

The treatment combination of corn cob biochar and bio land organic fertilizer as soil amendment in kale plant (brassica oleraceae var. acephala L.)

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KEYWORDS

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ABSTRACT Kale is rich in vitamins and easy to cultivate, yet land degradation often occurs. The combination of corn cob biochar and Bio land organic liquid fertilizer as soil amendment materials can reduce land degradation. This study aims to determine a proper dose combination of corn cob biochar and Bio Land on growing and yielding Kale. Results showed that the treatment using the combination of corn cob biochar and Bio Land affected the number of leaves, fresh weight, and plant height. Corn cob biochar dose of 6 t/ha and Bio Land of 15 l/ha were shown significantly improved the number of kale leaves, which were 25.50 strands at 5 mst, chlorophyll of 51.42 spad units, leaf area of 1164.5 cm³, root volume of 10.40 cm³. Kale leaves also reached fresh weight of 200.46 g, and dry weight of 26.81 g. Both soil's physical and chemical properties were increased in the number of organic C, pH, nitrogen elements, and cation exchange capacity (CEC). The combination of corn cob biochar and Bio Land enhanced the growing and yielding of kale, in which the readily-available corn cob's and Bio Land's nutrients accelerated absorption. Higher dose of combination between corn cob biochar and Bio Land resulted in higher kale yield.

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1. INTRODUCTION

Kale belongs to the family of cabbage, kailan, and broccoli. It is considered as a new type of green vegetable, named "The Queen of Greens" because of its complete nutrients, is high in antioxidants, and can increase immunity in battling the current Covid-19 pandemic (Thavara-jah et al., 2021). Kale can be planted in both the high and low lands. The morphological structure of kale is similar to kailan, with curlier and smoother leaves (Samec et al., 2019). A study shows that vegetables from the genus Brassica contain several minerals and vitamins to support a healthy diet. Kale, similarly, can reduce the risk of cancer and other chronic diseases (Samec et al., 2018).

The phytopharmaceutical research results of kale shows that the plant contains 100 grams of nutrients, including 49 kcal calories, 0.9 g fat, 38 mg sodium, 491 mg potassium, 9 g carbohydrates, 4.3 g protein, 9.990 UI vitamin A, 120 mg vitamin C, 150 g calcium, 1.5 mg iron, and 47 g magnesium. It is evident that kale is highly beneficial, especially in increasing the body's immune system, as well as preventing deficiencies of vitamin A, B, and C. However, further potential for this nutritional content has not been developed (Miglozzi et al., 2015; Siva et al., 2019; Pathirana et al., 2017).

Research on kale plants was scarce while decreases in soil fertility (land degradation) caused by various factors requires further investigation. Multiple ways have been carried out to maintain the stability of soil fertility, includ-

ing the application of biochar (biological charcoal) as a soil amendment. Biochar applications can supply soil nutrients, so that land structure can be maintained and land productivity will be increased (Yuniwati, 2018).

Among Biochar's special characteristics are its capability of retaining water and nutrients, reducing pollution, increasing cation exchange capacity (CEC), stabilizing pH, and increasing soil microorganisms. These features highly support plant growth and yield. Biochar's raw materials are coming from various kinds, including the results of complete combustion process of agricultural waste, such as plant waste and corn cobs. The application of Biochar can increase soil fertility, especially in meeting nutrient needs such as physical and chemical properties of the soil. Improvements in nutrient occurs within 0-10 cm layer, which serves to minimize leaching of nutrients, especially the loss of potassium and nitrogen (Yuannto & Utomo, 2018; Yuniwati, 2018; ?).

Biochar improves soil fertility that is damaged by the excessive use of inorganic fertilizers and chemical pesticides. Biochar helps restore the composition of soil nutrients, in which its pivotal role as a soil amendment is supported by its content and composition. Biochar includes relatively stable carbon compounds. It also has a high affinity for cations that is useful for reducing soil degradation, accelerating sustainable food production (?Mahmoud et al., 2019; Yuniwati, 2018).

Another soil amendment material is Bio Land liquid fertilizer. It comes from cow's urine and faeces that con-

tains several nutrients. Bio Land can react quickly due to its volatile feature, so it can be absorbed by plants more quickly and reacting perfectly in the soil. However, the volatile characteristic of Bio Land requires special application. When being applied, the soil around the plant needs to be loosened to result in effective POV that is environmentally friendly (Achmad et al., 2010; Gore et al., 2011; Adeside et al., 2020).

Among the advantages of Bio Land is quick overcome of nutrient deficiency, easy to make, and low price. Bio-urine liquid fertilizer contains more nitrogen, phosphorus, potassium, and water than solid cow faeces (Adrian et al., 2019; Ogunkeyede, 2020). Bio Land requires lesser volume of use, which is more efficient than solid organic fertilizer. Its application is also easier through spraying or watering (Ogunkeyede, 2020). Fermented Bio Land contains soil nutrients, including nitrogen, which accelerates the vegetative growth of plants. High organic C content is beneficial to improve the structure of soil organic content where the phosphorus stimulates root growth (Nobile et al., 2020).

2. METHOD

This present research was carried out in February 2020, in Pandesari, Pujon, Kabupaten Malang. The materials used were kale seeds, corn cobs biochar, and Bio Land liquid fertilizer from cow's feces. This present research employed completely randomized design (CRD) consisting of 6 treatments, namely:

1. (B1) 3 t/ha + Bio Land 15 l/ha 2. (B2) 6 t/ha + Bio Land 15 l/ha 3. (B3) 9 t/ha + Bio Land 15 l/ha 4. (B4) 3 t/ha + Bio Land 30 l/ha 5. (B5) 6 t/ha + Bio Land 30 l/ha 6. (B6) 9 t/ha + Bio Land 30 l/ha Each treatment was repeated 4 times and consisted of 3 plant samples. The observed variables were the root volume (cm³), number of leaves (strands), leaf area (cm²), leaf chlorophyll content (spad unit), plant fresh weight (g), and plant dry weight (g). Observational data were analyzed by using the BNJ test at 5% level.

3. RESULTS

The combination of corn cob biochar and Bio Land as a soil amendment on kale (*Brassica oleraceae* var. *acephala* L.) showed significantly different results. From the observation of leaf number, chlorophyll amount, leaf area, fresh weight, and dry weight, it can be seen that the application of corn cob biochar and Bio Land increased the production and yield of kale. This proves that corn cob biochar and Bio Land increased plant's macronutrients, soil fertility, and soil amendments.

3.1 The root volume, and the fresh and dry weight of kale

Results from further test analysis on the number of leaves (strands), chlorophyll amount, and leaf area showed that the combination of corn cob biochar and Bio Land grew plants significantly between treatments, as presented in Table 1.

The table shows that the combination of corn cob biochar and Bio Land had significant effect on the number of leaves on B2 treatment, namely 6 t/ha and 15 l/ha. The mean number of leaves were 1 ms (9.00), 2 ms (12.58), 3 ms (15.50), 4 ms (21.58) and 5 ms (25.50). The increase in the number of kale leaves to 5 mst proved that the combination of corn cob biochar and Bio Land improved the soil quality

TABLE 1. The effects of combination of corn cob biochar and Bio land on the number of leaves number, chlorophyll amount, and leaf width

corn cob biochar (t/ha) + bio land (l/ha)	Leaves(mst)					chlorophyll amount (spad unit)	leaf width (cm ²)
	1	2	3	4	5		
3 + 15 (B1)	6,59 b	9,42 b	11,38 b	12,96 c	17,08 b	43,45 c	631,5 b
6 + 15 (B2)	9,00 a	12,58 a	15,50 a	21,58 a	25,50 a	51,42 ab	1164,5 a
9 + 15 (B3)	6,25 b	8,67 b	11,42 b	17,04 abc	22,08 ab	45,68 bc	651,3 b
6 + 30 (B5)	7,25 b	10,42 ab	13,71 ab	19,71 ab	24,34 a	52,39 a	714,5 b
9 + 30 (B6)	6,17 b	8,50 b	11,75 b	15,79 bc	20,21 ab	47,34 abc	678,5 b
BNJ 5%	1,46	2,99	3,68	5,53	6,57	6,45	420,7

for kale. In this case, the biochar's impact on the macro and micro nutrients in the soil improved the soil function as a medium that supports plant vegetative growth (Yuannto & Utomo, 2018; Yuniwati, 2018; Kumar et al., 2019; Verruma-Bernardi et al., 2021).

The combination of corn cob biochar at 6 t/ha and Bio Land at 30 liters/ha l(B5) resulted in the improved chlorophyll amount of 52.39 spad units. This evidenced that the treatment (B5) resulted significantly different from others. Additions in the combination of corn cob biochar and Bio Land positively increased plant's nutrients and absorption in the photosynthesis process (Yuniwati, 2018; Carter et al., 2013).

Accordingly, the leaf width also improved from the combination of 6 t/ha corn cob biochar and 15 l/ha (B2) Bio Land (B2) with 1165.5 cm². It was significantly different from the combination given at other doses. This was because the wider the leaves, the more sunlight would be captured by plants to carry out photosynthesis. It was also because the plant leaves did not shade each other. Well-absorbed sunlight at all doses of the combination treatment of corn cobs biochar and Bio Land affected the physiological processes of plants, especially the photosynthesis process. This influenced the photosynthate produced as shown in the fresh weight and dry weight of the plant (Carter et al., 2013; Emongor et al., 2004)

Overall, Table 1 shows that the combination of corn cob biochar and Bio Land significantly affected all observed variables, including the average number of leaves 1, 2, 3, 4 and 5 mst, chlorophyll amount, and leaf width. It is evident that the more organic matter given, the more optimal plant growth obtained along the increase of plant's macro nutrients. The application of corn cob biochar retained more macro nutrients in the soil. Among the roles of corn cob biochar was acting as a medium for the growth of microorganisms to bind P, and bacteria to bind N, and to maintain macronutrients in the soil (Yuannto & Utomo, 2018). The main factor forming chlorophyll is nitrogen (N), in which element N is a macro nutrient needed by plants as the chlorophyll constituent. The combination of treatments with a dose of 6 t/ha corn cob biochar and Bio Land of 15 l/ha (B2) was able to optimize plant growth and production, with

an increase in leaf number and leaf width, and chlorophyll amount of 51.42 spad units (Qureshi & Wani, 2014; Ashenafi & Tewodros, 2018).

The process of photosynthesis occurred in the leaves produced photosynthate, which was translocated to the vegetative organs of plants, namely stems, roots and leaves. Photosynthate increased the number of leaves as an indicator of plant growth. The increase in the number of leaves signified the process of cell division and enlargement of the photosynthetic results of plants. The results of photosynthate translocated to kale leaves shown in the number of leaves on weeks 1, 2, 3, 4, and 5 were significant after planting. This was because leaf formation was influenced by the absorption and availability of nutrients (Carter et al., 2013; Dunshin et al., 2016). Corn cob biochar was able to retain nutrients and prevent water loss due to leaching. They improved soil properties, and optimized plant growth and production. Overall, corn cob biochar and Bio Land together had a significant effect on the growth of kale. In this phase, all leaves, roots, and branches began to stop growing, followed by the development of the adult/ generative phase. It was the phase where the plant grew from the initiation of the first flower to harvest (Pereira et al., 2020; Tikasz et al., 2019).

Accordingly, leaves serve as a place for absorption and conversion of sunlight through the process of photosynthesis, and as a source of food production for plant growth, development, and production. The process of photosynthesis is influenced by environmental factors, such as temperature and humidity. The average daily temperature during the study was 26 °C, while the average daily humidity during the study was 79%. These factors had a major role in the growth process because they affected plant metabolic activities. Temperature influenced several plant physiological activities, such as root growth, uptake of nutrients and water in the soil, photosynthesis, respiration and photosynthetic translocation (Antonious et al., 2018; Hasan, 2018).

In this case, the use of Bio Land increased the availability of nutrients, especially N, P, and K, and also other nutrients to proceed photosynthesis optimally. The combination of corn cob biochar at 6 t/ha and Bio Land at 30 l/ha resulted in 52.39 spad units. This showed that the more organic matter given, the more optimal growth would be obtained. This indicated the availability of adequate nutrients capable of increasing chlorophyll amount, especially macro nutrients (Stoimenov et al., 2015; Limantara et al., 2015). Biochar application increased the numbers of macro nutrients in the soil. Biochar also served as a habitat to support faster growth of microorganisms as P, and fixed bacteria as N to maintain macro nutrients in the soil. The main factor forming chlorophyll is nitrogen (N) as a macro nutrient that constitutes chlorophyll (Yuniwati, 2018; ?; Barickman et al., 2020; Das et al., 2015).

Leaves are the main organs of plants because they host the photosynthesis process. A plant's ability to carry out photosynthesis is largely determined by the leaf's width for larger leaves capture more sunlight (Carter et al., 2013; Antonious et al., 2018; Wijitkosum et al., 2019). It was shown in Table 1 that the highest mean of kale leaf's width (1164.5 cm_2) is resulted from the combination of corn cob biochar treatment at a dose of 6 t/ha, and Bio Land at 15 l/ha (B2). This was primarily because the availability of nutrients helped the formation of the vegetative part of the plant. Wider leaves captured more sunlight, and thus accelerate

TABLE 2. The effect of combination of corn cob biochar and Bio Land on root volume, and the fresh and dry weight of kale.

Combination of corn cob biochar (t/ha) + Bio Land (l/ha)	Root volume (cm^3)	Fresh weight (g)	Dry weight (g)
3 + 15 (B1)	5,40 ab	93,98 b	11,41 b
6 + 15 (B2)	10,40 a	200,46 a	26,81 a
9 + 15 (B3)	4,63 b	103,27 b	11,87 b
3 + 30 (B4)	5,80 ab	102,69 b	12,32 b
6 + 30 (B5)	8,85 ab	114,18 b	14,25 b
BNJ 5 %	5,39	84,12	11,05

photosynthesis. In this case, well-absorbed sunlight at all doses of the combination of corn cobs biochar and Bio Land affected plant's physiological processes, enhancing photosynthesis process. This ultimately affected the photosynthate products as shown in both fresh and dry weight of the plant (Naik et al., 2010; Das et al., 2015).

3.2 The root volume, and the fresh and dry weight of kale

The observation aimed to study the root volume, and the fresh and dry weight of kale (*Brassica oleracea* var. *acephala* L.) after treated with the combination of corn cob biochar and Bio Land as soil amendments. The results are presented in the following table 2.

Results from the combination of corn cob biochar at 6 t/ha and Bio Land at 15 l/ha (B2) were the highest yield of 10.40 cm^3 , which was significantly different from other treatments. Root volume was an important element because the cell surface of root hairs played a critical role in the absorption process. The quantity of nutrients reached the root surface through mass flow was influenced by several factors, such as the properties of the growing media, climate conditions, nutrient solubility, and plant species (Hasan, 2018; Antonious et al., 2018; Carter et al., 2013). Such properties were obtained from the improved soil fertility and soil amendments from corn cobs biochar and Bio Land (Yuannto & Utomo, 2018; Yuniwati, 2018).

The mean value of the highest root volume after the combination of corn cob biochar at a dose of 6 t/ha and Bio Land at 15 l/ha (B2) was 10.40 cm^3 . This showed that combined treatment improved soil's chemical properties, so that more nutrients are available and increasing the growth of roots. Nutrients were more easily absorbed by roots, in which more nutrients were retained, ultimately increasing plant's fresh and dry weight (Antonious et al., 2018). In other words, the application of biochar in a proper dose added nutrients to the soil amendment material. Biochar could bind cations that would be utilized by plants. Cations bound to particles or organic compounds would replace cations dissolved in the soil solution. Such exchange of adsorbed cations maintains the availability of cations for roots. Hence, kale's roots grew better as it could optimally absorb supporting water and nutrients (Yuniwati, 2018; Rolon et al., 2020; Cao et al., 2018).

The highest average value of fresh weight kale was obtained from the combination of corn cob biochar at a dose of 6 t/ha and Bio Land at 15 l/ha (B2), which was 200.46 g. Fresh weight was the accumulation of photosynthesis, and

TABLE 3. Effect of combination of corn cob biochar and Bio Land on soil's pH, C-organic, Nitrogen Content and CEC

Combination of corn cob biochar (t/ha) + Bio Land (l/ha)	pH	C-organic (%)	N(%)	CEC (cmol kg ⁻¹)
3 + 15 (B1)	5.16 a	1,25 a	0,09	14,42
6 + 15 (B2)	5,84 b a	1,52 b a	0,17 b	17,78 b
9 + 15 (B3)	5,07 a	1,19 a	0.11 a	13,74
3 + 30 (B4)	5.27 b	1,39 ab	0,12 a	14.16
6 + 30 (B5)	6.14 b	1,53 b	0,18 b	18,05 b

was highly influenced by the availability of nutrients. Improved soil fertility and amendments from the combination of corn cob biochar and Bio Land greatly affected the addition of fresh weight of kale (Adeside et al., 2020; Yoder, 2014; Kumar et al., 2019). This was due to the availability of sufficient macro and micro nutrients to support the growth and yield of kale. Crop yields are largely determined by biomass production at the time of growing, and also the distribution of biomass in the harvested portion. The production of biomass resulted in weight gain. followed by an increase in plant size, in which plant's fresh weight increased. This ideal condition occurs when nutrients and other supporting factors are available during plant growth, in which the photosynthetic results to organs goes well (Siva et al., 2019; Pathirana et al., 2017).

Results from the combination of 6 t/ha corn cob biochar and 15 l/ha Bio Land on dry weight was 26.81 g, which was significantly different from other treatments. The calculation of plant dry weight was used to see plant metabolism. Dry weight represents the results of plant metabolites contained by the leaves and other organs. Dry weight gain is a strong indicator of plant growth because it reflects the accumulation of organic compounds synthesized by plants from inorganic compounds, namely nutrients, water, and CO₂. The indicator of plant growth as a result of plant photosynthesis was the increase in the size of the dry weight, and the increase in protoplasm because of increasing size and number of cells in the plant body. Increased cell size in dry weight was due to the cell division in the meristematic areas of shoots and root tips. A plant's dry weight is determined by carbohydrates as the biggest composition of cell walls. High amount of carbohydrates is resulted from the number of nutrients absorbed by the roots and environmental conditions during the photosynthesis process, such as abundant sunlight as a source of energy. If the photosynthesis process runs optimally, the resulting photosynthate functions in leaf growth, and finally shown through increasing plant's fresh and dry weight, increasing leaf area, and also chlorophyll. Photosynthesis is inseparable from the amount of available nutrients obtained from the growing media and absorption of kale roots (Siva et al., 2019; Pathirana et al., 2017)

3.3 Soil amendment

The combination of corn cob biochar and Bio Land also affected soil amendments, as observed through pH, organic C, total N and CEC, as presented in Table 3.

It can be seen from the table that the combination of corn cob biochar at 6 (t/ha) and 15 l/ha (B2) Bio Land ob-

tained higher C-organic by 1.52%. Meanwhile, the combination of corn cob biochar at 6 (t/ha) and Bio Land at 30 t/ha (B6) reached 1.49%; and the combination of corn cob biochar at 9 (t/ha) and Bio Land at 30 l/ha (B6) reached 1.53%. Observation results on the amount of Nitrogen from the combination of corn cob biochar at 6 t/ha and Bio Land at 15 l/ha (B2) was 0.17%, while the combination of corn cob biochar at 9 t/ha and Bio Land at 30 l/ha (B6) was 0.18%.

Increasing CEC was obtained in the combination of corn cob biochar at 6 (t/ha) and Bio Land at 15 l/ha (B2) with 17.78 cmol kg⁻¹. The combination of corn cob biochar at 6 (t/ha) and Bio Land at 30 l/ha (B6) reached 18.05 cmol kg⁻¹, while the combination of corn cob biochar at 9 (t/ha) and Bio Land at 30 l/ha (B6) reached 17.92 cmol kg⁻¹. Overall, the combination of corn cob biochar and Bio Land affected soil properties, especially organic C, soil pH, amount of N, and CEC, which further increased soil amendment material as a planting medium. This is a natural phenomenon as soil organic matter is a negatively charged resource that can increase nutrient levels and fertility (Yuannto & Utomo, 2018; Yuniwati, 2018)

4. CONCLUSION

In conclusion, this present study shows that:

- The combination of corn cob biochar and Bio Land as a soil amendment improved plant nutrients.
- The combination of corn cob biochar and Bio Land affected the number of leaves, fresh weight, dry weight, root volume, leaf area, and chlorophyll amount of kale.
- The combination of corn cob biochar at 6 t/ha and Bio Land at 15 l/ha resulted in more leaves at 25.50 strands, higher chlorophyll at 51.42 spad units, and wider leaf area of 1164.5 cm².
- The combination of corn cob biochar at 6 t/ha and Bio Land at 15 t/ha resulted in better soil amendments with pH of 5.84, organic C of 1.52%, total N of 0.17%, and CEC of 17.78%.

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