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The types of growing media and plant density on the growth and yield of kailan (*Brassica oleracea* L.) In a floating raft system hydroponic

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Abstract

This research aimed to know the effect of the type of growing media and population density on the growth and yield of kailan (Brassica oleracea L.) hydroponically. The research was conducted in the greenhouse of the integrated agricultural system area at Curug Serang Banten Province. This research used a Randomized Completely Block Design (RCBD) as factorial with two factors. The first factor was the type of growing media (J) which consisted of 3 levels, J1 (Rockwool), J2 (Zeolite), and J3 (Sponge). The second factor was population density (K), which consisted of 3 treatment levels, K1 (3 plants per tub), K2 (4 plants per tub), and K3 (5 plants per tub). The results showed that the type of growing media had a significant effect on plant height growth 7 Day After Plating (DAP) of (4.67cm), 14 DAP (11.58 cm), 21 DAP (17.09 cm), 28 DAP (22.29 cm), 35 DAP (37.57 cm), number of leaves 14 DAP (4.59), 28 HST (6.96), 35 DAP (8.59) and the root weight of your plants was 35 DAP (3.43gram). Population density treatment had a significant effect on plant height growth 28 DAP (22.26 cm), 35 DAP (37,37 cm) and there was an interaction between media type treatment and population density on plant height parameters 35 DAP.

Keywords: Growing Media; Population Density; Kailan; Hydroponic

1. Introduction

Kailan (*Brassica oleracea* L*)* is one of the vegetables from the *Brassica* Family assumed to have originated from mainland China. It is a leaf vegetable plant that has high economic value. Emebu and Ayika (2011) stated that *Kailan* is highly nutritious.

Kailan in Banten is seldom to be cultivated. The Bureau of Statistics of Banten Province (2022) states that the production of cruciferous vegetables in general was 8.5 tons/ha in 2021 and it decreased to 3,2 tons/ha in 2022. With the growth of population and consumption demand, vegetable production must increase to meet the total vegetable need per capita per year.

One of the efforts to meet the market demand for vegetables is by increasing their production. Pitaloka (2017) opines that horticultural production activities, especially, vegetables, must yield products that can meet the requirements of quantity, quality, and continuity, and can compete in markets. To produce quality agricultural products, especially horticultural products, appropriate cultivation and handling techniques are the keys. A cultivation technique that produces quality and sustainable products is the hydroponic system.

Hydroponic is a cultivation method that uses water instead of soil as a supplier of nutrients and minerals for plant growth (Nurifah dan Fajarfika, 2020). Syah *et al*, (2015) define a floating raft system hydroponic as planting on a floating planting panel on the surface of the nutrient solution with roots hanging down into the water.

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The research results from Chandra *et al*, (2020) found that Rockwool planting medium at each nutrient solution discharge value could support the optimum growth of kale plant by providing the best influence on kale's growth parameters (plant height, number of leaves, and stem diameter) and yield parameters (root length, root weight, total fresh weight, and fresh consumption weight) compared to cocopeat and sponge growing media.

Plant cultivation using a floating raft hydroponic system should consider planting distance to obtain an ideal plant population that leads to optimal growth rate; hence, it will save nutrients efficiently. Plant population is also a factor that affects the yield of plants in an area.

Based on the aforementioned, a research is needed on the effect of types of growing media and population density on the growth and yield of kailan (*Brassica oleracea* L.) in a floating raft system hydroponic.

2. Research method

The current research was an experimental research conducted at a greenhouse of the Integrated Agricultural System Area, Curug Serang Banten.

Tools used in the research included hydroponic tubs size 45 cm x 45 cm, bamboo, hose, plastic cup, styrofoam, small sprayer, pipette, bucket, SPAD (Soil Plant Analysis Development), rope, pH meter, TDS meter, cutter, measuring cup, lux meter, meter, digital scales, stationery, camera, and thermohygrometer.

Materials for the research consisted of AB Mix Nutrient Solution, kailan seeds from Nita variety, water, rockwool, zeolite no. 2, sponge, and label.

2.1. Research Design

The research used the Randomized Completely Block Design (RCBD) as factorial with two factors, namely types of growing media (J) and population density (K).

The types of growing media (J) consisted of 3 levels:

J_1 = *Rockwool*
J_2 = Zeolite
J_3 = Sponge
Plant density factor (K) that consisted of 3 (three) treatment levels, namely:

K_1= 3 plants per plot
K_2= 4 plants per plot
K_3= 5 plants per plot

Of the two factors, there were 9 (nine) treatment combinations. Each treatment had 3 (three) repetitions thus 27 experimental units. Each experimental unit contained different kailan populations, which were 3, 4, and 5 plants in a plot; therefore, there were 108 plants.

The research implementation consisted of the preparation of a hydroponic installation size of 45 cm x 45 cm, the making of hydroponic nutrients 1300ppm per 5 liters of water, seed sowing, seedling transfer, maintenance, and harvesting.

The research result data generated during the observation would be analyzed using a variance analysis (F test). If a significant influence (*) or very significant influence (**) is found, a follow-up test will be conducted. The current research used the Duncan Multiple Range Test (DMRT) at a level of 5%.

3. Results and discussion

The results showed that the treatment of types of growing media (rockwool, zeolite, sponge) indicated a very significant influence result on plant height parameters at 7 DAP (Days After Planting), 14 DAP, 21 DAP, 28 DAP, 35 DAP and on plant root weight. The types of media also had a significant influence on the parameter of number of leaves at 14 DAP, 28 DAP, 35 DAP; however, there were no significant influence on the parameter of number of leaves at 7 DAP, 21 DAP and leaf area, leaf chlorophylls, wet weight per plant, and root length.

The population density treatment (3,4,5 plants) indicated a significant influence on plant height parameters at 28 and 35 DAP. However, the number of leaves, leaf area, chlorophylls, wet weight per plant, root weight, and root length indicated a non-significant influence.

The analysis results suggested that there was an interaction between the types of growing media and population density on the plant height parameter at 35 DAP.

Table 1 Recapitulation Of Variance Analysis Of Types Of Growing Media And Plant Density On The Growth And Yield Of Kailan (*Brassica Oleracea* L.) In A Floating Raft System Hydroponic

Observation Parameters	**Observation Time**	**Treatment**			**CD (%)**
		Kind of planting media (J)	**Plant Density (K)**	**Interaction (J*K)**	
Growth Components					
Plant Height (cm)	7 DAP	**	Ns	ns	10.55
	14 DAP	**	Ns	ns	7.62
	21 DAP	**	Ns	ns	9.73
	28 DAP	**	*	ns	6.23
	35 DAP	**	*	**	5.11
Number of leaves (strands)	7 DAP	ns	Ns	ns	21.71
	14 DAP	*	ns	ns	7.44
	21 DAP	ns	ns	ns	5.14
	28 DAP	*	ns	ns	5.69
	35 DAP	*	ns	ns	11.83
Yield Components					
Leaf area(cm^2)	35 DAP	ns	Ns	ns	24.89
Leaf chloropyll content ($\mu mol/cm^2$)	35 DAP	ns	Ns	ns	09.06
Wet weight per per plant (g)	35 DAP	ns	Ns	ns	27.00
Fresh weight of roots (g)	35 DAP	**	Ns	ns	29.16
Root length(cm)	35 DAP	ns	Ns	ns	27.88

Note : * : Significant effect on α = 5% ; ** : Very significant effect on α = 1%; ns : no significant; CD : Coefficient Diversity; DAP : Day After Planting

Table 2 indicates that kailan growth in the parameter of plant height experienced an increase every day. The best result in the plant height parameter was shown in the treatment of the types of growing media of rockwool at 35 DAP (37.57 cm). This result was assumed to be related to the rockwool growing medium having high porosity that allows maximum absorption of nutrient circulation by plant roots. According to Barus, *et al.* (2021), media porosity is the proportion of pore space (empty space) of the media contained in a media volume that can be occupied by water and air, so it is an indicator of the condition of soil drainage and aeration. A porous media means that it has sufficient pore space for water and air movement to enter and exit freely. In the treatment of growing medium of zeolite at 35 DAP and sponge at 35 DAP, the average plant height was 34.25 cm and 35.35 cm, respectively. Plant height between both media had a non significant difference. Zeolite growing medium has a similar characteristic to sands. It has high porosity yet is less able to bind and retain water and nutrients.

In the population density treatment, the best result was indicated by the treatment of a population of 3 plants in one hydroponic tub with an average result of 37.37 cm. This result is different from the previous research result and is assumed to be related to the wide planting distance. The population of 3 plants has a wider distance that allows more optimal light and absorption of nutrients. According to Fajri and Soelistyono (2018), a wide planting distance has lower competition between plants thus the availability of nutrients, water, and light is in conditions where the plant's needs are met. Wider planting distance provides better growing space, especially in the utilization of sun and nutrients; therefore, plant leaves could grow longer compared to those plants that are planted in narrower planting distance.

3.1. Plant Height

Table 2 Average Plant Height Of Kailan (*Brassica Oleracea* L.) In Relation To The Types Of Growing Media And Plant Density In A Floating Raft System Hydroponic

Observation Time	Kind of Planting Media (cm)	Plant density			Average
		3 plants per plot (K_1)	4 plants per plot (K_2)	5 plants per plot (K_3)	
		……………………………cm……………………………			
7 DAP	Rockwool (J_1)	4.91	4.97	4.13	4.67a
	Zeolit (J_2)	4.57	4.25	4.20	4.34b
	Spons (J_3)	3.10	2.91	3.21	3.07c
Average		4.15	4.53	3.73	4.14
14 DAP	Rockwool (J_1)	11.89	11.78	11.08	11.58a
	Zeolit (J_2)	10.14	9.36	11.03	10.18b
	Spons (J_3)	8.32	8.83	9.89	9.01c
Average		10.12	9.99	10.67	10.26
21 DAP	Rockwool (J_1)	17.78	16.61	16.89	17.09a
	Zeolit (J_2)	14.00	13.33	15.50	14.28b
	Spons (J_3)	15.22	15.39	14.78	15.13b
Average		15.67	15.11	15.72	15.50
28 DAP	Rockwool (J_1)	24.21	21.03	21.61	22.29a
	Zeolit (J_2)	20.38	19.35	19.89	19.87b
	Spons (J_3)	22.18	23.14	20.17	21.83a
Average		22.26a	21.17b	20.56b	21.33
35 DAP	Rockwool (J_1)	35.48c	38.67a	38.55a	37.57a
	Zeolit (J_2)	39.78a	30.39c	32.57c	34.25b
	Spons (J_3)	36.85b	35.38b	33.79b	35.34b
Average		37.37a	34.81b	34.97b	35.72

Note: Numbers followed by the same letter inthe same column or row are not significntly different based on the DMRT Test 5 %

3.2. Number of Leaves

Table 3 indicates that the parameter of the number of kailan leaves shows an increase in each interval of observation time. The treatment of types of growing media had a significant influence on the parameter of the number of leaves at 14.28 and 35 DAP but no significant influence at 7 and 21 DAP. The treatment of population density did not indicate a significant influence on the growth of the number of leaves. The results of the average number of kailan leaves in the treatment of types of growing media of sponge at 35 DAP indicated the highest yield, which was 8.59 leaves. The rockwool growing medium indicated a similar value, which was 8.26 leaves. The lowest yield was found in the treatment of zeolite growing medium with a yield of 7.41 leaves. This was presumed to be due to a sponge growing medium that has lots of pore space that allows maximum aeration process. Dian *et al.* (2014) stated aeration serves to maintain oxygen levels in the nutrient solution so that the nutrient absorption process by plant roots can be carried out optimally. At the 21 DAP, there was a decrease in the number of kailan leaves due to the attack of armyworm pest (*Spodoptera litura*) on several sample plants influencing the number of leaves during observation. The pest is one of the pests in cruciferous plants. The pest attacks the leaf part.

Table 3 The Average Number Of Leaves Of Kailan (*Brassica Oleracea* L.) In Relation To The Types Of Growing Media And Plant Density In Floating Raft System Hydroponic

Observation Time	Kind of Planting Media (cm)	Plant Density			Average
		3 3plants per plot (K_1)	4 plants per plot (K_2)	5 plants per plot (K_3)	
		...............................helai...............................			
7 DAP	Rockwool (J_1)	2.33	2.33	2.00	2.22
	Zeolit (J_2)	1.67	2.00	2.33	2.00
	Spons (J_3)	2.00	2.33	2.33	2.22
Average		2.00	2.22	2.22	2.15
14 DAP	Rockwool (J_1)	4.44	4.78	4.56	4.59a
	Zeolit (J_2)	4.33	4.00	4.44	4.26b
	Spons (J_3)	4.00	4.22	4.33	4.19b
Average		4.26	4.33	4.44	4.35
21 DAP	Rockwool (J_1)	5.78	5.33	5.44	5.52
	Zeolit (J_2)	5.33	5.22	5.44	5.33
	Spons (J_3)	5.33	5.22	5.56	5.37
Average		5.48	5.26	5.48	5.41
28 DAP	Rockwool (J_1)	7.00	7.11	6.78	6.96a
	Zeolit (J_2)	6.33	6.56	6.22	6.37b
	Spons (J_3)	6.44	6.33	7.00	6.59b
Average		6.59	6.67	6.67	6.64
35 HST	Rockwool (J_1)	8.22	8.89	7.67	8.26a
	Zeolit (J_2)	7.56	7.56	7.11	7.41b
	Spons (J_3)	8.56	7.44	9.78	8.59a
Average		8.11	7.96	8.19	8.09

Note: Numbers followed by the same letter inthe same column or row are not significntly different based on the DMRT Test 5 %

3.3. Leaf Area (Cm^2)

Table 4 Average Leaf Area Of Kailan (*Brassica Oleracea* L.) In Relation To The Types Of Growing Media And Plant Density In Floating Raft System Hydroponic

Observation Time	Kind of Planting Media (cm)	Plant Density			Average
		3 plants per plot (K_1)	4 plants per plot (K_2)	5 plants per plot (K_3)	
35 DAP		...............................cm^2.......................................			
	Rockwool (J_1)	51.14	52.85	41.26	48.42
	Zeolit (J_2)	54.62	5.77	28.35	44.58
	Spons (J_3)	41.74	49.71	59.26	50.24
Average		49.17	51.11	42.96	47.74

Table 4 indicates that the treatments of growing media and plant population did not have a significant influence on the leaf area parameter. The highest average score in this parameter was found in the treatment of sponge growing medium (50.24cm^2) and the density treatment of 4 (four) plants (51.11cm^2). This is assumed to be related to the environmental factors and light intensity received by plants during the growth period. The light intensity in the greenhouse in this research was 1491 lux. This value has met the criteria of optimum light intensity for kailan yet it is low compared to the maximum value of the optimum light intensity required. Alhadi. *et al* (2016), suggested that kailan growth optimally in a greenhouse with a light intensity of 1040 lux-80300 lux. Other factors affecting the growth of leaf area are temperature and humidity. If the temperature is too high and the humidity is too low, whereas the evapotransportation process occurs continuously, then plants will lose a lot of water which causes the cell pressure to relax and they will start to wilt and is unable to absorb nutrients and water optimally thus hampering the process of increasing leaf area.

3.4. Leaf Chlorophyll Content

Table 5 Average Leaf Chlorophyll Content Of Kailan (*Brassica Oleracea* L.) In Relation To The Types Of Growing Media And Plant Density In Floating Raft System Hydroponic

Observation Time	**Kind Of Planting Media**	**3 Plants Per Plot (K_1)**	**4 Plants Per Plot (K_2)**	**5 Plants Per Plot (K_3)**	Average
35 Dap		...........................µmol/Cm^2...............................			
	Rockwool (J_1)	53.44	65.84	51.87	56.38
	Zeolit (J_2)	53.52	54.86	52.68	53.69
	Spons (J_3)	52.02	51.55	55.76	53.11
Average		53.00	56.75	53.44	54.39

Table 5 suggested that the treatments of growing media and plant population density did not indicate a significant influence on the parameter of chlorophyll content. The highest average in the parameter was in the treatment of rockwool growing medium (56.63 µmol/cm^2) and population treatment of 4 (four) plants (56.75µmol/cm^2). This was due to internal and external factors of the plant, such as narrow leaf area and pale green color of leaves. Research by Dharmadewi (2020) which compared the chlorophyll content of several vegetable plants suggested that factors influencing the chlorophyll content of a plant include plant age, leaf morphology, physiological stages, and genetic factors. The difference in chlorophyll levels in plants is due to other pigments in the leaves that are more dominant or due to an adaptation factor in a plant. Moreover, leaf surface area can be a factor since leaf area could efficiently capture light energy for normal photosynthesis in low light-intensity conditions.

3.5. Fresh weight per plant (g)

Table 6 Average Fresh Weight Of Kailan (*Brassica Oleracea* L.)) In Relation To The Types Of Growing Media And Plant Density In Floating Raft System Hydroponic

Observation Time	**Kind of planting media (cm)**	**Plant Density**			**Averge**
		3 plants per plot (K_1)	**4 plants per plot (K_2)**	**5 plants per plot (K_3)**	
35 DAP		...........................g...............................			
	Rockwool (J_1)	21.17	19.89	15.10	18.72
	Zeolit (J_2)	17.79	15.95	10.19	14.64
	Spons (J_3)	14.52	14.86	20.24	16.54
Average		17.83	16.90	15.18	16.63

Keterangan: Angka yang diikuti huruf yang sama pada kolom dan baris yang sama berbeda tidak nyata berdasarkan UJI DMRT 5%

Based on Table 6, the treatment of the types of growing media and plant population density did not indicate a significant influence on the parameter of fresh weight per plant. This was due to the growth between the treatments were being relatively the same. According to Pratiwi *et al.*, (2015), the total fresh weight of a plant is affected by the condition of the leaves produced both in terms of the number of leaves and leaf area. The higher the number of leaves produced and the wider the leaf area, the higher the plant's total fresh weight is. One of the factors influencing the fresh weight per plant is the water content in the plant. In research on lettuce plants by Fitriansah (2019) found that the rate of increase in total fresh weight of lettuce plants was affected by the concentration level of dose and interval of nutrient addition since the application of the containing micro and macro nutrients could increase nutrient concentration in plant tissues thus increases plant fresh weight.

3.6. Root fresh weight per plant (g)

Table 7 Average Root Fresh Weight Per Kailan (*Brassica Oleracea* L.) In Relation To The Types Of Growing Media And Plant Density In Floating Raft System Hydroponic

Observation Time	Kind of planting media (cm)	Plant Density			Average
		3 plants per plot (K_1)	4 plants per plot (K_2)	5 plants per plot (K_3)	
35 DAP		..........................g..............................			
	Rockwool (J_1)	3.78	4.06	2.46	3.43a
	Zeolit (J_2)	2.50	2.57	1.33	2.13b
	Spons (J_3)	1.75	1.80	2.27	1.94b
Average		2.67	2.81	2.02	2.50

Table 7 showed that the treatment of the types of growing media and plant population density has a significant influence on the parameter of root fresh weight of kalian plants with an average of 3.43 grams. Rooting has a function to absorb water, nutrients, and organic matter from the media to stimulate plant growth and development. Faster nutrient absorption will accelerate root growth.

The rockwool growing media treatment has the highest average root weight, which was 3,43g. This was due to rockwool growing medium that can store more nutrient solution than sponge growing medium thus more nutrient availability (Meriaty *et al.*, 2021).

3.7. Plant Root Length (g)

Table 8 Average Root Length Of Kailan (Brassica Oleracea L.) In Relation To The Types Of Growing Media And Plant Density In Floating Raft System Hydroponic

Observation Time	Kind of Planting Media (cm)	Plant Density			Average
		3 plants per plot (K_1)	4 plants per plot (K_2)	5 plants per plot (K_3)	
35 DAP		..........................cm..............................			
	Rockwool (J_1)	20.89	24.63	15.11	20.21
	Zeolit (J_2)	23.53	23.28	24.39	23.73
	Spons (J_3)	26.56	26.83	27.26	26.88
Average		23.66	24.91	22.25	23.61

Based on Table 8 the treatment of the types of growing media and plant population density did not indicate a significant influence on the parameter of the kailan plant's root length. Growing media that has more pore space allows roots to reach nutrient solutions. The sponge has larger and more pore space compared to rockwool and zeolite. Agoes (1994) expressed that the advantage of the sponge-growing medium is that roots can easily penetrate the medium since its material is soft and is able to absorb and store high levels of water. Root length affects nutrient solution availability absorbed by plants and water absorption from the available nutrient solution in the hydroponic circuit. Nutrient absorbed by rooting causes the roots to become longer and heavier. As explained by Gardener *et al.* (1991) roots are a plant vegetative organ functioning in the supply of water, minerals, and essential materials for the plant's growth and development.

4. Conclusion

Conclusions can be drawn from the research results are:

- Type of growing media of *Rockwool* provides the best influence on the parameter of plant height at 7 days after planting (DAP) with an average (4.67cm), at 14 DAP (11.58 cm), 21 DAP (17.09 cm), 28 DAP (22.29 cm), 35 DAP (37.57 cm), on the parameter of number of leaves at 14 DAP with an average (4.59 leaves), 28 DAP (6.96 leaves), and 35 DAP (8.59 leaves), and on the parameter of root weight at 35 DAP with an average of (3,43 g).
- The plant density of 3 (three) plants per tub provides the best influence on the parameter of plant height at 28 and 35 DAP with an average of 22.26 cm and 37.57 cm, respectively).
- Interaction between the treatments of types of growing media and plant density was only found in the parameter of plant height observation at 35 DAP.

Suggestion

- Kailan cultivation in hydroponic can be done using rockwool a growing medium with a population density of 1, 2, and 3 plants per tub for a better yield.
- Further research is needed in the kailan hydroponic cultivation with different plant densities and types of growing medium using aerators

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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