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Optimization Of Bean Plant Growth Through Vermicompost Derived From Sugarcane Waste Amended With Biochar

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Abstract
This study assesses the efficacy of vermicompost from sugar cane waste products such as Bagasse and Press mud amended with biochar, which is applied as a soil enhancer for bean plants (Phaseouls vulgaris). The earthworm Eudrilus eugeniae was used in the vermicomposting process to convert the sugar cane waste into nutrient-rich organic manure. Biochar is a carbon-rich material that can enhance soil properties and can retain nutrients which was incorporated to improve the quality and effectiveness of the vermicompost. A pot experiment of bean plants was conducted to assess the effectiveness of the produced vermicompost. The study examined various parameters such as height of the plant, length of the root, number and length of the pods. Findings indicated that the vermicompost amended with biochar significantly improved soil fertility, leading to optimum plant growth and pod yield. Notably, the combination enhanced with 4% biochar produced the most favourable result in the case of bagasse; however, 2% and 4% showed the highest outcome for press mud. This study emphasises the possible advantages of vermicompost amended with biochar to develop a sustainable and efficient soil amendment. This combination promotes resource recycling and enhancement of agricultural productivity.
Keywords: *Bagasse, Press mud, Biochar, Vermicomposting, Eudrilus eugeniae*

1. INTRODUCTION

Agriculture plays a crucial role in India, serving as the primary source of income and a significant sector for employment generation, thereby contributing to the country's economic growth. Sugarcane is the main cash crop and is grown in both tropical and sub-tropical regions of the country (1). There is various waste products obtained during the processing steps of sugarcane, such as sugarcane bagasse, sugarcane molasses, press mud, etc. Press mud, a byproduct resulting from the extraction or filtration of sugar from sugarcane juice, possesses significant agricultural potential and is abundant in organic matter and essential nutrients (2). The press mud, being insoluble, decomposes naturally but takes a prolonged time. As it decomposes, it emits a strong, unpleasant smell and generates excessive heat (3). The use of press mud as a source of agricultural and horticultural nutrients is very important due to its high content of various micronutrients (4). Besides being a significant source of nutrients, press mud expedites root uptake of nutrients, reinforces membrane integrity, and activates osmo-protectant processes (5). (6) noted that press mud can be used as a soil fertiliser and conditioner as it ensures better crop growth and crop maturity. The usage of press mud can notably reduce the cost of inorganic fertiliser.Sugarcane bagasse (SCB), the fibrous residue left after the extraction of juice for sugar production, is a valuable substrate component for agricultural producers. This material is mainly composed of cellulose, lignin, and hemicellulose, which indicates its potential utility as a substrate (7). The use of sugarcane bagasse can improve the physical structure of the soil and enhance microbial activity in it (8). Composted bagasse is cost-effective, nutrient-rich, and environmentally sustainable in production. It contains a high amount of nutrients essential for plant development, thereby improving the chemical, physical and biological characteristics of the soil (9). Additionally, bagasse may improve soil's water retention in nutrient-poor soils, augment organic matter contents and improve the concentration of critical nutrients that include potassium, nitrogen, and phosphorus for the growth and development of a plant (10).Mainly due to poor management practices, a large proportion of these by-products are incinerated in the fields. Therefore, it results in extensive environmental degradation coupled with health hazards. Recently, there has been an attempt to use sugarcane press mud and bagasse for economically viable and eco-friendly treatment techniques like vermicomposting. Vermicompost is the best fertiliser for organic farming as it is nutrient-rich and has good quality humus, plant growth hormones, enzymes, and crop protection substances from pests and diseases (11, 12). The earthworm can be used as a vermicomposting agent as it is an economical and accepted method to improve soil fertility through its use as a fertiliser in agriculture (13). In vermicomposting practice, choosing the right species of earthworm is very important because it determines both the effectiveness and the result of the process (14). Eudrilus eugeniae, widely referred to as the African nightcrawler, is highly regarded for its swift composting capabilities and its ability to handle various types of waste materials (15,14). For this study Eudrilus eugeniae was selected for the vermicomposting process. The introduction of additive materials into the composting process, which has contributed to the production of agronomically beneficial substrates has immensely driven the development of waste recycling technologies (16). The use of biochar in recent years has become very important for improving organic matter transformation efficiency and significantly mitigating the loss of nitrogen through the minimization of NH_3 and N_2O emissions in the composting process (17). Biochar is a carbon-rich organic material, acting as an organic fertilizer and being a byproduct of the pyrolysis process of biomass at high temperature and low oxygen availability (18). Biochar addition has been found to improve different soil properties such as ion exchange capacity, porosity, water retention, nutrient retention, and microbial activity (19). This study analyses the application of biochar as an amendment in the vermicomposting of sugar cane waste to determine its suitability. French bean (Phaseolus vulgaris L.) is recognised as a widely cultivated and nutritious leguminous vegetable globally (20). It serves as an excellent source of protein, carbohydrates, minerals, vitamin A, and calcium and plays a significant role in fulfilling the protein requirement of the vegetarian population (21). According to (22), green beans are nutritious vegetables that have a platter of nutritional values with strong flavors and rich amounts of proteins, vitamins, minerals, and dietary fibre. Additionally, they are free from cholesterol and have only trace amounts of sodium and fat. As such, these beans are a good option for those who seek a healthy diet. The consumption of beans has been linked to a decreased risk of ischemic heart disease and other cardiovascular conditions, as well as stomach and prostate cancers, obesity, and improvements in stress, anxiety, and depression among the elderly populations (23). The present study aims to promote the plant growth of common bean-Phaseolus vulgaris providing vermicomposting of sugarcane trash (Press mud and Bagasse) and cow dung amended with biochar. Some growth parameters such as shoot length, number of leaves, root length, length and number of pods were analyzed. The scope of this project encompasses the utilization of sugarcane waste, particularly bagasse and pressmud, as raw materials for producing vermicompost enriched with biochar. It explores how varying proportions of biochar impact soil fertility, nutrient holding capacity, and growth and yield of bean plants. The study seeks to show the feasibility of agro-industrial residue utilization in useful organic amendments that enhance the quality of soil and crop productivity and mitigate environmental pollution. Additionally, the research provides practical insights into sustainable agriculture activities by maximizing organic waste recycling and indicating the importance of biochar in upgrading vermicompost quality as well as in maintaining long-term soil carbon sequestration. The project is beneficial to farmers, scientists, and policy makers who are looking for environmentally friendly alternatives to enhancing soil management as well as for sustainable crop production.

2. Experimental Procedures

2.1Retrieval of raw materials

Collected press mud and bagasse from the Kallakurichi Co-operative sugar mill, Moongilthuraipattu, Tiruvannamalai, Tamil Nadu. Earthworm Eudrlius eugeniae collected from the VST natural farm, Kundumaranapalli, Hosur, Tamil Nadu. Fresh cow dung from an animal farm house near the site. Biochar collected from Greenfield Eco Solution. Common bean seeds bought from a local nursery in Hosur.

2.2 Vermicompost formulation

Pretreated sugarcane wastes (press mud and bagasse) were mixed with cow dung at different ratios which were 1:1,2:1, 3:1 along with 2%, 4%, and 6% biochar (Table 1). Composting was done in agro grow bags having holes in order to prevent excessive water and anaerobic conditions. In every bag, there were 2 kg of compost and 20 exotic Eudrilus eugeniae earthworms used for the process of vermicomposting. The bags were placed undisturbed in a dark environment at 25 ± 3 °C maintained between 60 and 70% humidity to favour vermicomposting.

Table-1. The combinations of vermicomposting of sugar cane wastes (Press mud and Bagasse) with cow dung and biochar. (PM-press mud. BG- Bagasse, CD- cow dung, BC- Biochar

Press mud combinations	Bagasse combinations
C1-PM+CD (1:1)	**C13**-BG+CD (1:1)
C2-PM+CD+ BC (1:1+2%)	**C14**- BG +CD+ BC (1:1+2%)
C3-PM+CD+ BC (1:1+4%)	**C15**- BG +CD+ BC (1:1+4%)
C4-PM+CD+ BC (1:1+6%)	**C16**- BG +CD+ BC (1:1+6%)
C5-PM+CD (2:1)	**C17**- BG +CD (2:1)
C6-PM+CD+ BC (2:1+2%)	**C18**- BG +CD+ BC (2:1+2%)
C7-PM+CD+ BC (2:1+4%)	**C19**- BG +CD+ BC (2:1+4%)
C8-PM+CD+ BC (2:1+6%)	**C20**- BG +CD+ BC (2:1+6%)
C9-PM+CD (3:1)	**C21**- BG +CD (3:1)
C10-PM+CD+ BC (3:1+2%)	**C22**- BG +CD+ BC (3:1+2%)
C11-PM+CD+ BC (3:1+4%)	**C23**- BG +CD+ BC (3:1+4%)
C12-PM+CD+ BC (3:1+6%)	**C24**- BG +CD+ BC (3:1+6%)

2.3Soil conditioning and sowing

A well-drained red loamy soil, combined with produced vermicompost (PM + CD + BC and BG + CD + BC) in a ratio of 3:1 (Soil 3: vermicompost 1), was utilized for planting. Bush bean seeds were sown in a grow bag measuring 30 × 15 cm at a depth of 1.3 cm with a spacing of two inches apart and one inch deep. The grow bags were positioned in a warm, sunny area. Throughout the experiment, the temperature was maintained at 25 ± 5°C while humidity levels were kept at 65 ± 5% after irrigation.

2.4Growth monitoring

Plant height and number of trifoliate leaves had been measured at the interval of five days of vegetative growth stage as it becomes the indicators of growth progression. The plant used in this study commenced to produce flower buds after a month and the young marketable pods were harvested after six weeks. The root was carefully separated from the soil and washed with water to remove its soil as much as possible. The length of the removed root was measured using a ruler in centimeters.

2.5Seed germination

Seed germination is the first step toward the successful establishment of crops (24). It determines the initial crop growth rate and plant density in order to achieve the best possible yield and profitability (25). Seed germination is a process that begins with the absorption of moisture by the dried seed and ends with the emergence of the seed. It involves two-time events, such as germination and seedling growth. Time taken to complete the germination is one of the most important parameters that determine the quality of a seed (26). In this study, within 5-12 days the beans split the outer seed pods open and began to germinate, shoots sprouted from the soil surface. The bean root system was started to be developed at this point and used to absorb water and nutrients from the soil to begin generating the first leaves.

Pressmud **Bagasse**

Figure 1. Seed germination in biochar-amended vermicompost derived from pressmud + cow dung and bagasse + cow dung.

2.6Seedling stage

After germination, the seed coat has opened and the radicle or embryonic root has released first in anchoring the seedling to the soil. The stem-initiated growth and pushed the cotyledons or seed leaves out of the ground. The cotyledons then split apart and the first true leaves started their development. This stage was characterized by the establishment of the root system, which supported the plant's growth and nutrient uptake.

Pressmud **Bagasse**

Figure 2. Seedling stage in biochar-amended vermicompost derived from pressmud + cow dung and bagasse + cow dung.

2.7Leaf Development

With time, the matured leaves resulted in the falling of cotyledons while the stem started to produce new leaves. The plant had its leaves with alternate orientation on the stem, which contained 3 ovate-shaped leaflets. More leaves were formed on the stem that result in the production of energy through photosynthesis, contributing more energy towards sustaining growth.

Pressmud **Bagasse**

Figure 3. Leaf development in biochar-amended vermicompost derived from pressmud + cow dung and bagasse + cow dung.

2.8Flowering

After a month, it developed tiny, delicate white flowers that bloomed in bunches on the stem. These flowers were a necessary part of the plant's reproduction system. The flowers possessed both male and female parts and could even self-pollinate.

Pressmud **Bagasse**

Figure 4. Flowering in biochar-amended vermicompost derived from pressmud + cow dung and bagasse + cow dung.

2.9Formation and maturation of pod

After a few days, the flowers had vanished while small pods were visible. They developed to full mature pods that carried ripening beans. Within about 10 days, the pods had become full matured and ready for harvesting. The pods continued growing and began to mature while the flowers emerged indicating other pods were in the developing process.

Pressmud Bagasse

Figure 4. Formation and maturation of pod in biochar-amended vermicompost derived from pressmud + cow dung and bagasse + cow dung.

3 RESULTS AND DISCUSSION

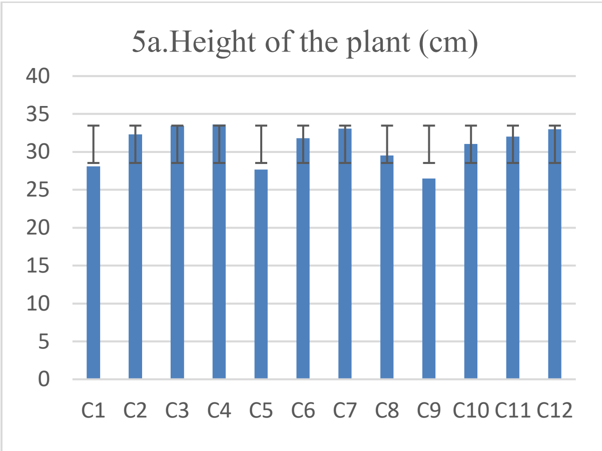
3.1Plant height

Plant height was measured at the 5 days of intervals and at centimeters from the surface it grows on to its top without involving the root. The plant heights for both press mud and bagasse treatments are presented in Tables 2. The average plants that were tallest were mostly seen in the organic amendments which utilized vermicompost combined with biochar whereas the shortest plants were found in the control group. Plant height of pressmud amended mixtures varied from 26.47 cm (C9) to 33.60 cm (C4) (Fig 5a). C4, C3, C12, and C7 had the maximum growth with values greater than 33 cm, reflecting optimal conditions for vegetative growth. C2, C6, C10, and C11 had moderate growth, whereas C5, C8, and C9 had comparatively less plant height. In general, pressmud treatments revealed consistent and increased plant growth, and a majority of mixtures reflected more than 30 cm plant height. Bagasse combinations had varied plant heights ranging from 21.00 cm (C21) to 32.47 cm (C15) (Fig 5b). There was significant growth in C15, C14, C19, and C13 with plant heights approximately or slightly above 30 cm, which reflects these combinations to be relatively more effective. There were however a number of combinations such as C17, C21, and C22 with highly stunted growth, proposing potential limitations to nutrient availability. The biochar-vermicompost complex is believed to enhance nutrient availability to plants by retaining nutrients in the soil which subsequently promotes increased plant height, leaf number, and leaf area (28. 29). According to (30) and (31) co-composted biochar has a great plant growth-promoting effect in comparison with pure biochar.

Table 2. Plant height of Phaseolus vulgaris treated with vermicompost from (a) Pressmud + Cow Dung + Biochar and (b) Bagasse + Cow Dung + Biochar. Values are expressed as mean ± SD.

Pressmud		Bagasse	
C1	28.08 ± 0.35	C13	30.37 ± 0.39
C2	32.30 ± 0.24	C14	30.93 ± 0.09
C3	33.47 ± 0.37	C15	32.47 ± 0.37
C4	33.60 ± 0.49	C16	27.75 ± 0.54
C5	27.67 ± 0.53	C17	21.77 ± 0.17
C6	31.80 ± 0.22	C18	24.20 ± 0.36
C7	33.07 ± 0.25	C19	30.67 ± 0.31
C8	29.53 ± 0.41	C20	29.77 ± 0.61
C9	26.47 ± 0.46	C21	21.00 ± 0.24
C10	31.03 ± 0.37	C22	23.88 ± 0.63

C11	32.00 ± 0.41	C23	25.83 ± 0.62
C12	33.00 ± 0.41	C24	27.73 ± 0.52



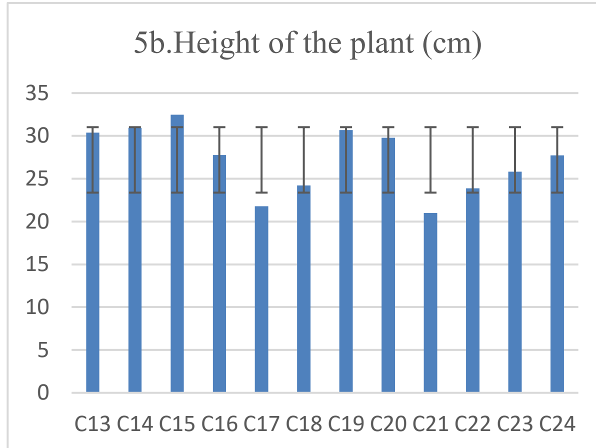


Fig 5. Effect of vermicompost application on the plant height of Phaseolus vulgaris: (a) Press mud + Cow Dung + Biochar, and (b) Bagasse + Cow Dung + Biochar. Values are presented as mean ± SD.

3.2 Number of leaves

The number of leaves on a plant is a significant characteristic that reflects its growth and development (32). Table 3 illustrated the number of leaves in the treatment of press mud and bagasse respectively. In the pressmud-amended combinations, the leaf number varied from 10.67 (C1) to 20.80 (C11) (Fig 6a). The maximum leaf numbers were observed in C11, C5, C12, C7, C8, and C10 which all had more than 19 leaves. Moderate leaf counts were present in C2, C3, C4, and C6 but were the lowest in C1 (10.67) and C9 (13.67). More variability was exhibited by the combinations based on bagasse with a leaf count of 11.10 (C21) to 18.47 (C20) (Fig 6b). The best responses were observed in C20 and C19, followed by C15 and C18. Nevertheless, some combinations C16 (11.20), C17 (12.57), C21 (11.10), and C23 (13.53) showed comparatively lower leaf numbers. The reduction in the number of leaves could be due to the greater lignocellulosic nature of bagasse, which retards degradation and release of nutrients. The availability of organic matter in vermicompost and biochar and their capacity to easily uptake nutrients and maintain soil moisture that eventually increases the number of leaves per plant. According to (33), the porous nature of biochar facilitates improved nutrient retention when combined with the nutrients from vermicompost which promotes robust leaf development and overall plant health.

Table 3. Number of leaves in Phaseolus vulgaris treated with vermicompost from (a) Pressmud + Cow Dung + Biochar and (b) Bagasse + Cow Dung + Biochar. Values are expressed as mean ± SD.

Pressmud		Bagasse	
C1	10.67 ± 0.47	C13	14.00 ± 0.41
C2	17.37 ± 0.52	C14	13.83 ± 0.24
C3	17.37 ± 0.39	C15	16.67 ± 0.47
C4	17.47 ± 0.66	C16	11.20 ± 0.59
C5	20.43 ± 0.42	C17	12.57 ± 0.42
C6	17.03 ± 0.29	C18	14.60 ± 0.43
C7	20.27 ± 0.31	C19	18.20 ± 0.43
C8	20.23 ± 0.56	C20	18.47 ± 0.37
C9	13.67 ± 0.47	C21	11.10 ± 0.45
C10	19.50 ± 0.41	C22	13.73 ± 0.21
C11	20.80 ± 0.59	C23	13.53 ± 0.41
C12	20.53 ± 0.41	C24	14.67 ± 0.47

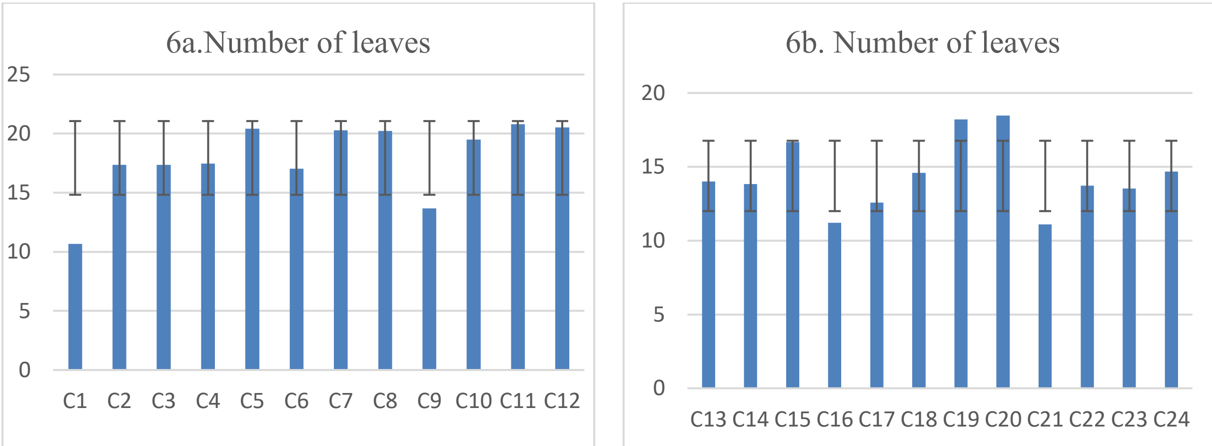


Fig 6. Effect of vermicompost application on the number of leaves of Phaseolus vulgaris: (a) Press mud + Cow Dung + Biochar, and (b) Bagasse + Cow Dung + Biochar. Values are presented as mean ± SD.

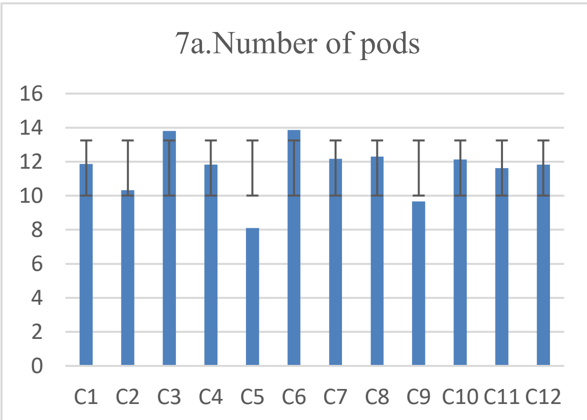
3.3 Number and length of pod

The length of the pod has a direct impact on the quantity of seeds produced as the longer pods yield a greater number of seeds (34). The pod length was measured using a ruler. The number of pods per plant in the biochar treatment group was significantly greater than that in the control group. The number of pods in the press mud and bagasse is displayed in Table 4. Pods per plant in pressmud-amended mixtures varied from 8.10 in C5 to 13.87 in C6 (Fig 7a). The maximum pod numbers were achieved in C6, C3, C10, C8 and C7, reflecting strong reproductive growth in these treatments. Medium pod counts were found in C1, C4, and C12. Lower pod formation occurred in C5 (8.10) and C9 (9.67). Overall, pressmud treatments promoted consistent and relatively high pod production. In bagasse-based combinations, pod numbers were more dispersed from 5.90 in C17 to 12.43 in C16 (Fig 7b). The combinations C16, C19, and C14 had comparatively high pod numbers, suggesting good reproductive growth. However, C17 (5.90), C18 (6.37), and C21 (7.93) had substantially lower pod counts, which could be attributed to reduced rates of nutrient release influenced flowering and pod formation. The length of pods in the press mud and bagasse is displayed in Table 5. Pod lengths in pressmud amended combinations varied from 9.33 cm for C10 to 10.73 cm for C6 (Fig.8a). Maximum pod length was seen in C6, C7, C1, C12, and C8. Pod lengths were moderate in C4, C5, and C9. The lowest pod was recorded in C10 (9.33 cm), followed by comparatively lower values in C2 (9.63 cm) and C11 (9.67 cm). Overall, pressmud treatments promoted uniform and generally longer pod development, with several combinations exceeding 10 cm. Pod length was more variable in the bagasse-based mixtures, varying from 8.47 cm in C17 to 10.93 cm in C19 (Fig 8b). The maximum pods were seen in C19, followed by C15, C22 and C13, reflecting strong growth performance in these configurations. The intermediate values were found in C23, C16, and C20. At the lower level, C17 (8.47 cm), C21 (8.53 cm), and C18 (8.83 cm) had shorter pods, reflecting potential nutrient constraints. (35) observed an increase in bean biomass and grain yield after the application of biochar and vermicompost. Furthermore, (36) reported that the incorporation of biochar and vermicompost positively influenced the yield of pod pepper.

Table 4. Number of pods of Phaseolus vulgaris treated with vermicompost from (a) Pressmud + Cow Dung + Biochar and (b) Bagasse + Cow Dung + Biochar. Values are expressed as mean ± SD.

Pressmud		Bagasse	
C1	11.87 ± 0.19	C13	10.50 ± 0.41
C2	10.33 ± 0.47	C14	10.67 ± 0.47
C3	13.80 ± 0.28	C15	11.53 ± 0.41
C4	11.83 ± 0.24	C16	12.43 ± 0.33
C5	8.10 ± 0.14	C17	5.90 ± 0.70
C6	13.87 ± 0.19	C18	6.37 ± 0.29
C7	12.17 ± 0.24	C19	12.23 ± 0.26
C8	12.30 ± 0.42	C20	10.20 ± 0.67

C9	9.67 ± 0.47	C21	7.93 ± 0.25
C10	12.13 ± 0.19	C22	8.50 ± 0.36
C11	11.63 ± 0.52	C23	9.83 ± 0.62
C12	11.83 ± 0.24	C24	10.73 ± 0.52



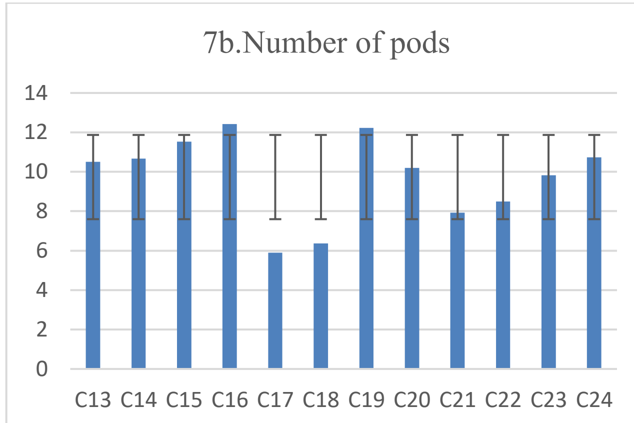
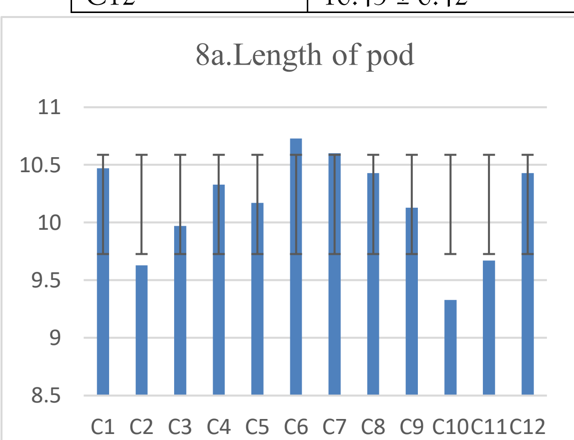


Fig 7. Effect of vermicompost application on the number of pods of Phaseolus vulgaris: (a) Press mud + Cow Dung + Biochar, and (b) Bagasse + Cow Dung + Biochar. Values are presented as mean ± SD.

Table 5. Length of pods in Phaseolus vulgaris treated with vermicompost from (a) Pressmud + Cow Dung + Biochar and (b) Bagasse + Cow Dung + Biochar. Values are expressed as mean ± SD.

Pressmud		Bagasse	
C1	10.47 ± 0.41	C13	10.40 ± 0.37
C2	9.63 ± 0.39	C14	9.80 ± 0.16
C3	9.97 ± 0.37	C15	10.47 ± 0.41
C4	10.33 ± 0.47	C16	9.90 ± 0.37
C5	10.17 ± 0.24	C17	8.47 ± 0.37
C6	10.73 ± 0.52	C18	8.83 ± 0.24
C7	10.60 ± 0.54	C19	10.93 ± 0.33
C8	10.43 ± 0.42	C20	9.87 ± 0.19
C9	10.13 ± 0.66	C21	8.53 ± 0.41
C10	9.33 ± 0.53	C22	10.47 ± 0.37
C11	9.67 ± 0.34	C23	10.27 ± 0.52
C12	10.43 ± 0.42	C24	9.80 ± 0.20



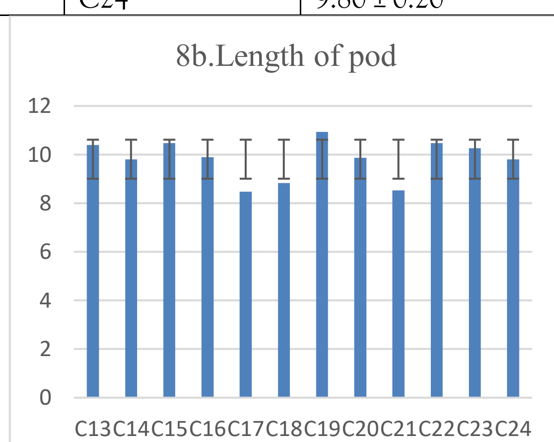


Fig 8. Effect of vermicompost application on the pod length of Phaseolus vulgaris: (a) Press mud + Cow Dung + Biochar, and (b) Bagasse + Cow Dung + Biochar. Values are presented as mean ± SD.

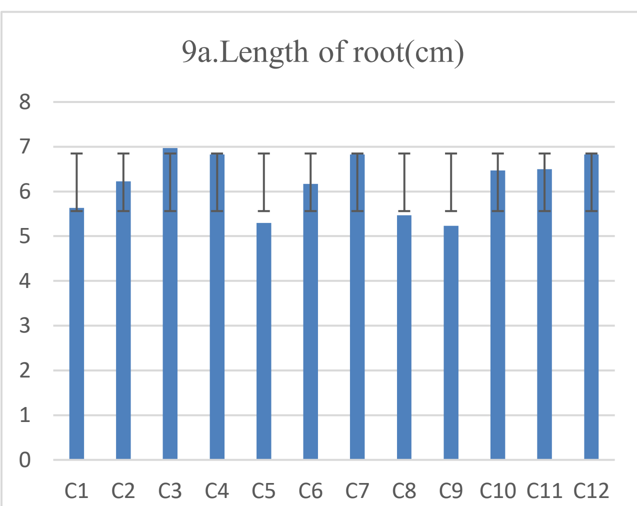
3.4 Length of root

The root is a basic organ for the multisensory perception of the environment (37). The length of root is indicated in Table 6. The root length in pressmud amended combinations varied between 5.23 cm in C9 and 6.97 cm in C3 (Fig 9a). The maximum roots were recorded in C3, C4, C7, C12 and C11. Moderate root lengths occurred in C10, C2 and C6. Shorter roots were observed in C1 (5.63 cm), C8 (5.47 cm), C5 (5.30 cm), and C9 (5.23 cm). As a whole, pressmud treatments promoted satisfactory root growth, with some combinations of over 6.5 cm.

In bagasse-based combinations, root length varied more noticeably, ranging from 4.13 cm in C17 to 6.47 cm in C14 (Fig 9b). The greatest root lengths were recorded in C14, C23, C15, C19, and C13. Lower root lengths were recorded in C17 (4.13 cm), C18 (4.23 cm), C21 (4.57 cm), and C16 (4.87 cm), possibly due to a lack of nutrient availability. A study on eggplant under deficit irrigation conditions reported that the combination of biochar and vermicompost enhanced root fresh weight, indicating better root growth (38). The synergistic effects of biochar and vermicompost are noteworthy as vermicompost supplies essential nutrients while biochar enhances cation exchange capacity and carbon sequestration over the long term (39, 36). Henceforth, this study suggests that vermicompost amended with biochar has a significant impact on bean growth, yield, and quality.

Table 6. Root length of Phaseolus vulgaris treated with vermicompost from (a) Pressmud + Cow Dung + Biochar and (b) Bagasse + Cow Dung + Biochar. Values are expressed as mean ± SD.

Pressmud		Bagasse	
C1	5.63 ± 0.66	C13	5.50 ± 0.41
C2	6.23 ± 0.53	C14	6.47 ± 0.37
C3	6.97 ± 0.46	C15	5.80 ± 0.22
C4	6.83 ± 0.69	C16	4.87 ± 0.29
C5	5.30 ± 0.29	C17	4.13 ± 0.34
C6	6.17 ± 0.46	C18	4.23 ± 0.76
C7	6.83 ± 0.29	C19	5.43 ± 0.25
C8	5.47 ± 0.78	C20	4.70 ± 0.22
C9	5.23 ± 0.26	C21	4.57 ± 0.42
C10	6.47 ± 0.46	C22	4.97 ± 0.37
C11	6.50 ± 0.16	C23	5.67 ± 0.53
C12	6.83 ± 0.61	C24	5.50 ± 0.36



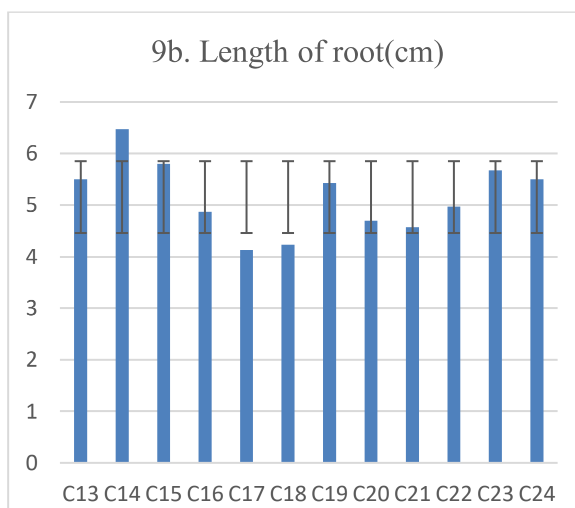


Fig 9. Effect of vermicompost application on the root length of Phaseolus vulgaris: (a) Press mud + Cow Dung + Biochar, and (b) Bagasse + Cow Dung + Biochar. Values are presented as mean ± SD.

4 CONCLUSION

This research validates that vermicompost produced from sugarcane waste, specifically bagasse and pressmud, enriched with biochar is a valuable organic amendment that significantly improves soil fertility and promotes healthy plant growth. The addition of biochar to vermicompost enhances these benefits by increasing nutrient retention, improving soil structure, and boosting overall plant yield. The greatest bean plant growth and yield were obtained with 4% biochar in bagasse-based vermicompost and with 2% and 4% biochar in pressmud-based vermicompost. These results emphasize that biochar addition with vermicompost is necessary for the optimal enhancement of soil health and crop performance. The use of vermicompost amended with biochar not only boosts nutrient cycling but also fosters sustainable agriculture by transforming agricultural by-products into valuable resources and mitigating environmental harm. This study recommends the field application of sugarcane waste in vermicomposting with biochar as an efficient method of enhancing soil quality and increasing crop yield. The study, in general, advocates for using these organic amendments as a viable method of resource recycling and sustainable farming.

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