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by Gustiar Fitra

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Growth and yield of lettuce (*Lactuca sativa* L.) grown on different planting media volumes in a floating cultivation system

Fitra Gustiar[1*)], Duwi Septiani[2], Hilda Agustina[3], Fikri Adriansyah[1], Fitri Ramadhani[1]
[1]Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya. Jl. Raya Palembang-Prabumulih Km 32, Indralaya, Ogan Ilir 30662, South Sumatra, Indonesia
[2]Department of Agroecotechnology, Faculty of Agriculture, Universitas Sriwijaya. Jl. Raya Palembang-Prabumulih Km 32, Indralaya, Ogan Ilir 30662, South Sumatra, Indonesia
[3]Department of Agricultural Engineering, Faculty of Agriculture, Universitas Sriwijaya. Jl. Raya Palembang-Prabumulih Km 32, Indralaya, Ogan Ilir 30662, South Sumatra, Indonesia
*)Email address: fitragustiar@unsri.ac.id

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ABSTRACT

Lettuce (*Lactuca sativa* L.) is one of the vegetables that is widely loved because of its taste and nutritional content. The increase in lettuce production can be increased by the use of swamp land with floating cultivation during the flood season. The size of the pots used in floating system cultivation will affect the growth and number of plants that will be produced. The study aimed to determine the optimal of planting media volume on the growth and yield of lettuce in floating cultivation system. The research used a randomized block design with 4 treatments of planting media volume, namely 1.9 L (P1), 2.7 L (P2), 3.6 L(P3), and 5 L (P4). Each treatment was repeated 4 times and each replication consisted of 5 plants. The results showed that at the beginning of the growth of the media volume of 2.7 L would be faster, but at the time of harvest almost all parameters showed that plants with a media volume of 5 L produced a larger plant weight than the plant unit. Although the use of smaller volumes of media results in a smaller plant weight, the raft is able to accommodate a larger number of pots. So that the use of a media volume of 1.9 L will be better used for floating lettuce production.

Keywords: gallon waste, leafy vegetables, planting media, raft, swamp area

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is a popular leafy cultivated and consumed widely vegetable that including in Indonesia. This plant is commonly consumed as salad mixes (Martinez et al., 2022). Novitasari and Risqa (2020) stated that lettuce contains iron, calcium, phosphorus, vitamins A, B, and C, and other nutrients. In addition, lettuce has various benefits including increasing body metabolism, supporting blood cell formation, and reducing the risk of cancer and cataracts (Arifin et al., 2023). Along with the increasing population and public awareness of nutritional value and health benefits, consumer demand for lettuce is increasing (Atika & Enceng, 2019).

Limited land is a major problem in increasing lettuce production due to the scarcity of productive land in Indonesia. In this case, the use of swamp area is one alternative land that can be used. Swampland refers to an area that is inundated, either seasonally or permanently, and overgrown with vegetation (Irwandi, 2015). The use of swampland during the flood season requires the selection of an alternative cultivation system that can be used (Wijaya & Nurul, 2018), such as a floating cultivation system. Specifically, there is no requirement for watering activities because water can be directly spread and continuously absorbed through the base of planting media (Siaga & Lakitan, 2021).

The success of cultivation is partly determined by planting media volume. The planting media volume should be at an ideal level to promote root growth and provide water and nutrients (Lehalima et al., 2021). The amount of nutrients

available to meet plant nutritional needs which are met by fertilization is correlated with the pot size (Astuti et al., 2015). According to Versari (2020), lettuce plants grew and produced more when treated with 5 L of planting media volume which allowed effective root development. In a floating cultivation system with a media volume of 5 L, there is a tendency for a heavier weight, leading to a limited number of plants accommodated by the floating raft per unit area is less. The objective of this research was to determine the size of the volume of floating lettuce cultivation medium that grows and produces optimal.

MATERIALS AND METHODS

This study was conducted at the Plant Ecology Laboratory, Department of Agricultural Cultivation and Reservoirs, Faculty of Agriculture, Sriwijaya University. The experiment was carried out from July to September 2024 using several equipment including soil moisture (Lutron PMS 714), floating rafts (2 x 1 m) and SPAD (Konica Minolta 502). The materials used were Grand Rapids lettuce seeds, cocopeat, pots, cow manure, NPK fertilizer, and topsoil. This study was conducted using a Randomized Block Design (RBD) with 4 treatments of planting pot sizes, namely P1 = 1.9 L, P2 = 2.7 L, P3 = 3.6 L, and P4 = 5 L (Figure 1a.). Each treatment was repeated 4 times and consisted of 5 plants, totaling 80 plants. The Observation was started 7 DAT (Days after transplanting), the variables observed were leaf length, width, and greenness, including number of leaves, canopy area, total leaf area, fresh weight per stalk, dry weight per stalk, stem diameter, and root length.

The floating raft used was a 2.1 m (length) x 1.3 m (width). The raft made from bamboo. The design had equipped with gallons on each side to ensure raf buoyancy ability. The raft used a wick system hydroponic method (Figure 1b). Observation data were analyzed using Analysis of Variance (ANOVA) with Least Significant Difference (LSD). The analysis was conducted using R-studio software.

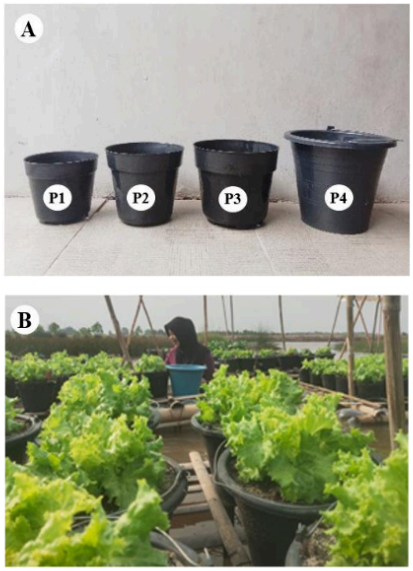

Figure 1. Pot sizes of planting media (A) and lettuce observation activities (B)

RESULTS

Planting Media Humidity

Soil moisture measurements were taken once in the afternoon. The treatment of various sizes of planting media pots found the highest humidity in P1 with an average humidity of 24.93%, while the lowest was in P4 with an average humidity of 18.7%, as showed in Figure 1.

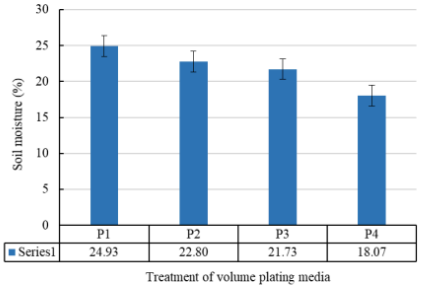

Figure 1. Soil moisture with various planting volumes. The planting volumes consist of 1.9 L (P1), 2.7 L (P2), 3.6 L (P3) and 5 L (P4).

Lettuce Plant Growth

Daily measurements help in monitoring leaf growth rate. The treatment of various sizes of planting media pot had no significant difference in the number of leaves at the beginning of growth 7 HST. However, a very significant effect was observed in the following week. The largest number of leaves at 11.92 was found in P1, while P3 had the smallest at 8.50, as showed in Figure 2.

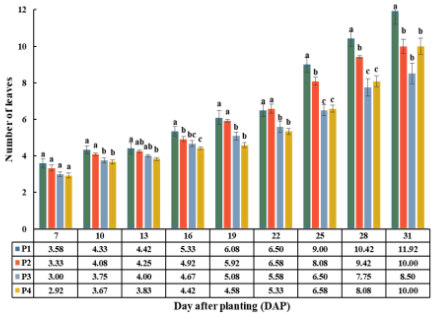

Figure 2. Number of lettuce leaf with various sizes of planting media pot volumes

Measurements of leaf length and width were carried out from the beginning of leaf blooming perfectly, which continued to increase every day. There was no difference at the beginning of leaf growth but after the 3rd day, enlargement in length and width growth stopped on the 11th day, as showed in Figure 3. The largest leaf length was found in P1 with a value of 7.3 cm, while the smallest was observed in P4 at 5.5 cm.

The highest leaf width of 7.23 cm was found in P1, while the lowest average of 5.13 cm was found in P4.

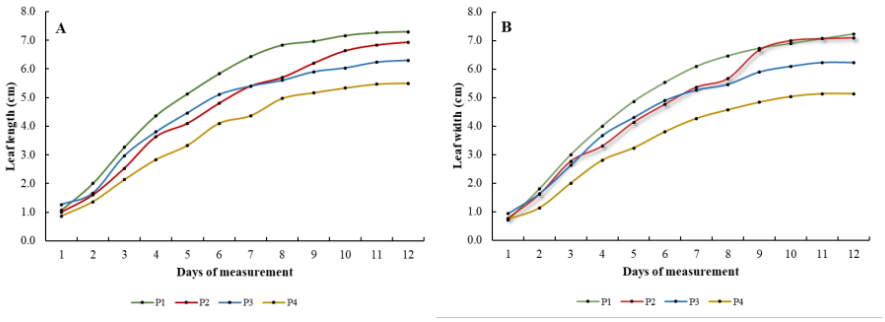

Figure 3. The rate of increase in length (A) and width (B) of lettuce leaf with various sizes of planting media pot volumes

Lettuce Morphological Observation

Lettuce morphological observation in Table 1 indicated that the treatment of pot size and volume showed no significant effect on the variables of plant height (TT) and root length (PA). However, a significant influence was observed on the variables in SPAD value, stem diameter (DB), canopy area (LK), and total leaf area (LDT), with differences in lettuce morphological size showed in Figure 4.

Fresh and Dry Weight of Lettuce

The production of the fresh and dry weight of lettuce plants was presented in Table 2. The results showed that the treatment of media pot volume size only affected fresh leaf weight (FLW) and dry leaf weight (DLW). There was no difference in the variables fresh stem weight (FSW), fresh root weight (FRW), dry stem weight (DSW), and dry root weight (DRW). However, overall the highest biomass weight was found in P4.

Yield of Lettuce (g/raft)

Lettuce plant production yield per raft unit was significantly influenced by the treatment of the volume size of the planting media pot. This was related to the number of pot that can be supported by the raft. The highest production was found in P1 while the lowest was in P3, with the difference showed in Figure 5.

Table 1. Comparison of lettuce plant growth with various volumes of planting media

Media Volumes	SPAD Value	PH (cm)	SD (mm)	RRL (cm)	CA (cm^2)	TLA (cm^2)
1.9 L (P1)	19.85 $_b$	1.01 $_a$	8.11 $_a$	29.67 $_a$	425.05 $_b$	832.88 $_a$
2.7 L (P2)	19.66 $_b$	0.89 $_a$	4.12 $_b$	30.32 $_a$	317.65 $_b$	647.88 $_{bc}$
3.6 L (P3)	22.82 $_a$	1.16 $_a$	7.26 $_a$	20.52 $_a$	382.77 $_b$	493.33 $_c$
5 L (P4)	23.22 $_a$	1.05 $_a$	7.94 $_a$	30.97 $_a$	686.10 $_a$	801.88 $_{ab}$
LSD0.5	2.67	0.33	1.67	8.77	143.27	184.61

Note: Soil Plant Analysis Development (SPAD); Plant height (PH); Stem diameter (SD); Root length (RRL); Canopy area (CA); Total leaf area (TLA). The planting volumes consist of 1.9 L (P1), 2.7 (P2), 3.6 L (P3) and 5 L (P4).

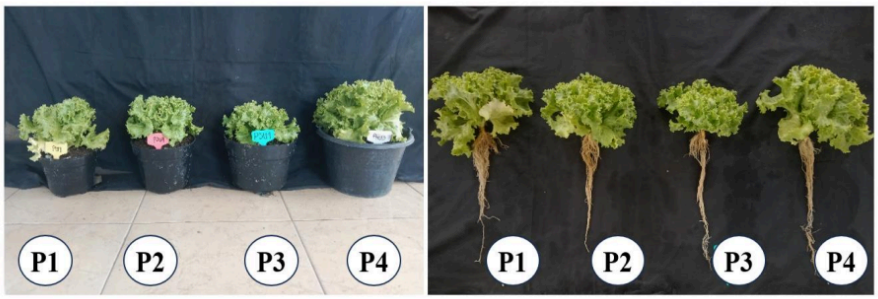

Figure 4. Comparison of lettuce plant yields in various sizes of planting media pot volumes

Table 2. Fresh and dry weight results for each lettuce plant treatment

Media Volumes	FLW (g)	FSW (g)	FRW (g)	DLW (g)	DSW (g)	DRW (g)
1.9 L (P1)	59.81 $_{ab}$	0.86 $_a$	7.14 $_a$	4.09 $_a$	0.09 $_a$	0.40 $_a$
2.7 L (P2)	49.08 $_{bc}$	0.58 $_a$	6.81 $_a$	3.74 $_a$	0.08 $_a$	0.39 $_a$
3.6 L (P3)	36.99 $_c$	0.77 $_a$	6.35 $_a$	2.75 $_b$	0.10 $_a$	0.33 $_a$
5 L (P4)	62.95 $_a$	0.71 $_a$	6.20 $_a$	4.39 $_a$	0.09 $_a$	0.41 $_a$
LSD0.5	13.80	0.29	2.08	0.71	0.03	0.09

Note: Fresh leaf weight (FLW); Fresh stem weight (FSW); Fresh root weight (FRW); Dry leaf weight (DLW); Dry stem weight (DSW); Dry root weight (DRW). The planting volumes consist of 1.9 (P1), 2.7 L (P2), 3.6 L (P3) and 5 L (P4).

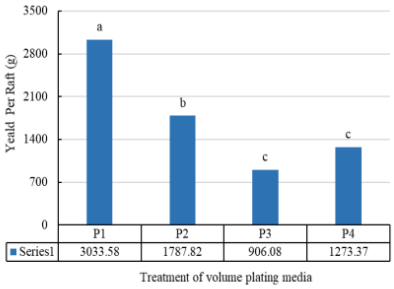

Figure 5. Comparison of lettuce prduction results of various volumes of planting media per raft unit

DISCUSSION

Plants consume large amounts of nutrients and energy to maintain their main functions, namely growth, respiration, and reproduction. Most of these resources are obtained from air and soil moisture (Villar-Salvador et al., 2015). In this case, soil moisture plays an important role in supporting the optimal growth and development of lettuce (*Lactuca sativa* L.). According to Sirait (2020), soil moisture that did not meet plant needs could inhibit optimal plant growth. In this study, soil moisture in P1 was higher than in P4 due to optimal development during the vegetative phase of the floating cultivation system since the smaller pot size could distribute water more efficiently.

Observations showed that P1 had the most leaves and the fastest growth in leaf length and width. This was because of better water and nutrient availability in the planting media, which helped photosynthesis and cell growth. Higher transpiration and mineral absorption in plants were linked to higher rates of photosynthesis (Petropoulos et al., 2016). Additionally, more stable conditions in smaller pots helped lettuce plants get more energy for growth, resulting in more and larger leaves. The amount of leaf area also grew as the leaves count increased. Similarly, Budiwansah and Maizar (2021) found that mustard green leaf area grew with the number of leaves. P1 had the largest total leaf area, matching the number of lettuce leaves in the pot. Plants with more and larger leaves tended to have a wider stem diameter. Results showed that P4 and P1 had similar stem diameters, while P2 had the smallest.

The height of plants in P1 was similar to P4 due to enough nutrients. Frasetya et al. (2021) noted that factors like light and water availability affect plant height. During the vegetative phase, lettuce plants grow taller through cell division, elongation, and early differentiation. Carbohydrates needed for these processes combine with nitrogen compounds to create protoplasm, which supports height growth. Nutrient availability affects how much sugar is accessible to plants (Wahyuningsih et al., 2024). Furthermore, fertilizer helps plant height increase because nutrients nitrogen (N), phosphate (P), and potassium (K) support physiological and metabolic functions. Nitrogen, especially, can encourage faster growth and increase plant height (Oviyanti et al., 2016). Observations showed that P4 had a higher degree of leaf greenness. Leaf green hue will gradually fade and turn yellow when plants do not receive enough N, which promotes general development (Waskito et al., 2017).

Root length and canopy area measurements showed that both parameters' growth produced comparatively better results in P4. This was because there was more room for lettuce roots to spread out and thrive. Consequently, the volume of P4 increased causing development in root length and canopy area. The development of lettuce plants in P1 stopped because there was no more space for roots to grow. Syifa et al. (2020) stated that mustard green roots lengthen in proportion to planting media volume. Cell division at the root tip meristem, followed by cell elongation and expansion, causes the growth in root length (Widiastuty, 2014).

Observations showed that there was no significant difference in fresh weight of leaves, stems, and roots produced by plants in P1 compared to P4. Meanwhile, P4 media was significantly different from P3. The fresh weight of plants was influenced by the growth of plant height and leaves area. The increase in fresh plant weight that is suitable for consumption is influenced by the moisture content in the tissue, where the physiological processes in plants are closely related to moisture and dissolved substances (Amin et al., 2017). The process of

photosynthesis will stimulate the accumulation of carbohydrates and proteins in the organs of the plant body, thereby affecting the wet weight of plants (Zulkifli et al,. 2022).

P4 has relatively higher results for dry weight parameters of leaves, stems, and roots. The reduction in dry weight in lettuce is continuous with the fresh weight of the plant. Dry weight of plants is significantly influenced by the absorption of nutrients such as N, P, and K. Among these elements, N plays an essential role in the formation of chlorophyll, which enhances the photosynthesis process.

When photosynthesis increases and assimilates fertilization runs smoothly, the dry weight of plants also improves with approximately 90% of dry weight coming from photosynthesis (Mukti et al., 2024). Assimilates are the energy used for growth although some are also stored as food reserves in storage organs. This is essential for assisting plants to survive in the absence of resources (Jobe et al., 2019). Compared to other media volume treatments, P1 yields more lettuce plants per unit area in terms of harvest. This is because the floating raft method has high production when planting media is smaller to retain more water.

CONCLUSSION

In this study, it was shown that the highest lettuce crop was found in the 5 L media (P4). Although the media volume of 1.9 L (P1) produces a lower weight, it had faster growth. The use of 1.9 L pots is better used for floating lettuce cultivation because with a smaller volume of media, the more pots are used so more assembly yield.

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