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The effects of Arenga wood-fiber size and nutrition concentration on growth and yield of substrate hydroponic Kailan (*Brassica alboglabra*)

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Abstract. This research objective was to determine the effects of interaction between Arenga wood-fiber size and nutrition concentration on growth and yield of substrate hydroponic kailan. The research was conducted at Greenhouse of Agriculture Faculty, Sebelas Maret University, Surakarta from March to May 2018. The study was designed as a completely randomized design with 2 factors. The first factor was substrate size (fiber size 1, 2 and 3 cm) and sand; the second factor was nutrition concentration (1.3, 2.3, and 4.3 mS/cm). Data analysis was based on F test at 5% level and continued with Duncan's Multiple Range Test. The observed variables were root length, root volume, number of leaves, chlorophyll content, leave area, stems diameter, fresh weight, and dry weight. The results showed that the substrate affected all plant variables except for root length. Nutrition has a significant effect on plant height and number of leaves. Fiber size 1 cm generated the highest yield, plant height, leaf number, chlorophyll content, stem diameter, fresh weight, and dry weight of plant.

1. Introduction

Kailan is a vegetable from the family of *Brassicaceae* (cabbage). These leafy vegetables are often called Chinese broccoli. Cabbage production in 2014 was decreased by -3.03 percent from 2013 or about 44,792 tons [1]. The low Kailan production was caused by several obstacles such as lack of information on appropriate agricultural technology and limited productive land area. People tend to cultivate crops and plantations that are easy to grow, in contrast to vegetables that require more intensive care. Based on the data, one of the efforts to increase the continuity of Kailan production was used hydroponics technology.

Arenga wood fiber is Arenga wood stem waste processing in the form of unused bark and can pollute the environment. Arenga wood fiber can be used as a substrate. The advantage of Arenga wood fiber as a plant grow substrate is the nature that can hold water and relative difficult to decompose.

The use of substrate hydroponic system was expected to increase the growth and yield of Kailan plants in terms of quality or quantity. Type of planting media and nutrients used is a factor that can affect the growth and development of Kailan plants. Therefore, there is a need for research on the use of Arenga



wood fiber substrate and appropriate nutrient concentrations to support the growth and yield of kailan hydroponic.

2. Methods

The study was conducted at greenhouse of Agriculture Faculty, Sebelas Maret University Surakarta from March to May 2018. Materials used in the study including of solid waste of Arenga wood fiber has been cut on size of ± 1 cm; ± 2 cm ± 3 cm, sand, Kailan seed, and AB-mix nutrition. The study was designed as a completely randomized design (CRD) with 2 factors as follows: The first factor is the substrate (fiber size ± 1 , ± 2 and ± 3 cm) and sand (as control), the second factor is the nutrients concentration (EC 1.3, 2.3, 3.5, and 4.3 mS/cm), and with 3 replications, resulted in total 48 treatment combinations. The observation variables including of root length, root volume, plant height, leaves number, chlorophyll content, leaves area, stem diameter, fresh weight, and dry weight. Data was analyzed using variance analysis and if there was significant difference then continued with DMRT test at 5% level.

3. Results and discussions

3.1. General condition of research

Greenhouse of Agriculture Faculty of Sebelas Maret University has a height of 95 m above sea level. Research location based on geographical location is at 110°33'25" of East Longitude and 7°33'31" of south latitude.

During the research, the temperature in the morning (7:00 to 9:00h) was 27.9 °C and RH 81.8%, during the day (12.00-14.00h) temperature was 31.5 °C and RH was 64.8% and, in the afternoon, (15.00-16.00h) temperature was 28.3 °C and RH 78.2%. The average daily temperature suitable for Kailan growth ranged from 15– 25 °C [2]. The light intensity during the research in the morning ranged from 2213-5690 lux, during the day ranged from 10290-18220 lux, and the afternoon ranges from 4540-5590 lux. Based on the observations, the environmental temperature is too high for the Kailan growth so that Kailan plants often withered especially during the day. While the air humidity suitable for Kailan is 60-90% so it can be concluded that the air humidity is suitable for Kailan growth.

3.2. Root length

The treatment of substrate and nutrient to root length variables were not gave significant difference. Table 1 was shown that the substrate treatment with the fiber size of ± 1 cm had mean of root length of 15.81 cm. The substrate treatment with size of ± 2 cm is 15.14 cm. The substrate treatment with fiber size of ± 3 cm has an average of 14.55 cm. The controls have an average of 16.99 cm. N1 nutrient treatment has a mean root length of 15.01 cm. N2 nutrient treatment has a mean root length of 15.88 cm. N3 nutrient treatment has mean root length of 16.80 cm. N4 nutrient treatment has mean root length of 14.80 cm. This suggests that providing nutrition can affect root growth. In accordance with this, optimal nutrition can provide sufficient phosphate (P) elements, plant roots will multiply and length [3].

Table 1. Mean of root length of Kailan (cm)

Treatment Fiber Size	EC 1.3 mS/cm	EC 2.3 mS/cm	EC 3.5 mS/cm	EC 4.3 mS/cm	Mean
± 1 cm	12.87	18.47	16.13	15.80	15.81
± 2 cm	17.77	16.50	14.70	11.60	15.14
± 3 cm	13.57	12.03	19.50	13.13	14.55
Sand (control)	15.87	16.53	16.83	18.70	16.99
Mean	15.01	15.88	16.80	14.80	

3.3. Root volume

The analysis result of Kailan root volume at 6 WAP did not show any interaction between substrate and nutrition. Substrate treatment has a significant effect on root volume. Table 2 shows that the substrate treatment with the fiber size of ± 1 cm had mean of root volume of 1.47 cm. The substrate treatment with size of ± 2 cm is 1.25 cm. The substrate treatment with fiber size of ± 3 cm has an average of 0.87 cm. The controls have an average of 2.91 cm. N1 nutrient treatment has a mean root volume of 1.69 cm. N2 nutrient treatment has a mean root volume of 1.64 cm. N3 nutrient treatment has mean root volume of 1.69 cm. N4 nutrient treatment has mean root volume of 1.48 cm. Solid fiber substrate causes aeration by stunted roots. This was evidenced in the highest bulk density of S1 than S2 and S3 but have the high value of water holding capacity so that the roots nutrients absorption can be much longer and more than S2 and S3. Media planting with aeration and holding capacity of good nutrients can stimulate root and shoot growth [4].

Table 2. Mean of root volume (ml)

Treatment	EC 1.3	EC 2.3	EC 3.5	EC 4.3	Mean
Fiber size	mS/cm	mS/cm	mS/cm	mS/cm	
± 1 cm	0.76	1.66	2.60	0.89	1.47 ^a
± 2 cm	1.88	1.25	0.81	1.09	1.25 ^a
± 3 cm	0.63	0.98	1.06	0.84	0.87 ^a
Sand (control)	3.49	2.69	2.32	3.13	2.91 ^b
Mean	1.69	1.64	1.69	1.48	

The number followed by the same letter in the column or row was not significantly different based on DMRT 5%

3.4. Plant height

The plant heights on the substrate of S1, S2 and S3 were lower than the control (S4) of 19.44 cm (Figure 1). It was suspected that sand is a medium that has a good aeration so that the roots nutrients absorption goes well. The shoots best growth on the composition of moss and husk charcoal planting media due to good physical properties, especially the total porosity and high 24 hours pores hold water [5]. With the highest water-holding ability, plant roots have the greatest absorption opportunities for nutrients, resulting in the highest growth of plant height.

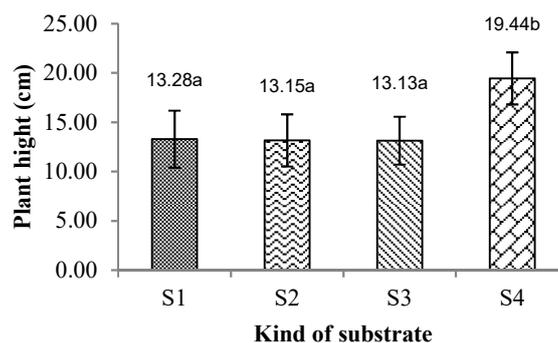


Figure 1. Plant height in difference substrate

The N3 provides the highest plant height of 16.70 cm, while the lowest plant height is N1 of 12.97 cm (Figure 2). Increasing in plant height is due to the availability of many N nutrients [6]. N3 and N4 Treatments were given relatively higher N element than N1 and N2. N4 treatment has the highest N element but has a high plant average of 15.30 cm lower than N3. The plant undergoes plasmolysis thus inhibiting plant growth. The high nutrient concentrations in the reservoirs can increase the osmotic

pressure that will cause the plant to undergo plasmolysis or discharge of cells from the plant tissue that will inhibit plant growth [3].

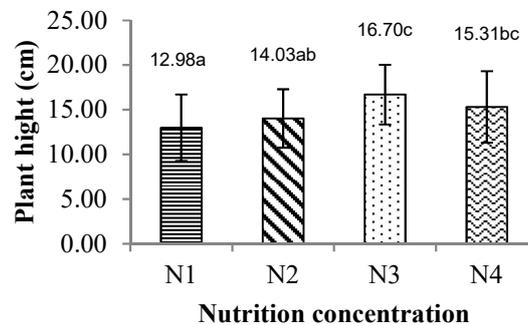


Figure 2. Plant height in difference nutrition concentration

3.5. Leaves numbers

The result of leaves number analysis was showed that there was not interaction between substrate and nutrition. Based on Figure 3 on S1 substrate was given the highest average of leaves number of 6.50 not significantly different from S2 of 6.18 strands and S3 of 6.23 strands lower than S4 (Control) of 8.61 strands. The substrate has a high bulk density and therefore the roots will be difficult to penetrate. When compared with the sand, the physical properties of the porous sand so that the roots that serve as the support of plants can grip the media well so that the plant stems upright, if the position of the plant upright so the stem can support the leaves well, so that sunlight can be absorbed optimally by the leaves and used for the photosynthesis process [6]

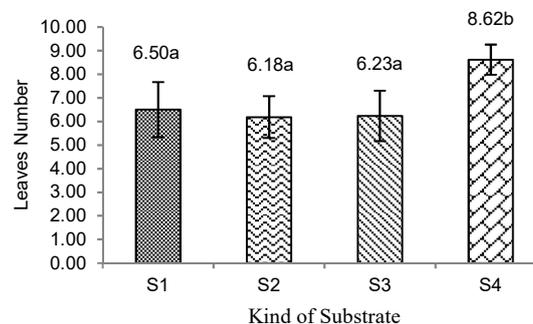


Figure 3. Plant height in difference substrate

Nutrient treatment significantly affected the leaves number. Based on Figure 4 the N1 treatment amounting to 6.30 strands, significantly different from the N2 of 6.83 strands, N3 of 7.50 strands, N4 of 6.90 strands. N3 and N4 treatment has high N content but N4 was given a lower yield than N3. It was suspected that the N3 nutrients can be absorbed by plants, especially N, which play a role in the vegetative growth of the plant. The formation of leaves organ was influenced by nitrogen element. N availability will also increase the larger leaves area [7].

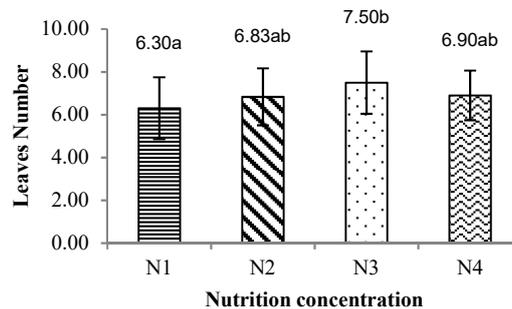


Figure 4. Leave numbers in difference nutrition concentration

3.6. Chlorophyll levels

There is no interaction between substrate influence and nutrient to chlorophyll content of Kailan. However, substrate treatment affected while nutrition did not affect chlorophyll content. Based on Figure 5, S1 treatment has a mean value of chlorophyll content of 50.95, not significantly different with S2 of 49.97 and significantly different S3 of 48.74 lower and significantly different from the sand (control) of 58.33. Sand is a medium that has a good aeration so that the roots nutrients absorption goes well. Factors forming chlorophyll content is an N element. Visually plants that are not given or lack of N nutrients yellowish leaf color, allegedly formation of chlorophyll disturbed due to the process of assimilation is not smooth. The availability of N will increase the larger leaves area [8].

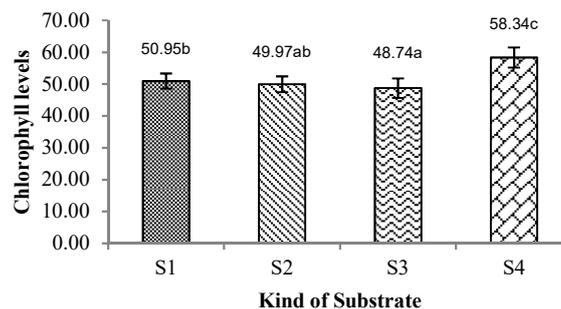


Figure 5. Chlorophyll level in difference substrate

3.7. Leaves area

There is no interaction between substrate and nutrient on the leaves area. However, substrate treatment was significant effect and nutrients had no significant effect on leaves area based on a 5% DMRT test. Figure 6 was shown the Arenga substrates is lower and significantly different from the sand (as control). The same reason with the addition of the number of leaves, the physical properties of porous sand so that the roots that serve as the support of plants can grip the media well so that the planting stems upright, if the position of the plant upright so the stem can support the leaves well, so that sunlight can be absorbed optimally by the leaves and used for the photosynthesis process [6]. Good aeration on planting medium can support plant roots in absorb water and nutrients optimally which then trans-located for metabolic processes that play a role in the increasing of leaves area [9].

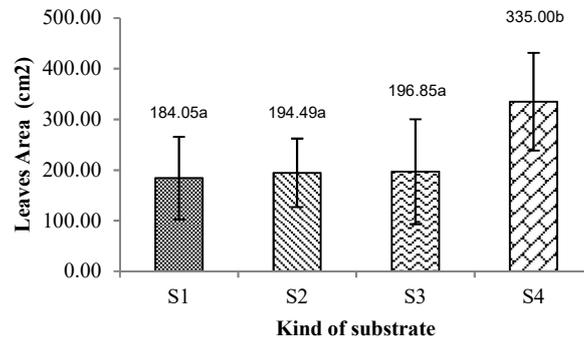


Figure 6. Leaves area in difference substrate

3.8. Stem diameter

Substrate treatment had a very significant effect on stem diameter. Nutrient treatment has no significant effect on stem diameter. Based on Figure 7, sand is a medium that has a good aeration so that the roots nutrients absorption goes well. The potassium element is an essential nutrient that was used in almost all processes to support plant life. Potassium belongs to an element that mobile in cells, plant tissues, xylem and phloem. Potassium is widely present in the cytoplasm. The importance of potassium in the addition of stem diameter associated with potassium function to increase levels of sclerenchyma in the stem [10]. Sclerenchyma has a function of thickening and strength in the stem tissues so that the plant is stronger or not easy collapsed. The K element serves to increase the synthesis and translocation of carbohydrates, thereby accelerating the thickening of cell walls and the rigidity of flower stalks, fruit, and branch.

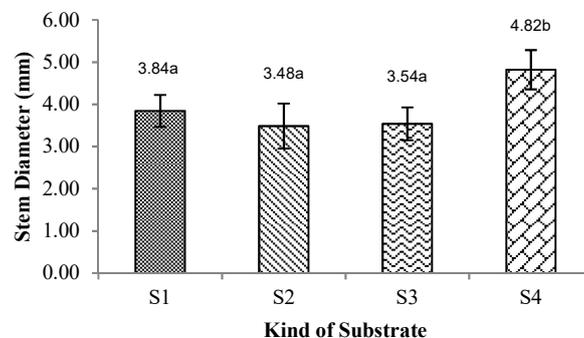


Figure 7. Stem diameter in difference substrate

3.9. Fresh weight of plant

The fresh weight of Kailan at age 6 WAP was showed that there was no interaction between substrates and nutrients. Substrate treatment had a very real effect on fresh weight variables. Nutrient treatment did not affect the fresh weight variables. Figure 8 shows the substrate treatment with the fiber size of ± 1 cm had mean of fresh weight of 17.65 gram and not significantly different with S2 of 14.95 g and S3 of 13.45 g. Fresh weight average of substrate plant was lower than control (41.44 ram). The substrate in the hydroponic system is only a support for the plant, and continues the excessive solution (no needed crops). Solutions present in the media must be rich in nutrients for plant growth. The fresh weight of the plant was determined by the size of the plant organs and the moisture content of the plant parts itself which was absorbed by the roots [11]. This means that all organs of plants containing assimilates and different relative water content resulting in differences in the appearance of the fresh weight of plant.

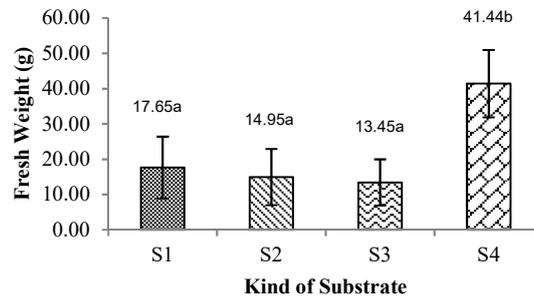


Figure 8. Plant height in difference substrate

3.10. Dry weight of plant

There was no interaction between substrate and nutrient treatment. The substrate treatment affected the variable dry weight of the plant. Nutrient treatment had no significant effect on dry weight variables. Figure 10 was shown that S1 had mean of fresh weight of 17.65 gram of 1.68 grams not significantly different from S2 of 1.47 grams and S3 of 1.36 g. Dry weight average of substrate plant was lower than Control of 3.92 g. Dry weight was affected by the fresh weight of the plant. In high rate of photosynthesis, the assimilation rate is high [12]. The net assimilation rate was affected the growth rate of the plant. The growth rate increases with the age of a plant. The relative growth rate affects the total dry weight of the plant. Provision of unbalance nutritional levels to the needs of plants resulting dwarf plants, leaves yellow and fall so that plants do not overshadow each other and the low leaves area of plant. When the plants are not shaded, high photosynthesis rate resulting in high net assimilation rate.

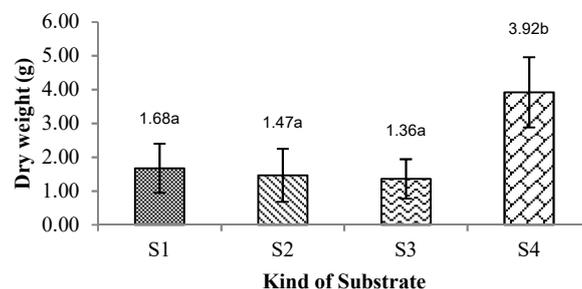


Figure 9. Plant height in difference substrate

4. Conclusions

Based on the results, it can be concluded that Arenga wood-fiber treatment affected the root volume, plant height, leaves number, chlorophyll content, leaves area, stem diameter, fresh weight of plant, and dry weight of plants. Increasing the nutrition concentration didn't affect the plant height and leaf variable.

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