The Effect of Coconut Coir Waste as A Mixture of Planting Media in A Natural Greenhouse

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ABSTRACT

The nutritional content of cocopeat does not fully meet plant needs, so it needs to be combined with other organic materials such as manure. In addition, the relatively large porosity of cocopeat will affect plant productivity. This study aims to evaluate the nutrient content of cocopeat and the evapotranspiration that occurs during the plant growth period. This research method is experimental using various combinations of planting media with different ratios of cocopeat, husk charcoal, and compost, namely Variation A (50: 30: 20), Variation B (20: 50: 30) and Variation B (20: 50: 30) C (30: 20: 50). The parameters observed included air temperature and humidity (outside and inside the greenhouse), evapotranspiration, growing media temperature, leaf area, plant height, and leaf width. The data obtained were then processed using a statistical approach to determine whether the soilless planting medium using cocopeat had a significant effect on plant growth. The results showed that the addition of cocopeat had a significant effect on the growth of mustard plants for the parameters of leaf area and width, but not on plant height. At the highest percentage of cocopeat (50%) the temperature of the growing media was relatively more stable, but additional fertilizer was still needed for additional nutrients because the nutrients contained in cocopeat, even though it had been added with compost and husk charcoal, did not support the growth of mustard plants. The value of plant evapotranspiration (Etc) outside the greenhouse (outdoor) and inside the greenhouse (indoor) is not much different, with an average value of 32.84 mm/day and 33.78 mm/day for October and 16.49 mm/day and 17.47 mm/day for November. The composition of the planting medium affected the leaf area and width of the mustard plant, but not the plant height. Mustard plants on growing media with the highest percentage of cocopeat had the best average leaf width compared to media with less cocopeat.

Keywords: *cocopeat, evapotranspiration, growing media.*

1. INTRODUCTION

Malaka Village has an area of ± 4,765.18 hectare, which consist of 12 hamlets is located west of the capital city of North Lombok Regency with a distance of ± 20 km. Malaka Village is classified as a village that has a tropical climate with an average temperature of 30 degrees Celsius with an average rainfall of 1,100 mm per year. Geographically, the village of Malacca is located at 110048'55.12" East Longitude and is located at 7002'27'.52" South Latitude. Malaka Village is one of the coconut producing villages in North Lombok Regency. Based on BPS data for North Lombok Regency [1], this regency has a large potential for coconut production. With such great potential, a lot of coconut fiber waste has not been utilized.

Cocopeat is an organic hydroponic growing medium, because it is made from coconut fiber powder. Cocopeat has a pH between 5.0 to 6.8 so it is very good for the growth of any plant. Cocopeat is easy to absorb and store water. It also has pores, which facilitate the exchange of air, and the entry of sunlight. The content of Trichoderma molds, a type of enzyme from fungi, can reduce disease

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in the soil. Thus, cocopeat can keep the soil loose and fertile [2].

Ramadhan et al. [3], in his research stated that the use of cocopeat as a mixture of planting media by 25% and 50% gave a good influence on the height, diameter and dry weight of roots for the commodity of Sea Sengon (*Paraserianthes falcataria*). Soeparjono [4] also stated that the combination of cocopeat as a planting medium gave the best response with the parameters of plant height, number of leaves and number of shoots on red ginger commodity.

Head of the West Nusa Tenggara (NTB) Food Security Agency (BKP), Husnanidiaty Nurdin, said that the level of community vegetable consumption in this area is the highest among 33 provinces in Indonesia. The data is based on the results of the National Social Economic Survey (Susenas) of the Central Statistics Agency (BPS), it was recorded that the consumption of vegetables in NTB reached 68 kilograms (kg) per capita per year or above the national average of 48.8 kg per capita per year, even the highest in Indonesia [5]. Based on some of these data, it can be concluded that the province of West Nusa Tenggara has the potential to use coconut fiber waste to be used as a planting medium (cocopeat) for vegetable commodities to fulfil vegetable consumption needs. Cocopeat application as a growing media, is used for vegetable production and it able to produce organic fresh vegetables in the Federated States of Micronesia [6]. The use of cocopeat is able to solve the problem of high land degradation, and the use of coconut waste is very much in the Micronesian islands, which have very high coconut production potential.

Jafari et al. [7] conducted measurements of evapotranspiration on citrus trees using a drip irrigation system in southern Iran, the evapotranspiration value was needed to provide irrigation input to plants so that the irrigation provided was precise and efficient, in accordance with what was needed by the plant.

The results obtained in this study were conventional irrigation provided over irrigation by 21%. This can be minimized or even avoided by applying the results of the crop water demand analysis obtained for future irrigation water supply inputs. The same statement was also explained by [8] that the evapotranspiration calculation results are used for irrigation control in greenhouses.

Kesti et al. [9] have done the research to determine the effect of using a combination of cocopeat and charcoal as a medium for planting mustard greens, b). to get the best dosage of the composition of the growing medium on the growth of mustard greens. The results showed that the use of cocopeat growing media and charcoal influenced germination and vigor index. Cocopeat and charcoal have a significant effect on fresh and dry weight and chlorophyll content of mustard greens.

Another study was also conducted by Heidari et al. [10]. A greenhouse experiment was conducted to evaluate the effect of the mixture of different growing media (palm trunk: resulted from palm trunk only; palm tree: resulted from all palm organs; coco peat; perlite; reused coco peat) on growth and nutrient uptake of lily cut flower. Because of the low cost, availability, and extensive cultivation area of date palm in Iran and over the world, palm wastes have a great potential to be used as an eco-friendly horticultural substrate mixture to substitute coco peat in lily soilless culture.

The results obtained on the research done by Qiu et al. [11] on the response of evapotranspiration and yields to the density of growing media on tomatoes grown in greenhouses. The density of the planting media affects the evapotranspiration value, the denser the planting medium, the higher the Leaf Area Index (LAI) and the higher the evapotranspiration value. This statement is also the same as the results of research conducted by Buttar et al. [12] that the value of evapotranspiration is higher when the value of solar radiation received by plants and growing media increases.

Therefore, testing the efficiency of using cocopeat growing media as well as laboratory testing of nutrients (moisture content, pH, etc.) as well as analyzing the evapotranspiration that occurs compared to using other growing media, with the same commodity, namely green mustard (*Brassica rapa*) needs to be done. Research on microclimate modeling to predict temperatures in natural greenhouses has been carried out by Singh et al. [13]. Based on this research and the model obtained can be used to evaluate the microclimate conditions in the greenhouse, the planting media used, as well as agricultural commodities grown in the greenhouse. It is hoped that the result of this research can help overcome two problems at once, namely the use of coconut fiber waste for green mustard planting media, and the production of green mustard greens as an effort to fulfill vegetable needs on the island of Lombok, West Nusa Tenggara.

2. RESEARCH DESIGN AND METHODOLOGY

The research was conducted in the natural greenhouse of the Agricultural Engineering and Environmental Conservation Laboratory, Agricultural Engineering Study Program, Faculty of Food Technology and Agroindustry, University of Mataram. The application of the research results is planned to be carried out in one of the coconut-producing villages in Pemenang District, North Lombok Regency, West Nusa Tenggara. Research tools used include the Automatic Weather Station

(AWS), soil moisture meter, pH meter, scales, laptop, and drip irrigation system. The materials used in this study included polybags, planting media, mustard seeds, and water.

The research was conducted with the following procedure:

1. Preparation of tools and materials

At this stage, prepare Automatic Weather Station (AWS), Green Mustard Seeds, Polybags and prepare Cocopeat planting media, husk charcoal planting media, and organic fertilizers.

2. Preparation of Planting Media

The available planting media were prepared in 5 polybags for each type of planting media combination shown in Table 1.

Table 1. Combination of cocopeat growing media

Type	cocopeat	husk charcoal	organic fertilizer
A	50	30	20
B	20	50	30
C	30	20	50

1. Installation of Automatic Weather Station (AWS)
Automatic Weather Station (AWS) is installed in a natural greenhouse.
2. Test the Automatic Weather Station (AWS) system
Automatic Weather Station (AWS) testing is done by checking that all sensors are working properly and the system is able to display and store data on all microclimate parameters for each desired timeframe.
3. Planting Mustard Greens on Planting Media
Green mustard seeds were planted in 15 polybags that had been prepared in a natural greenhouse.
4. Monitoring of Microclimate Parameters and Green Mustard Growth in Natural Greenhouse
Recording of microclimate parameter data (rainfall, temperature, water content and humidity) in a natural greenhouse. Several plant growth parameters were also recorded such as plant height and leaf area.
5. Influence Analysis
All recorded microclimate data were used as input for the effect analysis on the basis of which was approximated by equation 1.

$$EP = H + S - Pk - P \quad (1)$$

Description:
EP = Evapotranspiration (potential)
H = Rainfall
S = Water splash
Pk = Percolation water
P = Amount of water for soil saturation until field capacity is reached.

3. RESULTS DAN DISCUSSIONS

1. Climate Monitoring Outside the Greenhouse

To ensure that the research can continue even though the weather conditions are unfavorable, one of which is due to high rainfall, this research was carried out in the greenhouse of the Faculty of Food Technology and Agroindustry, University of Mataram. Plant growth in a greenhouse is strongly influenced by microclimate conditions, especially temperature and humidity parameters.

Changes in climate parameters in the atmosphere outside the greenhouse greatly affect the temperature and humidity of the air inside the greenhouse. In addition, the intensity of sunlight, rainfall, and wind speed are parameters that also greatly affect the microclimate conditions in the greenhouse. All of these parameters will affect the value of plant evapotranspiration (ETc) which represents plant water requirements.

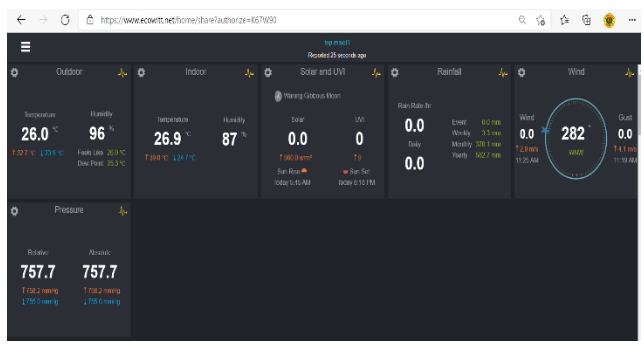


Figure 1 Real time view of AWS MISOL WS-2320 climate data on cloud

Climate data outside the greenhouse is monitored daily using the Automatic Weather Station (AWS) MISOL WS-2320. Figure 1 shows the display of climate data recorded by AWS and stored in the cloud on the https://ecowitt.net website. This data comes from sensors placed on the 2nd floor deck of Faculty of Food Technology and Agroindustry Building, which are sent continuously to AWS devices placed in the greenhouse (Figure 2). Besides functioning to display data in real time on the LCD screen, this device is also equipped with temperature and humidity sensors that function to measure temperature and humidity data in the greenhouse (indoor).

Figure 2 AWS display devices placed inside the greenhouse (a) and installation of AWS for observing climate data outside the greenhouse (b)

In addition to displaying data in real time, data stored in the AWS cloud can be downloaded in the form of graphical displays according to the specified time duration. Figure 3 shows the display of climate data in the form of temperature and humidity parameters outside the greenhouse for a duration of 1 day and 1 week.

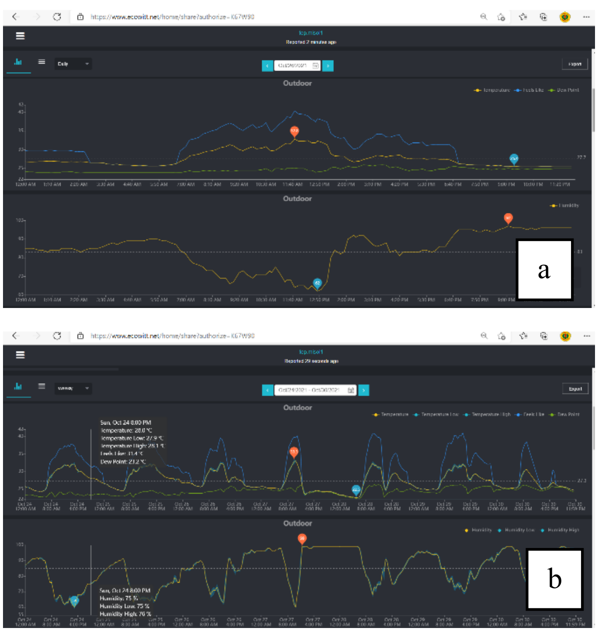


Figure 3 Display of temperature and humidity data outside the greenhouse (outdoor) for 1 day (a) and 1 week (b)

Based on Figure 3, it can be seen that the average air temperature has increased from 07.00 am to the highest point of 33.3°C during the day around 12.40 pm. After reaching the peak, the air temperature slowly decreases followed by an increase in air humidity (RH). This is in accordance with the research [14] which shows that temperature data is inversely proportional to air humidity.

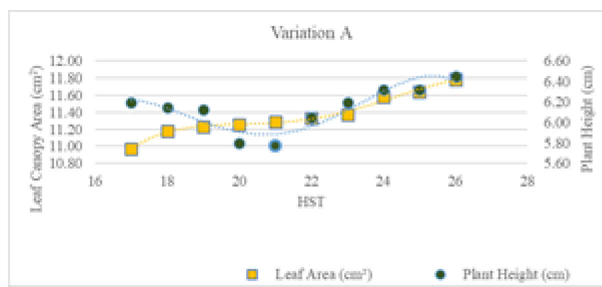
Preparation of Planting Media Variations

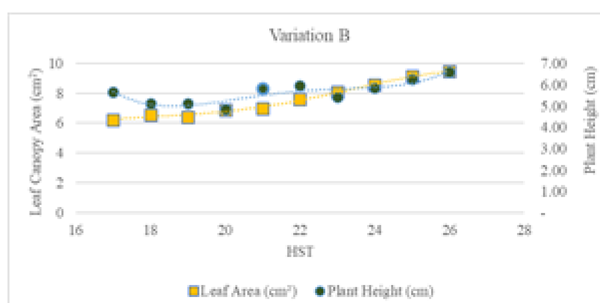
Mixture of planting media was filled in polybags with 3 different variations of the composition of the growing media (cocopeat: husk charcoal: organic fertilizer). Based on the field capacity test, the media with the highest percentage of cocopeat (variation A) was able to hold the most water (225 ml), so that the value of the field capacity was the largest. Cocopeat is known to have hydrophilic properties and has been shown to increase the water content of the soil layer. Cocopeat media has micro pores that are able to inhibit larger water movements, causing higher water availability [15].

Meanwhile, the planting medium that holds the least amount of water is the medium with the highest percentage of husk charcoal (variation B). According to Hasan et al. [16], rice husk charcoal has a high density and water holding capacity but also has a large pore space. The macro-pores found in husk charcoal are easy to pass water, so that husk charcoal is often added to soil with poor drainage to improve soil quality.

Effect of Media Composition on Plant Growth

The plant growth observed in this study included data on plant height and leaf width data measured using a ruler, as well as leaf canopy area data measured using the Easy Leaf Area application. The results of the measurement of growth data are then processed using Microsoft Excel and displayed in graphical form. Figure 4 shows data on leaf canopy area and average plant height for each treatment at 17 – 26 Days After Planting (DAP).





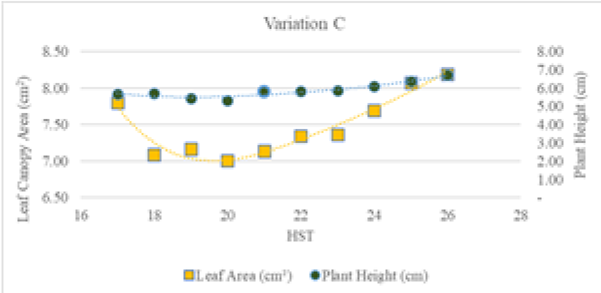


Figure 4 Graph of leaf area and plant height on variations in the composition of growing media for variation a (a), variation b (b) and variation c (c).

Based on Figure 5, it can be seen that the entire mustard plant experienced growth which was marked by an increase in leaf area and plant height. The decrease in the value of plant height in Variation A at 20 DAP was thought to occur because the plants withered due to too high temperatures in the greenhouse, especially during the day.

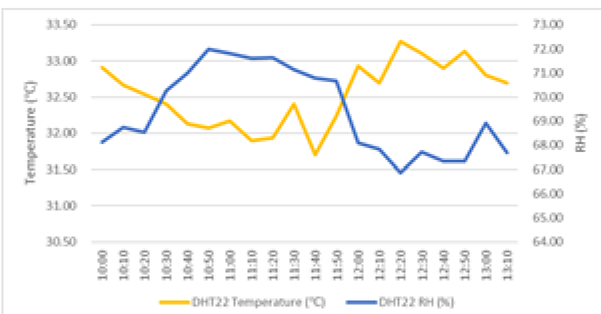


Figure 5 Average daily temperature and RH in the greenhouse at 10.00 – 13.10 WITA from the recording of the DHT22 sensor

Based on Figure 5, it can be seen that the value of air humidity in the greenhouse is inversely proportional to the value of air temperature. When the air temperature is high, the humidity value is low and vice versa, when the air temperature is low, the humidity in the greenhouse increases. Fluctuations in temperature and RH inside the greenhouse were also found in the temperature and RH data outside the greenhouse as shown in Figure 5.

Temperature is very influential on plant growth. This is in accordance with the previous researcher's statement which stated that without the right strategy, an increase in temperature will have an effect on most vegetable crops in terms of productivity, especially in the tropics [17]. To prevent plants from experiencing stress due to high temperatures in the greenhouse, especially during the day, an exhaust fan is used to dissipate heat and a fan to increase the rate of heat transfer from inside to outside the greenhouse.

Microclimate conditions in the greenhouse will indirectly affect the temperature of the growing media. Figure 6 shows the average temperature of the growing media for each variation in the composition of the growing media. Data collection was carried out using 3 (three) Dallas DS18b20 sensors which were plugged into one polybag for each variety of planting media, while other sensor was used as a comparison for the DHT22 sensor temperature data.

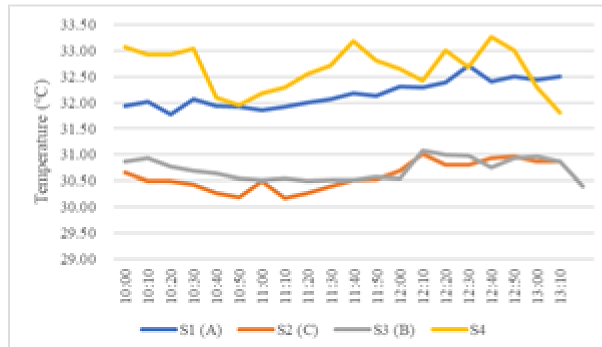


Figure 6 Data on the average temperature of the growing media at 10.00 – 13.10 Central Indonesian Time

In Figure 6 it can be seen that the planting medium of Variation B (the highest percentage of husk charcoal) and Variation C (the highest percentage of organic fertilizer) showed relatively lower temperatures than Variation A (the highest percentage of cocopeat). The temperature of the growing media in Variation A tends to approach the environmental temperature value as measured by S4 but shows a relatively stable pattern, with the rise and fall of air temperature in the greenhouse not causing the temperature of the growing media to fluctuate.

Changes in microclimate, especially air temperature, affect the value of plant evapotranspiration (ETc) in the greenhouse. Figure 7 shows the mustard plant ETc model based on data obtained by AWS during October 2021.

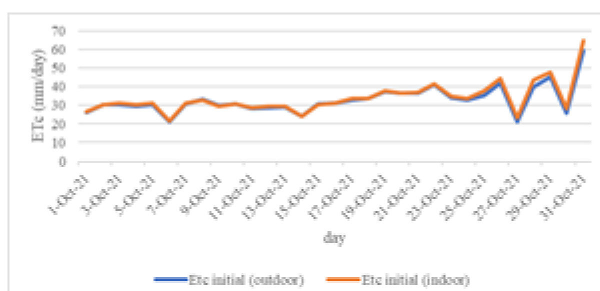


Figure 7 Modeling the value of ETc outside and inside the greenhouse in October

Based on Figure 7, it can be seen that the ETc values outside the greenhouse (outdoor) and inside the greenhouse (indoor) are not much different, with an average value of 32.84 mm/day and 33.78 mm/day, respectively. At the end of the month, the indoor ETc value was relatively higher than the outdoor ETc value. The highest ETc value is 59.27 mm/day for outdoor and 64.92 mm/day for indoor.

Meanwhile, Figure 8 also shows that the ETc value inside the greenhouse in November is greater than the ETc value outside the greenhouse. The maximum value of ETc inside and outside the greenhouse was 21.33 mm/day and 22.71 mm/day, respectively. In addition, when compared to October, the average evapotranspiration (ETc) value of mustard plants in November decreased by about 50% (Figure 8). The ETc values inside and outside the greenhouse were 16.49 mm/day and 17.47 mm/day, respectively. This condition is expected to occur because the air temperature in November is much lower than October due to high rainfall.

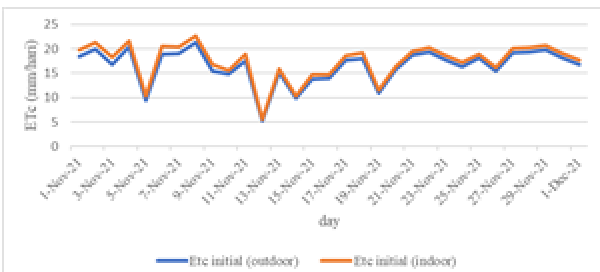


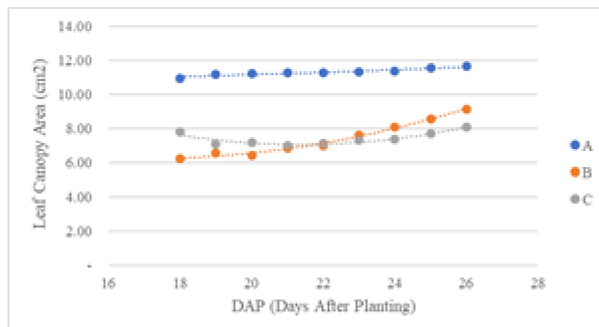
Figure 8 Modeling the value of plant evapotranspiration (Etc) outside and inside the greenhouse in November

Planting media with more cocopeat content is known to have smaller porosity than planting media with more husk charcoal content [18] or planting media with more organic fertilizer content [19]. The porosity of the growing media affects the air circulation in the growing media; Media with higher porosity will have better air circulation so that the transfer of heat absorbed by the media back into the air through the pores will occur more quickly. On the other hand, in media with low porosity, heat transfer is slower, so the temperature of the growing media tends to be stable and relatively high compared to media with high porosity.

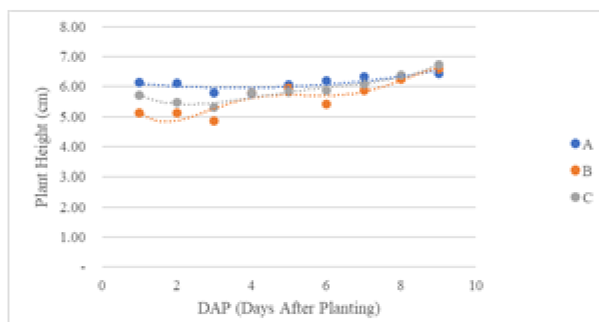
In addition, the leaf canopy area in Variation C decreased on day 18 DAP. This condition is thought to be due to yellowing of plant leaves due to lack of nutrients, especially element P. It is known that element P functions in stimulating growth and root development in young plants, and so that plant leaves do not turn yellow which then fall and plants become stunted [20]. The yellow leaf color is not read by the *Easy Leaf Area* application in the area calculation process. Therefore, the leaf canopy area data that are detected and displayed are reduced.

To prevent plant death due to lack of nutrients, AB Mix fertilizer was added in the middle of the planting period. Figure 7 shows the preparation of AB Mix fertilizer to be added to plants. The amount of AB Mix fertilizer solution added needs to be adjusted to the needs of the mustard plant. TDS (Total Dissolved Solid) and the pH of the AB Mix solution were measured using a TDS meter and a pH meter.

The plant growth data for each variation was then compared in a single graph to see the composition of the best growing media that supported plant growth (Figure 8). From the picture, it can be seen that the mustard plants planted with the highest cocopeat composition produced wider leaves. In terms of plant height, there was no difference between each variation. The results of this study are in line with previous studies which found that the addition of cocopeat to cocoa seedling growing media gave significant results for leaf area, but not significant for plant seedling height [21].



(a)



(b)

Figure 9 Comparison of plant growth in each variety of growing media: (a) leaf canopy area and (b) plant height (bottom)

The data were then tested using a one-way ANOVA approach, both for leaf canopy area data and plant height data, to determine whether or not variations in planting media had a significant effect on the two parameters observed. Table 2 and Table 3 show the results of the ANOVA test of mustard plant growth data in the study. Based on Table 2, the P-value is 1.03 E-12; P-value is less than 0.05. Thus, the addition of cocopeat to the growing media had a significant effect on the leaf canopy area parameters. Meanwhile, from Table 3, the P-value is 0.057189; P-value is greater than 0.05. Therefore, in terms of plant height, there was no significant effect of adding cocopeat to the growing media.

Table 2. ANOVA test results for leaf canopy area data for each treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	97.491	2	48.745	90.824	1.03E-12	3.354
Within Groups	14.490	27	0.536			
Total	111.982	29				

Table 3. ANOVA test results of plant height data for each treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.106	2	0.553	3.187	0.057	3.354
Within Groups	4.688	27	0.173			
Total	5.795	29				

The leaf canopy area of the mustard plant in Variation C (with the lowest cocopeat percentage, 20%) was the lowest estimated due to the low water content in the growing media, especially during the day. According to [22] drought stress can reduce plant productivity (biomass) due to decreased primary metabolism, reduced leaf area and photosynthetic activity. The addition of cocopeat to the growing media was proven to increase the water content in the growing media, which was indicated by a larger leaf canopy area in Variations A and B.

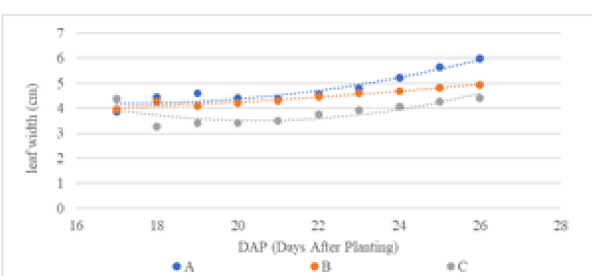


Figure 10 Data on plant leaf width

In addition to leaf canopy area and plant height, plant growth can be observed from changes in leaf width on each plant. The leaf width of the mustard plant observed in this study was one leaf that was the widest in each treatment variation. Figure 10 shows data on the leaf width of the mustard plant for 17 DAP – 26 DAP.

From Figure 10, it can be seen that for all variations of the growing media treatment, the leaf width of the mustard plant increased with the observation period. Mustard plants in variation A, with the highest percentage of cocopeat (50%), had the widest leaves at 26 DAP and mustard plants in variation C, with the lowest percentage of cocopeat (20%), had the narrowest leaves. This condition corresponds to the low leaf canopy area in variation C due to the low water content in the growing media. Figure 11 shows the condition of the mustard plant at the end of the observation period.

A B C

Figure 10 Mustard plant at the end of the observation period

Furthermore, the ANOVA test for leaf width showed a significant effect, which is presented in Table 4 below.

Table 4. ANOVA Test results of leaf area data for each treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.609	2	2.304	9.775	0.00064	3.354
Within Groups	6.365	27	0.235			
Total	10.974	29				

The ANOVA test results in Table 4 also show a P-value (0.00064) which is smaller than 0.05. Therefore, it can be stated that the addition of cocopeat has a significant effect on the leaf width of the mustard plant.

4. CONCLUSION

The cocopeat media does not contain sufficient nutrients for the growth of mustard plants. The addition of fertilizer is needed so that plants can still grow and produce as expected.

The value of plant evapotranspiration (Etc) outside the greenhouse (outdoor) and inside the greenhouse (indoor) is not much different, with an average value of 32.84 mm/day and 33.78 mm/day for October and 16,49 mm/day, respectively. 49 mm/day and 17.47 mm/day for November.

The composition of the growing media affects the leaf area and width of the mustard plant, but not the plant height. Mustard plants on growing media with the highest percentage of cocopeat had the best average leaf width compared to media with less cocopeat.

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