily available nutrients from inorganic fertilizers during the early stages of plant development and the continued availability of nutrients in forms available for plant uptake from vermicompost compost particularly at maturity stage (Ripoche et al., 2015).

Moreover, the enhanced plant growth after inorganic and vermicompost application has been associated with improved soil physical properties, such as reduced bulk density, improved infiltration and hydraulic conductivity and increased water content and plant- available water (Nath et al., 2023). Therefore, the combination of compost and a lower concentration of 50% mineral fertilizer can be a viable optimization ratio.

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Table 2. Length of Pods (cm)

TREATMENTS	MEAN
T_1 - 30-40-45 kg NPK ha^{-1} (RR)	16.59
T_2 – 3 Tons Vermicompost ha^{-1}	15.13
T_3 – 15-20-22.50 kg NPK ha^{-1} + 3 Tons Vermicompost ha^{-1}	15.80
T_4 - 15-20-22.50 kg NPK ha^{-1} + 3 Tons Cow Manure ha^{-1}	15.75
T_5 - 15-20-22.50 kg NPK ha^{-1} + 3 Tons Black Soldier Fly Frass ha^{-1}	15.39
T_6 -3 Tons Black Soldier Fly Frass ha^{-1}	15.48
T_7 -3 Tons Cow Manure ha^{-1}	15.72
F- RESULTS	ns
C. V. (%)	6.68

not significant

Length of Pods (cm). The combination of organic fertilizer and synthetic fertilizer did not increase the pod length of cowpea. Results showed that any of the plants applied with the combination of organic and inorganic fertilizers produced insignificant length of pods. Apparently, such fertilizer combination did not affect the pod length of the plants with mean values ranging from 15.13 cm to 16.59 centimeters.

The lack of response to fertilizer combinations might be due to the low soil pH and waterlogging condition due to frequent rainfall during the conduct of the study that can limit nutrient uptake. Both of which can restrict nutrient uptake regardless of the fertilizer type used in the study in which the low pH (4.97) can make essential nutrients less available and waterlogging can hinder root growth and nutrient absorption. On the other hand, waterlogged conditions limit the elongation of pods in cowpea mainly because they disrupt the plant's access to oxygen and nutrients which are essential for growth. Additionally, microbial activity is responsible for nutrient cycling, especially nitrogen transformations, is heavily reduced under these conditions (Topali et al., 2024). For crops like cowpea which rely heavily on efficient nutrient uptake for proper pod development and elongation, these combined stresses can significantly stunt pod growth ultimately reducing yield.

Table 3. Number of Pods per Plant

TREATMENTS	MEAN
T_1 - 30-40-45 kg NPK ha^{-1} (RR)	14.53
T_2 – 3 Tons Vermicompost ha^{-1}	10.73
T_3 – 15-20-22.50 kg NPK ha^{-1} + 3 Tons Vermicompost ha^{-1}	11.69
T_4 - 15-20-22.50 kg NPK ha^{-1} + 3 Tons Cow Manure ha^{-1}	15.68
T_5 - 15-20-22.50 kg NPK ha^{-1} + 3 Tons Black Soldier Fly Frass ha^{-1}	17.85
T_6 -3 Tons Black Soldier Fly Frass ha^{-1}	15.04
T_7 -3 Tons Cow Manure ha^{-1}	11.39
F- RESULTS	ns
C. V. (%)	21.98

ns-not significant

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Number of Pods per Plant. Variation did not exist in terms of the number of marketable pods per plant regardless of the fertilizer in combination (Table 4). It shows that the plants applied with the full recommended rate of inorganic fertilizer alone as well as the plants receiving the combination of the half rate of inorganic fertilizer with organic fertilizer produced pods ranging from 11.57 to 14.96.

This suggests that while fertilization influenced pod production to some extent, the differences among treatments were not statistically significant in terms of marketable pod might be attributed to other factors like genetics, environmental conditions, and nutrient interactions. The result of this study was consistent with the observations made in 2017 by Miheretu and Sarkodie-Addo that varieties differ in their response to the current climate and soil conditions and not always affected by fertilization. Likewise, they further claimed that the decrease in the number of pods per plant is mainly due to the abscission of flowers and pods of cowpea under stress condition. Again, number of pods per plant depends on the genetic potential of the variety to bear or produce different pod number.

This is contrary to the claim of Joshi et al. (2013) who reported that applied organic fertilizers (vermicompost, farm manure and black soldier fly) affected the number of branches. In comparison to chemical fertilizers, they also found that vermicompost enhanced wheat's growth, production, and quality. However, they observed that the majority of growth, production, and quality was higher when chemical fertilizers were applied at the recommended dosage, suggesting that chemical fertilizers outperformed vermicompost in improving these factors.

Table 4. Cost and Return Analysis

ITEM	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Total Cost of Production	10973.33	10183.33	9828.33	10128.33	10328.33	10183.33	8983.33
Gross Income	18012.9	13590	15714	16575.9	18297	17000.1	14079.0
Net Income	7039.57	3406.67	5885.67	6447.57	7968.67	6816.77	5095.67
ROI	**64.15**	**33.45**	**59.88**	**63.66**	**77.15**	**66.94**	**56.72**

Cost and Return Analysis. The cost and return analysis of producing cowpea using different sources of organic fertilizer is shown in Table 7. Results showed that the highest return was obtained by the plants fertilized with 15-20-22.50 kg NPK ha^{-1} + 3 Tons Black Soldier Fly Frass ha^{-1} (T_5) with 77.15 percent while the least was noted in the plants in Treatment 2 (15-20-22.50 kg NPK ha^{-1} + 3 Tons Vermicompost ha^{-1}) with 33.45 percent.

Conclusions

Based on the results of the study, although no differences were recorded in the growth characteristics of cowpea plants, applying 3 tons/ha, organic fertilizers such vermicompost, cow dung, and black soldier fly (BSF) frass produced pod weights comparable with the full recommended rate (RR) of inorganic fertilizer. Notably, the combination of the half the recommended rate of inorganic fertilizer with 3 tons/ha of BSF frass produced the heavier pods despite the differences were not statistically significant but register a sustainable and feasible with an ROI of 77.15 percent hence can be substitute for full inorganic fertilization in cowpea cultivation.

Recommendations

Based on the findings of the study, the application of BSF frass combined with half (½) of the recommended rate (15-20-22.50 kg NPK ha^{-1}) of inorganic fertilizer produced the highest yield and performed comparably to plants treated with the full RR of inorganic fertilizer. Although no statistically significant differences were observed among the treatments, these findings indicate that using BSF frass alongside with half the recommended rate of inorganic fertilizer (30-40-45 kg NPK ha^{-1}) is a feasible and effective strategy scheme in cowpea production, hence recommended. Further study is recommended under varying soil types, climatic conditions, and across multiple growing seasons to assess the long-term effects of combined organic-inorganic fertilization on soil health and nutrient availability to verify the mechanisms underlying the observed yield performance of the crop.

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