Study of buffer substrate and Arenga wood fiber size on hydroponic Kailan (*Brassica alboglabra*)

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Abstract. Kailan is a kind of vegetable that has high economic value, however its prospect is not well developed. One of obstacles in Kailan cultivation is the limitation of fertile soil, that can be solved by using hydroponic substrate. Considering its amount and potential, the fiber waste of Arenga wood was selected as substrate candidate. For that, this research aims to study the growth and yield of Kailan with different soaking treatment using buffer solution and size of Arenga wood fiber in the hydroponic substrate. Research was conducted at Green House Laboratory, Faculty of Agriculture Sebelas Maret University Surakarta from February to May 2017. The treatments were soaking buffer solution with EC 1.2 $mScm^{-1}$; 1.4 $mScm^{-1}$; and 1.6 $mScm^{-1}$ and the size of Arenga fiber <1 cm, 1-2 cm and 2-3 cm. In this experiment, sand media was used as control. Result show that, soaking in 1.6 $mScm^{-1}$ EC buffer solution with Arenga fiber size lower than 3 cm gives higher root volume compared to other treatments combination.

1. Introduction

Public awareness of health importance of and the fulfillment daily nutrition led to high quality vegetable and fruit production demand. Kailan belongs to a new vegetable and has not been developed although it has economic value and high prospect. The popularity and consumption of Brassica vegetables is increasing due to its nutritional value. Phenolics and other bioactive compounds are distributed differently depending on Brassica [1]. This vegetable also contains anticarcinogenic and antioxidant that are beneficial to the health of the body [2].

The cultivation problem of Kailan is lack of fertile agriculture soil. One effort to solved this, is by improving the culture technique using Hydroponics that land-saving crops. Some of of hydroponics advantages is the efficiency of water consumption and nutrition [3,4] minimize pesticide use and improve yields [5]

Most of the palm trees in the tropics are exploited from the wild plan and still few are cultivated [6]. Sugar is a widely used multipurpose tree species scattered in several regions of Indonesia [7]. Almost all physical parts of Arenga can be used from stems, roots, and leaves, the Arenga industry produces waste that has negative potential to cause problems if not handled properly. Arenga wood fiber waste has large amount and its utilization has not been maximized. Therefore, fiber from Arenga wood can be used as growing media for hydroponic substrate.

Growing media is important in hydroponic substrate cultivation activities. Each media has its own physical and chemical characteristic. It needs special treatment on organic media so that can improve the quality of planting media, one of them is by soaking in buffer solution (buffered substrate) [8] soaking buffer on coco coir medium gives a real effect on the number of flowers and the length of stems Gerbera plant (*Gerbera jamesonii*). Therefore, it is necessary to study the growth and yield of Kailan which is cultivated with soaking treatment in buffer solution and the size of Arenga wood fiber as growing media on hydroponic substrate.

2. Methods

This research was conducted at the Green House Laboratory Faculty of Agriculture Sebelas Maret University Surakarta in February to May 2017. The experimental study was completely randomized design (CRD). The treatments was soaking in buffer solution with EC 1.2 $mScm^{-1}$; 1.4 $mScm^{-1}$; and 1,6 $mScm^{-1}$ and the size of Arenga fiber at <1 cm, 1-2 cm, 2-3 cm and sand media used as control.

The study steps are laboratory media analysis consist of physical analysis (bulk density, particle density, and water holding capacity) and chemical analysis (N, P, K, Mg, Ca, Fe and Mn), followed with implementation of research include seeding, media preparation, planting and harvesting.

The variables observed were fresh weight, consumption weight, stem diameter, plant height, leaf number, leaf area, chlorophyll, root length, root weight, root volume, and biomass. Resulted data were analyzed using ANOVA (*Analysis of Variance*; α =5%), any significant differences will be followed with orthogonal contrast test.

3. Result and discussion

3.1. Weight

Plant weight is one of parameters in the observation variable [9] which is necessary to determine biomass content. The result of variance analysis showed that all treatments did not give real effect to all weight variable of KKailan, that are total weight and consumption weight. Table 1 shows the average of yield on total weight and consumption weight of Kailan, wherevalue are 8.09-11. g and 7.12-10.76 g respectively.

Environmental factors were suspected to be one of factors affecting plant growth especially fluctuating temperatures in the Greenhouse. The average daily temperature is 30^{o}C and the daily average humidity is 66.2%. The ideal temperature and humidity are the main concerns for hydroponic cultivation of Kailan because it is very important on plant growth. The air temperature affected tothe various physiological processes that take place in plant organs as they relate to the growth and production of plants [10]

The soaking buffer solution treatment on Arenga wood fiber media generally gives lower yield than without soaking in the buffer. The soaking buffer on Arenga wood fiber media causes the accumulation of Potassium (K). Known in the Arenga wood fiber has contained K elements of 17000 ppm. The unbalanced composition resulted in stunted growth of generalized KKailan plants. This suggests that all buffer soaking treatments and sizes have not yielded optimum results on total weight and consumption weight.

3.2. Stem

Growth is an important process in plant life. One of the characteristics of growth is the increase in plant stem size due to cell division and enlargement. Observation parameters in bar variable that is stem diameter and plant height presented in Table 2.

Measurement of stem diameter was done at the end of observation at 6 WAP. Each treatment showed average results of diameter Kailan not much different. The data presented shows the stem diameter range of 0.39-0.57 cm and plant height range 10.00-12.53 cm. The growth of diameter is influenced by the activity of photosynthesis, this growth takes place when the photosynthesis results such as respiration, leaf replacement, the growth of roots and height has been fulfilled [11].

Plant height is one of the parameters measured in this study. Plant height is calculated from the base of the stem to the point of growing. Based on High growth chart of Kailan (Figure 1) has a difference every week and continues to grow to 6 WAP. High growth gap of Kailan is less visible. The graph of treatment A (control treatment) showed slower increase in plant height compared to other treatments. Graph of treatment J (size 2-3 cm without soaking buffer solution) showed the most rapid increase of plant height.

Table 1. Average observation of Kailan weight variables

Fiber size (cm)	EC ($mScm^{-1}$)	Observation Variable (g)	
		Total weight	Consumption weight
<1	0	11.65	10.03
	1.2	10.25	9.01
	1.4	9.59	8.44
	1.6	10.32	9.33
1-2	0	8.09	7.12
	1.2	9.55	8.33
	1.4	9.77	7.95
	1.6	9.66	8.20
2-3	0	10.28	10.28
	1.2	8.63	7.18
	1.4	11.13	9.69
	1.6	9.39	7.89
Control		11.93	10.76

Information : EC (*Electrical Conductivity*)

Table 2. Average observation of Kailan stem variables

Fiber size (cm)	EC ($mScm^{-1}$)	Observation Variable	
		Stem diameter (cm)	Plant height 6 WAP (cm)
<1	0	0.50	11.10
	1.2	0.46	11.30
	1.4	0.45	10.87
	1.6	0.49	10.33
1-2	0	0.39	11.83
	1.2	0.53	10.97
	1.4	0.46	11.17
	1.6	0.48	11.03
2-3	0	0.52	12.53
	1.2	0.45	10.60
	1.4	0.49	12.11
	1.6	0,.47	11.27
Control		0.57	10.00

Information : EC (*Electrical Conductivity*), WAP (Week After Planting)

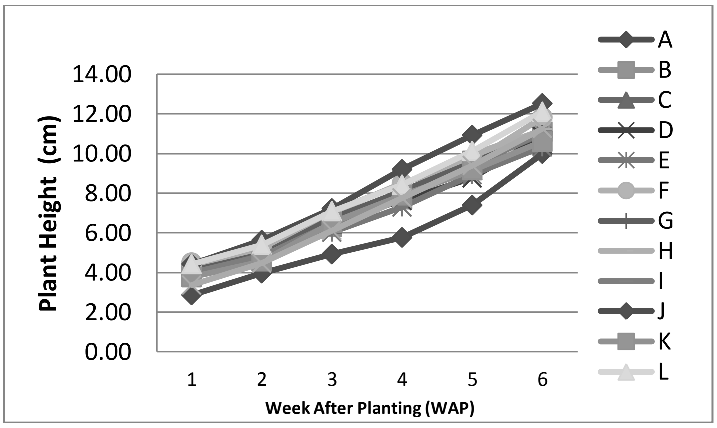

Figure 1. Height growth chart of Kailan

3.3. Leaves

The main organ of the plant where photosynthesis takes place is the leaves. Plants catch light using a pigment called chlorophyll that gives the green color to the plant [12]. The result of variance analysis showed that all treatments did not give any significant effect to all leaf variables is leaf number, leaf area and chlorophyll. The average observation result of Kailan leaf variables is presented in Table 3.

Table 3. Average observation of Kailan leaves variables

Fiber size (cm)	EC ($mScm^{-1}$)	Observation Variable: Leaf number (sheet)	Leaf area (cm^2)	Chlorophyll
<1	0	6.87	205.78	45.53
	1.2	6.80	211.89	47.03
	1.4	6.33	187.89	48.33
	1.6	6.93	222.00	48.93
1-2	0	6.73	180.78	45.17
	1.2	6.60	181.89	46.90
	1.4	7.33	207.56	45.03
	1.6	7.07	189.78	46.13
2-3	0	7.07	232.44	46.40
	1.2	6.13	157.56	47.90
	1.4	7.07	218.56	43.20
	1.6	7.07	184.33	47.37
Control		7.87	246.11	50.53

Information : EC (*Electrical Conductivity*)

Based on Table 3, it is known that the average range of Kailan leaf number is between 6.13-7.87. Average range of leaf area between 180.78 cm^2-246.11 cm^2. While the average range of chlorophyll is between 45.03-50.53. Known in the Arenga wood fiber media has contained K elements of 17000 ppm. [13] Mg deficiency may occur when NH^{4+}, K^+, or Ca^{++} concentrations in high rooting medium. The cause is the weakest Mg^{++} in the competition among the cations [14] adds that Magnesium in plants is a central atom in the formation of chlorophyll molecules, so it is very important in relation to photosynthesis.

The result showed a decrease of Magnesium (Mg) element as the value of EC buffer increases. The unbalanced composition resulted in the inhibition of chlorophyll growth in general Kailan plants.

Symptoms of magnesium nutrient deficiency (Mg) seen on the appearance of Kailan leaves. The leaves appearing yellow spots and in the bones of the leaves remain green. Magnesium (Mg) deficient plants show yellowing leaves while venous leaves remain green [14].

3.4. Roots

Root is an important part of a plant, good media greatly influence to the success of new roots growth and formation. Based on TTable 4 it is known that the average range of root length is 9.73-14,5 cm and the average of Kailan root weight result shows 1,11-1,70 g. In general, the treatment of soaking buffer on Arenga wood fiber media gives better result than sand media (control).

The treatment of soaking buffer on the Arenga wood fiber media causes the accumulation of Phosphate (P) and Calcium (Ca). It is shown in the results of chemical analysis of the content of Arenga wood fiber media, soaking buffer tends to increase the elements of P and Ca. Elements of P and Ca according to the previous study [13] play a role in the growing point of root formation.

Table 4. Average observation of Kailan root variables

Fiber size (cm)	EC (mScm^{-1})	Observation Variable		
		Root length (cm)	Root weight (g)	Root volume (mL)
<1	0	12.67	1.57	0.49
	1.2	11.77	1.67	0.44
	1.4	12.67	1.27	0.46
	1.6	14.50	1.76	0.51
1-2	0	13.30	1.19	0.49
	1.2	12.50	1.26	0.40
	1.4	12.63	1.39	0.49
	1.6	12.73	1.43	0.65
2-3	0	13.27	1.47	0.43
	1.2	10.83	1.11	0.46
	1.4	13.13	1.45	0.43
	1.6	12.87	1.70	0.70
Control		9.73	1.13	0.28

Information : EC (*Electrical Conductivity*)

Distribution of roots in the substrate can be affected by the particle size distribution of the substrate [16]. The result of physical analysis on Arenga wood fiber showed that the size treatment caused different values of bulk density, particle density and water holding capacity. The result of physical analysis showed sand medium having bulk density 1,54 g mL^{-1}. The average length of the control treatment root with the sand medium showed the lowest yield. The result of bulk density from low to high is shown consecutively on the medium of aren size 2-3 cm, 1-2 cm size, aren size <1 cm that is with value 0,06 g mL^{-1}; 0.07 g mL^{-1}; and 0.08 g mL^{-1}.

According to [17] by knowing the weight of bulk density and particle density it can be calculated the number of total pores of soil. Particle density sand media showed 2.10 g mL^{-1}; Arenga wood fiber <1 cm 0,50 g mL^{-1}; Size 1-2 cm 0.45 g mL^{-1}; And measures 2-3 cm 0.38 g mL^{-1}. This shows that the higher value of bulk density, the higher value of particle density shown in the sand media. Size of Arenga wood fiber affects the physical character which is indicated by the increasing value of bulk density and particle density as the smaller size of Arenga wood fiber.

The result of variance analysis showed that the treatment give a real effect to the root volume. The results are significantdifferent ($P<0.05$) from this root volume and then continued orthogonal contrast test (Table 5).

There are 12 comparisons presented in Table 5. Comparison based on fiber size grouping and EC buffer. The results show that there is no significant different on the same fiber size groupings and different EC buffers. These results indicate that the treatment of Arenga wood fiber size <1 cm, 1-2 cm and 2-3 cm did not give differences in yield to root volume growth. The difference of physical analysis result on very small palm fiber media causes overall size treatment does not give different result. Based on these results it can be seen that the larger the size of Arenga wood fiber does not affect the growth of Kailan root volume.

The result of orthogonal contrast test on Kailan root volume (Table 5) shows a significant difference in DHL vs EIM and BFJ vs EIM ratio and very significant difference in 3 comparison, A vs Others, EIM vs CDGHKL and CGK vs EIM. Comparison of A vs others compares control (sand media) with all treatments (palm fiber media). The results showed that treatment A (control) give the lowest yield on growth of root volume compared with all treatment using Arenga wood fiber media. This suggests that Kailan planting using Arenga wood fiber media gives better influence from sand media on root volume growth.

Table 5. Test of orthogonal contrast treatment to root volume

Comparison	Information
A vs Others	**
BFJ vs CDEGHIKLM	-
CGK vs DHL	-
C vs GK	-
D vs HL	-
E vs IM	-
EIM vs CDGHKL	**
BFJ vs CGK	-
DHL vs EIM	*
DHL vs CEGIKM	-
CGK vs EIM	**
BFJ vs EIM	*

Information :

*	:	significantly different (p>5%)
**	:	very significantly different (p>1%)
-	:	not significantly different
A vs Others	:	Control compared to all treatments
BFJ vs CDEGHIKLM	:	Arenga wood fiber size <1 cm, 1-2 cm and 2-3 cm without soaking buffer solution compared to B + soaking buffer solution EC 1.2 $mScm^{-1}$, 1.4 $mScm^{-1}$, 1.6 $mScm^{-1}$ and F + soaking buffer solution EC 1.2; 1,4; 1,6 and J + soaking buffer solution of EC 1,2 $mScm^{-1}$; 1,4 $mScm^{-1}$; 1,6 $mScm^{-1}$
CGK vs DHL	:	B + F; J + Soaking buffer solution EC 1.2 $mScm^{-1}$ compared to B; F; J + Soaking buffer solution EC 1.4 $mScm^{-1}$
C vs GK	:	B + Soaking buffer solution EC 1.2 compared with F + Soaking buffer solution EC 1.2 $mScm^{-1}$; J + Soaking buffer solution EC 1.2 $mScm^{-1}$
D vs HL	:	B + Soaking buffer solution EC 1.4 compared with F + Soaking buffer solution EC 1.4 $mScm^{-1}$; J + Soaking buffer solution EC 1.4 $mScm^{-1}$
E vs IM	:	B + Soaking buffer solution EC 1.6 $mScm^{-1}$compared with F + Soaking buffer solution EC 1.6 $mScm^{-1}$; J + Soaking buffer solution EC 1.6 $mScm^{-1}$
EIM vs CDGHKL	:	B; F; J + Soaking buffer solution EC 1.6 $mScm^{-1}$compared with B; F; J + Soaking buffer solution EC 1,2 $mScm^{-1}$and 1,4 $mScm^{-1}$
BFJ vs CGK	:	Arenga wood fiber size <1 cm, 1-2 cm and 2-3 cm without soaking buffer solution compared with B; F; J + soaking buffer solution EC 1.2 $mScm^{-1}$
DHL vs EIM	:	B; F; J + Soaking buffer solution EC 1.4 $mScm^{-1}$ compared with B; F; J + Soaking buffer solution EC 1.6 $mScm^{-1}$
DHL vs CEGIKM	:	B; F; J + Soaking buffer solution EC 1.4 compared with B Soaking buffer solution EC 1,2 $mScm^{-1}$and 1,6 $mScm^{-1}$; F + Soaking EC buffer solution 1,2 $mScm^{-1}$and 1,6 $mScm^{-1}$; J Soaking buffer solution EC 1,2 $mScm^{-1}$and 1,6 $mScm^{-1}$
CGK vs EIM	:	B + F; J + Soaking buffer solution EC 1.2 $mScm^{-1}$compared to B; F; J + Soaking buffer solution EC 1.6 $mScm^{-1}$
BFJ vs EIM	:	Arenga wood fiber size <1 cm, 1-2 cm and 2-3 cm without soaking buffer solution compared with B; F; J + Soaking buffer solution EC 1.6 $mScm^{-1}$

Comparison of DHL vs EIM, BFJ vs EIM, EIM vs CDGHKL and CGK vs EIM are groupings that compare the same size of Arenga wood fiber (<1 cm, 1-2 cm and 2-3 cm) with different EC of 1.2 mScm^{-1}; 1.4 mScm^{-1}; And 1.6 mScm^{-1}. The results showed that EIM treatment (EC immersion buffer 1,6 mScm^{-1} on Arenga wood fiber media size less than 3 cm) gave the best effect to growth of root volume. Based on this result it can be said that the higher giving EC buffer on Arenga wood fiber media can increase root volume in Kailan.

Root volume can be used as a plant growth parameter [18], growth and development in plants is a process of growth of size which includes volume, weight, cell number with cell differentiation which further form the plant organ.

3.5. Biomass

Biomass of Kailan consists of leaf biomass, stems and roots. The results of the variance analysis showed that all treatments had no significant different results. Based on Table 6, it is known that the average range of leaf dry weight is between 0.37-0.54 g. The average stem dry weight range is between 0.33-0.52 g. The more number of leaves and the wider the leaf that captures the light then the CO_2 assimilation increases so that the results of the dry weight of the plant is high.

Table 6. Average observation of Kailan biomass variables

Fiber size (cm)	EC (mScm^{-1})	Observation Variable			
		Biomass (g)			
		Leaf	Stem	Root	Total
<1	0	0.52	0.32	0.36	0.97
	1.2	0.49	0.32	0.35	0.93
	1.4	0.47	0.33	0.34	0.91
	1.6	0.46	0.36	0.37	0.97
1-2	0	0.40	0.30	0.33	0.82
	1.2	0.43	0.28	0.52	1.00
	1.4	0.40	0.30	0.35	0.86
	1.6	0.47	0.30	0.39	0.95
2-3	0	0.50	0.38	0.34	1.00
	1.2	0.37	0.25	0.34	0.74
	1.4	0.50	0.38	0.34	0.99
	1.6	0.42	0.32	0.43	0.93
Control		0.54	0.32	0.38	1.01

Information : EC (*Electrical Conductivity*)

Excess element K according to [19] potentially fix it the absorption of elements Calcium (Ca) and Magnesium (Mg). In addition, that if the excessive K element there is the possibility of an antagonist with elements of Fe and Mn. The results showed an increase in the elemental content of Calcium (Ca) and the decrease of Magnesium (Mg) element as the value of EC buffer increases. On the other hand, the buffer soaking treatment increases the Manganese (Mn) element. The need for plants to the element of Mn [19] is actually not too much, but has an important role in the process of forming chlorophyll, enzyme activator and nitrogen absorption. Biomass results in general show that buffer soaking treatment has not given optimal results.

4. Conclusions and suggestions

4.1. Conclusions

Based on the research results can be conclude:

- Size affects the physical character of Arenga wood fiber, shown by the increment of bulk density, particle density and water holding capacity value in line with smaller size of the fiber.
- Before soaking in buffer solution, Arenga wood fiberhas high content of Potassium (K) which is 17000 ppm.
- Soaking in the buffer solution increases Potassium (K) content and decreases Magnesium (Mg) as the value mirroring in the increment of EC buffer.
- Soaking buffer EC 1.6 $mScm^{-1}$ with size <3 cm gives high root volume.

4.2. Suggestions
Based on this research, it is necessary to modify the size of palm fiber and the reduction of potassium (K) element in the buffer solution.

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