

OPTIMIZATION OF LETTUCE GROWTH THROUGH SUBSTRATE AND NUTRIENT COMBINATIONS IN HYDROPONICS

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Abstract: This study investigates the effects of different growing substrates and nutrient treatments on the vegetative growth and average leaf weight of *Lactuca sativa* (lettuce) cultivated in a hydroponic system. Four substrates—vermiculite, perlite, coconut coir, and rockwool—were evaluated in combination with three nutrient regimes: mineral salts alone, mineral salts with humic acid, and mineral salts with microalgae. The results reveal that the inclusion of humic acid and microalgae significantly enhanced plant performance, with the highest average leaf weight observed in the rockwool + mineral salts + microalgae treatment (31.233 g). Rockwool outperformed other substrates due to its superior water retention and aeration properties. Microalgae supplementation contributed the most notable improvement, likely due to its bioactive compounds and nutrient-enhancing effects. These findings emphasize the importance of optimizing both substrate and nutrient combinations to improve lettuce yield in soilless cultivation systems.

Annotation

This study explores the impact of different hydroponic substrates and nutrient formulations on the average fresh leaf weight of *Lactuca sativa* (lettuce). Four types of growing media—vermiculite, perlite, coconut coir, and rockwool—were tested in combination with three nutrient treatments: mineral salts, mineral salts with humic acid, and mineral salts with microalgae. The results showed that both humic acid and microalgae significantly improved plant growth, with the rockwool and microalgae combination yielding the highest average leaf weight (31.233 g). These findings suggest that integrating organic supplements with suitable substrates can significantly enhance lettuce production in soilless systems.

Keywords

Hydroponics, *Lactuca sativa*, Rockwool, Microalgae, Humic acid, Substrate selection, Soilless cultivation, Leaf weight, Biofertilizer, Nutrient solution.

Introduction

Hydroponic systems have emerged as efficient alternatives to traditional agriculture, particularly for leafy vegetables like *Lactuca sativa* (lettuce). These systems offer precise control over environmental and nutritional conditions, enabling improved plant performance and sustainable production. A key factor in hydroponic cultivation is the selection of an appropriate substrate and nutrient formulation, both of which directly affect water retention, aeration, nutrient availability, and root development.

Previous research has identified substrates such as rockwool and coconut coir as effective growing media due to their structural stability and moisture retention capabilities. Meanwhile, the integration of organic inputs such as humic acid and microalgae into nutrient solutions has been shown to enhance nutrient uptake and plant growth. This study aims to evaluate the synergistic effects of different substrate–nutrient combinations on the vegetative growth and average leaf weight of lettuce under controlled hydroponic conditions.

In addition to its diversity and culinary utility, lettuce is a rich source of polyphenolic compounds and antioxidant vitamins A, C, and E (Romani, 2002). It is frequently associated with chronic disease prevention, including cardiovascular diseases and certain cancers, owing to its high radical scavenging activity and frequent raw consumption (Husain, 1987; Cartea, 2011). Optimal growth occurs at temperatures between 7°C and 24°C, making it ideal for many climate zones.

Lettuce is also appreciated for its low content of calories, fat, and sodium, while being rich in fiber, iron, and vitamin C (Kim et al., 2016). It contains various antioxidant and bioactive compounds such as carotenoids, phenolics, and anthocyanins, which contribute to its health-promoting effects (Simko, 2019). Regular consumption of lettuce supports protection against chronic illnesses and enhances overall diet quality (Nicolle et al., 2004). Shifting consumer habits and increased interest in fresh-cut salads (Damerum et al., 2020; Stuart, 2011) have also led to greater demand for lettuce varieties with diverse colors, textures, and flavors.

Materials and Methods. The study evaluated the effect of different growing media and nutrient solutions on the morphological parameters of *Lactuca sativa* leaves, specifically focusing on leaf length and width. The data presented in Table 1 shows that both the growing medium and the nutrient solution had a significant influence on leaf size.

The maximum leaf length and width were recorded in the Rockwool substrate under the Microalgae + Mineral salts treatment, reaching 18 cm in length and 9 cm in width. This was followed by the Humic acid + Mineral salts treatment in the same substrate, with values of 17 cm × 7 cm. The lowest values were observed in Perlite with Mineral salts only, showing 10 cm × 5 cm.

In general, the Microalgae + Mineral salts treatment resulted in the largest leaves across all substrates. Among the growing media, Rockwool consistently showed superior results, while Perlite demonstrated the least favorable outcomes. (table 3.1)

(table 3.1)

The findings indicate that the combination of nutrient solutions and growing media plays a crucial role in enhancing the vegetative growth of *Lactuca sativa*. The significant increase in leaf size observed with the Microalgae + Mineral salts treatment suggests that microalgae provide additional bioactive compounds, growth stimulators, and improved nutrient availability that positively affect plant development.

Among the substrates, Rockwool proved to be the most effective, likely due to its excellent water retention, aeration properties, and stable structure, which create optimal conditions for root development and nutrient uptake. This aligns with previous research indicating that Rockwool is highly suitable for hydroponic lettuce cultivation.

The poor performance of Perlite may be attributed to its lower water-holding capacity and limited nutrient retention compared to other media, which might restrict the continuous availability of nutrients and water to the plant roots. These results collectively demonstrate that selecting the appropriate substrate and nutrient combination is essential for achieving maximum growth performance in hydroponic systems.

To find the average fresh weight of a lettuce leaves, the method of adding three thefts and dividing the result by three was used. The results were analyzed graphically.

	The weight of the lettuce leaves								
	Mineral Salts			Mineral Salts+Humic acid			Mineral salts+Microalgae		
Vermiculite	20,8 gr	20,4 gr	21,4 gr	24,6 gr	25,4 gr	25,9 gr	29,4 gr	30,5 gr	32,4 gr
Perlite	19,6 gr	19,8 gr	20,3 gr	22,9 gr	23,6 gr	24,4 gr	27,4 gr	27,9 gr	28,6 gr
Coconut Coir	19,4 gr	20,8 gr	21,4 gr	22,3 gr	23,5 gr	23,8 gr	25,8 gr	26,4 gr	26,7 gr
Rockwool	20,8 gr	21,4 gr	22,7 gr	24,9 gr	25,3 gr	26,3 gr	29,8 gr	31,5 gr	32,4 gr

This result was calculated using the formula for finding the average:

$$(a + b + c)/3 = d$$

a, b, c – weight of lettuce leaves

3- fixed value

d- average value

The average weight of lettuce leaves grown in vermiculite.

For mineral salts:

$$\frac{(20,8 + 20,4 + 21,4)}{3} = 20,866$$

For mineral salts and humic acid:

$$\frac{(24,6 + 25,4 + 25,9)}{3} = 25,3$$

For mineral salts and microalgae:

$$\frac{(29,4 + 30,5 + 32,4)}{3} = 30,766$$

The average weight of lettuce leaves grown in perlite.

For mineral salts:

$$\frac{(19,6 + 19,8 + 20,3)}{3} = 19,9$$

For mineral salts and humic acid:

$$\frac{(22,9 + 23,6 + 24,4)}{3} = 22,966$$

For mineral salts and microalgae:

$$\frac{(27,4 + 27,9 + 28,6)}{3} = 27,966$$

The average weight of lettuce leaves grown in coconut coir.

For mineral salts:

$$\frac{(19,4 + 20,8 + 21,4)}{3} = 20,533$$

For mineral salts and humic acid:

$$\frac{(22,3 + 23,5 + 23,8)}{3} = 23,2$$

For mineral salts and microalgae:

$$\frac{(25,8 + 26,4 + 26,7)}{3} = 26,3$$

The average weight of lettuce leaves grown in rockwool.

For mineral salts:

$$\frac{(20,8 + 21,4 + 22,7)}{3} = 21,633$$

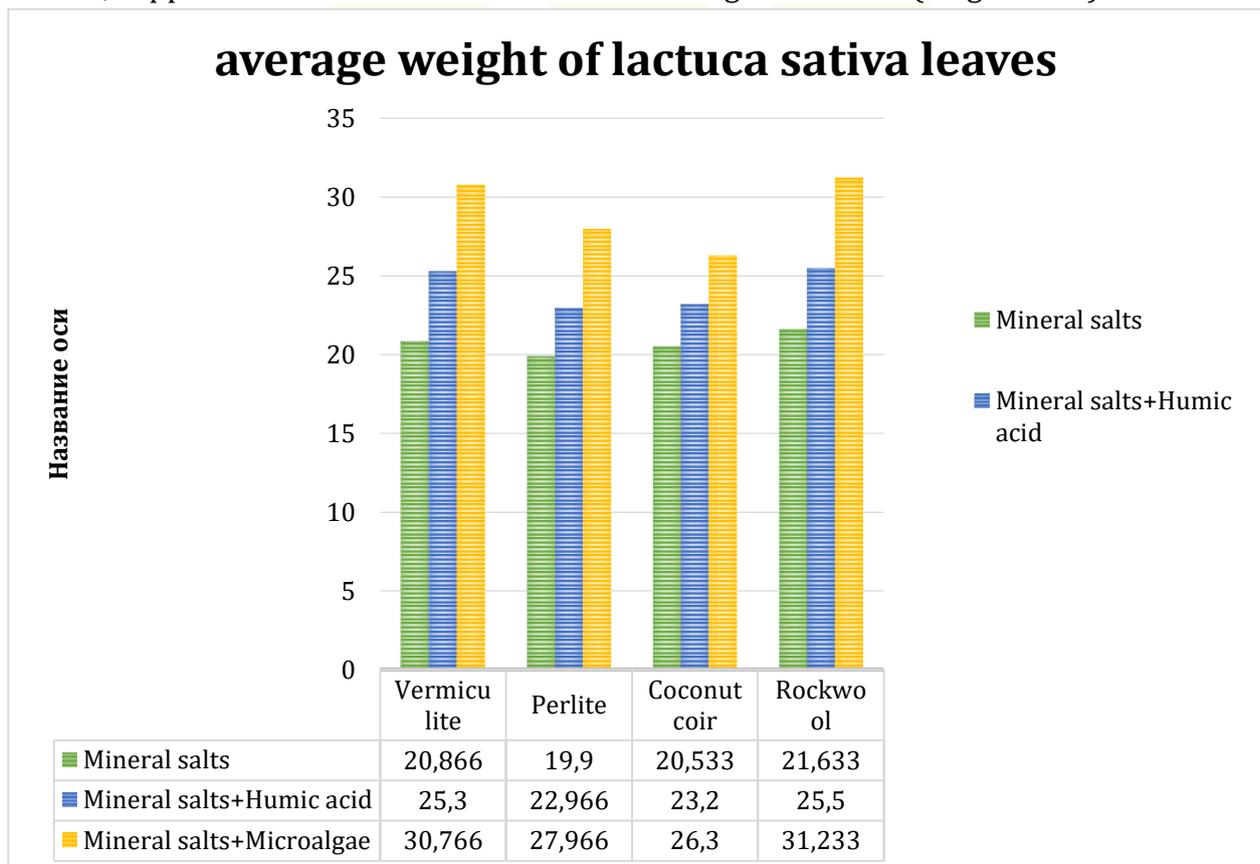
For mineral salts and humic acid:

$$\frac{(24,9 + 25,3 + 26,3)}{3} = 25,5$$

For mineral salts and microalgae:

$$\frac{(29,8 + 31,5 + 32,4)}{3} = 31,233$$

After finding the average weight values, they were analyzed graphically. The graph shows that the best results were observed for lettuce leaves grown in vermiculite and rockwool, supplemented with mineral salt and microalgae solutions (diagram 3.2).



(diagram 3.2)

The study evaluated the average weight of *Lactuca sativa* (lettuce) leaves grown in different substrates (Vermiculite, Perlite, Coconut coir, and Rockwool) under three nutrient conditions: Mineral salts, Mineral salts + Humic acid, and Mineral salts + Microalgae.

The results show that in all substrates, the addition of humic acid and microalgae significantly increased the average leaf weight compared to using mineral salts alone. The highest average weight was observed in the Rockwool + Mineral salts + Microalgae treatment (31.233 g), followed by Vermiculite + Mineral salts + Microalgae (30.766 g). The lowest average weight was found in Perlite + Mineral salts (19.9 g).

The findings of this study clearly indicate that both humic acid and microalgae have a positive effect on the growth performance of *Lactuca sativa*, as demonstrated by the increased average leaf weight. The positive impact of humic acid is likely due to its ability to improve nutrient uptake, stimulate root growth, and enhance plant metabolism. Meanwhile, microalgae may contribute through the production of bioactive compounds, growth hormones, and improved nutrient availability in the growing medium.

Among the substrates tested, Rockwool consistently supported the highest leaf weights, especially when combined with microalgae. This could be attributed to Rockwool's excellent water retention, aeration, and nutrient-holding capacity, creating an optimal environment for root development and nutrient absorption.

The results suggest that integrating organic supplements like humic acid and microalgae into soilless cultivation systems can significantly boost lettuce production. Particularly, the Mineral salts + Microalgae treatment demonstrated superior results across all substrates, recommending its potential application in modern hydroponic and soilless farming practices.

Conclusion

The results of this study clearly demonstrate that the choice of growing substrate and nutrient formulation plays a vital role in optimizing the growth of *Lactuca sativa* in hydroponic systems. Rockwool, due to its superior physical properties, consistently supported the highest growth metrics. The supplementation of mineral salts with humic acid and microalgae significantly increased the average leaf weight compared to mineral salts alone. Among the treatments, the combination of rockwool and mineral salts with microalgae yielded the most favorable results, indicating the potential of biofertilizers to enhance lettuce productivity. These findings suggest that integrating organic inputs into soilless cultivation can lead to more efficient and sustainable lettuce production.

References:

Используемая литература:

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1. Romani, A.; Pinelli, P.; Galardi, C.; Sani, G.; Cimato, A.; Heimler, D. Polyphenols in Greenhouse and Open-Air-Grown Lettuce. *Food Chem.* 2002, 79, 337–342. [CrossRef]
2. Husain, S.R.; Cilurd, J.; Cillard, P. Hydroxyl radical scavenging activity of Flavonoids. *Phytochemistry* 1987, 26, 2489–2491. [CrossRef]
3. Cartea, M.E.; Francisco, M.; Soengas, P.; Velasco, P. Phenolic Compounds in Brassica Vegetables. *Molecules* 2011, 16, 251–280. [CrossRef] [PubMed]
4. Simko, I., 2019. Genetic variation and relationship among content of vitamins, pigments, and sugars in baby leaf lettuce. *Food Sci. Nutr.* 7, 3317–3326.
5. Nicolle, C., Cardinault, N., Gueux, E., Jaffrelo, L., Rock, E., Mazur, A., Amouroux, P., R'émésy, C., 2004. Health effect of vegetable-based diet: lettuce consumption improves

cholesterol metabolism and antioxidant status in the rat. *Clin. Nutr.* 23, 605–614.

6. Damerum, A., Chapman, M.A., Taylor, G., 2020. Innovative breeding technologies in lettuce for improved post-harvest quality. *Postharvest Biol. Tec.* 168, 111266.

7. Kim, M.J., Moon, Y., Tou, J.C., Mou, B., Waterland, N.L., 2016. Nutritional value, bioactive compounds and health benefits of lettuce (*Lactuca sativa* L.). *J. Food Compos. Anal.* 49, 19–34. <https://doi.org/10.1016/j.jfca.2016.03.004>.