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Increasing Samhong King (*Brassica rapa var. chinensis* L.) plant production by embedded biochar application

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Abstract. The aim of this study was to determine effect of coconut fiber embedded biochar on the growth and production of Samhong King. The research used a non-factorial randomized block design. The treatments were control, cow manure 10 tonnes ha^{-1}, coconut fiber biochar 10 tonnes ha^{-1}, coconut fiber biochar 20 tonnes ha^{-1}, coconut fiber biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}, coconut fiber biochar 20 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}, coconut fiber embedded biochar 10 tonnes ha^{-1}, coconut fiber embedded biochar 20 tonnes ha^{-1}, coconut fiber embedded biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}, coconut fiber embedded biochar 20 tonnes ha^{-1} + cow manure 10 ton ha^{-1}. The parameters were plant height, leaves number, and plant weight. The results showed that the application of biochar, embedded biochar, cow manure did not significantly effect on the fresh weight of leaves. The plant height was significantly different in the 3rd week in the treatment of coconut fiber biochar 20 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}. The treatment of coconut fiber biochar 10 t ha^{-1} + cow manure 10 t ha^{-1} was significantly different in the 3rd week on the number of leaves.

1. Introduction

Mustard plant (*Brassica juncea* L.) is horticulture crop that is most favored by the people of Indonesia. Samhong king is one of the most popular types of mustard greens and the demand continues to increase in Indonesia. This type of mustard greens is characterized by wide leaves that are light green in color, thin and white stems, and jagged leaf edges so it is often called curly mustard greens. One of the advantages of samhong king over other types of mustard greens is that it tastes delicious and savory compared to other types of mustard greens which taste slightly

bitter. Samhong king has a content that is rich in nutrients, vitamin C, contains high fiber to improve body health [1].

Demand for vegetable commodities especially mustard plants in Indonesia continues to increase progressively in line with the increasing population and per capita consumption. Mustard production in Indonesia continues to decline from 2021 as much as 727,467 tonnes ha^{-1} to 686, 876 tonnes ha^{-1} in 2023 [2]. The decline in mustard production is indicated by the less than optimal absorption of nutrients in mustard plants due to decreased soil fertility. The decline in soil fertility is caused by the continuous use of inorganic materials and low input of organic matter, thus reducing the content of nutrients in the soil and damaging the physical, biological and chemical properties of the soil [3]. For this reason, it was necessary to make efforts to restore and improve soil fertility through the application of organic materials derived from agricultural residues. One of the organic materials from agricultural residues that can be utilized was biochar.

Biochar is a carbon-rich solid material produced from agricultural waste through incomplete combustion. The application of biochar into the soil provides many benefits, which can improve the physical, biological and chemical properties of the soil. The improvement of soil properties certainly affects the growth, development and production of a plant [4]. Biochar functions as a soil amendment that when applied to the soil will function as a soil carbon provider for a long time. Biochar can be in the soil for a long time and in a stable state, because biochar is not easily decomposed. The stable nature of biochar against oxidation in the soil can be used as an alternative in improving and increasing soil fertility [5]. Biochar has the ability to hold water quite high, the application of biochar into the soil will affect the ability of the soil to hold water, so that the ability of the soil to provide nutrients for plants will increase [6]. The purpose of this study was to determine the effect of coconut fiber embedded biochar on the growth and production of Samhong King plants.

2. Materials and method

The research was conducted from July to October 2024 at the Biochar Research Station, Research Center for Biochar and Sustainable Tropical Forests, Universitas Syiah Kuala, Laboratory of Plant and Soil Research, Agriculture Faculty, Universitas Syiah Kuala, and Laboratory of Agroclimatology, Agriculture Faculty, Universitas Syiah Kuala. The materials used were Samhong King mustard seeds, coconut fiber biochar, Urea fertilizer 75 kg ha^{-1}, KCl fertilizer 50 kg ha^{-1}, SP36 fertilizer 50 kg ha^{-1}, cow manure 10 tonnes ha^{-1}, Inceptisol soil and polybags. The tools used were hoe, scales, paddle, sprayer, ruler and stationery. The research data used a non-factorial randomized block design with 10 treatments, 3 replications and 4 samples. The treatments consisted of control (F0), cow manure 10 tonnes ha^{-1} (F1), coconut fiber biochar 10 tonnes ha^{-1} (F2), coconut fiber biochar 20 tonnes ha^{-1} (F3), coconut fiber biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1} (F4), coconut fiber biochar 20 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1} (F5), coconut fiber embedded biochar 10 tonnes ha^{-1} (F6), coconut fiber embedded biochar 20 tonnes ha^{-1} (F7), coconut fiber embedded biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1} (F8), coconut fiber embedded biochar 20 tonnes ha^{-1} + cow manure 10 ton ha^{-1} (F9).

Samhong King seed were sown in trays for 14 days, then the seedlings were transplanted into polybags with a size of 13 cm x15 cm. The composition of the seedling media used was a mixture of soil and cow manure in a ratio of 2:1. The planting medium was 2 kg of Inceptisol per polybag that had been sieved and treated then incubated for 1 week. The Inceptisol soil used came from Barbate, Krueng Raya, Aceh Besar District. After the incubation process was completed, Samhong King plant were planted after 28 day after sowing (Figure 1). Observations were done weekly for

5 weeks (Figure 2). Harvesting was done in the 5th weeks by pulling out all parts of the plant (Figure 3 and 4). The observation variables included plant height, number of leaves, and fresh weight. Data from the study were analysed by ANOVA test, and a significant effect analysed by the Duncan New Multiple Range Test (DNMRT) test.

Figure 1. Planting of Samhong King

Figure 2. Observation of experiment

Figure 3. Harvesting Samhong King plants

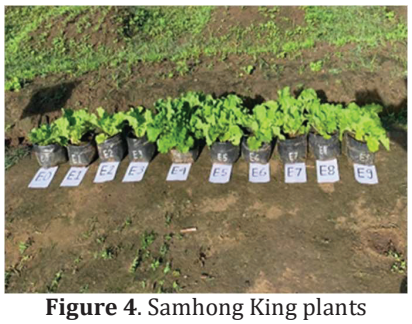

Figure 4. Samhong King plants

3. Results and Discussion

3.1 Plant height

The results showed that the treatments did not significantly affect on the height of Samhong King plants in the 1st, 2nd, 4th and 5th weeks. The height of Samhong King plants was significantly different in the 3rd week in the treatment of coconut fiber biochar 20 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1} with an average height of 11.53 cm. The lowest plant height was 10 tonnes ha^{-1} cow manure treatment with an average plant height of 8.56 cm. Although at week 5th there was not significant effect on the height of Samhong King plants, the 20 tonnes ha^{-1} coconut fiber embedded biochar treatment tended to be better with an average height of 17.48 cm.

The average height of mustard plants in weeks 1st, 2nd, 3rd, 4th, 5th can be seen in Table 1. Soil was a growing medium and provider of nutrients for plants. One of the factors that can affect plant growth and development was the availability of nutrients for plants [7]. Nutrients have a very important role for plants, the availability of sufficient nutrients for plants will support plant growth and produce quality products.

Table 1. Effect of biochar on plant height (cm)

Treatments	Weeks				
	1	2	3	4	5
Control	5.38	7.60	10.10 ^{c}	13.02	16.11
Cow manure 10 tonnes ha^{-1}	4.76	7.06	8.56 ^{a}	10.53	13.12
Coconut fiber biochar 10 tonnes ha^{-1}	4.68	8.11	10.16 ^{cd}	12.12	13.53
Coconut fiber biochar 20 tonnes ha^{-1}	4.28	7.27	10.23 ^{cd}	11.97	13.81
Coconut fiber biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	4.88	8.13	10.42 ^{d}	13.51	16.41
Coconut fiber biochar 20 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	5.57	9.58	11.53 ^{f}	13.50	16.13
Coconut fiber embedded biochar 10 tonnes ha^{-1}	4.63	7.54	9.70 ^{b}	12.47	14.22
Coconut fiber embedded biochar 20 tonnes ha^{-1}	5.48	9.24	11.14 ^{e}	14.91	17.48
Coconut fiber embedded biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	4.76	7.53	9.67 ^{b}	11.78	13.49
Coconut fiber embedded biochar 20 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	4.97	8.29	9.82 ^{b}	12.90	14.86

Numbers followed by the same letter in the same column are not significantly different in the DNMRT test ($\alpha = 0.05$).

3.2 Number of leaves

The results showed that the treatment did not significantly affect on the number of leaves of Samhong King plants in the 1st, 2nd, 4th and 5th weeks. The number of leaves was significantly different in the 3rd week in the treatment of coconut fiber biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1} with an average number of leaves 11.89. The lowest number of leaves was the

treatment of coconut fiber embedded biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1} with an average 8.56, but not significantly different with the treatment of cow manure 10 tonnes ha^{-1} with an average number of leaves 8.89 (Table 2).

Table 2. Effect of biochar application on number of leaves

Treatments	Weeks				
	1	2	3	4	5
Control	5.33	8.56	9.89 ^{e}	11.56	13.78
Cow manure 10 tonnes ha^{-1}	4.44	7.89	8.89 ^{ab}	10.33	12.56
Coconut fiber biochar 10 tonnes ha^{-1}	5.11	8.67	10.22 ^{ef}	12.22	13.00
Coconut fiber biochar 20 tonnes ha^{-1}	3.89	7.44	9.33 ^{c}	11.89	14.33
Coconut fiber biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	5.78	9.33	11.89 ^{g}	15.22	18.44
Coconut fiber biochar 20 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	5.11	8.56	10.44 ^{f}	13.33	15.22
Coconut fiber embedded biochar 10 tonnes ha^{-1}	4.67	7.11	9.44 ^{cd}	11.33	13.67
Coconut fiber embedded biochar 20 tonnes ha^{-1}	4.78	8.11	9.89 ^{e}	12.89	15.89
Coconut fiber embedded biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	4.44	7.00	8.56 ^{a}	11.67	14.67
Coconut fiber embedded biochar 20 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	4.56	7.78	9.33 ^{c}	12.00	14.67

Numbers followed by the same letter in the same column are not significantly different in the DNMRT test ($\alpha = 0.05$).

Mustard plants require sufficient nutrients for their growth. One of the nutrients needed by mustard plants was nitrogen. Nitrogen nutrients were very useful for plant leaf growth. Nitrogen serves to increase vegetative growth, so that plant leaves become wider, greener in color and better quality [8]. Nitrogen nutrients contained in cow manure have the main role to stimulate overall growth, especially stems, branches and leaves.

3.3 Fresh weight

The results showed that the treatment did not significantly affect on the fresh weight of Samhong King plants (Table 3). Fresh weight was influenced by weather elements, the higher the temperature causes the fresh weight of the plant to decrease [9]. In addition to plant height and number of leaves, leaf area was one of the factors that affect the fresh weight of a plant [10]. The more leaf area, the photosynthesis process will increase which causes the formation of carbohydrates will also increase so that the plant experiences an increase in fresh weight which spurs cell division and enlargement to take place faster.

Control treatment showed the results of the heaviest leaf fresh weight compared to other treatments with an average weight of 77.00 g. The lowest fresh weight was in the 10 tonnes ha^{-1} cow manure treatment with an average weight of 30.46 g.

Table 3. Effect of biochar application on fresh weight (g)

Treatments	Fresh weight leaves per plants (g)
Control	77.00
Cow manure 10 tonnes ha^{-1}	30.46
Coconut fiber biochar 10 tonnes ha^{-1}	49.38
Coconut fiber biochar 20 tonnes ha^{-1}	36.83
Coconut fiber biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	75.13
Coconut fiber biochar 20 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	56.33
Coconut fiber embedded biochar 10 tonnes ha^{-1}	47.39
Coconut fiber embedded biochar 20 tonnes ha^{-1}	65.71
Coconut fiber embedded biochar 10 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	28.16
Coconut fiber embedded biochar 20 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}	51.00

4. Conclusions

The application of biochar, embedded biochar, cow manure did not significantly affect on the fresh weight of Samhong King leaves. The height of Samhong King plants was significantly different in the 3rd week in the treatment of coconut fiber biochar 20 tonnes ha^{-1} + cow manure 10 tonnes ha^{-1}. The treatment of coconut fiber biochar 10 t ha^{-1} + cow manure 10 t ha^{-1} was significantly different in the 3rd week on the number of leaves.

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