



## Integration of Biochar-Banana Stem Compost: An Agronomic-Economic Evaluation for Brazilian Spinach Cultivation on Peat Soil

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**Abstract.** In addition to food crops, peatland also has potential for vegetable farming, such as Brazilian spinach. The aim of this study is to determine the most effective combination of banana stem biochar and banana stem compost doses for the growth and production of Brazilian spinach, as well as to analyze the feasibility of farming on peat soil. The research was conducted from October 2024 to March 2025 on land owned by farmers in Banyu Urip Village, Tanjung Lago District, Banyuasin Regency, South Sumatra. The Complete Randomized Factorial Design (CRFD) method was used in the study and consisted of two factors. The first factor was the dose of banana stem biochar: 5, 10, 15 tons/ha. The second factor was the dose of banana stem compost: 10, 20, 30, 40 tons/ha. Based on the results, the application of a combination of biochar and banana stem compost interacted significantly in increasing plant height (cm) and number of leaves (pieces) at 3 WAP and 4 WAP, as well as the fresh weight of Brazilian spinach plants at harvest. The length and fresh weight of Brazilian spinach roots at harvest were influenced by the main factors of banana stem biochar and banana stem compost. The combination of banana stem biochar and compost did not significantly increase the pH of peat soil. Based on the farming analysis, Brazilian spinach is viable to cultivate and provides the highest profit by applying 15 tons ha<sup>-1</sup> of banana stem biochar combined with 30 tons ha<sup>-1</sup> of banana stem compost.

**Keywords:** Carbon stabilization, Organic waste utilization, Peatland amelioration.

### 1. Introduction

Peatlands are one of the suboptimal lands commonly found in Kalimantan, Sulawesi, and Sumatra, composed of vegetation remains that have accumulated over a long period of time (Azhar *et al.*, 2025). Approximately 1.42 million hectares of peatlands in South Sumatra remain largely unused (Adli & Karmila, 2023). This large area of underutilized peatland highlights the urgent need for alternative and adaptable horticultural crops that can be sustainably cultivated under peat soil constraints, such as Brazilian spinach. Peatlands are characterized by low soil fertility, as indicated by acidic soil pH; very low availability of macronutrients such as N, P, and K; high soil CEC; and low wet saturation (Kunarso *et al.*, 2022). Peatlands are susceptible to changes in

characteristics, so caution is needed in managing them to prevent changes that reduce land productivity (Dharma *et al.*, 2025; Flood *et al.*, 2025). One way to overcome problems in peat soils is by adding soil amendments. Peat has great potential for agricultural cultivation. In addition to being used for food crops such as rice and secondary crops, it can also be used for horticultural crops, especially vegetables, such as Brazilian spinach. Despite the high potential of peatlands for horticultural crops, these limitations often result in restricted nutrient uptake, leading to inconsistent yields and low productivity of leafy vegetables when appropriate soil amelioration strategies are not applied.

Brazilian spinach, also known as *Alternanthera sissoo*, is a member of the Amaranthaceae family (Ellya *et al.*, 2021). Brazilian spinach is increasingly recognized as a nutritious leafy vegetable due to its high content of bioactive compounds and carotenoids, as well as vitamins C and K, folic acid, calcium, and iron (Ikram *et al.*, 2022). Compared to green spinach (*Amaranthus* spp.) or other commonly cultivated vegetables, there is limited understanding of how Brazilian spinach grows and produces biomass on peat soils, particularly under acidic conditions and low nutrient availability that are typical of peatland environments. Brazilian spinach can be a strategic option in expanding nutritious vegetable sources and strengthening national food security. Increasing Brazilian spinach production can be achieved through fertilization to meet the plant's nutrient requirements, especially in peatlands.

Fertilization is the addition of a substance to the soil with the aim of improving soil properties. One type of fertilization is the use of compost and biochar. Compost and biochar play complementary roles in improving peat soil quality. Compost increases soil microorganism activity and serves as a source of macro and micronutrients that are directly available to plants (Goldan *et al.*, 2023), while biochar improves soil structure, increases cation exchange capacity, and stabilizes carbon to prevent rapid decomposition (Li & Tasnady, 2023). The combination of the two has the ability to increase the pH of highly acidic peat soils, improve water retention, provide nutrients from compost in the short term, and maintain peat soil fertility in the long term thanks to the stable properties of biochar. Research by Kusuma *et al.* (2021) shows that applying 5t/ha of biochar with 5t/ha of manure can increase shallot production in peat soil while reducing carbon dioxide (CO<sub>2</sub>) flux. Zhou *et al.* (2023) recommend applying 10–20 tons/ha of biochar amended compost (BAC) to increase overall crop productivity. However, while biochar–compost applications in peatlands have been reported for various crops (Kusuma *et al.*, 2021; Zhou *et al.*, 2023), empirical evidence on their combined effects on the growth and yield of Brazilian spinach under peat soil conditions remains limited. on the combination of biochar and compost in peatlands, especially for Brazilian spinach cultivation.

Materials that have the potential to be used as biochar and compost are banana stems. This is because stems contain important elements for plants such as nitrogen (N), phosphorus (P), and potassium (K). Banana stem fibers contain 63% cellulose, 20% hemicellulose, and 5% lignin (There *et al.*, 2024). The results of a study by Alfarestu *et al.* (2025) state that kepok banana stem compost has a nitrogen content of 1.022%, phosphorus 0.45%, potassium 0.35%, organic carbon 21.22%, and a carbon/nitrogen ratio of 20.76%. In addition to being used as compost, banana stems also have the potential to be used as biochar. Banana stems have the potential to be used as biochar because they have a high lignocellulose content, in the form of cellulose, hemicellulose, and lignin, which are rich in carbon (There *et al.*, 2024). This content has great potential for the pyrolysis process, producing biochar with a stable carbon content that is durable in the soil.

In the village of Banyu Urip, Banyuasin Regency, banana plants are commonly found, but only the fruit is utilized, while the stems become waste after harvesting. Based on observations conducted in the village of Banyu Urip, research on the use of banana stems is needed as an ameliorant processed in the form of compost and biochar for Brazilian spinach cultivation, as well as the feasibility of farming on peatlands. The objective of this study is to find the most effective combination of banana stem biochar and banana stem compost doses for the growth and production of the best Brazilian spinach, as well as its suitability for cultivation on peatlands

## 2. Materials and Methods

The research was conducted from October 2024 to March 2025 on land owned by farmers in Banyu Urip Village, Tanjung Lago District, Banyuasin Regency, South Sumatra, which is characterized by a humid tropical climate with generally high rainfall and relatively stable warm temperatures typical of lowland peatland areas. The tools used in this research were writing instruments, sieves, hoes, scissors, wire, plastic labels, rulers, pH meters, zinc, smartphones, analytical scales, seedling trays, stoves, and waring. The materials used were water, Brazilian spinach from farmer, banana stems used for biochar and compost production, which derived from kepok bananas (*Musa acuminata*). 15:15:15 NPK compound fertilizer, polybags, and peat soil. The Complete Randomized Factorial Design (CRFD) method, consisting of two factors, was used to conduct this study. The first factor was the dose of banana stem biochar: B1 = 5 tons/ha, B2 = 10 tons/ha, B3 = 15 tons/ha. The second factor was the banana stem compost Dose: K1 = 10 tons/ha, K2 = 20 tons/ha, K3 = 30 tons/ha, K4 = 40 tons/ha. The experiment was repeated 4 times based on 12 treatment combinations. To identify the treatment levels that showed significant differences in response, data analysis was performed using Analysis of Variance (ANOVA) at a 95% confidence level, followed by a 0.05 LSD test.

This study began with the following steps: Biochar was produced from banana stems by cutting them into small pieces measuring approximately 5 to 7 cm, and air-drying them to reduce moisture content. Pyrolysis was conducted using a simple low-temperature pyrolysis method with a clay stove lined with wire and covered with zinc, under limited oxygen conditions, at approximately 200 °C for 3 h. This low-temperature pyrolysis approach was applied to produce biochar primarily as a functional soil amendment rather than a highly carbonized material. The resulting biochar was visually characterized by a deep black color with a light and brittle texture, then ground to obtain a finer particle size before application. Preparation of the planting medium involved collecting peat soil from a depth of 0-20 cm (topsoil). The research planting medium consisted of dried and sieved peat soil. Next, the soil was placed in 30 x 35 cm polybags weighing 3 kg. Brazilian spinach cuttings were sown using seedling trays filled with sifted and dried soil. Brazilian spinach cuttings measuring 5 cm were planted in seedling trays and grown for 10 days until the seedlings had 4-5 fully opened leaves and were free from pests and diseases. Biochar and compost were applied to the planting medium 7 days before planting. The biochar treatment doses were 7, 15, and 22 grams per 3 kg of peat soil, while the compost treatment doses were 15, 30, 45, and 60 grams per 3 kg of peat soil. Planting was carried out in polybag growing media by transferring uniformly grown Brazilian spinach seedlings. The base fertilizer used was NPK 15:15:15 compound fertilizer at a recommended dose of 5 g/plant. It was applied one week after planting. Plant maintenance consisted of watering in the morning and evening, weeding (removing weeds around the plants), replanting (replacing dead or non-growing plants), and pest control. Harvesting is done when the Brazilian spinach is 30 days old after planting (DAP). Harvesting can be done by slowly pulling out the plants up to the roots and cleaning them of any soil. The variables observed in this study were soil pH value, as the primary focus of the research was on plant growth, yield response, and economic feasibility of Brazilian spinach cultivation under different biochar–compost treatments. Soil pH was determined using a portable pH meter on soil–water suspensions, plant height (cm), number of leaves (pieces), fresh weight of production (g), fresh weight of roots (g), root length (cm), and analysis of the economic feasibility. The analysis was based on cost–benefit (B/C) ratio and revenue–cost (R/C) ratio calculations. Total production costs included variable costs, consisting of planting materials (Brazilian spinach cuttings), biochar and compost production inputs, fertilizers, labor costs for land preparation, planting, maintenance, and harvesting. Fixed costs were not included because the experiment was conducted at a small-scale farm level using existing farmer-owned land and simple equipment. Total revenue was calculated based on the fresh weight yield of Brazilian spinach at harvest multiplied by the prevailing local market price at the time of the study. The B/C ratio was calculated as the ratio between net benefit

(total revenue minus total cost) and total cost, while the R/C ratio was calculated as the ratio between total revenue and total cost. An R/C ratio greater than 1 indicates that the farming activity is economically profitable, whereas an R/C ratio equal to 1 indicates a break-even point, and a value less than 1 indicates an unprofitable activity.

### 3. Result and Discussion

#### 3.1. Soil pH Value

The combined application of banana stem biochar and banana stem compost had no significant effect on peat soil pH after harvesting. Both before and after planting, peat soil pH ranged from 5.5 to 6.5, which falls within the slightly acidic category. This relatively higher pH compared to typical acidic peat soils may be associated with the degree of peat decomposition and prior land management practices at the study site. Based on the soil analysis assessment criteria established by the Soil Research Institute in 2023. [Table 1](#) shows the average soil pH values before and after planting.

Table 1. Average soil pH values before and after planting.

Soil pH value before planting			
Compost Dose (K)	Biochar Dose (B)		
	B1 (5 tons/ha)	B2 (10 tons/ha)	B3 (15 tons/ha)
K1 (10 tons/ha)	5.83	5.93	5.88
K2 (20 tons/ha)	5.93	5.90	5.88
K3 (30 tons/ha)	5.90	5.98	5.90
K4 (40 tons/ha)	5.90	5.95	5.93
Soil pH value after planting			
Compost Dose (K)	Biochar Dose (B)		
	B1 (5 tons/ha)	B2 (10 tons/ha)	B3 (15 tons/ha)
K1 (10 tons/ha)	6.03	6.03	6.08
K2 (20 tons/ha)	6.03	6.08	6.10
K3 (30 tons/ha)	6.03	6.05	6.18
K4 (40 tons/ha)	6.03	6.03	6.08

Based on [Table 1](#), the average pH increase in each treatment combination was only 0.2 pH units. The dose of banana stem biochar and compost had no significant effect on peat soil pH, likely due to the high acid buffer capacity of peat soils. The very high soil pH value content of organic acids (fulvic, humic, and phenolic) creates an environment that is highly resistant to pH changes ([Ukalska-Jaruga et al., 2021](#)). These compounds release H<sup>+</sup> ions into the soil solution, creating an acidic environment (pH 5-6) and providing great resistance to pH changes ([Naz et al., 2022](#)). The addition of alkaline soil amendments, such as biochar, was not sufficient to neutralize the high concentration of organic acids present in peat soils due to their strong buffering capacity.

### 3.2.Plant Height (cm) and Number of Leaves (Leaves)

The absence of a significant interaction at 1–2 weeks after planting (WAP) is likely associated with the initial establishment phase of Brazilian spinach, during which root systems are still developing and nutrient uptake remains limited. During this early stage, plant growth primarily relies on internal nutrient reserves. As the plants enter the active vegetative growth phase at 3–4 WAP, root development becomes more extensive, enabling improved nutrient uptake. In addition, nutrient mineralization from banana stem compost and the gradual improvement of soil chemical conditions by biochar may require time before becoming available to plants, resulting in a delayed interaction effect on plant height and leaf number. Banana stem biochar and banana stem compost affect plant height and number of leaves, but the interaction is not apparent at 1 and 2 WAP, but is apparent at 3 and 4 WAP. This delayed interaction is thought to be related to the early growth phase of Brazilian spinach, during which the root system is still developing and nutrient uptake from soil amendments is still limited. As the plants grow, the roots develop more extensively, allowing for better nutrient uptake. In addition, the mineralization of nutrients from banana stem compost and the gradual chemical modification of the soil induced by biochar take time before having a measurable effect on plant growth. Figure 1 shows the average plant height (cm) from 1-4 WAP, and Table 2 shows the interaction of banana stem biochar-compost treatment on plant height at 3-4 WAP. The actual interaction of the banana stem biochar-compost treatment on the number of leaves at 3-4 WAP is presented in Table 3. Figure 2 shows the average number of leaves (pieces) from 1-4 WAP.

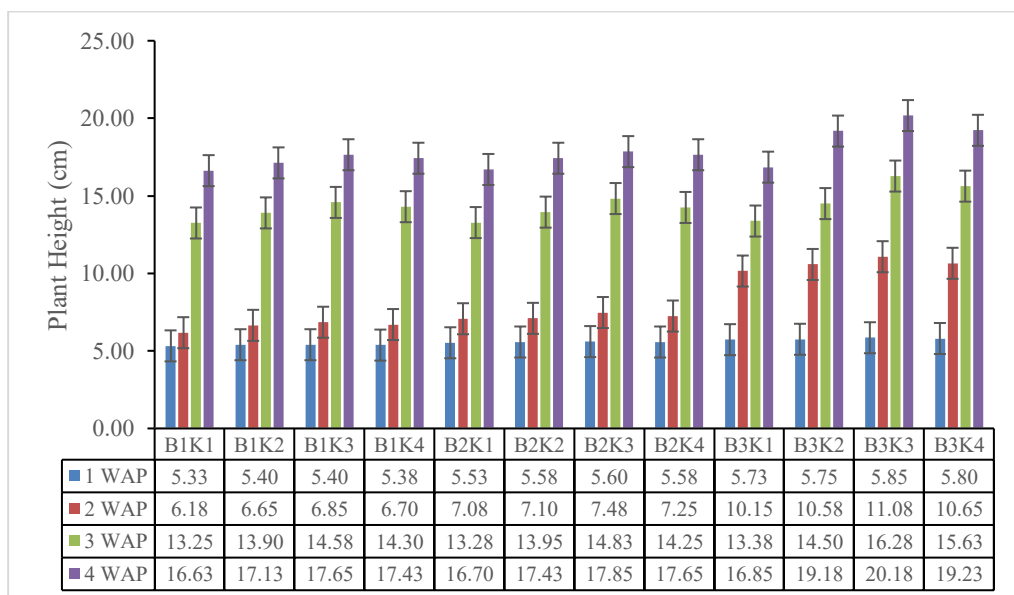


Figure 1. Graph of average height (cm) of Brazilian spinach each week

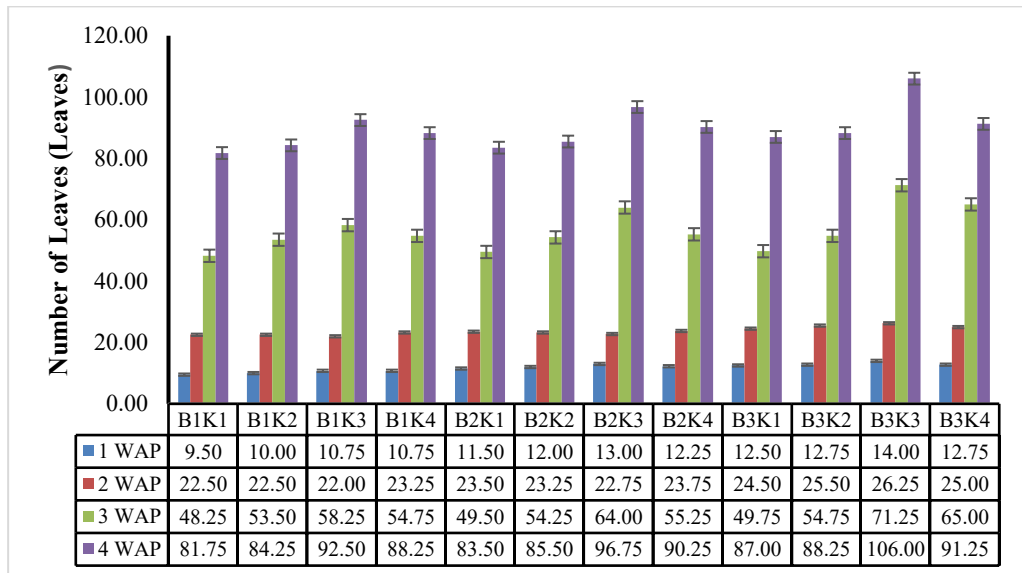


Figure 2. Graph showing the average number of Brazilian spinach leaves each week

Based on the results shown in Figure 1 and Figure 2, there was an increase in the number of plants and leaves each week from various treatment combinations. Treatment B3K3 (15 tons/ha of banana stem biochar with 30 tons/ha of banana stem compost) had the highest number of leaves and plant height, while treatment B1K1 (5 tons/ha of banana stem biochar with 10 tons/ha of banana stem compost) had the lowest number of leaves and plant height. The significant interaction between banana stem biochar-compost on plant height and number of leaves of Brazilian spinach is shown in Table 2 and Table 3. Treatment B3K3, consisting of 15 tons/ha of banana stem biochar and 30 tons/ha of banana stem compost, was the treatment combination that had the highest number of leaves and plant height at 3 WAP and 4 WAP and was significantly different from other treatment combinations in terms of number of leaves and plant height.

Table 2. Interaction effects of banana stem biochar and compost on plant height of Brazilian spinach at 3 and 4 weeks after planting (WAP)

3 WAP			
Compost dose (K)	Biochar 5 t ha <sup>-1</sup> (B1)	Biochar 10 t ha <sup>-1</sup> (B2)	Biochar 15 t ha <sup>-1</sup> (B3)
K1 (10 t ha <sup>-1</sup> )	13.25 a	13.28 a	13.38 ab
K2 (20 t ha <sup>-1</sup> )	13.90 b	13.95 b	14.50 c
K3 (30 t ha <sup>-1</sup> )	14.58 c	14.83 c	16.28 e
K4 (40 t ha <sup>-1</sup> )	14.30 bc	14.25 b	15.63 d
<b>LSD (0.05) = 0.56</b>			
4 WAP			
Compost dose (K)	Biochar 5 t ha <sup>-1</sup> (B1)	Biochar 10 t ha <sup>-1</sup> (B2)	Biochar 15 t ha <sup>-1</sup> (B3)
K1 (10 t ha <sup>-1</sup> )	16.63 a	16.70 a	16.85 a
K2 (20 t ha <sup>-1</sup> )	17.13 ab	17.43 b	19.18 d
K3 (30 t ha <sup>-1</sup> )	17.65 b	17.85 c	20.18 e
K4 (40 t ha <sup>-1</sup> )	17.43 b	17.65 bc	19.23 d
<b>LSD (0.05) = 0.72</b>			

Note: The LSD 0.05 test shows a significant difference in the numbers followed by different letters.

Table 3. Interaction effects of banana stem biochar and compost on leaf number of Brazilian spinach at 3 and 4 weeks after planting (WAP)

<b>3 WAP</b>			
<b>Compost dose (K)</b>	<b>Biochar 5 t ha<sup>-1</sup> (B1)</b>	<b>Biochar 10 t ha<sup>-1</sup> (B2)</b>	<b>Biochar 15 t ha<sup>-1</sup> (B3)</b>
K1 (10 t ha <sup>-1</sup> )	48.25 a	49.50 a	49.75 a
K2 (20 t ha <sup>-1</sup> )	53.50 b	54.25 b	54.75 b
K3 (30 t ha <sup>-1</sup> )	58.25 c	64.00 d	71.25 e
K4 (40 t ha <sup>-1</sup> )	54.75 b	55.25 b	65.00 d
<b>LSD (0.05) = 2.51</b>			
<b>4 WAP</b>			
<b>Compost dose (K)</b>	<b>Biochar 5 t ha<sup>-1</sup> (B1)</b>	<b>Biochar 10 t ha<sup>-1</sup> (B2)</b>	<b>Biochar 15 t ha<sup>-1</sup> (B3)</b>
K1 (10 t ha <sup>-1</sup> )	81.75 a	83.50 a	87.00 bc
K2 (20 t ha <sup>-1</sup> )	84.25 ab	85.50 b	88.25 cd
K3 (30 t ha <sup>-1</sup> )	92.50 e	96.75 f	106.00 g
K4 (40 t ha <sup>-1</sup> )	88.25 c	90.25 d	91.25 de
<b>LSD (0.05) = 3.13</b>			

Note: The LSD 0.05 test shows a significant difference in the numbers followed by different letters.

Tables 2 and Tables 3 indicate a clear interaction between banana stem biochar and banana stem compost at 3 and 4 WAP. At both observation times, increasing compost dose consistently enhanced plant height and leaf number, particularly when combined with higher biochar rates. The highest plant height and leaf number were observed at the combination of 30 tons ha<sup>-1</sup> compost and 15 tons ha<sup>-1</sup> biochar, while lower amendment rates resulted in significantly lower growth responses. These results demonstrate that the positive effects of compost on Brazilian spinach growth were amplified by biochar application, confirming the presence of interaction effects at later growth stages. Biochar acts as a stable carbon sink in peat soil while modifying the rhizosphere environment to support plant growth through improving nutrient availability, soil physical properties, and microbial activity (Mosa *et al.*, 2023). Research by Aminah *et al.* (2025) shows that the application of 100-200 g of biochar per polybag can increase pakcoy plant growth in peat soil. Meanwhile, banana stem compost is an organic fertilizer that provides essential nutrients for vegetative growth. These two combinations create an ideal growth environment, where the improvement in physical properties by biochar plays a role in better root development, so that the absorption of nutrients released from compost becomes more efficient and can be absorbed well by plants. The combination of biochar and biofertilizer in tomato plants can increase plant height and the number of leaves in peat soil (Alianti *et al.*, 2016). The combination of 15 tons/ha of banana stem biochar with 30 tons/ha of banana stem compost increases the number of plants and leaves of Brazilian spinach. This is because both are able to balance the stable carbon role of biochar, which improves the physical-chemical properties of peat soil, and compost provides nutrients quickly and supports microbial activity. This synergy not only increases nutrient

availability and absorption efficiency but also enriches soil carbon reserves, thereby directly increasing plant height and leaf number and supporting sustainable production on peatlands.

### 3.3. Fresh Weight of Plants

Banana stem biochar combined with banana stem compost had a significant effect on the fresh weight of Brazilian spinach at harvest. The average fresh weight of plants for each treatment combination is shown in Table 4. The fresh weight of Brazilian spinach plants treated with a combination of 15 tons/ha of banana stem biochar and 30 tons/ha of banana stem compost had the highest average and was significantly different from the fresh weight of Brazilian spinach in other treatment combinations.

Table 4. Average fresh weight of plants (grams) for each treatment combination

Compost Dose (K)	Biochar Dose (B)		
	B1 (5 tons/ha)	B2 (10 tons/ha)	B3 (15 tons/ha)
K1 (10 tons/ha)	132.88 a	133.63 a	134.53 a
K2 (20 tons/ha)	136.05 ab	138.45 b	138.90 b
K3 (30 tons/ha)	139.50 b	142.90 c	151.58 d
K4 (40 tons/ha)	138.78 b	139.70 bc	139.08 b

**LSD = 4.9**

Note: The LSD 0.05 test shows a significant difference in the numbers followed by different letters.

Based on visual and descriptive observations during the experiment, plants with greater height and higher leaf number generally exhibited higher fresh weight yield. The combination treatment of 15 tons/ha of banana stem biochar with 30 tons/ha of banana stem compost achieved the highest yield. The application of biochar to peat soil plays a crucial role in improving soil carbon stability and its aromatic carbon structure, which is resistant to decomposition, functioning as a carbon sink (Mosa *et al.*, 2023). The combination of increased carbon stability and optimal nutrient availability from banana stem compost creates an ideal rhizosphere environment for plant biomass synthesis, as seen in the increase in fresh plant weight. The results of the study by Nursia *et al.* (2024) show that the weight of soybean pods treated with biochar-compost at a ratio of 1:4 is higher than that of other treatments. This combination produces a synergistic effect where biochar maintains soil stability, while compost supplies nutrients, thereby supporting optimal growth and yield.

### 3.4. Root Length and Fresh Root Weight

The dose of banana stem biochar and banana stem compost, based on the results of variance analysis, each had a significant effect on root length and fresh root weight, but the two did not interact significantly. However, no significant interaction was observed, possibly because biochar mainly improved soil physical conditions, while compost primarily supplied readily available

nutrients. Table 5 shows the main effects of banana stem biochar and banana stem compost dose on root length and fresh root weight.

Table 5. Average root length and fresh root weight due to the main effects of biochar and banana stem compost

Biochar Dose (B)	Root length (cm)	Root weight (g)
B1 (5 tons/ha)	21.95 a	4.70 a
B2 (10 tons/ha)	22.26 ab	4.91 ab
B3 (15 tons/ha)	22.77 b	5.07 b
<b>LSD 0.05</b>	<b>0.481</b>	<b>0.257</b>

Compost Dose (K)	Root length (cm)	Root weight (g)
K1 (10 tons/ha)	21.12 a	4.67 a
K2 (20 tons/ha)	21.55 a	4.84 a
K3 (30 tons/ha)	23.94 c	5.16 b
K4 (40 tons/ha)	22.64 b	4.90 ab
<b>LSD 0.05</b>	<b>0.556</b>	<b>0.297</b>

Note: The LSD 0.05 test shows a significant difference in the numbers followed by different letters.

Table 5 shows that root length and fresh root weight of plants were on average influenced by the main factor of biochar, with the highest results found at a banana stem biochar dose of 15 tons/ha, but this was not significantly different from a banana stem biochar dose of 10 tons/ha. Although increasing compost dose generally enhanced root length and root fresh weight, the highest dose (40 tons/ha) did not result in further improvement compared to 30 tons/ha. This response suggests that an excessive organic amendment may have reduced soil aeration or increased moisture retention in peat soil, potentially limiting oxygen availability in the root zone. Moreover, high compost application rates may temporarily immobilize nutrients during microbial decomposition, thereby reducing nutrient availability for root growth. It is suspected that this biochar dose plays a role in increasing recalcitrant carbon with a porous structure. Peat soil has a high organic carbon content but is dominated by complex compounds (humic acid, fulvic acid, and lignin) that are difficult to decompose and therefore less available to plants (Paleckiene *et al.*, 2021). Biochar is widely reported to contain stable aromatic carbon, which may contribute to microaggregate formation and improvements in soil physical properties such as porosity and bulk density, thereby potentially supporting root development application of biochar introduces stable aromatic carbon into the peat system (Sharma & Kumar, 2023; Yameen *et al.*, 2024). The average root length and fresh root weight of plants due to the main effect of banana stem compost were found at a compost dose of 30 tons/ha. It is suspected that this dose is the appropriate compost dose and plays a role in supplying labile carbon (organic acids, sugars, polysaccharides) that directly becomes food for rhizosphere microbes. This microbial activity produces exudates (such as glomalin) and phytohormones (auxin and cytokinin) that stimulate the formation of lateral roots and root hairs, thereby increasing root biomass and plant root length (Liu *et al.*, 2023).

### 3.5. Economic Feasibility Analysis

An economic feasibility analysis of Brazilian spinach farming on peatlands was conducted to determine the profitability and feasibility of farming for future development. Table 6 shows the results of the economic feasibility analysis of the combination of biochar and banana stem compost doses on Brazilian spinach in peatlands for each treatment.

Table 6. Economic feasibility analysis of Brazilian spinach production

Treatment Combination	B/C Ratio	R/C Ratio	Remark
B1K1 (5 tons biochar/ha+10 tons compost /ha)	1.98	0.98	A viable but unprofitable business
B1K2 (5 tons biochar /ha+20 tons compost /ha)	2.02	1.02	A viable and profitable business
B1K3 (5 tons biochar /ha+30 tons compost /ha)	2.08	1.08	A viable and profitable business
B1B4 (5 tons biochar /ha+40 tons compost /ha)	2.07	1.07	A viable and profitable business
B2K1 (10 tons biochar /ha+10 tons compost /ha)	1.99	0.99	A viable but unprofitable business
B2K2 (10 tons biochar /ha+20 tons compost /ha)	2.06	1.06	A viable and profitable business
B2K3 (10 tons biochar /ha+30 tons compost /ha)	2.13	1.13	A viable and profitable business
B2K4 (10 tons biochar /ha+40 tons compost /ha)	2.08	1.08	A viable and profitable business
B3K1 (15 tons biochar /ha+10 tons compost /ha)	2.00	1.00	A viable business at break-even point
B3K2 (15 tons biochar /ha+20 tons compost /ha)	2.07	1.07	A viable and profitable business
B3K3 (15 tons biochar /ha+30 tons compost /ha)	2.26	1.26	A viable and profitable business
B3K4 (15 tons biochar /ha+40 tons compost /ha)	2.07	1.07	A viable and profitable business

Explanation:  $B/C > 1$  = Business is feasible to develop,  $B/C < 1$  = Business is not feasible to develop,  $B/C = 1$  = Business is still feasible to develop,  $R/C > 1$  = Business is profitable,  $R/C < 1$  = Business is loss-making,  $R/C = 1$  = Business is at break-even point.

Based on the economic analysis results shown in Table 6, all treatment combinations are feasible to continue and develop. Treatment B1K1 (5 tons/ha of banana stem biochar + 10 tons/ha of banana stem compost) had a B/C ratio of 1.98, which means that the farming business is feasible for development, but a R/C ratio of 0.98, which means that the farming business is not profitable. Treatment B2K1 (10 tons/ha of banana stem biochar + 10 tons/ha of banana stem compost) has a B/C ratio of 1.99, which means that the farming business is feasible to develop, but an R/C ratio of 0.99, which means that the farming business is not profitable. B3K1 (15 tons of banana stem biochar /ha + 10 tons of banana stem compost/ha) has an R/C ratio of 2.00, which means that the farming business is feasible to develop, but it has a B/C ratio of 1.00, which means that the farming business is at a break-even point. The B/C ratio and R/C ratio calculations produced the highest values for the B3K3 treatment combination (15 tons of banana stem biochar /ha + 30 tons of

compost /ha), namely 2.26 and 1.26, which means that the farming business is feasible and profitable.

Farming feasibility analysis is a step taken to determine whether a business is feasible to start or not, by considering a number of specific indicators or criteria. A business is considered feasible if the profits received are sufficient to cover all operational costs, both direct and indirect. The B/C factor shows the ratio between benefits and costs. If the ratio is greater than 1, the benefits are greater than the costs, indicating that the farming business is efficient and economically feasible (Triyono *et al.*, 2025). The revenue/cost ratio (R/C) is the ratio between total revenue and total production costs. If the value is greater than 1, the business is considered profitable and feasible to run. Conversely, if the value is less than 1, the business is not profitable (Aji & Priyono, 2025). From the results of this study, the combination that provides the greatest profit is B3K3 (15 tons of biochar/ha + 30 tons of banana stem compost/ha) because it provides the highest R/C and B/C ratios.

#### 4. Conclusion

This study demonstrated that the combination of banana stem biochar and banana stem compost significantly increased plant height and leaf number at 3–4 WAP, as well as the fresh weight yield of Brazilian spinach at harvest. Biochar and compost individually affected root length and fresh root weight, while their interaction was not significant for these parameters. The application of both amendments did not significantly alter peat soil pH under the conditions of this experiment. Economic analysis indicated that Brazilian spinach cultivation on peat soil is feasible, with the highest profitability obtained from the application of 15 tons/ha of banana stem biochar combined with 30 tons/ha of banana stem compost. Future studies are recommended to evaluate long-term soil physical and chemical changes and to assess the consistency of crop responses under different peatland conditions. The combination of biochar and banana stem compost did not significantly increase peat soil pH, likely due to the strong acid buffering capacity characteristic of peat soils. Future studies are recommended to evaluate long-term soil physical and chemical changes and to assess the consistency of crop responses under different peatland conditions.

#### Abbreviations

B/C Ratio	Benefit-Cost Ratio
LSD	Least Significant Difference
R/C Ratio	Revenue-Cost Ratio
WAP	Week After Planting

#### Data Availability Statement

Data will be available upon request

### Authors' Contribution

**Shabilla Amartiya Sari:** drafting, conceptualization, methodology, and resources. **Tri Putri Nur:** investigation, data curation, and resources. **Mulyadi:** investigation, data curation, and resources. **Lisa Amelia:** data curation, preparation, investigation, resources, and initial draft writing. **Nuni Gofar:** supervision, resources, conceptualization, and methodology.

### Declaration of Competing Interest

The authors declare that they have no conflict of interest or competing interests.

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