THE EFFECT OF PLANT DENSITY ON THE GROWTH AND PRODUCTION OF PAKCOY (*Brassica rapa* L.) USING TABLE MODEL DFT HYDROPONICS

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ABSTRACT

Plant spacing that is too close in hydroponics can cause competition between plants to obtain nutrients to be high, thus affecting plant growth and production. This can be overcome by regulating plant density or plant spacing. The research method used three plant density treatments, namely D1 (12cmx25cm), D2 (24cmx25cm), and D3 (36cmx25cm). The measurement results of the three treatments, which included plant height, number of leaves, and plant weight, were compared to determine the differences using one way ANOVA at a 5% level, and if the results were significantly different then continued with the BNJ test at a 5% level. The results showed that there was no significant difference in average plant height in D1, D2, and D3. There was a significant difference in the average number of leaves in the three treatments, and there was a significant difference in the average plant weight between D1 and D3. The average results of plant height, number of leaves, and plant weight in D3 had the best effect on the growth and production of pakcoy plants.

Keywords: *Plant density, Pakcoy, Growth, Production*

A. Introduction

Hydroponics is a modern farming option due to limited agricultural land, especially in urban areas, and can be done all year round. Hydroponics is also clean, environmentally friendly and practical to maintain (Halim, 2021). Meanwhile, Susilawati (2019) stated that hydroponics is the agricultural system of the future, which does not require a large area and does not have to be planted on land because it does not use soil as a growing medium. Under the same conditions, the growth rate of hydroponic plants is 50% faster compared to plants grown in the field, because with hydroponics the plants directly absorb nutrients from the nutrient solution. Hydroponic plants can grow clean, healthy and strong.

DFT (Deep Flow Technique) is a hydroponic method where the nutrient solution is applied about 4-6 cm and deeper than the NFT which circulates for 24 hours and the plant roots are in the nutrient layer, so that if the electricity goes out the nutrient solution is still available for the plant (Suryani, 2019). According to Wibowo (2020) DFT is a hydroponic method with a nutrient layer height of 3-4 cm, and the table model is one of the preferred models because it

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has aesthetic value and is easy to make. This model looks like a table with a one-plane nutrient solution delivery system. Furthermore, Yusra et al. (2024) said that plant roots are in a pool of circulating nutrient solution 3-4 cm thick, so that if the pump stops, the plant roots can still utilize the existing nutrient solution.

Pakcoy is a vegetable plant that is currently popular for cultivation in Indonesia using the hydroponic method, has the characteristics of fibrous roots, short stems, green and wide leaves, does not rot quickly, and can be planted in the lowlands. Pakcoy harvest can be done 20-30 days after planting (Susilawati, 2019). Referring to Susilo (2017), pakcoy is included in the Brassicaceae family and is often called spoon mustard greens because the leaves are spoon-like and have short stems, or sweet mustard greens because the leaves taste sweet, and can be harvested at 30-35 days after planting.

Plant density, which is characterized by plant spacing that is too tight in the cultivation of pakcoy plants, causes competition between plants in receiving sunlight to be high. On the other hand, plant spacing that is too large causes the population of plants per area to be small (Sodikin et al., 2022). In tabletop DFT hydroponics, plant spacing that is too close not only affects the receipt of sunlight, but also affects the dissolved oxygen content in the nutrient solution.

Sodikin et al. (2022) have conducted research on the effect of pakcoy population density but using a floating raft hydroponics system, while using table model DFT hydroponics has never been carried out. Therefore, in this research we will study the effect of pakcoy plant population density using table model DFT hydroponics.

B. Literature Review and Hypothesis Development

Several studies have been conducted on the effect of planting distance on the growth and yield of pak choy plants both in the field and hydroponically. Irawati et al. (2017) conducted research on the use of types of mulch and plant spacing patterns on the growth and production of pakcoy, and the results showed that the best treatment was a plant spacing pattern of 20 cm x 20 cm combined with the use of black and silver plastic mulch. Research by Alfandi et al. (2017) regarding the effect of the combination of planting distance and seedling age on the growth and yield of pakcoy plants, recommends that pakcoy yields increase with seedling age of 14 days and planting distance of 10 cm x 15 cm.

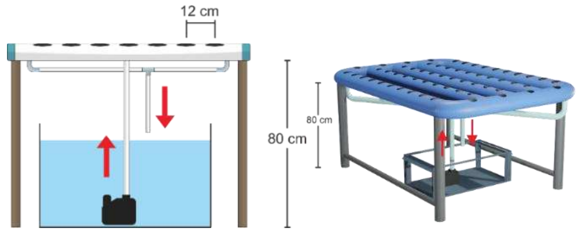
Wangge & Benu (2012) conducted research on the effect of planting distance on the growth and yield of pakcoy mustard greens, showing that using a planting distance of 20 cm x 20 cm had a very significant effect on plant growth and yield. Research by Manalu & Sugito (2020) on the effect of vermicompost fertilizer dosage and planting distance on the growth and yield of pakcoy plants shows that the highest results were obtained at a vermicompost fertilizer dosage of 15 t.ha-1 with a planting distance of 25 cm x 25 cm.

Susilo (2017) said that the distance between planting holes in hydroponic mustard cultivation is 25 cm x 25 cm. Research by Harun et al. (2022) regarding the productivity of pak choy plants using a hydroponic floating raft system with a planting distance of 20 cm x 15 cm (15 plants.raft-1) producing a fresh weight of 164 g.plant-1. The aim of this research is to determine the effect of pakchoy plant population density using table model DFT hydroponics on plant growth and production.

C. Research Method

The research was carried out in a greenhouse at the Banjarnegara Polytechnic. The research period is from April 2024 to June 2024. This research uses three table model DFT hydroponic kits for plant density D1, D2, and D3, netpots made of plastic cups, measuring cups, plastic trays, buckets, dippers, soldering iron, electric cables, ruler, TDS meter, pH meter, DO meter, and digital scales. The materials used are pakcoy seeds, rockwool, husk charcoal, AB mix, and water.

The data measured in this study were plant height (cm) and number of leaves (strands) once a week for each treatment, plant density D1, D2, and D3, as well as plant weight (g) at harvest. In addition, the concentration, pH, temperature and dissolved oxygen (DO) content of the nutrient solution are measured once a week. The results of measuring plant height, number of leaves, and fruit weight in plant density treatments D1, D2, and D3 were compared to determine any differences using one way ANOVA with a level of 5%. If the results are significantly different then continue with the BNJ test at the 5% level (Hartono, 2012). The hypothesis used is that there are no significant differences in plant height, number of leaves, and plant weight in the three plant density (Ho) treatments and there are significant differences in plant height, number of leaves, and plant weight in the three plant density (Ha) treatments (Hasan, 2008).



(a) (b)

Figure 1. Table model DFT hydroponics
(a) side view, and (b) isometric view (Wibowo, 2020)

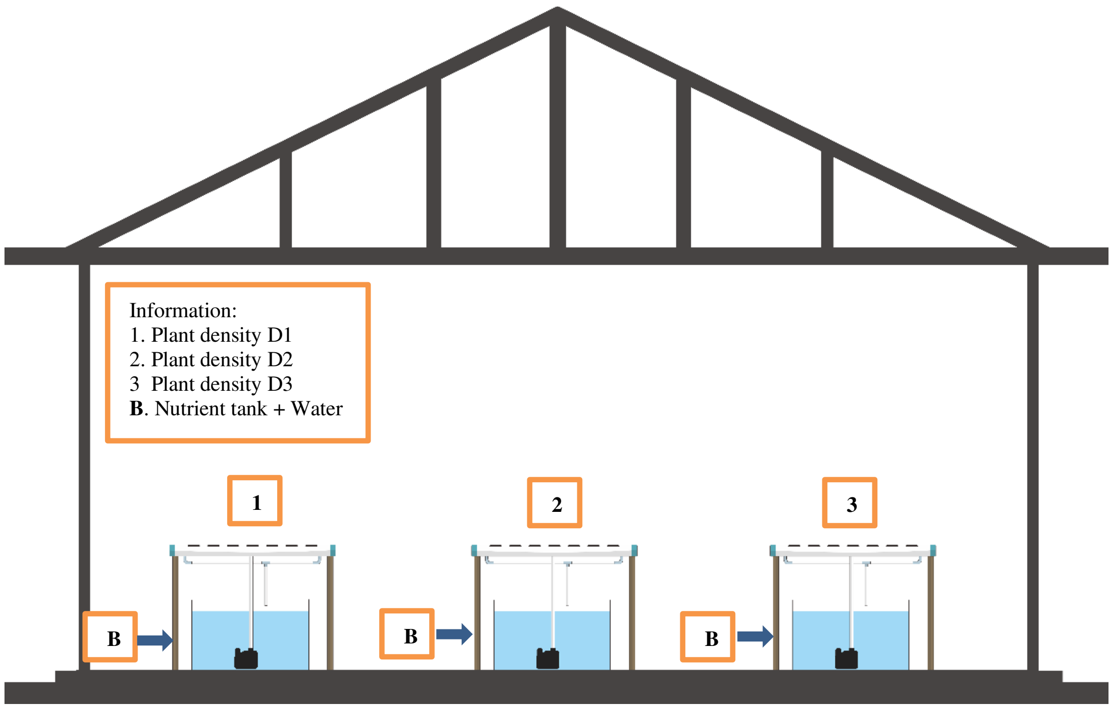


Figure 2. Research installation layout

D. Discussion

1. Data Uniformity

The table model DFT hydroponic construction used in this research uses five pipe lines, which are hereinafter referred to as subgroups (k pipe). Data on average plant height, number of leaves, and plant weight at harvest were tested to determine uniformity in the densities of D1, D2, and D3. The average plant height, number of leaves and plant weight are in the uniform category if they are between BKA (Upper Control Limit) and BKB (Lower Control Limit). According to (Heldayani & Yuamita, 2022) BKA and BKB can be calculated using the equation:

$$BKA = \bar{x} + k\sigma \quad \text{.....(1)}$$

$$BKB = \bar{x} - k\sigma \quad \text{.....(2)}$$

Information:

x̄ = average plant height, number of leaves, and plant weight

σ = deviation standard

k = level of trust

The results of data uniformity test calculations are presented in Table 1.

Table 1. Data uniformity test results

Parameter	Plant Density	Subgroup average (k pipe)					Ave-rage	STD σ	BKA	BKB	Infor-mation
		1	2	3	4	5					
Plant height	D1	19,5	18,1	19,7	15,6	18,4	18,3	1,487	19,7	16,8	NU
	D2	18,6	18,8	18,2	18,7	19,0	18,7	0.628	19,3	18,0	U
	D3	19,6	20,4	20,6	19,5	19,8	20,0	0,712	20,7	19,2	U
Number of leaves	D1	16,6	15,6	18,1	14,0	16,6	16,2	1,430	17,6	14,7	NU
	D2	20,6	20,0	19,0	19,6	20,0	19,8	0,926	20,8	18,9	U
	D3	22,0	22,0	23,0	23,3	21,8	22,4	0,818	23,2	21,6	U
Plant weight	D1	75,2	58,8	84,1	48,8	69,9	67,4	12,647	80,0	54,7	NU
	D2	89,2	87,8	89,0	90,2	86,2	88,5	13,103	101,6	75,4	U
	D3	111,3	114,8	113,3	112,0	111,3	112,5	10,107	122,6	102,4	U

Information: U=Uniform, NU=Not Uniform

Based on Table 1, it shows that the data on plant height, number of leaves, and plant weight at D1 density results are not uniform, especially in the 3rd and 4th subgroups (k pipe). This means that the growth and production of pakcoy plants at D1 density (planting distance 12 cm x 25 cm) is not uniform. This non-uniformity is caused by plant spacing that is too close, resulting in very large competition between plants to obtain nutrients. On the other hand, looser plant spacing will reduce competition between plants in their growth, so that growth and production are also uniform.

2. Nutrient Solution

In hydroponic plant cultivation, the nutrient solution is one of the factors that influences plant growth, especially those related to the concentration, temperature and pH of the nutrient solution. These three parameters are measured once a week and the measurement results are presented in Table 2.

Table 2. Concentration, temperature, and pH of the nutrient solution on plant density

Weeks	D1			D2			D3		
	Concen-tration (ppm)	Tempe-rature (ºC)	pH	Concen-tration (ppm)	Tempe-rature (ºC)	pH	Concen-tration (ppm)	Tempe-rature (ºC)	pH
1	974	25,2	5,0	984	25,1	5,0	986	23,6	5,2
2	1023	26,7	5,0	1390	26,7	5,1	1390	26,7	5,9
3	1392	25,6	6,0	1392	25,2	6,9	1392	24,8	6,8

4	1396	28,2	6,3	1382	27,1	5,9	1398	26,8	6,4
5	1366	25,1	6,6	1388	25,8	6.9	1394	26,7	6,4
Average	1162	26,2	5,8	1307	26,0	6,0	1312	25,7	6,2

The concentration of the nutrient solution shows the level of nutrient content in the solution. The measurement results of the average nutrient solution concentration for D1 density were 1162 ppm, for D2 it was 1307 ppm, and for D3 it was 1312 ppm (Table 2). According to Bayu (2016) the concentration of nutrient solution for pakcoy plants is 1050-1400 ppm. Thus, the average concentration of the nutrient solution at the three densities is correct.

Temperature affects the pH of the nutrient solution. The measurement results (Table 2) show that the average pH of the nutrient solution is greater if the average temperature of the nutrient solution is lower/smaller. According to Sutiyoso (2009) that a pH of 5.5-6.5 is a good degree of acidity for plant growth in hydroponic cultivation. The average pH measurement results of the nutrient solution at density D1 is 5.8, density D2 is 6.0, and density D3 is 6.2. This shows that the pH of the nutrient solution at these three densities is good for plant growth.

3. Plant growth and production

Plant growth can be determined by measuring plant height and number of leaves once a week, while plant weight is measured at harvest. The average results of plant growth and production measurements are presented in Table 3.

Table 3. Average results of plant growth and production measurements

Weeks	Plant height (cm) at density		
	D1	D2	D3
1	5,0	4,9	5,4
2	8,2	10,9	12,7
3	12,3	13,7	16,3
4	15,8	17,1	18,4
5 (harvest)	18,2	18,7	20,0
Weeks	Number of leaves (pieces) in density		
	D1	D2	D3
1	5,5	6,0	5,4
2	7,1	8,9	8,9
3	9,6	11,4	12,8
4	12,3	15,3	17,4
5 (harvest)	16,1	19,9	22,4
Weeks	Plant weight (g) at density		
	D1	D2	D3
5 (harvest)	66,6	88,5	112,5

The best average plant height, number of leaves and plant weight was at D3 density, while the lowest was at D1 density. The closer the planting distance, the smaller the dissolved oxygen (DO) content in the nutrient solution, which causes plant roots to be less able to absorb nutrients. This is confirmed by the results of DO content measurements as presented in Table 4. The average DO content at density D1 is the smallest, so it affects the ability of plant roots to absorb nutrients, which in turn affects plant growth. Dewi cit Dharmayanti et al. (2021) stated that lack of oxygen (deoxygenation) can affect plant growth and production because in hydroponics the dissolved oxygen content is very important for plants.

Table 4. Dissolved oxygen (DO) content

Weeks	DO content (mg/l) at density		
	D1	D2	D3
1	10,89	10,84	10,92
2	10,30	10,80	10,89
3	10,72	11,10	10,91
4	10,90	10,84	11,16
5	11,15	11,13	11,15
Average	10,79	10,94	11,01

4. ANOVA test

The results of measuring plant height, number of leaves, and weight of Pakcoy plants at densities D1, D2, and D3 were compared using the One Way ANOVA test at the 5% level, and continued with the BNJ (Tukey's HSD) test if the results were significantly different. This is to determine the influence of these three variables and the results are presented in Table 5.

Table 5. One Way ANOVA test results at 5% level

Parameter	F-count	F-table	Information
Plant height	5,941	3,545	F-count > F-table
Number of leaves	84,355	3,545	Thus, H1 is accepted, meaning that plant density influences plant height, number of
Plant weight	47,838	3,545	leaves, and weight of pakcoy plants

Post-ANOVA analysis

According to Hartono (2012), post-ANOVA analysis can be carried out using the BNJ test (Tukey's HSD), with the aim of finding out which plant densities are different and have an influence on plant height, number of leaves, or plant weight, and the results are presented in Table 6.

Table 6. Average differences between plant densities

Plant height (HSD = 3,689)			
Plant density	D1	D2	D3
D1	-	0,5	1,8
D2	0,5	-	1,3
D3	1,8	1,3	-
Number of leaves (HSD = 3,694)			
Plant density	D1	D2	D3
D1	-	3,8	6,3
D2	3,8	-	2,5
D3	6,3	2,5	-
Plant weight (HSD = 34,428)			
Plant density	D1	D2	D3
D1	-	21,9	45,9
D2	21,9	-	24,0
D3	45,9	24,0	-

Note: there is a significant difference if the average difference is > HSD

The results of post-ANOVA analysis showed that there was no significant difference in average plant height in plant density D1, D2, and D3. Meanwhile, in the average number of leaves, there was a significant difference between the density of D1 plants and the density of D2 and D3 plants. Furthermore, in the average plant weight, there was a significant difference between the density of D1 plants and the density of D3 plants. The average results of plant height, number of leaves and plant weight at plant density D1 were the lowest when compared with D2 and D3, and the highest was at plant density D3. Thus, D3 plant density has the best effect on the growth and production of pakcoy plants.

E. Conclusion

The results showed that there was no significant difference in average plant height at plant densities D1, D2, and D3, and there was a significant difference in the average number of leaves between plant densities D1 and plant densities D2 and D3, while on average There was a significant difference in average plant weight between D1 plant density and D3 plant density. The average results of plant height, number of leaves and plant weight at plant density D1 were the lowest when compared with D2 and D3, and the highest was at plant density D3. D3 plant density has the best effect on the growth and production of pakcoy plants.

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