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The Influence of Rubberwood Biochar Size on the Effectiveness of Using Urea Fertilizer in the Cultivation of Pakcoy (Brassica chinensis L.)

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Abstract. *The effectiveness of fertilizer and crop production can be increased through the provision of biochar as a soil amendment. This research aims to evaluate the effect of the combination of varying sizes of rubber wood biochar with doses of urea fertilizer on the growth of pak choy mustard plants. The research was conducted with two factors arranged in a completely randomized design. The first factor is the size of the rubber wood biochar and the second factor is the dose of Urea fertilizer, each consisting of 4 levels. All treatment combinations were carried out with 3 repetitions. The response variables observed include soil pH, plant height, number of leaves, canopy area, and fresh plant production. The results showed biochar size factor had a significant effect on soil pH and fresh weight. The urea fertilizer dosage factor shows a significant influence on the plant height and fresh weight. The treatment with the most optimal growth was 1 mm biochar produced yield of 19.03 g/plant, while Urea dose of 2 g/plant produced pak choy plants of 20.72 g/plant.*

Keywords: *Biochar, Pakchoy, rubberwood, size, Urea.*

1. Introduction

Pakcoy (*Brassica rapa* L.) is a type of vegetable plant that belongs to the Brassicaceae family. The pak choy plant originates from China and was widely cultivated after the 5th century in South and Central China as well as Taiwan. Pakcoy mustard greens have a leaf structure that is stemmed and oval in shape with a dark green color, the structure grows semi-erect or semi-horizontal. The leaf stalks are white or light green, thick and have a plant height of around 15 to 30 cm (Surtinah, 2010).

One important factor in cultivating plants is the type of soil. The type of soil that dominates Lampung Province is ultisol soil. Ultisol soil has a multitude of problems, such as low soil pH, low levels of organic matter, and very low N, P, and K nutrient content which can interfere with plant growth to a minimum (Notohadiprawiro, 2006). Ultisol soil has a fairly high level of degradation,

making this land have a low fertility level. Therefore, it is necessary to add organic materials such as manure, compost or biochar to speed up the process of restoring soil quality (Kurnia *et al*. 2005).

According to research from Rondon *et al*. (2007), biochar is an alternative to the concept of processing critical lands. Biochar is made through a pyrolysis or combustion process without oxygen or using very limited oxygen. Biochar is composed of aromatic carbon rings which are more stable and last longer in the soil (Maguire & Aglevor, 2010). The use of biochar has been widely used by most farmers in rural areas using traditional methods. The resulting research shows that biochar has the potential to restore the fertility of critical lands due to soil degradation that occurs due to excessive use of chemical fertilizers. The advantage that biochar has is that it is resistant to weathering processes so that its use can last quite a long time in restoring degraded agricultural land and the use of biochar is also an action that helps conserve soil carbon (Glaser *et al*., 2002). Ogawa *et al*. (2006) added that the use of biochar on agricultural land functions to increase nutrient availability, nutrient retention and water retention; as a good habitat for symbiotic microorganisms; can increase plant productivity; and able to reduce the rate of CO_2 emissions.

The use of biochar in soil can be influenced by the size of the biochar itself. The smaller the size of the biochar, the greater the surface area of the biochar pores. Low density biochar has a high surface area. This is because the greater the amount of pore space that biochar has, the lighter the material, which means the lower the volume weight of the biochar (Soemeinaboedhy & Tejowulan, 2007). The size of biochar to be applied to agricultural land can be determined using a sieve. There are 2 results obtained in the sieving or filtering process, namely particle sizes that are larger than the size of the sieve holes (over size) and sizes that are smaller than the sieve holes (under size). The screen in question is the surface of a sieve that has a number of holes of the same size which is flat (horizontal or slanted) and can also be cylindrical (Fellows, 1990).

Another factor that influences the characteristics of biochar is the type of raw material. Biochar from hardwood will have different characteristics with softwood biochar. Likewise, biochar from non-woody biomass will have different properties than biochar from woody materials. Based on the function of biochar on soil and one of the determinants of biochar quality, namely material and size, it is necessary to carry out research on the use of rubber wood biochar of different sizes combined with the addition of urea at various doses in pakchoy cultivation in ultisol soil.

2. Experiment Methods

This research was conducted from August to September 2021 in a greenhouse at the Integrated Field Laboratory, Faculty of Agriculture, University of Lampung. The materials used in this research were ultisol soil, rubberwood waste, rubber wood biochar, soil, urea fertilizer, rice husk charcoal, pak choy mustard seeds and water.

2.1. Materials

2.1.1 Soil

The soil used in this research was the Ultisol type which contains low nutrients. This aims to ensure that a more real effect from the treatment of biochar doses and fertilizer doses can be observed. The soil is dried in the sun for 5-7 days, then sieved using a 5 mm soil sieve to separate rocks and weeds. Table 1 showed the characteristic of ultisol soil.

Plant cultivation is best carried out in soil water content of field capacity condition. Therefore, this condition was determined by packing 3 kg of soil in a cloth bag. The soil was then soaked in water until completely wet, then drained by hanging for 24 hours or until no more water drips. The weight of the soil after draining is assumed to be a condition of field capacity and is used as a benchmark for providing irrigation water during plant cultivation.

Table 2. Characteristic of ultisol soil

Property	Value	Criteria
N-total (%)	0.04	Very low
P-available (ppm)	11.85	Moderate
K-exc (me/100g)	0.09	Very low
C-Organik (%)	0.38	Very low
pH	5	Moderate

2.2.2 Rubberwood biochar

Biochar was made by reducing the size of dry rubberwood, and then pyrolyzing it in a 40 x 50 cm barrel for 3-4 hours which produces 2.48 kg of biochar. The biochar was ground and sieved to have three different sizes, namely small (pass through 1-cm sieve), medium (pass through 3-cm, but not pass through 1-cm sieve), and big (not pass through 3-cm sieve). The biochar was then packed in a zipped plastic bag for use and further analysis. Figure 1 showed rubberwood chips and rubberwood biochar of different size ready for using as soil amendment. The Characteristic of the biochar was analyzed at the LTSIT (University of Lampung) and the results were presented in Table 2.

Figure 1. (a) Rubberwood chips; (b) Small rubberwood biochar; (c) Medium rubberwood biochar; (d) Big rubberwood biochar

Table 2. Characteristic of rubberwood biochar

Parameter	Value	Test method
N (%)	0.27	In house method
P (%)	0.18	EPA 200.7 Rev. 5
K (%)	0.77	EPA 200.7 Rev. 5
pH	10.01	pH Meter

Ash (%)	6.55	Furnace
Moisture content (%)	7.457	Oven

2.2.3 Urea and Packchoy Seeds

The urea fertilizer used in this study contained 46% nitrogen (N). Urea and pakchoy seeds were were purchased from a local farm kiosk. This fertilizer is applied directly with the soil at 6 days before planting.

2.2. Experimental Design

The research was arranged in a Factorial Completely Randomized Design (CRD). The first factor was the size of the rubberwood biochar consisting of 4 levels, namely B1 (without biochar), B2 (using biochar 1 mm), B3 (using biochar 5 mm), and B4 (using biochar 10 mm). Biochar is applied at a dose of 62g/plant, equivalent to 10 tonnes/ha). The second factor was the dose of Urea fertilizer consisting of 4 levels, namely P1 (0 g/plant or without Urea), P2 (Urea 1 g/plant), P3 (Urea 2 g/plant), and P4 (Urea 3 g/plant). All treatment combinations were carried out in 3 repetitions so that there were 48 experimental units.

2.3. Research Implementation

2.3.1 Preparation of planting media

A total of 3 kg of sieved soil was put into a pot with a diameter of 20 cm. Biochar was then added according to the biochar size treatment at a dose of 62 g, except for control (no biochar). Water was added in such a way to make the soil media was in the 80-100% field capacity.

2.3.2 Seedling

Seedling for pakchoy seeds was conducted in a tray containing husk charcoal. The seeds were spread on husk charcoal, then sprayed with water twice a day. Seedling was carried out for 2 weeks until 3-5 true leaves appeared.

2.3.3 Transplanting

Good pak choy seedlings were selected and planted in the afternoon (16.00 – 17.30). Pakcoy planting was done in pots with a diameter of 20 cm. In every pot was planted one seedling. The pots were arranged randomly with a distance of 25 cm x 25 cm.

2.3.4 Plant Maintenance

Maintenance activities included watering and pest control. Irrigation water was done once a day at the afternoon (16.00 – 17.30). The pot was weighed to determine water loss due to evaporation. Water was given according to the amount of water lost and returned to field capacity conditions. Whereas, pest control was carried out manually as necessary.

2.3.5 Harvesting

Harvesting was carried out when the plants are 30 days after transplanting (DAT). Harvesting was done early in the morning so that the plants do not wilt due to hot air temperatures.

2.4. Observation Variables

Parameter penting yang diukur pada penelitian ini meliputi:

a. Water content (%): Moisture content of biochar was measured by drying the samples in the oven (Memmert UM 500) for 24 hours at 105 °C. Water content (KA) was calculated from wet wight (BB) and dry weight (BK) of the samples according to the following:

$$KA = \frac{BB-BK}{BK} \times 100\% \quad (1)$$

b. Ash content (%): Ash content of biochar was measured by burning the oven dry biochar in a muffle furnace (Stuart) at 550 °C for 2.5 h. Ash content (AC) was calculated from:

$$AC\ (\%) = \frac{\text{Ash (g)}}{\text{Dry sample (g)}} \times 100\% \quad (2)$$

c. pH: The pH of biochar and soil was measured using a pH meter. Sample (soil or biochar) was ground into fine particles and was mixed with water. The probe of pH meter was inserted into the solution and took the reading.
d. Soil nutrient: Analysis for soil nutrient was conducted at the Soil Lab., Faculty of Agriculture, University of Lampung.
e. Plant height (cm): Plant height was measured weekly from the petiole to the tip of the longest leaf using a ruler.
f. Number of leaves: The number of leaves was counted weekly for leaves that are completely open.
g. Canopy area (cm^2): Measurement of canopy area was carried out using the canopy cover free application on the smartphone. A frame made of styrofoam measuring of 60 x 60 cm was placed at the pot surface and the image of the plant was taken using a smartphone a a position such that the frame was at the maximum size of the camera's screen. After filtering, the canopy area was displayed in % of the frame area.
h. Plant yield: Plant yield (fresh) measured from top shoot of the plant after harveting.

2.5. Data Analysis

The treatment response data obtained were analyzed through analysis of variance (ANOVA) using the SAS application program. If the ANOVA test shows a significant effect, then proceed with the LSD (least squared difference) test at the 5% level.

3. Results and Discussion

3.1. Effect of treatment on soil pH

The initial soil pH value in this study was 5 and the soil was classified as having a moderate acidity level. The effect of treatment combination of rubberwood biochar size and urea fertilizer dosage on soil pH is presented in Figure 1. The ANOVA results show that urea dose only or its interaction with biochar size was not significantly affect the soil pH. Rubberwood biochar has pH of 10.01 and therefore application of biochar increased soil pH significantly as compared to those soils without biochar addition. The pH change of biochar-amended soil, however, is relatively same. This means that the biochar size is not statistically different on the soil pH. Soil with biochar application has a pH of around 7 so that organic compounds, microorganisms, nutrients and minerals are in optimal conditions for plants to grow optimally.

3.2. Plant height

The effect of the interaction between biochar particle size treatment and urea fertilizer dose on the height growth of pakcoy plants is presented in Figure 3. From the results of the analysis, the data shows that plant height growth from various treatments at 0-5 DAT is still the same and does not show an interaction between biochar and different fertilizer doses. given. Furthermore, at 12-35 HST, treatments B2, B3 and B4 experienced better and more uniform growth compared to treatment B1.

The dose of urea fertilizer (P1, P2, P3 and P4) at a biocahr size of 1 mm (B1) produced a

significant difference in the growth of pak choy from 0-35 DAP as compared to the control treatment. Plant height at 0-20 HST in the interaction of treatments B2, B3, and B4 with P1, P2, P3, and P4 was relatively the same, however at 24-35 HST in treatments B1P2 and B3P2 there was a significant increase in plant height compared to the other treatments.

The ANOVA test showed that the biochar size alone or its interaction with the dose of urea fertilizer had no significant effect on the height of the pak choy plants at 35 HST. The single factor of urea fertilizer dose, however, produced a significant effect on the height of pakchoy. It was surprising that without urea (P1) produced the best plant height, namely 17.37 cm. Although the plant height was not statistically different to that of P3 (Urea 2 g/plant), it was significantly higher than the plants of P2 and P4.

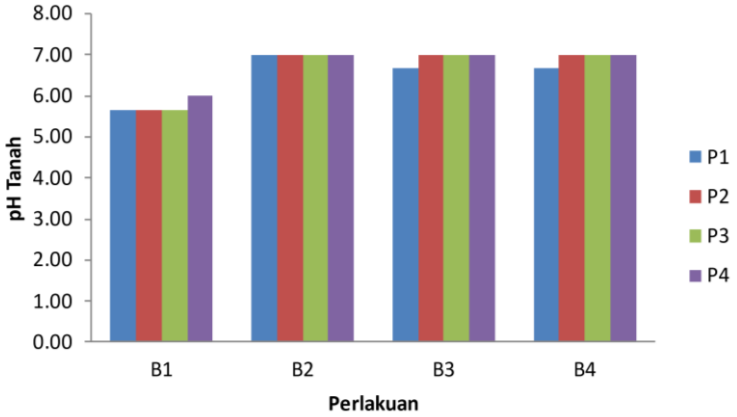

Figure 1. Effect of treatment on soil pH after harvest

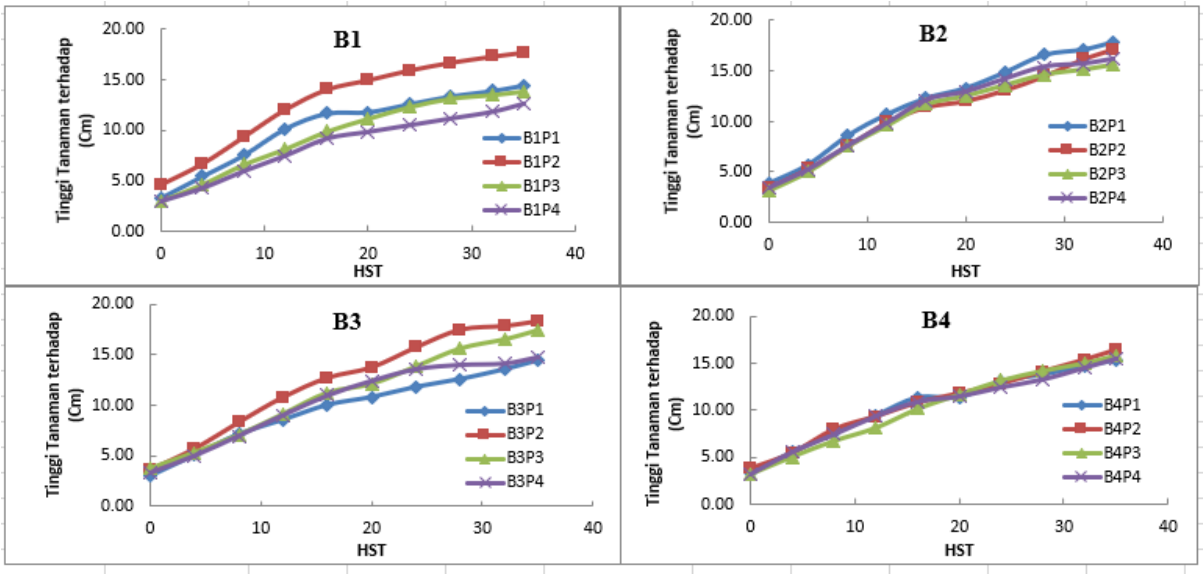

Figure 3. Effect of treatment on plant height development up to 35 HST

3.3. Number of Leaves

The interaction effect of biochar size treatment and urea fertilizer dosage on the number of leaves of Pakcoy plants is presented in Figure 4. The results showed that the development of leaf number at 0-20 HST was not significantly different. However, at 21-35 HST, the B1P2 treatment experienced a greater increase in the number of leaves compared to the other treatments, while the number of leaves was the least in the B4P1 treatment compared to the other treatments. The ANOVA test results showed that the biochar size and urea fertilizer dosage and their interactions

did not have a significant effect on the number of pak choy plants at 35 HST. This is caused by the high variability in data on the number of leaves in each treatment, which shows that the growth of pak choy in one treatment varies greatly.

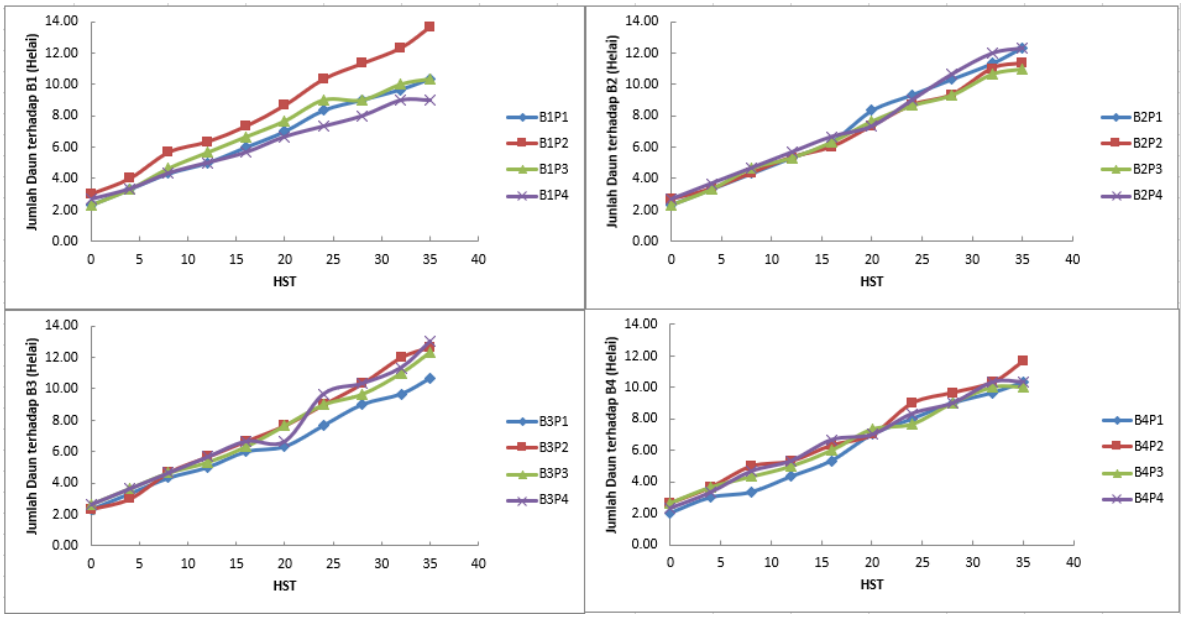

Figure 4. Effect of treatment on the development of the number of leaves of pak choy plants

3.4 Canopy Area

The interaction effect of biochar size treatment and urea fertilizer dose on the canopy area of pak choy plants is presented in Figure 5. The data shows that at 0-10 DAP the canopy area in each treatment had equivalent development without any significant differences. Furthermore, at 11-35 HST, the development of canopy area in treatments B2, B3 and B4 also had an equivalent increase, except for treatment B1. Treatment B1 has different conditions, where the highest canopy area is in treatment B1P2, while the lowest is in treatment B1P4, experiencing canopy area development which tends to be very low compared to other treatments. The ANOVA test results also showed that the factors of biochar size and urea fertilizer dosage and their interactions had no significant effect on the canopy area of pak choy plants at 35 HST. Again, this is caused by the high variability in data on the number of leaves in each treatment, which shows that the growth of pak choy in one treatment varies greatly.

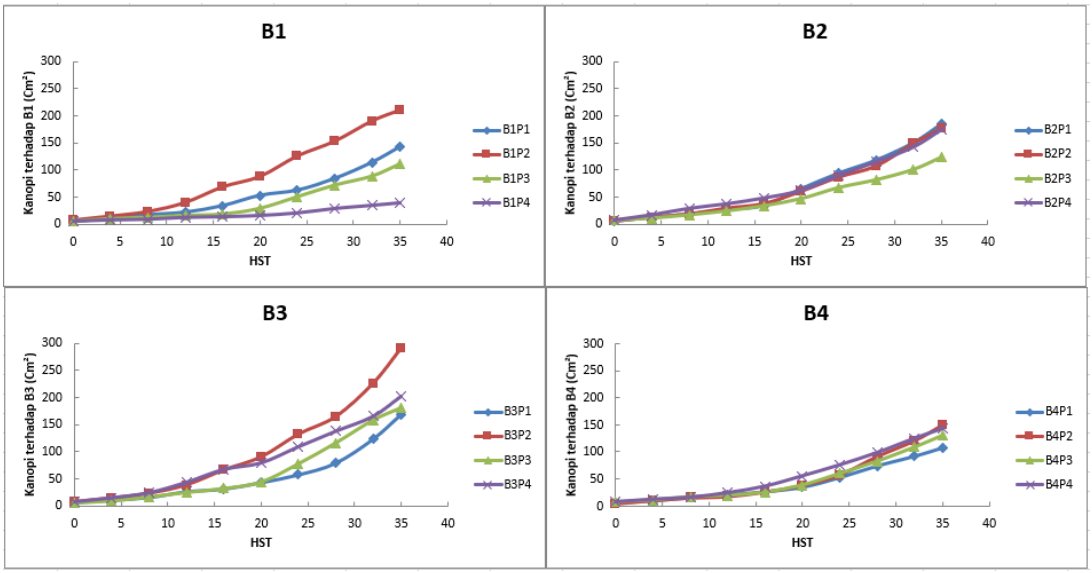

Figure 5. Effect of treatment on the development of pakchoy plant canopy area up to 35 HST

3.5. Fresh Yield

Figure 6 shows some samples of pakchoy produced from different treatments. The variability of the pakchoy yield can be observed from the figure. Figure 7 shows that pakchoy yield greatly varies from less than 5 g/plant to around 35 g/plant. The ANOVA test results also showed that the single factors of biochar size and urea fertilizer dosage had a significant effect on the yield of pak choy plants harvested at 35 HST. However, the interaction of these two factors did not have a significant effect on crop yields. From the LSD test results, it can be seen that the B3 treatment produced the largest fresh upper stover weight (19.03 g/plant) and was significantly different compared to the other treatments (B1, B2, and B4). This shows that the finest biochar particle size (1 mm) provides the best effect. The smaller the particle size means the larger the specific surface area so that it can absorb fertilizer better.

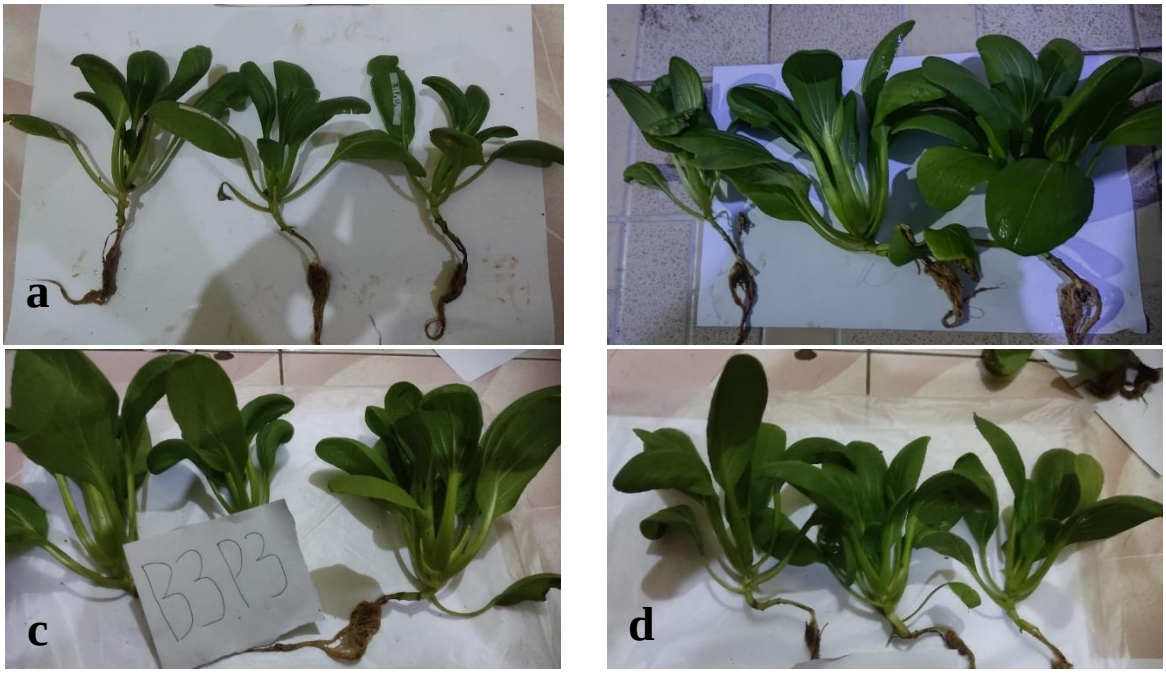

Figure 6. Samples of harvested pakchoy from some treatments: (a) B1P3; (b) B2P3; (c) B3P3; (d) B4P3

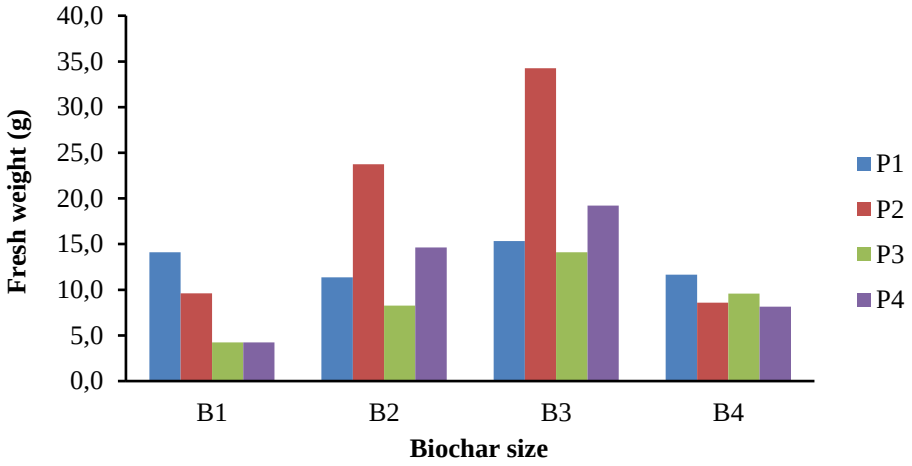

Figure 7. Effect of treatment on the fresh yield of pakchoy at 35 HST

4. Conclusion

Based on research that has been carried out, it can be concluded:

1. Biochar size shows a significant influence on soil pH parameters and fresh weight of pak choy plants.
2. The dose of urea fertilizer shows a significant influence on the parameters of plant height and plant fresh weight.
3. The results of the study showed that urea fertilizer treatment with a dose of 2 g/plant produced the highest pakcoy production (20.72 g/plant) compared to other urea doses, while biochar with a particle size of 1 mm produced the highest plant production (19.03 g/plant) compared to other biochar sizes.

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