

Enhancing Growth and Yield of *Vigna unguiculata* subsp. *sesquipedalis* Using Vermicompost Produced by *Eudrilus eugeniae* from Banana Leaf Biomass, Cow Dung, and *Azolla pinnata*

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ABSTRACT

Vermicomposting provides an efficient and accelerated method for recycling the organic matter in the ecosystem. This study decisively illustrates that the effect of vermicompost prepared using *Eudrilus eugeniae* from banana leaf biomass, cattle waste, and *Azolla pinnata* distinctly improves the growth and maturation of *Vigna unguiculata* subsp. *Sesquipedalis*. The application of azolla with an appropriate concentration of substrates had a profound effect on the growth of *Vigna unguiculata* subsp. *Sesquipedalis* in plant height, leaf number, root length & pod formation. This growth response is attributed to the presence of active enzymes, beneficial microbes, nutrient-rich and well-conditioned vermicompost. This method of vermicomposting emphasizes the potential of using different types of agricultural wastes for producing superior-quality fertilizers for cultivating highly beneficial plants. Vermicompost synthesised from banana leaf biomass (BLB), cattle waste (CW), and azolla (AZ) represents a substitute to chemical fertilizers, improving soil fertility and texture, and is a good companion for farmers.

Keywords: Vermicompost, *Eudrilus eugeniae*, Banana leaf biomass, *Azolla pinnata*, *Vigna unguiculata*, Plant growth.

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1. Introduction

Vermicomposting is one of the feasible approaches in agriculture to convert the bulk organic byproducts into a promising fertilizer for plant growth. Vermicompost is a soft and porous substance formed through the stabilization of organic wastes by earthworms and associated microbes. Application of vermicompost into the soil helps to improve aeration and capacity to retain water (Paczka et al., 2021). Singh et al. (2015 & Gupta et al. (2019) detailed the role of vermicomposting in sustainable agriculture. Application of vermicompost increases the porosity, thereby improving the soil water holding capacity. Vermicompost is rich in mineral nutrients, including essential plant growth hormones. It also acts as a good buffering agent and reduces attack by pests and insects. Munnoli. et al., 2010 reported that the earthworm gut breaks down the substrates, providing a larger surface area for microbial activity, whereas in conventional composting, the process is rather slow as it depends on the penetrating capacity of enzymes. *Eudrilus eugeniae*, commonly known as African nightcrawlers, are exotic species that can break down substantial quantities of organic substrates more

rapidly than native species (Singh et al., 2017). Raphael et al. (2010) reported the effective degradation of coir waste into nutrient-rich vermicompost using *Eudrilus eugeniae* more effectively than native species. This earthworm has an effective bioconversion capacity, which was proven from studies conducted on the decomposition of highly cellulosic substrates like rice straw (Yan et al., 2012), paper mill sludge (Ahmad et al., 2022), sugarcane trash (Balachandar et al., 2020), and pressmud (Suthar, 2009).

According to recent studies, India produced 38.64 tonnes of bananas per hectare in 2023–2024, up 3.79 tonnes from the year before (Arvind Vaman Dalavi, 2025). Major banana cultivation resides in southern India. The harvested fruit is either consumed fresh or used for making products like chips, baby foods, and beverages. Furthermore, the pseudostem and peels are employed in the production of biodegradable packaging, biofilms, textiles, and cosmetic products (Chaudari et al., 2025). Banana leaves are commonly used to make biodegradable plates, wrappers, and livestock feed. These findings indicate that every part of the banana plant is being utilised. However, the production of excess banana leaves often leads farmers to burn them in the field, which causes significant air

pollution. However, since these leaves are rich in nutrients, they can be effectively converted into fertilizer through composting. Specifically, their high lignocellulosic content can be efficiently decomposed through the process of vermicomposting.

Enriching the vermicompost with beneficial microorganisms such as azospirillum, azotobacter, pseudomonas, etc., increases the degradation process and elevates the final product value. In sustainable agriculture, enriched vermicompost is crucial and becoming more important (Raghupathi & Palaneeswar, 2023). *Azolla pinnata* is a fast-growing aquatic fern commonly known also as water fern, mosquito fern, fairy weeds, or duckweeds (Gayathry et al., 2025), exhibits a symbiotic relationship with *Anabaena azollae*, a blue-green algae. This symbiotic association makes azolla rich in nitrogen and is considered a “green nitrogen fertilizer” (Yadav et al., 2022). Other than nitrogen, they are rich in macro minerals such as potassium, calcium, phosphorus, and magnesium, and trace elements like iron, manganese, zinc, and vitamin A, vitamin B12 and vitamin E (Alalade et al., 2006; Semae et al., 2025). Decomposition of azolla biomass during vermicomposting releases these mineral nutrients into the final product. *Azolla pinnata* is a readily cultivated plant that, in the right circumstances, doubles its biomass every three days and develops exponentially (Kour et al., 2020).

Vigna unguiculata subsp. *sesquipedalis* plant is a tropical leguminous plant also called yardlong beans; string beans (Zainudin et al., 2022). They belong to the class Dicotyledoneae, order Fabales, family Fabacea, genus *Vigna* subspecies *unguiculata* subsp. *sesquipedalis*. (Ashebir et al., 2013). Studies have reported the significant amount of proteins, vitamins, carbohydrates, fats and fibers present in cowpeas making them an affordable food that meets all the dietary requirements of a common man (Gupta et al., 2016; Mehreen, et al., 2020; Bejarano, et al., 2014). *Vigna unguiculata* subsp. *Sesquipedalis* is recognized for its medicinal properties, contributing to enhance cell signaling, reduction of blood glucose, blood pressure, and cholesterol levels, improvement of cardiac muscle function, and is rich in antioxidants and dietary fiber, thereby modulating the body's metabolic activity (Duraipandian et al., 2022).

In this study, vermicompost was produced using *Eudrilus eugeniae* with substrates comprising banana leaf biomass (BLB) and cattle waste (CW) amended with azolla (AZ) in varying proportions. The efficacy of the resulting vermicompost was evaluated using the

common yardlong pea plant, *Vigna unguiculata* subsp. *sesquipedalis*.

2. Experimental methodology:

Vermicompost was produced using the biological activity of *Eudrilus eugeniae* that can convert the biomass consisting of banana leaf biomass, cattle waste enriched with azolla in different proportions. The efficiency of the produced vermicompost was tested using the common yardlong pea plant, *Vigna unguiculata* subsp. *sesquipedalis*, to evaluate its effectiveness as an organic fertilizer.

2.1 Collection and preparation of vermicomposting materials

Banana leaves (*Musa paradisiaca*) used for vermicomposting were procured from a banana plantation located in Payyanur of Kannur District, Kerala. The collected leaves were washed in clean water and cut into small pieces of 2-3 cm. Banana leaves being large and flat have a low surface area to volume ratio for initiating decomposition, whereas chopped banana leaves increases the available surface area for microbial action (Mishra, & Yadav., 2021). The enriching agent of the vermicompost *Azolla pinnata* was harvested from the College of Agriculture, Padannakad, Kannur. To facilitate composting, fresh cow dung was obtained from an adjacent farmhouse located in Payyanur. *Eudrilus eugeniae* of medium size was collected from Sreevalsam Agri Farm in Pilathara, Kannur.

2.2 Pretreatment of banana leaves for composting.

Finely chopped banana leaves were precomposted in 9 x 12-inch-sized growbags with intermittent watering for 30 days. This process facilitates the softening of leaves and the easy breakdown of lignin, making it readily accessible to composting organisms. Care must be taken to prevent waterlogging in the bag; the perforations in the growbag facilitate the draining of excess water. To prevent direct sunlight and leaf drying, the precomposting process should be done in a shady area.

2.3 Vermicomposting of precomposted banana leaves.

The precomposted banana leaf biomass (BLB) was transferred to 15x18-inch-sized grow bags along with cattle waste (CW) and *Azolla* (AZ) in 16 different formulations. BLB and CW were mixed in ratios of 1:1, 2:1, 3:1 and 4:1 for 2 kg, with each combination amended with 10%, 20%, 30% of AZ. The specific proportions are detailed in **Table 1**. Each sample is designated as C1A to C4D. Twenty-five medium-sized *Eudrilus eugeniae* earthworms were added to the

grow bags of a 2 kg substrate mixture. A moisture level of 60–70% and a constant temperature of 25 ± 30°C were maintained by consistent watering and maintaining the grow bags in a shaded environment. Earthworms eat complex substrates during composting and use digestive enzymes such as cellulase, amylase, lipase, and protease to break them down (Aira et al., 2006). The final vermicompost on the 75th day was collected, sieved, and preserved for further studies. Upon conclusion of the investigation, data such as the number and weight of earthworms, cocoon production, physicochemical characteristics, enzyme concentration, and microbial population in the vermicompost were analyzed.

Table1. Composition of substrates used for vermicompost production (BLB: Banana leaf biomass, CW: cattle waste, and AZ : Azolla)

Compositions	Varying percentage of Azolla	Experimental Denominations
Composition 1(1:1)		
BLB+ CW	Absence of azolla	C1A
BLB+ CW	10	C1B
BLB+ CW	20	C1C
BLB+ CW	30	C1D
Composition 2(2:1)		
BLB+ CW	Absence of azolla	C2A
BLB+ CW	10	C2B
BLB+ CW	20	C2C
BLB+ CW	30	C2D
Composition 3(3:1)		
BLB+ CW	Absence of azolla	C3A
BLB+ CW	10	C3B
BLB+ CW	20	C3C

BLB+ CW	30	C3D
Composition 4(4:1)		
BLB+ CW	Absence of azolla	C4A
BLB+ CW	10	C4B
BLB+ CW	20	C4C
BLB+ CW	30	C4D

2.4 Plant Growth Bioassay

In the experiment the effect of the range of vermicompost produced from BLB+CW+AZ were studied on the growth and development of *Vigna unguiculata* subsp *sesquipedalis*, commonly called yardlong pea.. A total of 16 distinct vermicompost formulations (labeled C1 to C16) were evaluated for their growth-promoting efficiency. The experimental design followed a randomized approach with each treatment performed in triplicate to ensure statistical reliability. A control group (C0) consisting of a soil and cow dung mixture devoid of vermicompost, was maintained under identical conditions for comparative analysis. Potting mixture proportions are depicted in Table:2.

Efficiency of the prepared vermicompost was evaluated by studying the growth response of yardlong pea in red loamy soil with varying vermicompost formulations. Red soil has light and porous structure that helps to increase aeration and root penetration (Bhattacharyya & Dilip., 2015), it has good drainage, prevents water logging near roots and is rich in minerals such as K, Fe, N & P (Brady & Weil., 2016). Red loamy soil was mixed with vermicompost in the ratio 3:1 (w/w) respectively and transferred into pots with 12 inch diameter and 10 inch depth. Yardlong pea seeds were sown in each pot at a consistent depth. Sufficient moisture was provided throughout the period of experiment to ensure ideal germination and growth of plants. The pots were positioned in an open area with optimum sunlight and maintained at a temperature between 28 ± 5 °C during the study period. No additional nutrients were applied to the experimental units during the period to make sure that all the growth responses derived only from the applied vermicompost. The plant cultivation was carried out for 60 days, during this period growth and development of the plant was recorded at an interval

of 5 days. Data such as plant height, leaf count, and root length and flower number were documented for comparative analysis.

Table 2: Potting Media Ratios: Red Soil + Vermicompost (BLB+CW+AZ)

Treatments	Compositions (Red soil:Vermicompost-3:1)
C0	Red soil:Cattle Waste
C1	Red soil+ Vermicompost (C1A)
C2	Red soil+ Vermicompost (C1B)
C3	Red soil+ Vermicompost (C1C)
C4	Red soil+ Vermicompost (C1D)
C5	Red soil+ Vermicompost (C2A)
C6	Red soil+ Vermicompost (C2B)
C7	Red soil+ Vermicompost (C2C)
C8	Red soil+ Vermicompost (C2D)
C9	Red soil+ Vermicompost (C3A)
C10	Red soil+ Vermicompost (C3B)
C11	Red soil+ Vermicompost (C3C)
C12	Red soil+ Vermicompost (C3D)
C13	Red soil+ Vermicompost (C4A)

C14	Red soil+ Vermicompost (C4B)
C15	Red soil+ Vermicompost (C4C)
C16	Red soil+ Vermicompost (C4D)

2.5 Plant growth Progress

Healthy seeds were sowed that showed the sprouting of wholesome plantlets within a few days. By the tenth day all the seedlings were established with healthy leaf formation. The growth parameters, including plant height, number of leaves, and other developmental characteristics, were monitored and recorded periodically. Flowering of the yardlong pea plants commenced after one month, followed by pod formation. After 60 days of cultivation, the plants were harvested, and the roots were carefully separated and washed to remove adhering soil. The final root length was then measured and documented for subsequent analysis.

2.6 Sprouting and seedling establishment.

Even though plants have different defensive mechanisms against environmental stress, the sprouting and seedling period is a high risk phase to these stresses (Irik., & Bikmaz., 2024). Sprouting of seed is a critical process (Carrera et al., 2020) that requires sufficient quantities of micro and macro nutrients such as N, P, K along with various enzymes and hormones that encourages metabolic process and initiates seed germination in a short period of time (Atakli et al., 2022; Yogananda et al., 2019). Carrera et al., (2020) reported the antagonistic relationship of ABA (abscisic acid) and GA (Gibberelic acid) in the process of germination. The process is initiated when the concentration of GA overcomes the concentration of ABA. Vermicompost being naturally rich in GA could easily induce the shift in the enzyme concentration and initiate germination process (Ayyasamy et al., 2021). Seeds of *Vigna unguiculata* subsp *sesquipedalis*, showed germination within 4 - 10 days after sowing. During germination the seed coats break open due to imbibition of water and increased pressure (Sakthivel et al., 2020). *Vigna* plant exhibits epigeal germination in which the hypocotyl elongates rapidly pushing the cotyledons out of the soil as a hook. Within 6 - 12 days first true leaves developed, synchronised with the firm root development (Afonso et al., 2025).

2.7 Phenological development of *Vigna unguiculata* subsp. *sesquipedalis*,

During maturation, the cotyledons drop off leading to the development of two simple leaves in opposite directions. The dropping of cotyledons is visualized by reduction in colour from green to pale green to colourless due to the breaking down of chlorophyll. The hormones ethylene and abscisic acids are responsible for the senescence of cotyledons (Du et al., 2013). Mostly after 20th day the plants show branching and finally twines develop at the apical part of the branch that whorl around the supports. Twines often grow as small curls to find the presence of objects around them, they exhibit thigmotropism (Zainudin et al., 2022). By day 30th day some plants showed first blooms, following the elongation and whorling of the twines.

3. Result and Discussion

3.1 Evaluation of Plant Height Response to Vermicompost Treatments

The plant height was measured in centimeters from the ground level to the apical tip, excluding the root. The height of the plants was recorded for 30 days; subsequent measurements were discontinued due to the development of twines. Plants grown in vermicompost exhibited significant height development. Specifically, samples C2 (56.67 ± 2.52 cm), C6 (54 ± 1.53 cm), C1 (51.67 ± 4.51 cm), and C7 (50.33 ± 2.08 cm) showed greater heights compared to the control sample C0 (35.67 ± 2.08 cm). The enhanced growth observed in the plants can primarily be attributed to the synergistic effects of improved nutritional availability, the presence of biostimulants, and increased microbial activity. Nutritional availability ensures that essential macro and micronutrients are accessible in optimal quantities, supporting physiological processes and biomass accumulation. Manivannan et al., 2015 & Tanuja et al., 2019 reported that the plant growth is mainly attributed to the microbial activity that improves nutrient availability and the presence of biostimulants in the vermicompost intensify the metabolic activities and stress tolerance facilitating enhanced plant growth. Figure 1. Demonstrates the plant height under vermicompost and control treatments of different combinations from C0 to C16. Maximum plant height was observed in samples C1 to C8 (BLB: CW - 1:1 & 1:2), this might be due to the nearly equal concentrations of cattle waste and leaf biomass used in the treatment. The use of this mixture improved soil conditions and nutrient availability stimulating plant growth. Studies on growth of *Vigna unguiculata* by Zalaghi et al. 2019 detailed that the use of combined form of animal manure and vermicompost leads to

increased growth parameters than when either of the amendments was added alone.

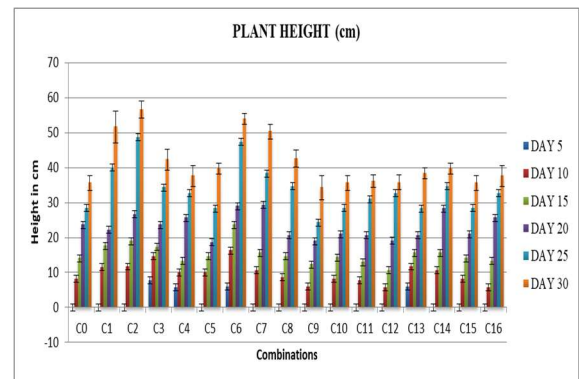


Figure 1. Represents the outcome of the plant height of *Vigna unguiculata* subsp. *Sesquipedalis* on the application of vermicompost. Data in the figure are presented as mean \pm standard deviation (SD).

3.2 Effects of Vermicompost on Leaf Development

On application of the vermicompost of various proportions to *Vigna unguiculata* subsp. *Sesquipedalis*, the leaf development parameters such as number of leaves formed, its growth and expansion was studied. When compared to the control plant, the plants provided with vermicompost showed increased leaf development marked by improved leaf colour due to the presence of sufficient chlorophyll, larger flattened leaves and increased leaf count. Vermicompost provides the plants with nutrients rich in minerals, and microbial population leading to improved vegetative growth and photosynthetic efficiency. During the study period of 30 days, the total number of leaves ranged from 13.67 ± 3.57 to 27 ± 4.58 . The highest leaf counts were recorded in the combinations C6 (27 ± 4.58), C3 (26 ± 3.0), C7 (25 ± 4.01), and C2 (24 ± 4.58). From the results obtained it is visible that the combined effect of the mineral nutrients and microflora in the vermicompost has profound result in leaf growth parameters. Hence the application of vermicompost not only benefits plant height but also contributes to the development of healthy leaves which is very essential for plant metabolism and physiological development.. Figure 2. Demonstrates the number of plant leaves developed on the usage of vermicompost and control treatments across different combinations from C0 to C16. Figures 3a, 3b, and 3c show the germination, developmental stages, and pod emergence of plants treated with C2, C3, and C6, respectively.

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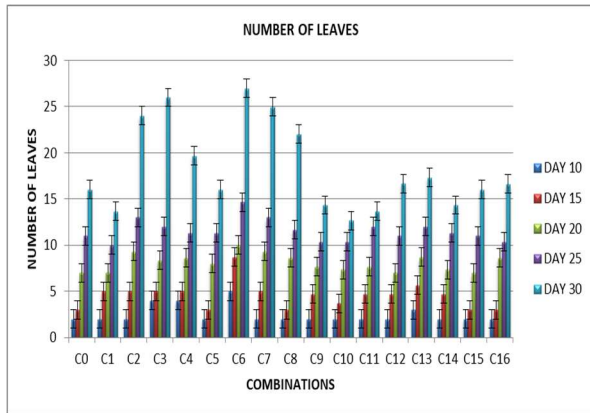


Figure 2. Effect of vermicompost application on the leaf number of *Vigna unguiculata* subsp. *sesquipedalis*. Data are presented as mean \pm standard deviation (SD).

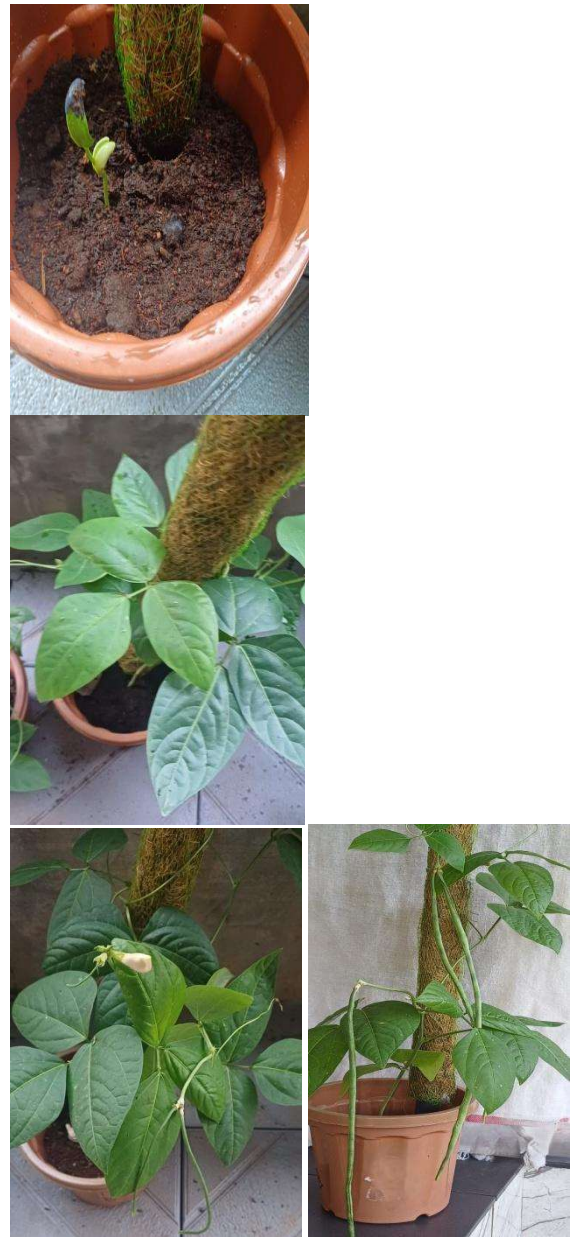


Figure: 3a. *Vigna unguiculata* subsp. *sesquipedalis* germination and development stages in treatment C2 with red soil+ Vermicompost (1:1 BLB: CW with 10% AZ)



Figure: 3b. *Vigna unguiculata* subsp. *sesquipedalis* germination and development stages in treatment C3 with red soil+ Vermicompost (1:1 BLB: CW with 20% AZ)



Figure: 3c. *Vigna unguiculata* subsp. *sesquipedalis* germination and development stages in treatment C6 with red soil+ Vermicompost (2:1 BLB: CW with 10% AZ).

3.3 Impact of Vermicompost on Root Development

In the present study, root length of *Vigna unguiculata* subsp. *sesquipedalis* measured 60 days after sowing showed significant improvement compared to the control. Over the 60-day study period, root length ranged from 11.67 ± 1.247 cm to 16.33 ± 1.247 cm. The control plants (C0) exhibited root lengths of 12 ± 0.707 cm. The longest roots were observed in treatments C3 (16.33 ± 1.247 cm), C6 (16 ± 0.816 cm), C4 (15.33 ± 1.247 cm), and C1 (15 ± 2.449 cm). These variations in root length can be attributed to the enhanced nutrient availability and improved soil conditions provided by the specific treatment combinations.

Previous studies on the root development of various vigna species such as *Vigna mungo* (Raihing 2022), *Vigna radiata* (Atakli et al., 2022) and root development in the seedling stages of both *Vigna mungo* and *Vigna radiata* (Bhattacharya., 2019) exhibited increased root growth when compared with the control plant roots. The presence of growth hormones such as IAA and gibberellins, micronutrients such as nitrogen, phosphorus and potassium along with essential micronutrients increases the length of roots. Figure 4 represents the

length of *Vigna unguiculata* plants when treated with vermicompost and control, ranging from C0 to C16.

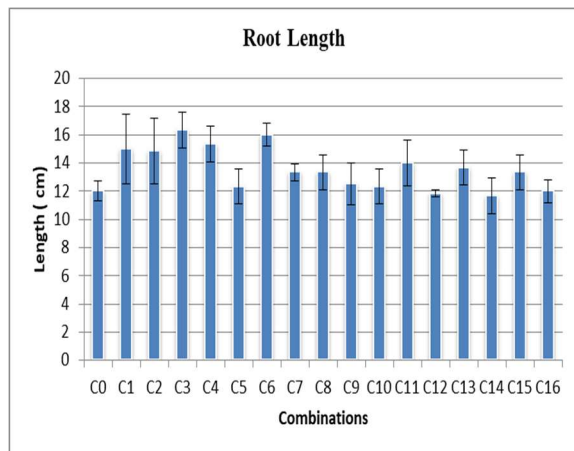


Figure 4. Illustrates the length of roots in *Vigna unguiculata* subsp. *Sesquipedalis* treated with different proportions of vermicompost and control. Mean \pm standard deviation (SD) is used to express the values.

3.4 Impact of Vermicompost on Pod Formation

On the 55th day of cultivation the number of pods formed in *Vigna unguiculata* subsp. *Sesquipedalis* was recorded. Highest number of pods was recorded in pots C2 (8.67 ± 0.58), C1 (6.67 ± 1.53), and C5 (6.33 ± 2.08), meanwhile the control pot (C0) showed a lower pod count 3.33 ± 0.58 . The number of pods formed in *Vigna unguiculata* subsp. *sesquipedalis* when treated with different proportions of vermicompost and the control from C0 to C16 is illustrated in Figure 5. There are variations in the number of pods among different treatments, this is attributed to the fact that application of vermicompost had a favourable impact in the pod formation due to the presence of essential mineral nutrients and growth promoters.

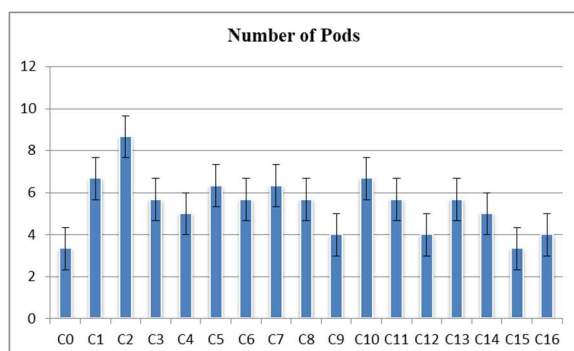


Figure 5. Represents the number of pods developed in *Vigna unguiculata* subsp. *Sesquipedalis* on application of vermicompost under different proportions and control. The value is expressed in mean \pm standard deviation (SD).

4. Conclusion

This study confirms that the application of vermicompost prepared from banana leaf biomass, cattle waste and azolla using *Eudrilus eugeniae* significantly enhanced the growth of yardlong beans (*Vigna unguiculata* subsp. *Sesquipedalis*). The idealized nutrient supply from banana leaves and cattle waste enriched with azolla substantially increased the plant growth most notable through their height, leaf development, root length and pod formation.

These findings highlight the value of converting agricultural residues into high-quality organic amendments through vermicomposting, offering a sustainable alternative to chemical fertilizers that promotes soil health and crop productivity in leguminous crops.

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