JURNAL
MULTI DISIPLIN
DEHASEN (MUDE)
E-ISSN: 2828-1799
Dikelola dan Diterbitkan Oleh
LPPJPHKI Universitas Dehasen Bengkulu

Business Analysis Of Utilizing Lettuce Roots As A Substitute For Rockwool As A Growing Medium In Lettuce (*Lactuca Sativa* L.) Hydroponic Cultivation Systems

Ilham Iqbal Athallah [1], M. Saikhu [2], Arum Pratiwi [3*]
[1,3)] Department of Susitainable Agriculture, Institusi Politeknik Pembangunan Pertanian Malang
[2)]Department of Agribusinnes, Institusi Politeknik Pembangunan Pertanian Malang
Email: [1)] 1qb4lml4t1@gmail.com ;[2)] msaikhu@polbangtanmalang.ac.id
[3*)] arumpratiwi@polbangtanmalang.ac.id

ARTICLE HISTORY
Received [10 Juli 2025]
Revised [12 Agustus 2025]
Accepted [18 Agustus 2025]

KEYWORDS
Hydroponics, Lettuce Root Waste, Lettuce, Growing Medium, Farm Efficiency.

ABSTRAK
Hidroponik merupakan solusi pertanian perkotaan dengan keterbatasan lahan, namun penggunaan rockwool sebagai media tanam yang relatif mahal meningkatkan biaya produksi. Penelitian ini bertujuan untuk menganalisis pemanfaatan limbah akar selada sebagai alternatif media tanam dalam budidaya hidroponik selada (Lactuca sativa L.) serta pengaruhnya terhadap pertumbuhan tanaman dan efisiensi biaya usaha tani. Metode penelitian menggunakan Rancangan Acak Lengkap (RAL) dengan empat perlakuan: P0 (100% rockwool sebagai media tanam), P1 (50% rockwool + 50% limbah akar selada), P2 (50% limbah akar selada + 50% rockwool), dan P3 (100% limbah akar selada). Variabel yang diamati meliputi tinggi tanaman, luas daun, bobot segar, serta analisis kelayakan usaha (rasio R/C, rasio B/C, ROI, dan periode pengembalian modal). Hasil penelitian menunjukkan bahwa perlakuan P3 menghasilkan pertumbuhan luas daun tertinggi (78,12 cm²) dan bobot segar terbesar (133 g), disertai dengan penurunan biaya variabel sebesar 7% dibandingkan dengan P0. Analisis finansial menunjukkan rasio R/C sebesar 2,48 dan ROI sebesar 33%, yang mengindikasikan kelayakan usaha. Dengan demikian, limbah akar selada merupakan alternatif media tanam yang layak, mampu meningkatkan produktivitas dan efisiensi biaya usaha tani. Penelitian lanjutan disarankan untuk menguji inovasi ini pada komoditas lain serta mendorong adopsi oleh petani hidroponik.

ABSTRACT
Hydroponics is a solution for urban agriculture with limited land, but the use of the expensive rockwool as a growing medium increases production costs. This study aims to analyze the utilization of lettuce root waste product as an alternative for growing medium in hydroponic lettuce cultivation (Lactuca sativa L.) and its effect on plant growth and farming cost cost efficiency. The research method used a Completely Randomized Design (CRD) with four treatments: P0 (100% rockwool as growing medium), P1 (50% rockwool + 50% lettuce root waste), P2 (50% lettuce root waste + 50% rockwool), and P3 (100% lettuce root waste). Observed variables included plant height, leaf area, fresh weight, and business feasibility analysis (R/C ratio, B/C ratio, ROI, and payback period). Results showed that P3 produced the highest growth in leaf area (78.12 cm²) and fresh weight (133 g), along with a 7% reduction in variable costs compared to P0. Financial analysis indicated an R/C ratio of 2.48 and ROI of 33%, demonstrating business feasibility. In conclusion, lettuce root waste is a viable alternative growing medium that enhances productivity and farming cost efficiency. Further research is recommended to test this innovation on other crops and promote its adoption among hydroponic farmers.

INTRODUCTION

The development of technology and globalization has intensified competition and daily activities in urban life, leaving limited time and space for residents to engage in household-scale farming (Noor et al., 2021). Urban farming emerges as a solution by enabling communities to utilize limited space, increase income, and benefits with plant farming (Murwani et al., 2021). One practical method adopted in space-constrained urban areas, such as in Parepare City, is the hydroponic farming system (Nurdin, 2022). Hydroponics is considered an ideal farming method due to its efficient water use, low environmental impact, and reduced risk of unhealthy crops compared to conventional agriculture (Waluyo et al., 2021). Its flexible design allows it to fit into small urban spaces, while optimal nutrient circulation ensures superior yields. As a result, hydroponics has gained popularity among people, contributing both to individual well-being and to national food security (Mulyana et al., 2022).

Growing medium is a vital component in hydroponic systems, serving as a support structure and facilitating nutrient uptake of the plant. An ideal growing medium should possess good water absorption and air circulation to support root development and overall plant growth (Sirajuddin et al., 2024). However, the commonly used rockwool—made from melted stone fibers— is quite costly for hydroponic farmers. It increasing variable costs and reducing profit margins. To address this, alternative growing media made of agricultural waste, such as post-harvest root residues, are being explored. These lettuce roots, usually discarded, can potentially lower production costs, enhance farming cost efficiency, and reduce environmental waste. Research by Sumyati et al. (2022) found that media containing lettuce root waste provided favorable results for plant growth. Lettuce (*Lactuca sativa L.*) is a high-value horticultural crop commonly cultivated in hydroponic systems due to its nutritional richness and high market demand (Sobari et al., 2019). Hydroponic systems enable better yields and higher market quality compared to conventional methods through efficient water and nutrient circulation. Therefore, using root waste as an alternative medium holds great potential in enhancing sustainability, reducing costs, and promoting environmentally friendly lettuce cultivation (Irsyad et al., 2023).

LITERATURE REVIEW

Hydroponic Cultivation System of Lettuce

Hydroponics is a plant cultivation method that does not utilize soil as a growing medium. Instead, plant roots are directly exposed to nutrient-rich solutions containing essential elements (Romalasari et al., 2019). Lettuce (*Lactuca sativa L.*) is one of the most commonly cultivated horticultural commodities in hydroponic systems due to its relatively short growth cycle and consistently high market demand (Ferrarezi et al, 2024). In this system, the growing medium plays a vital role as a mechanical support for plant roots and as a medium for nutrient and water exchange.

Rockwool as a Conventional Growing Medium

Rockwool is among the most widely used inorganic growing media in hydroponic cultivation. It is manufactured by melting basalt rock and spinning it into fibers, resulting in a lightweight, highly porous structure that effectively retains moisture (Nopriadi et al, 2021). Although functionally effective for supporting plant growth, the use of rockwool poses environmental challenges due to its non-biodegradable nature and difficulty in recycling (Eka et al, 2022). Moreover, the relatively high cost of rockwool presents a barrier, especially for small- to medium-scale hydroponic producers.

Potential of Lettuce Roots as an Alternative Growing Medium

Lettuce roots left behind after harvest are generally considered organic waste and discarded. However, several studies have suggested that plant root waste has the potential to be repurposed as a biodegradable alternative growing medium (Sumyati et al., 2022). Dried lettuce roots possess a fibrous structure capable of retaining water and nutrients, while also providing sufficient mechanical support for initial plant development. Utilizing lettuce roots aligns with the principles of the circular economy, as it reduces organic waste and lowers production costs.

Business Analysis of Hydroponic Cultivation

Business feasibility analysis is a crucial component in designing and developing hydroponic cultivation ventures. This analysis includes the evaluation of financial aspects such as production costs, revenue, profitability, and operational efficiency (Sirajuddin et al., 2024). Innovations involving more economical and environmentally friendly growing media are believed to enhance production efficiency and product competitiveness. Therefore, assessing the business feasibility of using lettuce roots as a substitute for rockwool is essential to determine the commercial and sustainable applicability of this innovation.

METHODS

Research Type and Design

This study applied four different treatments based on the composition of the growing media used. Treatment P0, as the control, applied 100% rockwool as the growing medium. Treatment P1 used a combination of rockwool and lettuce root waste in a 50:50 ratio. Conversely, treatment P2 also applied a 50:50 combination, but with lettuce root waste as the primary component and rockwool as a complement. Treatment P3 applied 100% lettuce root waste as the growing medium. These varying compositions were

JURNAL MULTI DISIPLIN DEHASEN (MUDE)
E-ISSN: 2828-1799
Dikelola dan Diterbitkan Oleh
LPPJPHKI Universitas Dehasen Bengkulu

intended to evaluate the effectiveness of lettuce root waste as an alternative to rockwool in hydroponic cultivation systems.

The observed variables in this study consisted of three main parameters used to assess the growth and yield performance of lettuce plants. The first was **plant height**, which was observed on days 7, 14, and 21 after transplanting to measure the vertical growth rate of the plants. The second was **leaf area**, also measured on days 7, 14, and 21, as an indicator of the plant's ability to conduct photosynthesis and accumulate biomass. The third was **fresh weight**, which was recorded at the time of harvest to evaluate the production yield directly. These three variables were measured quantitatively and served as key indicators in assessing the influence of different growing media on lettuce growth in a hydroponic system.

Location and Time of Research

This study will be conducted from April to July 2025. The research location is the Hydroponic Greenhouse of the TEFA Integrated Farming System, located at Jl. Dr. Cipto No.144a, Bedali, Lawang, Malang Regency. The research site has a temperature range of 22.5–26.2°C, an elevation of 0–650 meters above sea level on highland terrain, and water pH levels ranging from 6.5 to 8.5 (neutral to slightly alkaline) (Environmental Agency of Malang Regency, 2022)..

Data Analysis Technique

The data obtained in this study were analyzed using ANOVA (Analysis of Variance), which is used to determine whether there are significant differences among the four growing media treatments (P0, P1, P2, and P3). ANOVA is considered appropriate for this research as it involves more than two treatment groups. If ANOVA results indicate significant differences, the analysis is followed by the Least Significant Difference (LSD) test, also known as Fisher's LSD. The LSD test is used to compare the means between treatments and is commonly applied in agricultural, biological, and social science research to determine the level of significance between treatments (Saleh et al., 2018).

RESULTS AND DISCUSSION

Plant height

Growing media is an important factor in the growth and development of plants, particularly hydroponic lettuce (*Lactuca sativa L.*). The plant height of lettuce serves as an indicator of the growing medium's ability to absorb and retain the nutrient solution circulated in the hydroponic system.

Table 1 Plant Height

Treatment	Day After Planting 7	Day After Planting 14	Day After Planting 21
P0	3.33^{b}	4.5^{a}	8.16^{a}
P1	2.33^{a}	4.66^{a}	9.08^{a}
P2	2.16^{a}	5.58^{b}	9^{a}
P3	3.45^{b}	5.58^{b}	9.33^{a}

*Note: The same letters within the same column indicate no significant difference.

The LSD test showed that significant differences in plant height occurred on days 7 and 14, with Treatments P2 and P3 performing better during early and mid-vegetative stages, while no significant differences were observed by day 21, indicating uniform growth across treatments. These results suggest that growing media using lettuce root waste, either partially or entirely, enhances early lettuce growth due to improved aeration and water retention. This supports findings by Ferrarezi et al. (2024), who emphasized the importance of early performance and consistency in media selection. Plant height remains a vital indicator of treatment effectiveness, as highlighted by Delfiya and Ariska (2022).

Leaf Area

The growth and development of lettuce (*Lactuca sativa* L.) is influenced, among other factors, by the growing medium. Another key indicator of lettuce plant performance is leaf area. Leaf area plays a significant role in determining the amount of nutrients the plant receives through photosynthesis.

Table 3 Leaf Area

Treatment	Day after Planting 7	Day after Planting 14	Day after Planting 21
P0	4.6[a]	9.45[a]	45.79[a]
P1	4.67[a]	13[ab]	47.62[a]
P2	3.54[a]	15.04[b]	45.79[a]
P3	8.16[b]	19.42[c]	78.12[b]

*Note: The same letters within the same column indicate no significant difference.

The LSD test results showed that Treatment 3 (100% root waste) **consistently produced the** largest leaf area at all observation times (7, 14, and 21 DAP), with significant differences compared to other treatments. While Treatments 0, 1, and 2 showed no significant differences among each other at certain stages, Treatment 3 stood out from the early to harvest phases. This indicates that root waste media supports better leaf development, likely due to its ability to provide optimal aeration and water retention. Leaf area is a key indicator of photosynthetic capacity, and the superior performance of Treatment 3 suggests its strong potential as an effective and efficient growing medium. These findings are supported by Nopriadi et al. (2021), who also found that alternative organic media significantly affected plant growth in hydroponic systems.

Fresh Weight

Another indicator detrimental to the performance of lettuce in relation to the growing medium used is harvest weight. This is because good growth and development of lettuce plants have a linear impact on the significant increase in weight as the plant matures.

Table 3 Fresh Weight

Treatment	Total Weight	Top Weight	Bottom Weight
p0	89.66[a]	69.66[a]	17.16[a]
p1	111.5[ab]	88.66[ab]	18.83[a]
p2	125[bc]	109.66[c]	21[a]
p3	133[c]	103.33[bc]	21.16[a]

*Note: The same letters within the same column indicate no significant difference.

The LSD test results showed significant differences in total and upper fresh weight among treatments, with **Treatment 3** consistently showing the highest average, while root fresh weight showed no significant differences across all treatments. Treatments using **lettuce root waste** demonstrated a notable impact on improving shoot biomass, indicating their effectiveness as growing media. These findings align with Sumyati et al. (2022), who found that using vetiver root waste enhanced the growth and fresh weight of mustard greens. Overall, **fresh weight** serves as a key indicator of lettuce productivity and efficient resource use in hydroponic systems.

Bussiness Analysis

Variabel Cost Comparison

To evaluate the efficiency between the control treatment (P0) and the best-performing treatment (P3), a cost comparison analysis was conducted focusing on variable costs. This analysis considered not only a single planting cycle but also subsequent cycles to assess long-term efficiency. In the first cycle, both P0 and P3 were assumed to have the exact cost since both used rockwool as the growing medium—P0 as the conventional method, and P3 to obtain the root waste material initially. However, starting from the second cycle, cost differences emerged as P3 no longer required rockwool, reducing its variable costs significantly over time.

Table 4 Variabel Cost Comparison

	Cycle 1	Cycle 2	Total of Two Cycle	Average per Cycle
P0	Rp 529,333.33	Rp 529,333.33	Rp 1,058,666.66	Rp 529,333.33
P3	Rp 529,333.33	Rp 494,333.33	Rp 1,023,666.66	Rp 511,833.33
Selisih	Rp 0.00	Rp 35,000.00	Rp 35,000.00	Rp 17,500.00
Presentase	0%	7%	3%	3%

JURNAL MULTI DISIPLIN DEHASEN (MUDE)
E-ISSN: 2828-1799
Dikelola dan Diterbitkan Oleh
LPPJPHKI Universitas Dehasen Bengkulu

Revenue Per Periode
$TR_i = Y_i \times Py_i$
TR_i = 91 kg x Rp 20,000
TR_i = Rp 1,940,000

Explanation
Total Revenue (TR) :Total income or revenue
Yield (Y) :Total production obtained from a farming activity
Price per Yield (Py) :Price per unit of the agricultural product
Index (i) : Time index per farming production period

The calculation of business revenue is obtained by multiplying the yield by the price per yield. This range of revenue per period illustrates the projected revenue within one period.

Fix Cost and Variable Cost
TC = FC + VC
TC = Rp 254,250 + Rp 529,333
TC = Rp 783,853.00

Explanation:
TC: Total Cost
FC: Fix Cost
VC: Variable Cost

Fixed costs include expenses that remain constant regardless of production volume, such as depreciation of installations, electricity, and equipment. Meanwhile, variable costs are flexible and depend on the production quota to be achieved within a period, covering expenses like nutrients, water, and labor. These two components together form the total cost per cycle.

Profit
Profit = TR – TC
Profit = Rp 1,940,000 - Rp 783,853
Profit = Rp 1,156,147.00

Net profit is obtained from the difference between total revenue and total cost. This value reflects the profit earned in one cycle.

R/C Ratio

$$\text{R/C Ratio} = \frac{\text{total Revenue}}{\text{total cost}}$$

$$R/C\ Ratio = \frac{\text{Rp } 1{,}940{,}000}{\text{Rp } 783{,}853}$$

$$\text{R/C Ratio} = 2{,}48$$

The R/C Ratio indicates business efficiency. A value above 1 means revenue exceeds costs, showing financial viability. A ratio below 1 suggests inefficiency. This metric helps assess cost management and profitability.

B/C Ratio

$$B/C\ Ratio = \frac{\text{Benefit}}{\text{total cost}}$$

$$B/C\ Ratio = \frac{\text{Rp } 1{,}156{,}147}{\text{Rp } 783{,}853}$$

$$B/C\ Ratio = 1.48$$

The B/C Ratio (Benefit-Cost Ratio) shows that for every rupiah invested, it generates a profit of Rp 1.48. Since this value exceeds the minimum feasibility threshold (1.00), the business is highly viable, delivering significant returns relative to costs.

Break Even Point

$$BEP=\frac{FC}{Py\text{-}VC}$$

$$BEP=\frac{Rp\ 254{,}250}{Rp\ 20{,}000\text{-}Rp\ 5{,}457}$$

$BEP\approx 17$

From the above formula, it can be concluded that the minimum production quantity required to reach BEP (Break Even Point) is approximately 17 kg per period.From the formula above, it can be concluded that to reach the Break Even Point (BEP), a minimum production of approximately 17 kg per period is required.

Revenue on Investment

$$ROI(\%)=\frac{\text{total laba bersih tahunan}}{\text{total investasi awal}}\ x\ 100\%$$

$$ROI(\%)=\frac{Rp\ 1{,}156{,}147\ x\ 7}{Rp\ 23{,}822{,}500}\ x\ 100\%$$

$$ROI(\%)=\frac{Rp\ 8{,}093{,}029}{Rp\ 2{,}822{,}500}\ x\ 100\%$$

$$ROI(\%)=33\%$$

ROI (Return on Investment) reflects the percentage of potential capital return. A positive ROI value indicates that the business is profitable and worth further development.

Payback Period

$$\text{Payback Period}=\frac{\text{total Initial Investment}}{\text{net profit per month}}$$

$$\text{Payback Period}=\frac{Rp\ 23{,}822{,}500}{Rp\ 1{,}156{,}147}$$

$$\text{Payback Period}=21\ \text{cycle}$$

Payback Period indicates the time required to recover the initial capital investment. A shorter payback period means the business reaches breakeven faster and begins generating net profit sooner.In the first cycle, both treatments incurred the exact cost—P0 consistently used rockwool, while P3 initially used rockwool to obtain root waste for future cycles. In the second cycle, P3's cost was Rp 35,000 (around 7%) lower than P0, as it fully utilized root waste as the growing medium. On average, across the two cycles, the cost difference between the two treatments was approximately Rp 17,500 or 3%, favoring P3 in terms of efficiency.

CONCLUSION AND SUGGESTION

This study demonstrates that lettuce root waste can serve as an effective alternative growing medium for hydroponic lettuce (*Lactuca sativa L.*). Results show that using 100% root waste (P3) produced the best growth and productivity, with significant improvements in plant height, leaf area, and fresh weight compared to rockwool (P0). Additionally, business feasibility analysis revealed a 7% cost reduction in subsequent cycles, supported by an R/C ratio of 2.48 and B/C ratio of 1.48, indicating high profitability. These findings confirm that root waste can effectively replace rockwool while offering a sustainable solution for urban agriculture.

The research highlights the potential of circular economy principles through agricultural waste utilization and opportunities for cost-efficient hydroponic agribusiness development. For broader implementation, further exploration of root waste composition for other crops, farmer training in waste processing techniques, and eco-friendly marketing strategies are recommended. This innovation not only addresses business efficiency challenges but also advances sustainable farming practices, providing both economic and environmental benefits.

REFERENCES

Delfiya, M., dan Ariska, N. (2022). Pengaruh Kombinasi Media Tanam terhadap Pertumbuhan dan Hasil Tanaman Sawi (Brassica Juncea L.). Comserva Indonesian Jurnal of Community Services and Development, 1(9), 614–622. Doi: Org/10.36418/Comserva.V1i9.124

Eka M., Agustina B., Yamin, Serly N. S., dan Desliana O. H.. (2022). Edukasi Hidroponik sebagai Pertanian Alternatif bagi Calon Petani Millenial di Desa Meranjat Kecamatan Indralaya Selatan Kabupaten Ogan Ilir. J-Abdi: Jurnal Pengabdian Kepada Masyarakat, 2(5), 5013–5018. Doi: Org/10.53625/Jabdi.V2i5.3583

Ferrarezi, R., K, Q., Lx, N., Sd, P., Jonathan, C, G., Fhe, De O., dan Mj, H. (2024). Multi-Season Evaluation of Substrates for Optimized Arugula and Lettuce Production in Hydroponics. Hortscience, 59(3), 403–411.

Irsyad, H., Putra, R. M., Rahmadani, N., dan Hendri, P. H. (2023). Teknologi Efesiensi Biaya Produksi di Gonjong Agrofarm. Jurnal Abditani, 6(1), 91–95.

Murwani, I., Muslikah, S., dan Mardiyani, S. A. (2021). Pemberdayaan Masyarakat Kota di Wilayah RW VI Kelurahan Jatimulyo Malang melalui Model Budidaya Sayur Organik. Cendekia : Jurnal Pengabdian Masyarakat, 3(1), 9. Doi: Org/10.32503/Cendekia.V3i1.1411

Noor, M., Bin, A., Fadhil, M., Alyani, N., Azazi, N., Shaed, M. M., Shaharudin, M., dan Samsurijan, B. (2021). Issues and Challenges of Urban Residents in Waqf Land Area George Town, Penang 1 Mohammad Noor Asyraf Bin Mohammad Fadhil, 1 Noor Alyani Nor Azazi, Maslina Mohammed Shaed, 1 Mohamad Shaharudin Bin Samsurijan. Turkish Online Journal Of Qualitative Inquiry (Tojqi), 12(5), 273–302.

Nopriadi, Haitami, dan Seprido. (2021). Uji Berbagai Media Tanam terhadap Pertumbuhan dan Produksi Tanaman Romaine (Lactuca Sativa Var. Longifolia) secara Hidroponik Sistem Nft Test Various Media Planting on The Growth and Production of Romaine Plants (Lactuca Sativa Var. Longifolia) On Hydroponic. Jurnal Green Swarnadwipa, 10(3), 414–422.

Nurdin, N. (2022). Efektivitas Program Pengembangan Pertanian Perkotaan (Urban Farming) Berdasarkan Target Groupdi Kota Parepare. Universitas Hasanuddin.

Romalasari, A., dan Sobari, E. (2019). Produksi Selada (*Lactuca Sativa L.*) Menggunakan Sistem Hidroponik dengan Perbedaan Sumber Nutrisi. Agriprima : Journal of Applied Agricultural Sciences, 3(1), 36–41. Doi: Org/10.25047/Agriprima.V3i1.158

Saleh, H., Wulandari, S., dan Meli, A. (2018). Metodologi Penelitian Biologi_1. Metodologi Penelitian Biologi.

Sirajuddin, R., Alimuddin, S., dan Nontji, M. (2024). Respon Tanaman Selada (*Lactuca Sativa L.*) terhadap Pemberian Limbah Ampas Teh dan Berbagai Media Tanam pada Hidroponik Sistem Wick. Agrotekmas Jurnal Indonesia: Jurnal Ilmu Peranian, 4(3), 355–362. Doi: Org/10.33096/Agrotekmas.V4i3.405

Sumyati, D., Rahmat, B., dan Natawijaya, D. (2022). Pemanfaatan Limbah Akar Wangi sebagai Kombinasi Media Hidroponik, Briket sebagai Bahan Bakar. Media Pertanian, 7(2), 78–88. Doi: Org/10.37058/Mp.V7i2.5701

Waluyo, M. R., Nurfajriyah, Mariati, F. R. I., dan Rohman, Q. A. H. H. (2021). Pemanfaatan Hidroponik sebagai Sarana Pemanfaatan Lahan Terbatas bagi Karang Taruna Desa Limo. Ikraith-Abdimas, 4(1).

Wardhana, I., Hasbi, H., dan Wijaya, I. (2015). Kambing dan Interval Waktu Aplikasi Pupuk Cair Super Bionik [Response Growth and Production Lettuce Plants (Lactuca Sativa L .) on The Granting of Fertilizer Dose Coop Goat and Liquid Fertilizer Application Interval Time Super Bionic, Agritrop Jurnal I. Agritrop Jurnal Ilmu-Ilmu Pertanian, 7, 165–185.