
**THE EFFECT OF PLANTING MEDIA AND PLANT DENSITY ON THE GROWTH
AND PRODUCTION OF SAMHONG MUSTARD (*Brassica juncea* L.) WITH DFT
HYDROPONICS**

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ABSTRACT

Hydroponics efficiently optimizes vegetable growth through the selection of growing media and plant density. This study examined the effects of planting media and plant density on the growth and production of samhong mustard using the DFT hydroponic table model. The research applied four treatments combining rockwool (M1) and rice husk charcoal (M2) media with planting distances of 12×25 cm (D1) and 24×25 cm (D2). Data on leaf number, plant height, and weight were analyzed using two-way ANOVA and Tukey's HSD at a 5% level. Results showed that both planting media and density significantly influenced plant growth and production. Rice husk charcoal medium and wider spacing (M2D2) produced optimal individual plant growth, while M2D1 yielded the highest total production due to higher plant population.

Keywords: *Planting media, Plant density, Growth, Production, Samhong mustard*

A. Introduction

Limited land availability no longer constrains vegetable production, as advances in science and technology have enabled cultivation without depending on conventional farmland through hydroponic techniques. Various vegetables commonly consumed in Indonesia, such as mustard greens, lettuce, spinach, kale, tomatoes, green beans, and celery, can be cultivated hydroponically (Susilo, 2017). Mustard greens contain essential nutrients beneficial for human health, including vitamins A, B, and C, carbohydrates, lipids, proteins, and minerals (Haryanto et al., 2003). Indonesia is known to have diverse mustard green varieties such as pakchoy, white mustard, and caisim (Susilo, 2017). Samhong mustard,

belonging to the *Brassicaceae* family and closely related to pakchoy, are characterized by their curled leaves, elongated white stems, and broad leaf surfaces (Wibowo, 2021; Satuharapan, 2020).

Hydroponics is increasingly recognized as a future-oriented agricultural approach due to its efficiency, profitability, pesticide-free production, suitability for limited land, independence from seasonal constraints, and appeal as a productive hobby (Susilawati, 2019). The Deep Flow Technique (DFT) system maintains plant roots submerged in a nutrient solution flowing continuously at a depth of 4–6 cm, ensuring nutrient availability even during electricity interruptions (Suryani, 2019). One widely applied variant is the tabletop DFT model, which uses a flat structure with a single-plane nutrient flow system (Wibowo, 2020).

Among factors influencing hydroponic success, growing media selection is particularly critical. Commonly used substrates include rockwool and charcoal rice husk (Ginanjari et al., 2021). Rockwool, produced from high-temperature processing of limestone, basalt, and coal, is highly absorbent and widely used, though its fibers pose potential carcinogenic risks (Warjoto et al., 2020). Conversely, charcoal rice husk is a lightweight, porous, sterile, and nutrient-bearing medium that is affordable and easily obtainable (Suryani, 2019).

Plant density is another important consideration, as it influences dissolved oxygen levels and solar radiation capture due to competition among plants (Wibowo & Cahyani, 2025). Excessively high or low density can reduce the effective number of plants per unit area and intensify competition for sunlight (Sodikin et al., 2022). However, studies assessing the combined effects of growing media and plant density using tabletop DFT systems, particularly for samhong mustard, remain limited.

B. Literature Review and Hypothesis Development

Previous studies have examined the effects of hydroponic media and planting density on leafy vegetables. Research by (Wahyuningsih et al., 2016) investigated substrate types and nutrient composition using rice husks and sand for pakchoy, while other studies explored density optimization in floating raft systems. The literature indicates a gap regarding the use of tabletop DFT systems to assess media and plant density interactions for samhong mustard, despite the common application of rockwool and charcoal husk as substrates (Sodikin et al., 2022).

An ideal hydroponic medium should retain moisture, remain porous, and maintain a pH between 5.8 and 7.2. Rockwool meets these criteria due to its high water retention and oxygen availability, but it is often costly and imported. Charcoal rice husk offers advantages including sterility, water retention,

neutral pH, lightweight structure, and affordability, though it typically supports only two planting cycles (Prihmantoro & Indriani, 2005; Susilawati, 2019). These characteristics make both substrates relevant for comparison in hydroponic systems.

Planting density also has a significant impact on plant growth and productivity. Optimal spacing for pakchoy has been reported to vary, including 20×20 cm (Irawati et al., 2017), 10×15 cm (Alfandi et al., 2017), and 25×25 cm (Manalu & Sugito, 2020). Harun et al. (2022) applied 20×15 cm spacing in floating raft hydroponics. In the present study, planting distances of 12×25 cm (D1) and 24×25 cm (D2) were applied alongside rockwool (M1) and charcoal husk (M2) media in a table model DFT system to evaluate their effects on the growth and yield of samhong mustard.

C. Research Method

This research was conducted from March 2025 to July 2025 in a greenhouse located at the Banjarnegara Polytechnic. The equipment used in the investigation included a tabletop DFT hydroponic installation (consisting of four complete sets), as well as a DO meter, pH meter, TDS meter, and digital scales. The materials used included samhong mustard seeds, burnt rice husks, rockwool, AB mix fertilizer, and water.

This study combined planting media (M) and plant density (D) into four different treatments, namely M1D1, M1D2, M2D1, and M2D2. The planting media used were rockwool (M1) and charcoal (M2), while the plant densities applied were D1 (with a planting distance of 12cmx25cm) and D2 (with a planting distance of 24cmx25cm). Data collected included the number of leaves (strands) and plant height (cm) every week for each treatment, along with plant weight (g) at harvest. In addition, measurements of temperature, pH, concentration, and dissolved oxygen (DO) levels in the nutrient solution were carried out every week. Measurements of plant growth and yield for treatments M1D1, M1D2, M2D1, and M2D2 were subjected to comparative analysis to distinguish differences using two-way ANOVA, equipped with the BNJ test at a significance level of 5% (Hartono, 2012).

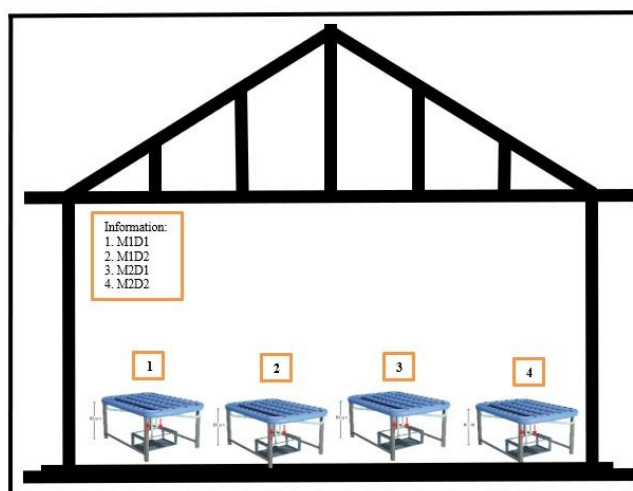


Figure 1. Research layout

D. Discussion

1. Data Normality and Uniformity Test

Nurdiyantoro et al. (2009) emphasized that normality testing for data is performed to ensure the distribution characteristics of the data obtained before applying it to hypothesis testing. Normality testing can be performed using various methodologies, one of which is the Chi-Squared (χ^2) test. The formula for calculating χ^2 is as follows:

$$\chi^2 = \frac{(O_1 - E_1)^2}{E_1} + \frac{(O_2 - E_2)^2}{E_2} \dots + \frac{(O_n - E_n)^2}{E_n} \dots \dots \dots (1)$$

Description:

O = Observed frequency (obtained)

E = Expected frequency

The results of the normality test regarding the number of leaves, plant height, and plant weight data at harvest for treatments M1D1, M1D2, M2D1, and M2D2 showed that the calculated χ^2 value was lower than the χ^2 table value. This finding implies that the four treatments in the three parameters showed a normally distributed data set. Therefore, the data obtained from the measurements can be used in subsequent statistical analysis (Nurdiyantoro et al., 2009). The results of the normality test are detailed in Table 1.

Table 1. Results of data normality test

Parameter	Treatment	Lots of data	db	α	χ^2_{count}	χ^2_{table}	Information
Number	M1D1	48	4	5%	8,0727	9,4880	Normal

of leaves	M1D2	24	3	5%	3,9494	7,8150	Normal
	M2D1	48	4	5%	8,1092	9,4880	Normal
	M2D2	24	3	5%	7,6568	7,8150	Normal
Plant height	M1D1	48	4	5%	4,0173	9,4880	Normal
	M1D2	24	3	5%	5,2377	7,8150	Normal
	M2D1	48	4	5%	7,3876	9,4880	Normal
	M2D2	24	3	5%	6,1055	7,8150	Normal
Plant weight	M1D1	48	4	5%	7,8129	9,4880	Normal
	M1D2	24	3	5%	4,1160	7,8150	Normal
	M2D1	48	4	5%	6,9683	9,4880	Normal
	M2D2	24	3	5%	7,5458	7,8150	Normal

The study used a DFT hydroponic table model, where each hydroponic structure was carefully designed with five perforated pipe lines designated for planting locations. Data collected at harvest, including leaf number, plant height, and plant weight measurements for treatments M1D1, M1D2, M2D1, and M2D2, underwent a uniformity test. To conduct a uniformity test, it is necessary to first determine the Upper Control Limit (UCL) and Lower Control Limit (LCL), which can be calculated using the following formula:

$$UCL = \bar{x} + k\sigma \dots\dots\dots(2)$$

$$LCL = \bar{x} - k\sigma \dots\dots\dots(3)$$

Description:

$\bar{x}$ = average number of leaves, plant height, and plant weight

σ = standard deviation

k = confidence level

According to Heldayani & Yuamita (2022), data is considered uniform if it falls between the BKA and BKB thresholds. The uniformity test findings are presented in Table 2.

Table 2. Results of data uniformity test

Parameter	Treatment	Average on the pipe line					Average	STD σ	UCL	LCL	Note
		1	2	3	4	5					
Number of leaves	M1D1	22,2	20,8	22,3	21,1	22,2	21,7	1,13	22,4	21,0	NU
	M1D2	22,6	23,0	24,0	22,8	22,6	23,0	1,40	24,3	21,7	U
	M2D1	22,8	21,0	22,9	21,8	22,3	22,2	1,51	23,1	21,2	NU
	M2D2	25,2	24,4	26,0	24,4	25,4	25,1	1,30	26,2	23,9	U
Plant	M1D1	28,8	26,9	29,0	28,1	28,4	28,2	1,68	29,3	27,2	NU

height	M1D2	29,7	28,8	30,2	28,9	29,3	29,4	1,23	30,5	28,3	U
	M2D1	29,0	27,4	29,3	28,1	28,8	28,5	1,43	29,4	27,6	NU
	M2D2	30,8	30,0	31,6	30,3	30,6	30,6	1,17	31,7	29,6	U
Plant weight	M1D1	181,2	135,8	188,0	138,7	183,4	165,4	40,18	190,8	140,0	NU
	M1D2	281,2	273,0	282,8	264,4	268,4	274,0	25,55	296,8	251,1	U
	M2D1	218,6	167,1	226,4	169,1	223,8	201,0	45,06	229,5	172,5	NU
	M2D2	304,2	316,0	363,8	257,0	247,0	297,6	82,26	371,2	224,0	U

Information: U= Uniform, NU=Not Uniform

The number of leaves, plant height, and plant weight measurements for the M1D1 and M2D1 treatments showed inconsistent results, while the M1D2 and M2D2 treatments showed consistent results (see Table 2). The M1D1 and M2D1 treatments used a spacing of 12cm x 25cm, while the M1D2 and M2D2 treatments used a spacing of 24cm x 25cm. Variations in data regarding the number of leaves and plant height for the M1D1 and M2D1 treatments were seen in pipe 2, while variations in plant weight occurred in pipes 2 and 4. The positions of pipes 2 and 4 were blocked by other pipes, resulting in increased competition between plants for sunlight. In addition, the dense spacing in the M1D1 and M2D1 treatments resulted in low average dissolved oxygen content, which impacted the ability of plant roots to absorb nutrients (Table 3).

Table 3. Average dissolved oxygen content

Treatment	Week					Average
	1	2	3	4	5	
M1D1	10,16	9,97	4,67	4,57	4,18	6,71
M1D2	10,42	10,01	7,88	6,73	6,24	8,26
M2D1	10,40	9,99	7,50	5,73	5,21	7,77
M2D2	10,43	10,02	9,14	7,24	6,89	8,74

Based on Table 3, the dissolved oxygen levels in the four treatments in the first week were quite high, but as the weeks increased, the values decreased. This is due to the increasing age of the plants which also increases the length of the plant roots, resulting in the nutrient pipe space being filled by plant roots and the dissolved oxygen (DO) levels decreasing. Measurements also showed that the dissolved oxygen levels in the M1D2 and M2D2 treatments were higher than in the M1D1 and M2D1 treatments. The cause is that the planting distance in the M1D2 and M2D2 treatments is wider than in the M1D1 and M2D1 treatments. Wibowo & Cahyani (2025) stated that the density of planting distance affects plant competition in obtaining nutrients. Planting distances that are too close cause competition

between plants to obtain nutrients to be higher, so that growth and results are inconsistent. Conversely, wider planting distances reduce competition so that plant growth and results are more even.

2. Nutrient Solution

Nutrient solutions serve as an important source of macro and micronutrients necessary for plant development in hydroponic cultivation systems (Ariananda et al., 2020). Furthermore, Wibowo & Cahyani (2025) emphasized that key nutrient solution parameters essential for plant health include temperature, pH, and nutrient solution concentration. In this investigation, assessments of all three parameters were conducted weekly, with the findings documented in Table 4.

Table 4. Temperature (°C), pH, and concentration (ppm) of nutrient solution

Week	Temperature, pH, and concentration of nutrient solution in the treatment											
	M1D1			M1D2			M2D1			M2D2		
	(°C)	pH	ppm	(°C)	pH	ppm	(°C)	pH	ppm	(°C)	pH	ppm
1	31,3	5,8	1152	31,0	5,6	1148	31,1	5,7	1112	31,1	5,8	1108
2	31,5	5,9	1240	31,6	5,9	1248	31,3	5,8	1230	31,4	5,9	1174
3	30,5	6,1	1270	30,1	6,2	1238	30,4	6,0	1238	30,6	6,1	1232
4	27,5	6,2	1332	27,3	6,3	1282	27,7	6,1	1296	27,3	6,2	1260
5	26,9	6,4	1340	27,2	6,4	1348	26,9	6,3	1332	27,5	6,3	1328
Average	29,5	6,1	1267	29,4	6,1	1253	29,5	6,0	1242	29,6	6,1	1220

Wibowo & Cahyani (2025) stated that the temperature of a nutrient solution is inversely correlated with its pH. The results presented in Table 4 support this statement, showing that lower temperatures in the nutrient solution correspond to higher pH levels. Sutiyoso (2009) indicated that the optimal pH range for plant growth in hydroponic systems lies between 5.5 and 6.5.

In addition, Wibowo & Cahyani (2025) emphasized that the nutrient levels in nutrient solutions are measured as nutrient solution concentrations. Samhong mustard, which is a member of the pakchoy family, has been identified by Bayu (2016) as requiring nutrient solution concentrations ranging from 1,050 to 1,400 ppm. The average nutrient solution concentrations obtained from the measurements (Table 4) are as follows: M1D1 at 1,267 ppm, M1D2 at 1,253 ppm, M2D1 at 1,242 ppm, and M2D2 at 1,220 ppm. These results indicate that the nutrient solution concentrations in all four treatments are within the appropriate range.

3. Plant growth and production

The number of leaves and height of samhong mustard plants were recorded weekly over a five-week period to assess plant growth, while plant weight measurements were taken at harvest time, which

occurred in the fifth week. As noted by Susilo (2017), samhong mustard is categorized in the same group as pakchoy, commonly referred to as curly mustard, and is classified as an annual vegetable belonging to the *Brassicaceae* family, with a harvest age of 30 to 35 days after planting (dap). The average results of samhong mustard measurements are presented in Table 5.

Table 5. Average growth and production of samhong mustard

Week	Number of leaves (strands) in the treatment			
	M1D1	M1D2	M2D1	M2D2
1	7,0	7,1	7,2	9,0
2	10,7	11,3	12,4	13,9
3	13,4	15,2	15,3	16,4
4	16,8	18,8	18,7	20,5
5 (harvest)	21,7	23,0	22,2	25,1
Week	Plant height (cm) in treatment			
	M1D1	M1D2	M2D1	M2D2
1	9,4	10,6	10,7	14,4
2	17,0	18,1	18,0	21,1
3	23,1	24,6	23,8	26,1
4	27,2	28,1	26,7	28,5
5 (harvest)	28,2	29,4	28,5	30,6
Week	Plant weight (g) in treatment			
	M1D1	M1D2	M2D1	M2D2
5 (harvest)	165,4	274,0	201,0	297,6
Total weight	7.939,2	6.560,0	9.648,0	7.142,4

Plant growth and production, as measured by the number of leaves, plant height, and plant weight, overall the best average per plant was in the M2D2 treatment, namely rice husk charcoal planting media with a planting distance of 24cmx25cm, (Table 5). This occurs because in this treatment, the density is looser so that plant roots can absorb nutrients more easily due to the higher dissolved oxygen content in the nutrient solution (Table 3). Dewi cit Dharmayanti et al. (2021) revealed that for plants grown hydroponically, dissolved oxygen content has an important influence on plant growth and yield. Furthermore, Wibowo & Cahyani (2025) stated that in nutrient solutions, the level of dissolved oxygen (DO) will decrease as the planting distance becomes denser, so that nutrient absorption by plant roots decreases and has a negative impact on plant growth and production.

However, if calculated overall based on the number of plants in each treatment, the best plant weight is in M2D1 (Table 5). This is because the number of plants in that treatment is twice as much

due to the planting distance being half the planting distance in the M2D2 treatment. Based on the type of planting media applied, plant growth and yield using rice husk charcoal media showed superior performance compared to rockwool media. This is because the volume of rice husk charcoal media per netpot is higher than rockwool media, so it can accommodate more nutrients and plant root growth is also more optimal. From an economic aspect, the cost of using rice husk charcoal media is more affordable compared to using rockwool. With the size that has been determined in the research method, for 100 netpots, half a sack of rice husk charcoal is needed at a cost of IDR 10,000 (ten thousand rupiah), while if using rockwool it uses a quarter of a slab at a price of IDR 25,000 (twenty five thousand rupiah). By utilizing rice husk charcoal media, costs can be saved up to 60%.

4. ANOVA Test

The study included four different treatments, each combining variables related to the planting medium and planting density. The planting medium used was rockwool (M1) and charcoal husk (M2), with planting densities of 12cmx25cm (D1) and 24cmx25cm (D2). The analytical approach used a Two-Way ANOVA test at a 5% significance level, followed by a Tukey's HSD (BNJ) test to determine the impact of the treatments on the parameters examined. The parameters assessed included the number of leaves, plant height, and plant weight. The results of the analysis are depicted in Table 6.

Table 6. Results of Two Way ANOVA test analysis at the 5% level

Planting Media Factor (M)		
Parameter	F-count	F-table
Number of leaves	16,43	4,49
Plant height	6,16	4,49
Plant weight	4,51	4,49
Density Factor (D)		
Parameter	F-count	F-table
Number of leaves	45,65	4,49
Plant height	27,24	4,49
Plant weight	54,15	4,49

The analysis results show that for the planting media and plant density factors, the F-count is greater than the F-table (Table 6). Thus, the alternative hypothesis (Ha) is accepted, meaning that both the planting media and plant density have a significant influence on the number of leaves, plant height, and weight of samhong mustard plants.

Post ANOVA analysis

Post-ANOVA analysis was conducted with the aim of determining whether there were differences in plant density treatments on the number of leaves, plant height, or plant weight, using the BNJ (Tukey's HSD) test, and the results are presented in Table 7.

Table 7. Average differences between plant densities

Parameter	Average difference	HSD
Number of leaves	2,10	0,8835
Plant height	1,64	0,8933
Plant weight	102,57	39,62

Hartono (2012) stated that when the mean difference exceeds the HSD, there is a significant difference. The analysis results revealed that the mean difference exceeded the HSD in all three parameters (Table 7). This finding indicates that a significant mean difference exists between the groups. Therefore, differences in leaf number, plant height, and plant weight were observed between the D1 and D2 densities, with the D2 density showing a more beneficial impact on the growth and production of samhong mustard plants.

E. Conclusion

The findings of the research conducted showed that the planting medium used and plant density significantly affected the number of leaves, plant height, and weight of samhong mustard plants. Rice husk charcoal media (M2) showed superior results compared to rockwool media (M1). There were differences in the number of leaves, plant height, and plant weight at densities D1 (12cmx25cm) and D2 (24cmx25cm), with the D2 density showing a more beneficial effect on the growth and yield of samhong mustard plants. Optimal growth and yield per individual plant were achieved under the M2D2 treatment, which used rice husk charcoal planting media with a spacing of 24cmx25cm. When calculated overall plant weight based on the number of plants in each treatment, the M2D1 treatment produced the most profitable results.

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