



RESEARCH ARTICLE

Growth and yield of lettuce (*Lactuca sativa* L.) on floating culture system with different substrate composition and number of wicks

F Gustiar^{1*}, D W Widjajanto², A Muslim¹, R P Ria¹, B Setiawan¹ & S A Sari¹

¹Faculty of Agriculture, Sriwijaya University, Jl. Raya Palembang-Prabumulih KM 32, Indralaya, Ogan Ilir 30662, South Sumatra, Indonesia

²Department of Agriculture, Faculty of Animal and Agricultural Sciences Universitas Diponegoro, Semarang 50275, Central Java, Indonesia

*Correspondence email - fitragustiar@unsri.ac.id

Received: 04 March 2025; Accepted: 21 May 2026; Available online: Version 1.0: 02 September 2025

Cite this article: Gustiar F, Widjajanto DW, Muslim A, Ria RP, Setiawan B, Sari SA. Growth and yield of lettuce (*Lactuca sativa* L.) on floating culture system with different substrate composition and number of wicks. Plant Science Today. 2026;13(sp7):01–08. <https://doi.org/10.14719/pst.14382>

Abstract

During the flooding period, agricultural activities in freshwater swamp ecosystems are highly limited. Floating culture is an alternative cultivation system for lettuce production under flooded conditions. This study aimed to determine the effective substrate composition and number of wicks for improving the growth and yield of lettuce (*Lactuca sativa* L.) in a floating culture system. The experiment was conducted at the Freshwater Swamp Field Laboratory, Sriwijaya University, South Sumatra, Indonesia. The study used a 2.0 m × 1.3 m bamboo raft supported by used mineral water gallons and was arranged in a factorial randomised block design (FRBD) with two factors. The first factor was substrate composition, consisting of M1 = soil, M2 = soil + cow manure + sand (4: 2: 1) and M3 = soil + cow manure + rice husk biochar (4: 2: 1). The second factor was the number of wicks, consisting of S2 = two wicks, S3 = three wicks and S4 = four wicks. Each treatment combination was replicated three times. The results showed that M3 produced the highest fresh leaf weight at 51.60 g and dry leaf weight at 6.13 g, while M1 produced the lowest fresh leaf weight at 10.02 g and dry leaf weight at 1.12 g. The use of four wicks (S4) resulted in the highest fresh leaf weight at 43.51 g and dry leaf weight at 4.68 g. The best treatment combination was M3S4, which produced the highest fresh leaf weight at 61.06 g, dry leaf weight at 7.32 g, fresh stem weight at 1.62 g, dry stem weight at 0.29 g and fresh root weight at 1.69 g. These findings indicate that the combination of soil, cow manure, rice husk biochar and four wicks can improve lettuce yield and may serve as a practical cultivation option for freshwater swamp areas during flooding periods.

Keywords: floating culture; freshwater swamp; lettuce; rice husk biochar; substrate composition; wick irrigation

Introduction

The increasing global population has led to a continuous rise in food demand. One strategy to increase agricultural production is expanding cultivation areas. However, the availability of productive agricultural land is becoming increasingly limited, causing agricultural expansion to shift toward suboptimal lands, including freshwater swamp areas. Indonesia has approximately 33.4 million ha of swamp land distributed mainly across Sumatra, Kalimantan and Papua (1). These areas have considerable potential for agricultural development, but their utilisation is constrained by fluctuating water levels and prolonged inundation. At the beginning of the dry season, when water levels decline, swamp land is generally used for rice cultivation. During the rainy season, however, agricultural activities in lowland swamp areas are very limited due to flooding.

Floating culture is one alternative technology that can be applied during the flooding period. This technique uses rafts to support crop production under inundated conditions and allows vegetables to be cultivated on the water surface (2). This system is consistent with the principles of sustainable agriculture because it enables the productive use of marginal land, supports food

production under climate-related constraints and reduces dependence on conventional dry land. In this system, plants do not require intensive manual watering because water can be supplied continuously through capillary movement from the water below the raft (3, 4). Therefore, floating cultivation has the potential to improve water-use efficiency and support food production in flood-prone swamp ecosystems.

Floating cultivation with potted plants on rafts differs from hydroponic floating systems. In hydroponic systems, water generally serves as the main medium for nutrient delivery. In contrast, floating cultivation in swamp land relies on planting substrates as the primary source of nutrients, while swamp water mainly supports moisture supply through capillary movement (2). This system allows lettuce plants to grow above the water surface, reduces the risk of submergence and minimises direct contact between roots and swamp water. Lettuce (*Lactuca sativa* L.) is a suitable vegetable for this system because it has a short growth cycle, high market demand and can be cultivated intensively in limited spaces.

The success of floating cultivation is strongly influenced by substrate composition and wick number. A suitable substrate provides a favorable environment for root growth, nutrient

availability, aeration and water retention. Meanwhile, the wick functions as a channel for water movement from the swamp water below the raft to the planting substrate. Different numbers of wicks may affect the amount of water absorbed and distributed to the root zone. Therefore, optimising both substrate composition and wick number is essential to improve plant growth and yield in floating cultivation systems.

The addition of organic and porous materials can improve the physical and chemical properties of planting substrates. Sand can improve substrate porosity and support root development, although it is relatively heavy, easily dries and may require sterilisation before use (5). Rice husk charcoal is another potential substrate amendment because it contains high carbon, has a porous structure and is relatively sterile (6). However, rice husk charcoal may decompose over time. Cow manure can also improve substrate fertility by enhancing soil chemical, physical and biological properties. The combination of soil, organic manure and porous materials is expected to create a more suitable substrate for lettuce growth in floating cultivation systems.

Previous studies have reported the potential of floating cultivation for vegetable production in swamp areas. However, information on the combined effects of substrate composition and wick number on lettuce growth and yield in floating culture systems remains limited, particularly for lowland swamp ecosystems in South Sumatra. This gap is important because substrate composition determines root-zone conditions, while wick number determines the continuity of water supply. A better understanding of these factors is needed to develop practical and adaptive cultivation techniques for flood-prone agricultural areas.

This study aimed to evaluate the effects of different substrate compositions and wick numbers on the growth and yield of lettuce cultivated using a floating culture system in lowland swamp conditions. The results are expected to support the development of adaptive, low-cost and sustainable vegetable cultivation technology for swamp areas, particularly during flooding periods when conventional agricultural activities are limited.

Materials and Methods

This study was conducted at the Laboratory of Plant Ecology, Department of Agronomy and the Freshwater Swamp Field Laboratory, Faculty of Agriculture, Sriwijaya University, South Sumatra, Indonesia. The study was conducted from May to August 2024. The experiment was carried out under open environmental conditions in a freshwater swamp field, where the plants were

exposed to natural sunlight, rainfall, air temperature and relative humidity during the cultivation period. This study used a factorial randomised block design (FRBD) with 2 treatment factors. The first factor was substrate composition (3 treatments combination), consisting of M1 = soil, M2 = soil + cow manure + sand (4: 2: 1) and M3 = soil + cow manure + rice husk biochar (4: 2: 1). The second factor was the number of wicks (3 treatments combination), consisting of S2 = two wicks, S3 = three wicks and S4 = four wicks (Fig. 1A). Each treatment combination was replicated three times, resulting in 27 experimental units. Each experimental unit consisted of one pot containing three lettuce (*L. sativa*) plants; therefore, a total of 81 plants were used in this study. Lettuce seedlings aged 14 days after sowing were transplanted into the pots and maintained for 35 days after transplanting until harvest. During the experiment, the general air temperature in the study area ranged from approximately 23 to 32 °C, with relative humidity ranging from approximately 77 to 88 %. This study used pots with a diameter of 20 cm arranged on a floating raft. Pots were filled with planting substrate according to the treatment composition. Each pot used flannel cloth as wick material to connect the water below the raft to the planting substrate through capillary movement.

The parameters observed included substrate moisture content and lettuce growth and yield variables. Growth parameters consisted of leaf length, leaf width, leaf area, number of leaves, stem diameter, root length and plant height. Leaf greenness was measured using a SPAD meter Minolta 504, while canopy area and leaf area were measured using the Easy Leaf Area Meter. Yield parameters consisted of fresh weight and dry weight. Additionally, several yield parameters such as fresh and dry weights were also measured. Data on lettuce plant growth and yield were analysed using analysis of variance (ANOVA) with R Studio statistical analysis software. When the ANOVA showed significant differences among treatments, mean comparisons were performed using the Least Significant Difference test at the 5 % probability level (LSD 0.05). The floating raft was made of 200 x 130 cm bamboo with the upper and lower parts separated and modified to avoid direct contact with the water in the freshwater swamps using 9 plastic gallons as floats. The design of the floating raft and the lettuce cultivation activities are shown in Fig. 1. Growth parameters were recorded at 7, 14, 21, 28 and 35 days after transplanting (DAT), while yield parameters were measured at harvest. Floating cultivation was carried out using a wick system hydroponic cultivation approach where the planting media derive a water supply without direct contact with the surface of the freshwater swamps. Flannel cloth was used as a connector for water with substrate and capillary capacity, the distance between the base of the pot and the water surface was ± 10 cm.

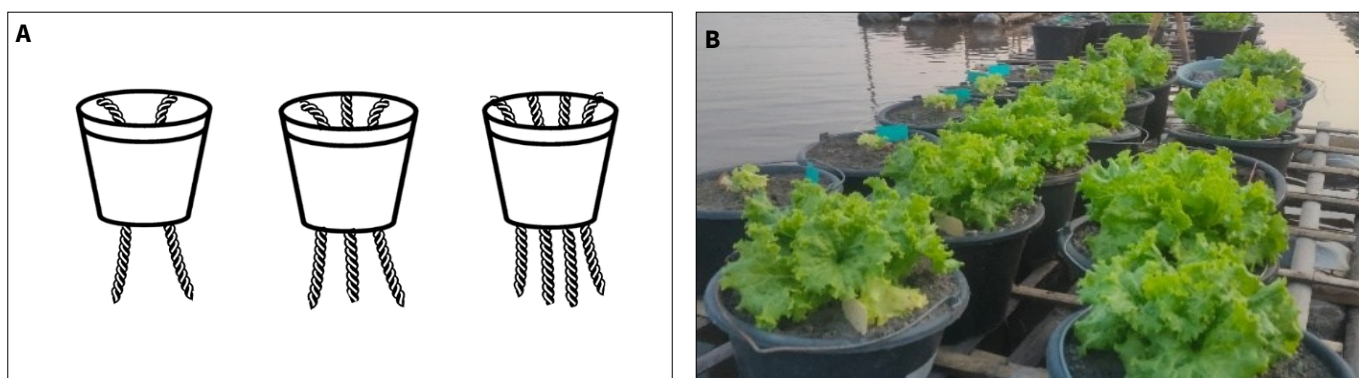


Fig. 1. Treatment of the number of wicks in the pot and conduct of the research. A: treatment of the number of wicks in the pot; B: conduct of the research.

Results

Physical properties of planting media and soil moisture

The treatment of the number of wicks in the pot and the conduct of the research is shown in Fig. 1. Soil moisture differed among substrate compositions and wick treatments (Fig. 2). M3 produced the highest soil moisture at 23.57 %, followed by M2 at 20.62 %, while M1 showed the lowest value at 6.78 %. For wick number, S3 had the highest soil moisture at 18.26 %, followed by S4 at 17.92 % and S2 at 14.80 %. The highest interaction value was observed in M2S3 at 24.60 %, whereas the lowest value was recorded in M1S2 at 6.00 %.

The number of wicks also affected soil moisture. S3 showed the highest soil moisture at 18.26 %, followed by S4 at 17.92 % and S2 at 14.80 %. The interaction between substrate composition and wick number showed that M2S3 produced the highest soil moisture at 24.60 %, followed by M3S4 at 23.90 %, M3S3 at 23.50 %, M3S2 at 23.40 % and M2S4 at 22.20 %. In contrast, the lowest soil moisture was recorded in M1S2 at 6.00 %, followed by M1S3 at 6.60 % and M1S4 at 7.60 %. Soil-based media without organic or porous amendments had the lowest soil moisture, whereas mixed substrates containing cow manure, sand, or rice husk biochar maintained higher moisture values.

Growth and morphology of lettuce plant

The number of lettuce leaves affected by planting media and number of wicks is shown in Fig. 3. Substrate composition significantly affected lettuce growth and morphology (Table 1). The highest plant height was recorded in M3 at 1.68 cm, which was not significantly different from M2 at 1.59 cm, while M1 produced the lowest plant height at 0.25 cm. A similar trend was observed for canopy area and total leaf area. M2 produced a canopy area of 497.33 cm² and total leaf area of 840.74 cm², while M3 produced a canopy area of 489.77 cm² and total leaf area of 869.74 cm². Both treatments were significantly higher than M1, which only produced a canopy area of 29.62 cm² and total leaf area of 20.19 cm².

The growth rate of lettuce leaf length and leaf width in various media conditions and number of wicks is shown in Fig. 4. The SPAD value was also higher in mixed substrate treatments. M2 showed the highest SPAD value at 21.24, followed by M3 at 18.98, while M1 showed the lowest value at 12.83. Stem diameter was highest in M3 at 1.13 mm, followed by M2 at 0.91 mm and M1 at 0.41 mm. Root length was highest in M2 at 18.34 cm, followed by M3 at 17.00 cm, while M1 showed the lowest root length at 8.34 cm.

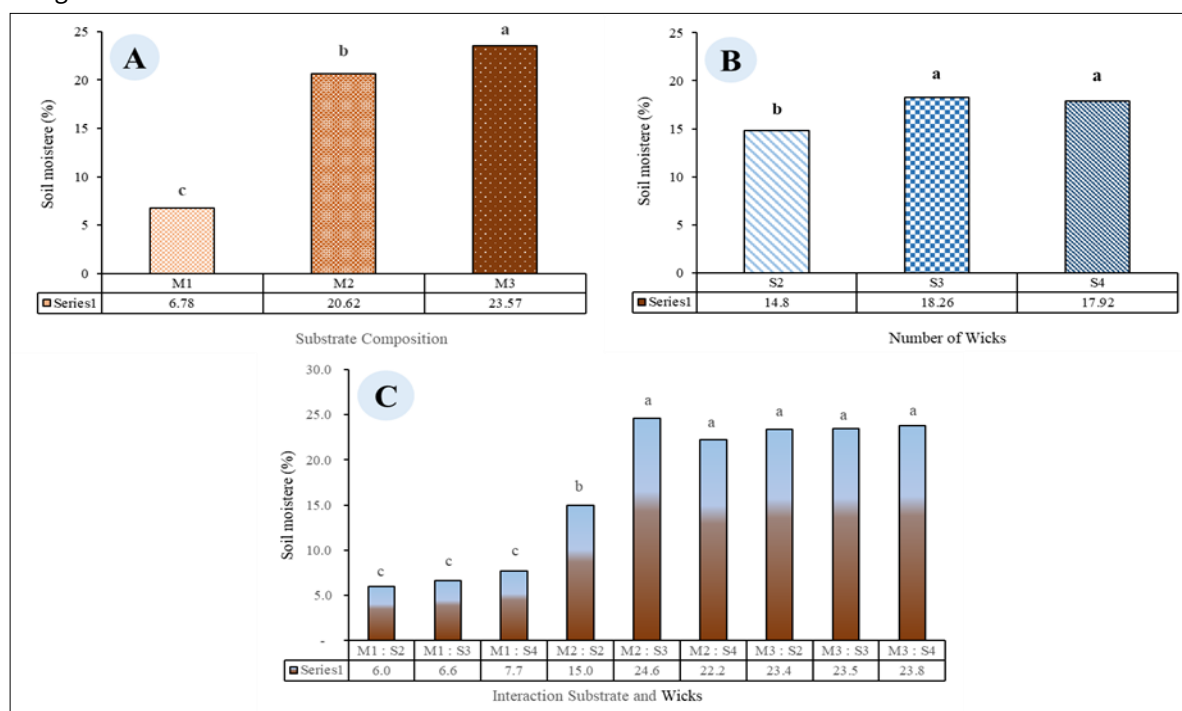


Fig. 2. Soil moisture under different media compositions and numbers of wicks. A: media compositions; B: number of wicks; C: interaction between media composition and number of wicks.

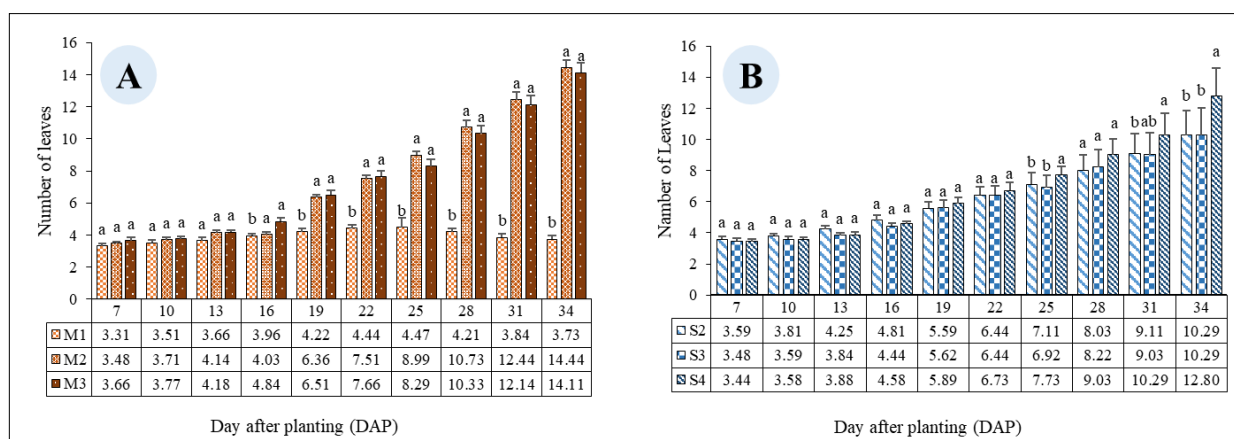
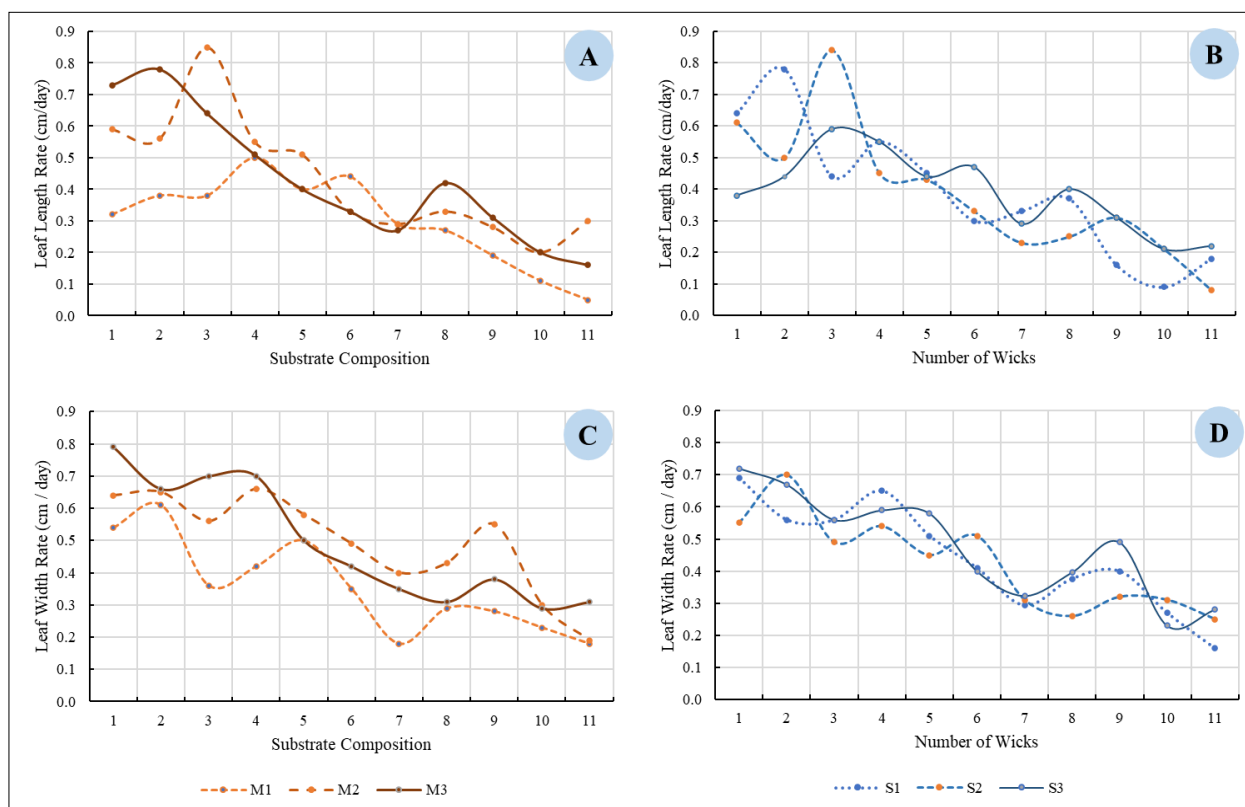


Fig. 3. Number of leaves under different planting media and numbers of wicks. A: planting media; B: number of wicks.

Table 1. Morphology of lettuce in various planting media compositions and number of wicks

	PH (cm)		SPAD Value		CA (cm ²)		TLA (cm ²)		SD (mm)		RL (cm)	
Substrate composition												
M1	0.25	b	12.83	b	29.62	b	20.19	b	0.41	c	8.34	b
M2	1.59	a	21.24	a	497.33	a	840.74	a	0.91	b	18.34	a
M3	1.68	a	18.98	a	489.77	a	869.74	a	1.13	a	17.00	a
LSD _{0.05}	0.25		3.92		111.11		180.00		0.10		3.00	
Number of wicks												
S2	1.09	a	18.61	a	276.52	b	444.77	b	0.62	c	12.73	b
S3	1.14	a	17.56	a	344.84	ab	598.08	ab	0.81	b	14.26	ab
S4	1.29	a	16.89	a	395.35	a	687.03	a	1.02	a	16.69	a
LSD _{0.05}	0.25		3.92		111.11		180.00		0.1		3.00	
Interaction substrate and wicks												
M1:S2	0.18	c	12.30	cd	18.73	c	11.56	d	0.22	f	5.83	e
M1:S3	0.28	c	12.06	d	31.33	c	26.18	d	0.41	e	7.92	de
M1:S4	0.30	c	14.13	bcd	38.79	c	22.82	d	0.60	d	11.27	cd
M2:S2	1.58	ab	23.92	a	417.53	b	578.48	c	0.64	d	15.33	cd
M2:S3	1.57	ab	21.53	a	456.19	ab	810.03	bc	0.89	c	18.37	ab
M2:S4	1.63	ab	18.28	abcd	618.28	a	1133.72	a	1.20	a	21.32	a
M3:S2	1.50	b	19.62	ab	393.31	b	744.29	bc	1.02	ab	17.01	ab
M3:S3	1.57	ab	19.10	abc	547.00	ab	958.04	ab	1.11	ab	16.50	ab
M3:S4	1.97	a	18.27	abcd	528.98	ab	907.15	ab	1.27	a	17.50	a
LSD _{0.05}	0.44		6.80		192.44		311.77		0.17		5.20	

PH: plant height; CA: canopy area; TLA: total leaf area; SD: stem diameter; RL: root length.



Growth rate of lettuce leaf length and leaf width under different media conditions and numbers of wicks. A: leaf length under different media conditions; B: leaf length under different numbers of wicks; C: leaf width under different media conditions; D: leaf width under different numbers of wicks.

The number of wicks affected several lettuce morphology variables. S4 produced the highest plant height at 1.29 cm, canopy area at 395.35 cm², total leaf area at 687.03 cm², stem diameter at 1.02 mm and root length at 16.69 cm. S2 produced the lowest canopy area at 276.52 cm², total leaf area at 444.77 cm², stem diameter at 0.62 mm and root length at 12.73 cm.

The interaction between substrate composition and wick number showed that M3S4 produced the highest plant height at 1.97 cm and stem diameter at 1.27 mm. The highest canopy area was observed in M2S4 at 618.28 cm², while the highest total leaf area was also recorded in M2S4 at 1133.72 cm². The highest SPAD value was recorded in M2S2 at 23.92, while the highest root length was

observed in M2S4 at 21.32 cm. The lowest values for most growth variables were recorded in the M1S2 treatment, including plant height at 0.18 cm, canopy area at 18.73 cm², total leaf area at 11.56 cm², stem diameter at 0.22 mm and root length at 5.83 cm. The visual morphology of lettuce in various planting media compositions and number of wicks is shown in Fig. 5.

Yield of lettuce plant

Lettuce yield differed among substrate compositions, wick numbers and their interactions (Table 2). Based on substrate composition, M3 produced the highest fresh weight of leaves at 51.60 g, dry weight of leaves at 6.13 g, fresh weight of stems at 1.16 g, dry weight of stems at 0.25 g and fresh weight of roots at 1.20 g. M2 produced comparable



Fig. 5. Visual morphology of lettuce under different planting media compositions and number of wicks.

Table 2. Yield of lettuce on various compositions of planting media and the number of potting wicks

	FWL (g)		DWL (g)		FWS (g)		DWS (g)		FWR (g)		DWR (g)	
Substrate composition												
M1	10.02	b	1.12	b	0.14	c	0.07	c	0.15	b	0.07	b
M2	46.58	a	5.41	a	0.70	b	0.18	b	1.11	a	0.56	a
M3	51.60	a	6.13	a	1.16	a	0.25	a	1.20	a	0.49	a
LSD _{0.05}	9.81		1.04		0.29		0.05		0.22		0.09	
Number of wicks												
S2	28.66	b	3.64	b	0.47	b	0.14	b	0.53	c	0.39	a
S3	36.02	ab	3.93	ab	0.58	b	0.17	ab	0.79	b	0.40	a
S4	43.51	a	4.68	a	0.95	a	0.19	a	1.11	a	0.46	a
LSD _{0.05}	9.81		1.04		0.29		0.05		0.22		0.09	
Interaction substrate and wicks												
M1:S2	9.70	e	1.14	d	0.14	d	0.06	e	0.14	e	0.04	c
M1:S3	9.75	e	0.68	d	0.13	d	0.08	de	0.14	e	0.07	c
M1:S4	10.60	e	1.53	d	0.15	d	0.06	de	0.19	e	0.11	c
M2:S2	37.38	d	4.62	c	0.42	cd	0.14	cd	0.85	cd	0.47	b
M2:S3	43.46	bcd	5.21	bc	0.61	bc	0.19	bc	1.04	cd	0.55	ab
M2:S4	58.89	ab	6.40	ab	1.09	b	0.22	abc	1.45	ab	0.64	a
M3:S2	38.90	cd	5.16	bc	0.86	bc	0.22	abc	0.68	d	0.42	b
M3:S3	54.84	abc	5.90	ab	1.01	b	0.25	ab	1.22	bc	0.47	b
M3:S4	61.06	a	7.32	a	1.62	a	0.29	a	1.69	a	0.57	ab
LSD _{0.05}	10.02		1.12		0.14		0.07		0.15		0.07	

FWL: fresh weight of leaves; DWL: dry weight of leaves; FWS: fresh weight of stems; DWS: dry weight of stems; FWR: fresh weight of roots; DWR: dry weight of roots.

yield values, with fresh leaf weight of 46.58 g, dry leaf weight of 5.41 g, fresh stem weight of 0.70 g, dry stem weight of 0.18 g and fresh root weight of 1.11 g. The lowest yield was recorded in M1, with fresh leaf weight of 10.02 g, dry leaf weight of 1.12 g, fresh stem weight of 0.14 g, dry stem weight of 0.07 g and fresh root weight of 0.15 g.

The number of wicks also influenced lettuce yield. S4 produced the highest fresh leaf weight at 43.51 g, dry leaf weight at 4.68 g, fresh stem weight at 0.95 g, dry stem weight at 0.19 g and fresh root weight at 1.11 g. S2 produced the lowest fresh leaf weight at 28.66 g, dry leaf weight at 3.64 g, fresh stem weight at 0.47 g, dry stem weight at 0.14 g and fresh root weight at 0.53 g. Dry root weight did not differ markedly among wick treatments, with values of 0.39 g in S2, 0.40 g in S3 and 0.46 g in S4.

The interaction treatment M3S4 produced the highest lettuce yield, with fresh leaf weight of 61.06 g, dry leaf weight of 7.32 g, fresh stem weight of 1.62 g, dry stem weight of 0.29 g and fresh root weight of 1.69 g. M2S4 also produced high yield values, with fresh leaf weight of 58.89 g, dry leaf weight of 6.40 g, fresh stem weight of 1.09 g, dry stem weight of 0.22 g and fresh root weight of 1.45 g. The lowest yield was generally observed in the M1S2 and M1S3 treatments. M1S2 produced fresh leaf weight of 9.70 g, dry leaf weight of 1.14 g, fresh stem weight of 0.14 g, dry stem weight of 0.06

g, fresh root weight of 0.14 g and dry root weight of 0.04 g. The M3S4 treatment combination produced the best lettuce yield performance among all treatments, while M1-based treatments consistently resulted in the lowest growth and yield.

Discussion

Moisture dynamics of growing media under floating cultivation systems

The variation in soil moisture among treatments indicates that moisture dynamics in floating cultivation are controlled by the interaction between substrate physical properties and capillary water movement. Planting media composed of soil, manure, sand and rice husk charcoal provides a more favourable physical environment for plant growth than soil alone. The inclusion of sand contributes to the enlargement of macropores, which enhances water infiltration and air movement within the medium. Porosity plays a crucial role in regulating water availability, aeration and root growth space, thereby creating optimal conditions for root development (7). Increased macroporosity facilitates drainage and gas exchange, preventing excessive waterlogging and reducing the risk of oxygen deficiency in the root zone (8).

Rice husk charcoal contributes predominantly to the formation of micropores, which function as water retention sites within the planting media (9). Its lightweight and highly porous structure enables it to absorb and store water, releasing it gradually according to plant demand (10). This characteristic is particularly advantageous under floating cultivation systems, where stable moisture availability is essential. The combination of macropores from sand and micropores from rice husk charcoal creates a balanced pore distribution, allowing the medium to retain sufficient water while maintaining adequate aeration for root activity.

The effectiveness of moisture regulation is further supported by the wick irrigation system, which operates based on capillary principles (11). The wick functions as a pathway for water movement from the swamp water below the raft to the planting medium. However, the effectiveness of this process depends not only on the number of wicks but also on the capacity of the substrate to absorb and distribute water. A greater number of wicks can increase water entry points into the medium and improve moisture distribution in the root zone. This condition helps maintain a stable and humid microenvironment around the roots, supports water and nutrient uptake and reduces the risk of water stress in lettuce grown under floating cultivation systems.

Effects of growing media and wick irrigation on lettuce growth

The planting medium plays a critical role in determining lettuce vegetative performance, particularly leaf development. Media dominated by soil tend to exhibit dense structure, limited porosity and suboptimal drainage and aeration. These physical constraints restrict root expansion and reduce oxygen diffusion into the root zone, thereby limiting the efficiency of water and nutrient uptake (12). As root function becomes impaired, vegetative growth processes, including leaf formation, are consequently inhibited.

Conversely, planting media incorporating organic and porous amendments exhibit improved structural properties, including higher porosity and enhanced air circulation (13). These conditions support water absorption and help maintain moisture availability within the root zone (14). In the floating cultivation system, this condition is important because the planting medium depends on capillary water movement rather than direct contact with swamp water. Improved porosity also enhances the performance of the wick irrigation system because water can move more evenly through the medium (15). Roots developing under such conditions tend to be healthier and more extensive, enabling more efficient nutrient acquisition.

Optimal root development directly supports leaf growth by improving access to water and nutrients required for photosynthesis and tissue formation (16). Even moisture distribution promotes consistent physiological activity, whereas restricted root growth limits nutrient uptake and suppresses vegetative development, including leaf initiation and expansion (17). Therefore, the interaction between porous media and an effective wick system creates a favorable root-zone environment for sustained lettuce growth.

Nitrogen availability further explains the differences in leaf growth. Manure serves as a source of organic nitrogen, while rice husk charcoal helps retain nutrients and provides a suitable habitat for soil microorganisms (18). Enhanced microbial activity promotes mineralisation and nitrification processes, allowing nitrogen to become more readily available for plant uptake (19). Adequate

nitrogen supply supports chlorophyll synthesis, protein formation and cell division, which are essential for leaf elongation and expansion.

The improved growth response in amended media can therefore be associated with better substrate structure, stable moisture supply and increased nutrient availability. These conditions support root development, nitrogen metabolism, chlorophyll formation and photosynthetic efficiency, as reflected by better vegetative performance (20). Organic-enriched and porous media combined with sufficient wick pathways provide a more suitable cultivation environment for lettuce than unamended soil under floating cultivation conditions (21).

Lettuce yield response to growing media and wick irrigation

Lettuce biomass accumulation was improved using mixed planting media and an appropriate wick configuration. The higher yield obtained from media enriched with cow manure and rice husk biochar indicates that substrate quality plays an important role in supporting lettuce growth under floating cultivation systems. Cow manure contributes nutrients, particularly nitrogen, which is essential for chlorophyll synthesis, leaf development and photosynthetic activity (22). Meanwhile, rice husk biochar improves the physical structure of the medium by increasing porosity, aeration and water-holding capacity, allowing roots to absorb water and nutrients more efficiently (23).

The wick irrigation system also contributed to yield improvement by supplying water from the swamp water to the planting medium through capillary movement. A greater number of wicks can improve water distribution in the root zone, particularly when combined with porous and organic-enriched media. This condition helps maintain moisture availability, supports root activity and reduces the risk of water stress during plant growth.

The superior yield response in the M3S4 treatment suggests that the combination of soil, cow manure, rice husk biochar and four wicks provided a favourable balance between nutrient availability, aeration and moisture supply (24). Therefore, this substrate-wick combination can be considered a practical option for lettuce cultivation in floating systems, especially in freshwater swamp areas during flooding periods.

Conclusion

The results showed that the use of mixed planting media improved lettuce growth and yield in the floating culture system. The M3 substrate, consisting of soil, cow manure and rice husk biochar, produced better growth and yield than soil alone, with the highest fresh leaf weight of 51.60 g and dry leaf weight of 6.13 g. This improvement was associated with enhanced substrate structure, moisture retention, aeration and nutrient availability. The number of wicks also influenced lettuce performance. The S4 treatment produced the highest fresh leaf weight of 43.51 g and dry leaf weight of 4.68 g, indicating that four wicks provided better water supply to support plant growth. The best treatment combination was M3S4, which produced the highest yield, with 61.06 g fresh leaf weight, 7.32 g dry leaf weight, 1.62 g fresh stem weight, 0.29 g dry stem weight and 1.69 g fresh root weight. The combination of soil, cow manure, rice husk biochar and four wicks can be recommended as a practical option for lettuce cultivation in floating systems, particularly in freshwater swamp areas during flooding periods.

Acknowledgements

The authors would like to express their sincere appreciation to the Editor and Reviewers of the ICAS Conference for their valuable comments and constructive suggestions, which have greatly contributed to the improvement of this manuscript. The authors also gratefully acknowledge Sriwijaya University for providing facilities and institutional support during the implementation of this research. In addition, the authors extend their gratitude to all individuals and parties who have contributed, directly or indirectly, to the completion of this study.

Authors' contributions

FG conceived and designed the study and was responsible for drafting the manuscript. DWW contributed to the development of the data collection methodology. AM contributed to the study design, performed statistical analysis, and critically reviewed the manuscript. RPR and SAS were responsible for data analysis and contributed to manuscript writing. BS participated in data collection. All authors read and approved the final version of the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

References

- Wandansari NR, Pramita Y. Potential for the utilization of swamplands to support agricultural development in border areas. *Agriekstensia J Penelit Terap Bidang Pertanian*. 2019;18:66–73. <https://doi.org/10.34145/agriekstensia.v18i1.29>
- Gustiar F, Septiani D, Agustina H, Adriansyah F, Ramadhani F. Growth and yield of lettuce (*Lactuca sativa* L.) grown on different planting media volumes in a floating cultivation system. *J Lahan Suboptimal*. 2025;14(1):44–50. <https://doi.org/10.36706/jlso.14.1.2025.721>
- Ria RP, Gustiar F, Ramadhani F, Zaman AK. Effect of fertilization methods on growth of Grand Rapids lettuce in floating cultivation systems. In: *BIO Web Conf*. 2025;197:02006. <https://doi.org/10.1051/bioconf/202519702006>
- Susilawati S, Irmawati I, Harun MU, Ichwan B. Shallot cultivation in tropical climate ecosystems using floating and non-floating systems with different doses of cow manure. *Adv Horticult Sci*. 2024;38:25–34. <https://doi.org/10.36253/ahsc-14940>
- Gustiar F, Susilawati S, Widjajanto DW, Ria RP, Muda SA, Setyawan LAP, et al. Drought stress and selective manure on the growth and yield of chaya (*Cnidioscolus aconitifolius*) in a tropical climate. *Agron Res*. 2025;23:1–16.
- Nurmalasari AI, Supriyono S, Budiastuti MTS, Sulisty TD, Nyoto S. Pemanfaatan jerami padi dan arang sekam sebagai pupuk organik dan media tanam dalam budidaya kedelai. *Prima J Community Empowering Serv*. 2021;5:102–9. <https://doi.org/10.20961/prima.v5i2.44766>
- Balliu A, Zheng Y, Sallaku G, Fernández JA, Gruda NS, Tuzel Y. Environmental and cultivation factors affect the morphology, architecture and performance of root systems in soilless grown plants. *Horticulturae*. 2021;7:243. <https://doi.org/10.3390/horticulturae7080243>
- Phogat VK, Tomar VS, Dahiya R. Soil physical properties. In: *Soil science: an introduction*. 2015. p. 135–71.
- Adekiya AO, Ayeni JF, Olayanju A, Aremu C, Akpor OB, Olaniran AF, et al. Potentials of soilless substrates from biochar and rice husk as a replacement for cocopeat in Nigeria on tomato (*Solanum lycopersicum*). *Res Crops*. 2022;23:139–48. <https://doi.org/10.31830/2348-7542.2022.020>
- Machfudz M, Basit A. Yield and nutritional quality of green leafy lettuce (*Lactuca sativa* L.) under soilless culture system using various composition of growing media and vermicompost rates. *Caraka Tani J Sustain Agric*. 2021;36:201–12. <https://doi.org/10.20961/carakatani.v36i2.46131>
- Ma B. Analysis of capillary flow in a parallel microchannel-based wick structure with circular and noncircular geometries. *Langmuir*. 2020;36:13485–97. <https://doi.org/10.1021/acs.langmuir.0c02226>
- Sharma PK, Kumar S. Soil structure and plant growth. In: *Soil physical environment and plant growth: evaluation and management*. Cham: Springer International Publishing; 2023. p. 125–54. https://doi.org/10.1007/978-3-031-28057-3_5
- Younis A, Ahsan M, Akram A, Lim KB, Zulfiqar F, Tariq U. Use of organic substrates in sustainable horticulture. In: Hasanuzzaman M, Hawrylak-Nowak B, Islam T, Fujita M, editors. *Biostimulants for crop production and sustainable agriculture*. 2022. p. 122–38. <https://doi.org/10.1079/9781789248098.0009>
- Nurhidayat N, Ansari AS, Sholihah A, Chiangmai PN. Vermicompost and rice husk biochar interaction ameliorates nutrient uptake and yield of green lettuce under soilless culture. *J Horticult Res*. 2022;30:55–66. <https://doi.org/10.2478/johr-2022-0018>
- de Araújo AG, Sims B, Desbiolles J, Bolonhezi D, Haque E, Jin H, et al. The status of mechanization in conservation agriculture systems. In: *Advances in conservation agriculture*. Burleigh Dodds Science Publishing; 2020. p. 427–96.
- Lakitan B, Siaga E, Fadilah LN, Nurshanti DF, Widuri LI, Gustiar F, et al. Accurate and non-destructive estimation of palmate compound leaf area in cassava (*Manihot esculenta* Crantz) based on morphological traits of its selected lobes. *Int J Agric Technol*. 2022;19(1):129–44.
- Mosahrroff M, Hasma S, Uddin MK, Shamsuzzaman S, Mahmud MH, Islam MR, et al. Effects of rice husk biochar on nutrient uptake and yield of leafy vegetables: a review. *J Survey Fish Sci*. 2022;9:260–72.
- Leghari SJ, Wahocho NA, Laghari GM, Hafeez Laghari A, Mustafa Bhabhan G, Hussain Talpur K, et al. Role of nitrogen for plant growth and development: a review. *Adv Environ Biol*. 2016;10:209–19.
- Lyu H, Li Y, Wang Y, Wang P, Shang Y, Yang X, et al. Drive soil nitrogen transformation and improve crop nitrogen absorption and utilization—a review of green manure applications. *Front Plant Sci*. 2024;14:1305600. <https://doi.org/10.3389/fpls.2023.1305600>
- Mohammed B, Biloei SF, Dóczy R, Grove E, Railo S, Palme K, et al. Converging light, energy and hormonal signaling control meristem activity, leaf initiation, and growth. *Plant Physiol*. 2018;176:1365–81. <https://doi.org/10.1104/pp.17.01730>
- Bhatti AA, Haq S, Bhat RA. Actinomycetes benefaction role in soil and plant health. *Microb Pathog*. 2017;111:458–67. <https://doi.org/10.1016/j.micpath.2017.09.036>
- De Vivo M. Crucial role of asymmetric cell division in plant adaptation to hard and dry soils [doctoral thesis]. Rome: Sapienza University of Rome; 2025.
- Sandhu N, Sethi M, Kumar A, Dang D, Singh J, Chhuneja P. Biochemical and genetic approaches improving nitrogen use efficiency in cereal crops: a review. *Front Plant Sci*. 2021;12:657629. <https://doi.org/10.3389/fpls.2021.657629>
- Abubakari AH, Atuah L, Banful BK. Growth and yield response of lettuce to irrigation and growth media from composted sawdust and rice husk. *J Plant Nutr*. 2018;41:221–32. <https://doi.org/10.1080/01904167.2017.1384013>

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics,

NAAS, UGC Care, etc See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Copyright: © The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited (<https://creativecommons.org/licenses/by/4.0/>)

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.