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Study of planting media and nutrition concentration on growth rate and yield of Lettuce (*Lactuca sativa* L.) in NFT hydroponic systems

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Abstract. Lettuce (*Lactuca sativa* L.) is a vegetable whose commercial value is quite good and the demand for lettuce has increased, including from hydroponic results. The use of rockwool planting media in hydroponics is often not available when needed and is expensive. Therefore it is necessary to study of using local planting media, such as: coconut fiber and rice husk charcoal as a replacement of rockwool planting media and whether the increased concentration of nutrients given to the planting media affects the rate of plant growth and yield of lettuce. The purpose of this research to study are interaction between planting media and nutrient concentrations (AB Mix) on the growth and development rate of plants, as well as the yield of lettuce hydroponically with the NFT system. The research was arranged in factorial with two factors using a Split Plot Design. The the main plot is AB Mix nutritional concentration (K) consisting of 3 levels (600 ppm, 900 ppm and 1200 ppm), while the subplot is a planting media (M) consisting of 3 treatment, namely: Rockwool, Coconut Fiber, and Rice Husk Charcoal. The results showed that the combination treatment of rice husk charcoal planting media and AB Mix concentration of 1200 ppm (M3K3) produced the best growth and increased the fresh weight of lettuce plants by 447,54% compared to the combination treatment of rockwool media and AB mix concentration of 600 ppm (M1K1). Rice Husk Charcoal planting media increases the growth rate of plant length and leaf area respectively by 26% and 81,54% compared to rockwool planting media. AB Mix concentration of 1200 ppm gives the best response and increases the growth rate of plant length and lettuce leaf area respectively by 367,5% and 165% compared to the concentration of 600 ppm.

1. Introduction

Lettuce (*Lactuca sativa* L.) is a horticultural commodity that has good prospects and commercial value. The use of lettuce as a fresh vegetables for dishes such as salads and also functional food as a remedy for heartburn and to facilitate digestion. As a major component in making salads, lettuce has a high water content, besides that lettuce also contains a source of minerals, vitamins, and fiber.

The success of hydroponic plant cultivation is largely determined by several factors that influence, including planting media and nutrition. Planting media is a place to grow and uphold a plant which can also function as a storage area for water and nutrients or nutrients needed by plants. A good planting medium must meet the requirements, among others, that it is not easy to rot, does not become a source of pests and diseases, creates good aeration, is able to store water and nutrients properly, is easy to obtain



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in the desired amount and the price is relatively cheap. Until now, the dependence of hydroponic farmers on imported planting media in the form of rockwool is still very high. Meanwhile, the abundant agricultural industrial waste has not been utilized in such a way. Therefore, efforts to reduce dependence on the use of imported hydroponic planting media need to be done through the use of agricultural industrial waste as an alternative solution to problems in the use of planting media in hydroponic vegetable cultivation.

Based on several hydroponic studies that have been conducted, it shows that the media has an effect on plant growth and yield. The best planting media for the growth and yield of hydroponic lettuce was the planting medium for husk and cocopeat charcoal which was significantly different from other planting media[1]. Furthermore, the planting medium had an effect on plant height, number of leaves, and wet weight of lettuce plants, where the planting medium for rice husk charcoal produced the best growth [2].

AB mix nutrition with various concentrations had a significantly different effect on the growth and yield of red lettuce plants [3]. A concentration of 1000 ppm of AB mix nutrients produces the best growth and yield. Based on the background and rationale above, it is necessary to conduct research on lettuce plants with a hydroponic system in order to get the best planting media and the right concentration of AB mix nutrients on the growth rate and yield of lettuce plants.

2. Methodology

This research took place from January to February 2020. The research was conducted in Watudandang Village, Prambon Sub-District, Nganjuk District at an altitude of 57 m above sea level.

The tools used in this research include: hydroponic installation of the NFT system, TDS meter, pH meter, sprayer, measuring cup, seed tray, hacksaw, rockwool perforation, netpot, ruler and yellow trap, digital scales. While the materials used include: Junction lettuce seeds, AB Mix nutrients, husk charcoal, cocopeat and rockwool.

This research is a factorial experiment with two factors arranged in a Split Plot Design which consists of the main plot (main plot) and sub plot (sub plot). As the main plot is the nutrient concentration of AB Mix (K) which consists of 3 levels, namely: K1: 600 ppm, K2: 900 ppm, K3: 1200 ppm. As a subplot is a kind of planting media (M) which consists of 3 levels, namely: M1: Rockwool, M2: Cocopeat, M3: Husk Charcoal. All treatment combinations were repeated 3 times. The variables observed included: plant length growth rate, leaf area growth rate and leaf fresh weight.

Observation data were analyzed statistically using Analysis of Variants (Anova) at the accuracy level of 1% and 5%. If the results of the analysis show a significant or very significant effect, then a further test with the 5% test (HSD) is held. Meanwhile, to determine the highest growth rate of lettuce plants from the parameters of plant length and leaf area was carried out using regression analysis.

3. Results and discussion

3.1. Plant length growth rate

The results of the statistical analysis of the various effects of the variety of planting media and the concentration of AB Mix on the growth rate of plant length and leaf area growth rate of lettuce at early growth stage (age 24 - 31 DAP), middle growth stage (age 31 - 38 DAP) and late growth stage (age 38 - 45 DAP) indicates that there is no significant interaction. However, the single factor kind of planting medium (M) had a significant effect on the growth rate of plant length at the middle growth stage (age 38 - 45 DAP), while the nutrient AB Mix concentration factor (K) had a significant effect on the growth rate of lettuce plant length at all growth stages. Almost the same thing is shown by the treatment of the kinds of planting media (M) on the leaf area of lettuce, where the kind of planting media have a significant effect on the middle and late growth stages, while the AB Mix concentration has a significant effect on all growth stages of lettuce plants. The average growth rate of lettuce plant length by the influence of the kind of planting media and the concentration of AB Mix is presented in Table 1, while

the growth rate of lettuce leaf area by the influence of the planting media and the concentration of AB Mix is presented in Table 3.

Table 1. Average growth rate of Lettuce plant length by the effect of treatment of kinds of planting media and concentration of AB Mix

Treatment	Plant length growth rate (cm / week)		
	Early period (24-31 DAP)	Middle period (31-38 DAP)	End period (38-45 DAP)
Kinds of planting media			
Rockwool (M1)	0.57	0.81 a	0.35
Cocopeat (M2)	0.61	0.89 a	0.49
Husk charcoal (M3)	0.55	1.07 b	0.63
HSD 5%	ns	0.78	ns
AB Mix concentration			
600 ppm (K1)	0.36 a	0.65 a	0.29 a
900 ppm (K2)	0.73 b	0.94 b	0.26 a
1200 ppm (K3)	0.65 bc	1.18 c	0.93 b
HSD 5%	0.13	0.11	0.35

Notes: Average number followed by the same letter for age and treatment the same, showing no significant difference in the HSD test at the 5% level, ns = Not significantly different

Table 1 shows that the husk charcoal planting media (M3) produced the highest growth rate of lettuce plant length at the mid-growth stage (age 31-38 DAP) by increasing the length growth rate of lettuce plants by 32% compared to the treatment of Rockwool (M1) planting media. In table 1 it is also shown that the concentration of AB Mix 1200 ppm (K3), significantly resulted in the highest growth rate of lettuce plant length in the middle growth stage (age 31-38 DAP) and was significantly different from AB Mix concentrations of 600 ppm and 900 ppm. The increase in lettuce plant length growth rate at the age of 31 - 38 DAP (mid-growth stage) by the influence of AB Mix concentration of 1200 ppm was 81.54% compared to the concentration of AB Mix 600 ppm.

The growth pattern of lettuce plants based on the growth rate of plant length and leaf area by different kinds of planting media and AB Mix concentrations showed a slow increase in the early growth period (age 24 - 31 DAP), then the growth rate increased gradually and the rate was fast (exponential) in the mid-growth period (age 31–38 DAP) and after that (age 38–45 DAP) the growth rate begins to decline again when lettuce has reached its maximum growth limit.

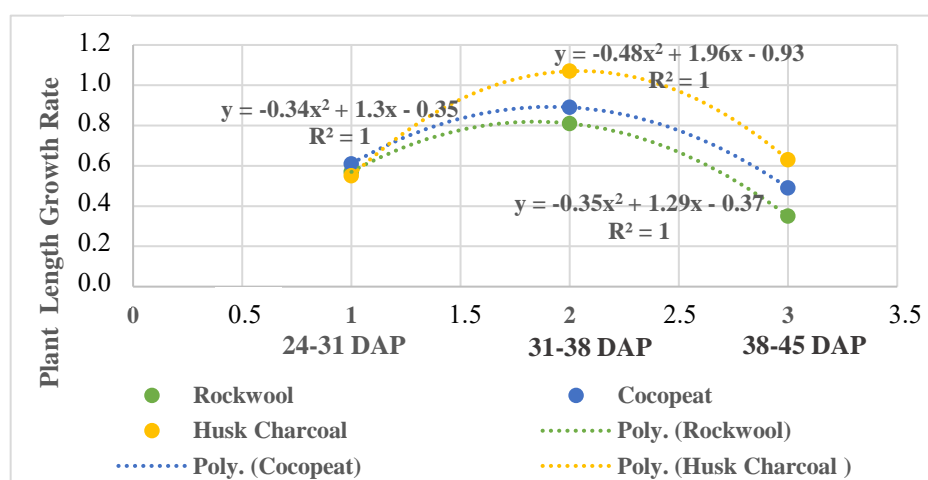


Figure 1. Quadratic regression curve of the length growth rate of lettuce plants treated with different kinds of planting media

Based on the results of the regression analysis of the effect of the type of planting medium (M) and the concentration of AB Mix (K) nutrients on the growth rate of lettuce plant length, it was found that these two factors separately produced quadratic regression as shown in Figure 1 and Figure 2.

In Figure 1 and Figure 2, it is known that the effect of the treatment of different types of planting media and the concentration of AB Mix nutrients on the growth rate of lettuce plant length produces a quadratic curve with a line equation as in Table 2.

In Figure 1 shown that the husk charcoal planting medium (M3) produced the highest length growth rate of lettuce, followed by Cocopeat planting medium and the lowest by rockwool. Husk charcoal and Cocopeat, which are abundant in rural areas, are not only used as substitution to rockwool media, but can actually improve growth rate of lettuce and prolong the growth rate of lettuce plants.

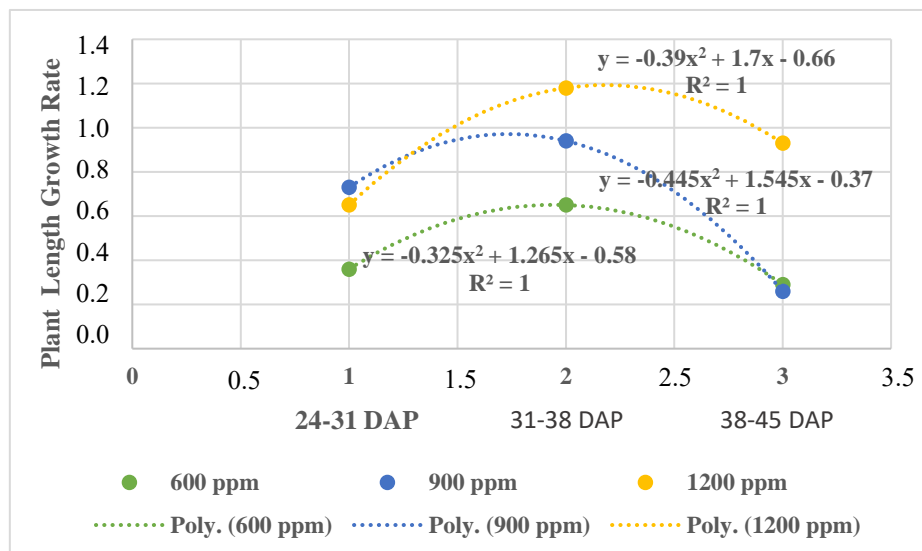


Figure 2. Quadratic regression curve of the length growth rate of lettuce treated with AB Mix concentration

In Figure 2 an increasing concentration of AB Mix nutrients from 600 ppm to 900 ppm has an impact on increasing the growth rate of plant length and even the concentration of AB Mix is increased again to 1200 ppm still has a significant effect in the form of increasing the growth rate of lettuce plant length and extending the growing period by high growth rate over the age of 38 DAP.

Table 2. Equations of regression lines growth rate of length of Lettuce plants due to the treatment of planting media and nutrient concentrations of AB Mix

Treatment	Line equations	Plant age when growth rate of plant length is highest
M ₁	$y = -0.35x^2 + 1.29x - 0.37$ ($R^2 = 1$)	X = 1.84 / 34 DAP
M ₂	$y = -0.34x^2 + 1.30x - 0.35$ ($R^2 = 1$)	X = 1.91 / 35 DAP
M ₃	$y = -0.48x^2 + 1.96x - 0.93$ ($R^2 = 1$)	X = 2.04 / 36 DAP
K ₁	$y = -0.325x^2 + 1.265x - 0.58$ ($R^2 = 1$)	X = 1.95 / 35 DAP
K ₂	$y = -0.445x^2 + 1.545x - 0.37$ ($R^2 = 1$)	X = 1.74 / 32 DAP
K ₃	$y = -0.390x^2 + 1.700x - 0.66$ ($R^2 = 1$)	X = 2.18 / 38 DAP

3.2. Leaf area growth rate

The growth rate of lettuce leaf area by the influence of the variety of planting media and the concentration of AB mix nutrients from the initial growth period to the final growth period is presented in Table 3.

In Table 3, shown that the planting medium for husk charcoal (M3) produced the highest growth rate of lettuce leaf area at all growth stages, both during early, middle and late growth stages. In Table 3, it

is also known that the husk charcoal planting medium can increase the growth rate of lettuce leaf area during the 38-45 DAP period by 230.87% compared to the treatment of Rockwool (M1) planting media.

Table 3, it is known that the highest growth rate of lettuce leaf area in Rockwool and Cocopeat planting media occurs during the middle growth stage, namely the age of 31 - 38 DAP, while at the late growing stage, the growth rate of lettuce leaf area decreases again. Another case in the Husk Charcoal planting media used in hydroponic cultivation of lettuce with the NFT system, it was shown that the growth rate of lettuce leaf area still increased significantly until before harvest (age 45 DAP).

Table 3. Average growth rate of lettuce leaf area by the effect of treatment kinds of planting media and ab mix concentrations

Treatment	Leaf area growth rate (cm ² / week)		
	Early stage 24-31 DAP	Middle period 31-38 DAP	End period 38-45 DAP
Kinds of planting media			
Rockwool (M1)	25.20	67.89 a	39.26 a
Cocopeat (M2)	24.53	80.49 a	68.24 a
Husk Charcoal (M3)	30.04	100.18 b	129.90 b
HSD 5%	ns	14.13	39.97
AB Mix concentration			
600 ppm (K1)	7.36 a	26.52 a	43.66 a
900 ppm (K2)	35.84 b	98.04 b	77.92 ab
1200 ppm (K3)	36.57 bc	123.99 c	115.81 bc
HSD 5%	8.63	14.13	39.97

Note: Average number followed by the same letter for age and treatment the same, showing no significant difference in the HSD test at the 5% level, ns = Not significantly different

In table 3 it is also known that the concentration of AB Mix nutrients of 1,200 ppm produces the best lettuce leaf area growth rate and is significantly different from the concentrations of 600 ppm and 900 ppm. The increase in leaf area growth rate by the nutrient concentration of AB Mix 1,200 ppm at the age of 31 -38 DAP was 367.53% compared to the concentration of AB Mix 600 ppm.

The growth pattern of lettuce plants by the influence of AB Mix concentration treatment experienced a slow increase at the early planting age (age 24-31 DAP), then the growth rate increased rapidly (exponentially) in the middle of the growing period (age 31-38 DAP) and then the rate until growth decreases again after the plant is 38 DAP.

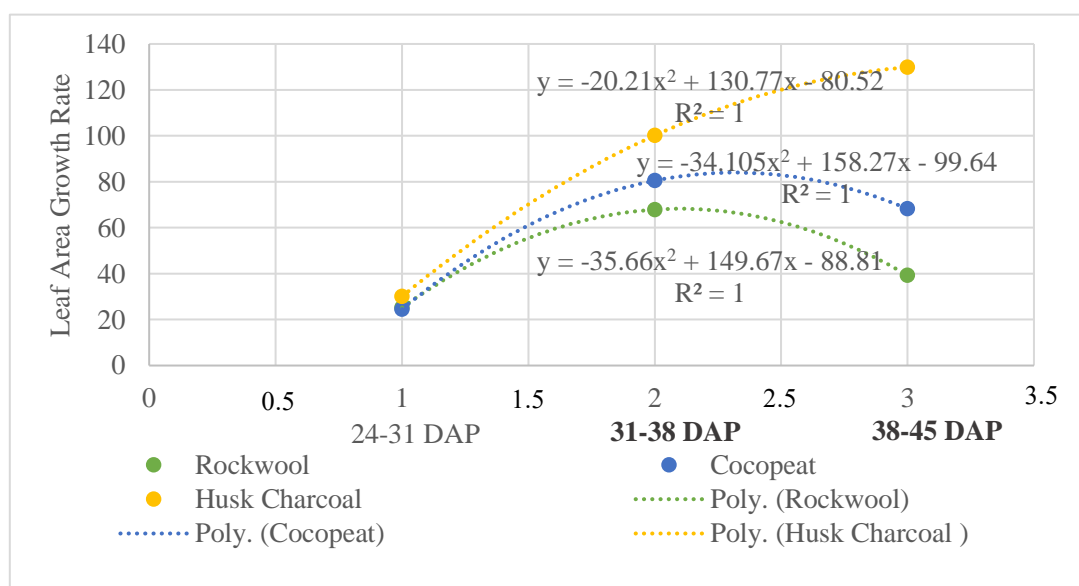


Figure 3. Quadratic regression curve for the growth rate of lettuce

Based on the results of the regression analysis of the effect of the kinds of planting media (M) and the concentration of AB Mix (K) nutrients on the leaf area growth rate of lettuce, it was found that these two factors separately produced quadratic regression as shown in Figure 3 and Figure 4.

In Figure 3 and Figure 4, it is known that the effect of the treatment of different kinds of planting media and the concentration of AB Mix nutrients on the growth rate of lettuce plant leaf area produces a quadratic curve with the line equation as shown in Table 4.

In Figure 3, it is shown that the planting media husk charcoal (M3) produced the highest leaf area growth rate, followed by Cocopeat and Rockwool planting media. This shows that husk charcoal and cocopeat can be used as an alternative to hydroponic planting media which substitute rockwool and even husk charcoal and cocopeat can improve the growth rate of lettuce plant leaf area and extend the growth rate of lettuce plants.

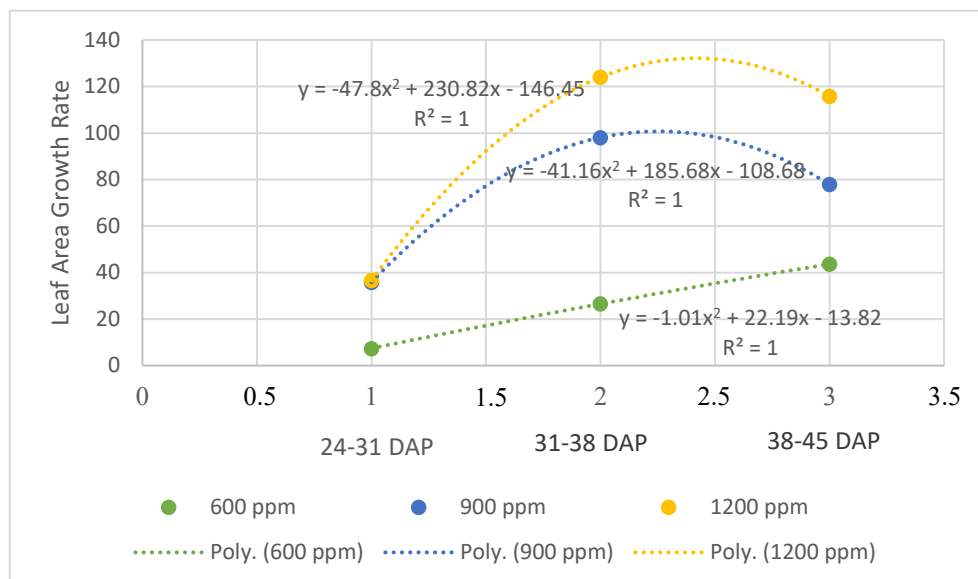


Figure 4. Leaf area due to the treatment of various planting media

In Figure 4 it is known that an increase in the concentration of AB Mix nutrients from 600 ppm to 900 ppm has a significant effect on increasing the growth rate of leaf area and even an increase in AB Mix concentration until 1200 ppm still shows a significant effect on increasing the growth rate of leaf area of lettuce plants until approaching harvest (age 45 das).

Table 4. Equation of regression lines growth rate of leaf area of lettuce plants due to treatment of planting media and nutrient concentrations of AB mix

Treatment	Line equations	Plant age when the growth rate of leaf area is highest
M ₁	$y = -35.66x^2 + 149.67x - 88.81$ ($R^2 = 1$)	X = 2.10 / 34 DAP
M ₂	$y = -34.105x^2 + 158.27x - 99.64$ ($R^2 = 1$)	X = 2.32 / 35 DAP
M ₃	$y = -20.21x^2 + 130.77x - 80.52$ ($R^2 = 1$)	X = 3.26 / > 45 DAP
K ₁	$y = -1.01x^2 + 22.19x - 13.82$ ($R^2 = 1$)	X = 10.99 / -- DAP
K ₂	$y = -41.16x^2 + 185.68x - 108.68$ ($R^2 = 1$)	X = 2.26 / 34 DAP
K ₃	$y = -47.8x^2 + 230.82x - 146.45$ ($R^2 = 1$)	X = 2.41 / 37 DAP

The growth pattern of lettuce is shown by the growth rate of plant length and leaf area of lettuce, where the growth rate is slow at the early of growth (age 7-14 das), then starts to increase at the age of 24-31 das and the growth rate decreases at the age of lettuce plants 38-45 das. This is in accordance with the opinion of Praba et al [4], that the growth rate of cultivated plants generally starts with slow growth

at the beginning of planting then increases at the end of vegetative time and then decreases when the plant has reached its maximum growth limit.

3.3. Effect of combined treatment kinds of planting media and AB Mix concentration on fresh weight of Lettuce by hydroponics

Based on the results of the statistical analysis of the effects of the kind of planting media and the concentration of AB Mix nutrients on fresh weight of lettuce plants, it shows that there is a significant interaction. The average fresh weight of lettuce plants by the influence of the planting media and concentration of AB Mix is presented in Table 5.

Table 5. Average weight of fresh lettuce by combination of treatment types of planting media and ab mix concentration at age 45 dap

Treatment	Fresh Weight (g)
Rockwool+ Concentration 600 ppm (M1K1)	60.33 a
Cocopeat+ Concentration 600 ppm (M2K1)	89.67 b
Husk Charcoal + Concentration 600 ppm (M3K1)	149.67 c
Rockwool+ Concentration 900 ppm (M1K2)	180.33 d
Cocopeat+ Concentration 900 ppm (M2K2)	240.00 f
Husk Charcoal + Concentration 900 ppm (M3K2)	300.33 h
Rockwool+ Concentration 1200 ppm (M1K3)	200.33 e
Cocopeat+ Concentration 1200 ppm (M2K3)	270.33 g
Husk Charcoal + Concentration 200 ppm (M3K3)	330.33 i
HSD 5%	16.89

Notes: The average number followed by the same letter shows that it is not significantly different at the HSD test level of 5%

Table 5 shows that the combination treatment of rice husk planting media with AB Mix concentration of 1200 ppm (M3K3) increasing the yield of fresh lettuce plants by 447.54% compared to the combination of rockwool planting media with AB Mix concentration of 600 ppm (M1K1). Table 5 shows that the husk charcoal planting medium with AB Mix nutrient concentration until 1200 ppm produced the highest fresh weight of lettuce plants and was significantly different from other treatment combinations. The husk charcoal planting medium contains organic material that is given AB Mix nutrients with high concentrations, which means that more nutrients can be absorbed by plants so that plant growth is more optimal and yields in the form of plant fresh weight are higher. This is in accordance with the opinion of potassium (K) needed by plants and does not easily clump or compact so that plant roots can grow perfectly in comparison with plants using cocopeat and rockwool planting media [5]. Husk charcoal is able to influence the availability of phosphorus, phosphorus is an important part that plays a role in photosynthetic reactions which affect the net assimilation rate which affects the total fresh weight of plants. [6]

Husk charcoal has special characteristics, therefore it can be used as a growing medium for hydroponics [7]. The chemical composition of roasted husks is SiO_2 with a content of 52% and C as much as 31%. While the other contents consist of small amounts of Fe_2O_3 , K_2O , MgO , CaO , MnO , and Cu as well as several other organic materials [8]. This condition will have a positive impact on the growth and yield of lettuce, where the roots will develop well so that nutrient uptake by the roots will be optimal [9]. It can be seen that the husk charcoal planting media (M3) showed better growth in almost all observed parameters and compared to other planting media treatments[10].

Rice husk charcoal media is a medium that has gone through the combustion process so that it has high carbon content and is easily decomposed. In addition, rice husk charcoal has high absorption because it has larger pores so that it can absorb the nutrients that are around it to be stored in these pores [11].

4. Conclusion

There is a significant interaction between the combination of different kinds of planting media and the concentration of AB Mix on fresh weight of lettuce plants. The combination treatment of husk charcoal planting media and AB Mix concentration of 1200 ppm (M3K3) resulted in an increase in fresh weight of lettuce plants by 447.54% compared to the combination treatment of rockwool planting media with AB Mix concentration of 600 ppm (M1K1). Kinds of planting media had a significant effect on the growth rate of plant length and leaf area of lettuce plants. The husk charcoal medium produced the best growth rates for plant length and leaf area with an increase of 32% and 230.87% respectively compared to the use of rockwool planting media. The concentration of AB Mix nutrients significantly affected the growth rate of plant length and leaf area of lettuce plants. AB Mix concentration of 1,200 ppm produced the best growth rate of plant length and leaf area with an increase of 81.54% and 367.53% respectively compared to a concentration of 600 ppm.

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