JPPIPA 12(8) (2026)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Comparative Financial Efficiency of Patchouli Farming under Intercropping and Mixed-Garden Systems: Implications for Sustainable Smallholder Land Use

Khairun Nisa*, Zakki Muhtaram

[1] Agribisnis, Universitas Teuku Umar, Aceh Barat, Indonesia.

Received: June 02, 2026
Revised: July 22, 2026
Accepted: August 25, 2026
Published: August 31, 2026

Corresponding Author:
Khairun Nisa
khairunnisa@utu.ac.id

DOI: 10.29303/jppipa.v12i8.15503

Abstract: Patchouli (*Pogostemon cablin* Benth.) is a high-value aromatic crop that supports smallholder livelihoods in Indonesia. This study compared the financial performance of patchouli farming under intercropping and mixed-garden systems in Aceh Jaya Regency. A census of 30 eligible farmers was conducted, comprising 10 intercropping and 20 mixed-garden farmers. Farm-level performance was evaluated using production cost, revenue, income, income per hectare, revenue-cost (R/C) ratio, and break-even indicators, while differences between systems were tested using the Mann–Whitney U test. Intercropping generated mean income of IDR 58.40 million/farm and IDR 87.00 million/ha, compared with IDR 54.00 million/farm and IDR 73.56 million/ha under mixed gardens. Mean R/C ratios were 4.42 and 4.18, respectively, indicating that both systems were financially feasible. Intercropping also showed slightly lower break-even price and land requirements, but none of the principal financial or break-even indicators differed significantly between systems ($p > 0.05$). Thus, intercropping showed a descriptive financial advantage, but not statistically significant superiority. Farm-management strategies should prioritize crop arrangement, cost control, and productivity improvement.

Keywords: Break-even point; Economic efficiency; Intercropping; Mixed garden; Patchouli farming; R/C ratio

Introduction

Patchouli (*Pogostemon cablin* Benth.) is a high-value aromatic crop whose essential oil is widely used in fragrance, cosmetic, pharmaceutical, and related industries (Kumar et al., 2024). Indonesia remains one of the dominant suppliers of patchouli oil to the international market, making the commodity economically important for smallholder production systems. Recent national statistics nevertheless indicate continuing fluctuations in patchouli cultivation and production, highlighting the importance of improving farm-level performance rather than relying solely on market opportunities or area expansion.

Patchouli (*Pogostemon cablin* Benth.) is a high-value aromatic crop whose essential oil is widely used in fragrance, cosmetic, pharmaceutical, and related industries. Indonesia remains one of the dominant suppliers of patchouli oil to the international market, making the commodity economically important for smallholder production systems. Recent national statistics nevertheless indicate continuing fluctuations in patchouli cultivation and production, highlighting the importance of improving farm-level performance rather than relying solely on market opportunities or area expansion.

At the farm level, patchouli is cultivated under different land-use arrangements that may generate different economic outcomes. In this study, intercropping refers to the planned cultivation of patchouli together with a limited number of companion crops within the same plot using a relatively systematic spatial or row arrangement. In contrast, a mixed-garden system refers to a more heterogeneous land-use

How to Cite:
Nisa, K., & Muhtaram, Z. (2026). Comparative Financial Efficiency of Patchouli Farming under Intercropping and Mixed-Garden Systems: Implications for Sustainable Smallholder Land Use. *Jurnal Penelitian Pendidikan IPA*, *12*(8), 259–267. https://doi.org/10.29303/jppipa.v12i8.15503

arrangement in which patchouli is integrated among several annual and perennial crops, particularly woody or perennial species, with a less regular spatial configuration. This distinction is important because the two systems differ not merely in crop diversity but also in the organization of land, labor, inputs, competition among crops, and the timing and sources of farm returns.

From a farm-management perspective, intercropping may improve the utilization of land and selected production inputs by allowing complementary crops to share the same production space and some management operations (Li et al., 2021). Mixed gardens, in contrast, offer broader crop diversification and may distribute household income and production risk across commodities and time (Low et al., 2023). These potential advantages involve trade-offs. Greater crop complexity may increase management requirements and competition for production resources, while differences in canopy structure and shade can affect patchouli growth and essential-oil performance . Experimental evidence demonstrates that changes in light and shade conditions can significantly alter patchouli growth and essential-oil yield and composition (Yogendra et al., 2025; Ribeiro et al., 2021). Consequently, differences between structured intercropping and mixed-garden systems may ultimately be reflected in production costs, revenue, profitability, and break-even conditions. Economic efficiency generally reflects both technical and allocative efficiency, whereas the present study focuses on financial performance indicators such as production costs, revenue, income, R/C ratio, and break-even measures (Rauf et al., 2024).

Previous patchouli studies have addressed production, oil processing, marketing performance, export competitiveness, agronomic characteristics, and the performance of particular intercropping combinations. The manuscript itself already identifies evidence that selected patchouli-food crop combinations can improve resource-use efficiency and economic returns, while previous research in Aceh has shown that mixed-garden systems may provide advantages in soil quality and patchouli-related agronomic characteristics (Nisa et al., 2024). However, these findings do not establish whether structured intercropping and mixed-garden systems provide comparable farm-level financial performance under the same regional production environment. The novelty of this study therefore lies in directly comparing these two distinct patchouli land-use systems using farmer-level cost, revenue, income, R/C ratio, and break-even indicators, while explicitly considering differences in land-use organization.

Accordingly, this study compares the financial performance of patchouli farming under intercropping and mixed-garden systems in Aceh Jaya Regency. Specifically, it evaluates farm costs, revenue, income, revenue-cost ratios, break-even prices, break-even production levels, and land break-even points and examines whether the principal economic outcomes differ between the two farming systems. The results are expected to provide evidence for farm-management and extension decisions concerning the selection and improvement of patchouli land-use systems rather than merely determining whether patchouli farming is profitable.

Method

Research Location and Study Period

The study was conducted in Aceh Jaya Regency, Aceh Province, Indonesia. Aceh Jaya was selected purposively because patchouli is actively cultivated in the region and both intercropping and mixed-garden systems are practiced by smallholder farmers. The presence of the two cropping systems within the same regional production environment provided an appropriate setting for comparing their farm-level financial performance.

The preliminary survey and field data collection were conducted from March to December 2025. The preliminary survey was used to identify active patchouli farmers, characterize the prevailing cropping systems, and determine farmers who met the inclusion criteria for the study.

Research Design and Respondent Selection

The study employed a quantitative comparative design to evaluate the financial performance of patchouli farming under intercropping and mixed-garden systems.

Respondents were determined using a census approach (total sampling), in which all eligible farmers in the study population were included (Hartati 2020). The inclusion criteria were farmers who cultivated patchouli under either an intercropping or mixed-garden system and who had complete records of production costs and output for the observed production period.

Based on these criteria, 30 eligible patchouli farmers were identified and included in the analysis, consisting of 10 farmers practicing intercropping and 20 farmers practicing mixed-garden cultivation. The unequal number of respondents between the two groups therefore reflects the actual distribution of eligible farmers in the study area rather than unequal sampling allocation.

The individual farmer was used as the unit of analysis. Financial indicators were first calculated for each farm and were subsequently summarized and compared between the two cropping systems.

Operational Definition of Cropping Systems

For the purpose of this study, the two farming systems were distinguished according to their crop composition and spatial organization. The intercropping system was defined as a relatively planned cropping arrangement in which patchouli was cultivated together with another dominant companion crop within the same land unit. In the observed farms, this system was characterized by a more structured combination of patchouli and companion crops within the production area.

The mixed-garden system was defined as a more heterogeneous cropping arrangement in which patchouli was grown together with several annual and/or perennial crops within the same garden. Compared with intercropping, mixed gardens were characterized by greater crop diversity and a less uniform spatial arrangement.

This operational distinction was used to classify respondents into the two comparison groups before the financial analysis was conducted.Field documentation of the observed systems and patchouli oil samples is presented in Figure 1.

(A) (B)

Figure 1. Observed patchouli-based cropping systems in Aceh Jaya Regency: (A) patchouli intercropping system with oil palm and (B) mixed garden system consisting of patchouli and perennial or annual companion crops

Data Collection and Study Variables

Primary data were obtained through direct interviews with farmers using a structured questionnaire and were complemented by available farm records (Fauziah & Soejono, 2019). The data collected included cultivated land area, patchouli-oil production, selling price, and production expenditures associated with patchouli farming.

Secondary information was obtained from scientific publications, government reports, and other relevant sources related to patchouli production, farming systems, farm financial analysis, and land-use management.

The principal variables analyzed in this study were cultivated land area (ha), patchouli-oil production (kg), selling price of patchouli oil (IDR/kg), production cost (IDR), total revenue (IDR), farm income (IDR), income per hectare (IDR/ha), revenue-cost ratio (R/C ratio); break-even price (IDR/kg), break-even production (kg), and break-even land area (ha).

To avoid bias arising from differences in farm size, farm income was analyzed both on a per-farm basis and after standardization by cultivated land area.

Financial Performance Analysis

The financial analysis was conducted at the individual-farm level. Total production cost was calculated as the sum of all recorded expenditures associated with patchouli production.
Total cost was calculated as follows:

$$TC = FC + VC \tag{1}$$

where TC is total cost, FC is fixed cost, and VC is variable cost.

Total revenue was calculated as the product of patchouli-oil production and the selling price received by the farmer:

$$TR = Y \times Py \tag{2}$$

where TR is total revenue, Y is production, and Py is selling price.

Farm income was calculated as the difference between total revenue and total production cost:

$$I = TR\text{-}TC \tag{3}$$

where I is farm income.

Because cultivated land area differed among individual farmers, income was also standardized on a per-hectare basis:

$$I_A = \frac{I}{A} \tag{4}$$

where I_A is income per hectare, I is income, and A cultivated patchouli area of farmer. This indicator was used to reduce potential farm-size bias when comparing the financial performance of intercropping and mixed-garden farmers.

The revenue-cost ratio was used to assess the ability of farm revenue to cover production costs:

$$R/C = \frac{TR}{TC} \tag{5}$$

An R/C ratio greater than 1 indicates that the farming activity generates revenue exceeding production costs, an R/C ratio equal to 1 indicates a break-even condition, and an R/C ratio below 1 indicates that revenue is insufficient to cover production costs.

For descriptive comparison with the original farm-level accounting, an aggregate R/C ratio for each cropping system could also be calculated by dividing total group revenue by total group production cost. However, statistical comparisons between systems were based on R/C ratios calculated for individual farmers.

Break-Even Analysis

Break-even analysis was used to estimate the minimum price, production level, and land area required for patchouli farming to cover production costs under the observed production and market conditions (Subastian & Yuliawati, 2024).

$$\mathrm{BEP_{price}} = \frac{\mathrm{TC}}{\mathrm{Y}} \tag{6}$$

where $\mathrm{BEP_{price}}$ represents the minimum selling price of patchouli oil required to cover total production costs (Rachmawati et al., 2023).

The break-even production level was calculated as:

$$\mathrm{BEP_{production}} = \frac{\mathrm{TC}}{\mathrm{Py}} \tag{7}$$

where $\mathrm{BEP_{production}}$ represents the minimum patchouli-oil production required to cover production costs at the observed selling price (Ma'ruf et al., 2019).

The break-even land area was estimated as:

$$\mathrm{BEP_{land}} = \frac{\mathrm{TC}}{\text{Reveneu per Land Unit}} \tag{8}$$

Lower break-even values indicate that a farm requires a lower price, production level, or land area to recover its production costs. However, comparisons of break-even indicators between cropping systems were evaluated together with their farmer-level variation rather than solely on the basis of group averages.

Statistical Analysis

Descriptive statistics were used to summarize the financial characteristics of the two patchouli farming systems. Mean values and measures of dispersion were calculated for cultivated land area, production, production cost, revenue, income, income per hectare, R/C ratio, and break-even indicators.

Because the number of observations was relatively small and several key financial variables did not satisfy the assumption of normal distribution, differences between intercropping and mixed-garden farmers were evaluated using the two-sided Mann–Whitney U test (Nuha et al., 2023). The analysis was performed using individual-farmer observations rather than aggregated group values.

The null hypothesis stated that the distribution of the financial indicator under the intercropping system did not differ from that under the mixed-garden system. Statistical significance was evaluated at the 5% level ($\alpha = 0.05$). A p-value below 0.05 was interpreted as evidence of a statistically significant difference between the two farming systems, whereas a p-value of 0.05 or greater indicated insufficient evidence to reject the null hypothesis (Nuha et al., 2023).

The statistical comparison focused on farm income, income per hectare, R/C ratio, and break-even indicators. The inferential results were interpreted together with descriptive financial indicators to avoid concluding that one farming system was superior solely from differences in arithmetic averages (Yanuar et al., 2022; Yuwinti et al., 2023).

Result and Discussion

Financial Performance of Patchouli Farming Systems

Both patchouli farming systems generated positive farm income and revenue-cost (R/C) ratios greater than one, indicating that patchouli production was financially feasible under the observed conditions (Muhtaram et al., 2021). Intercropping farmers cultivated an average of 0.70 ha, whereas mixed-garden farmers cultivated an average of 0.75 ha. Mean patchouli-oil production during the observed seven-month production period was 63.00 kg/farm under intercropping and 59.10 kg/farm under the mixed-garden system. The corresponding mean production costs were IDR 17.20 million and IDR 16.92 million per farm, respectively.

Mean revenue reached IDR 75.60 million/farm under intercropping and IDR 70.92 million/farm under mixed-garden cultivation. After deducting recorded production costs, mean farm income was IDR 58.40 million/farm for intercropping and IDR 54.00 million/farm for mixed gardens. Thus, the descriptive results indicate slightly higher revenue and income under intercropping. However, these differences should not be interpreted as evidence of superior financial performance without considering farmer-level variation and statistical testing.

The aggregate R/C ratio was 4.40 for intercropping and 4.19 for mixed gardens. An aggregate R/C ratio of 4.40 indicates that each IDR 1.00 of recorded production cost was associated with IDR 4.40 of gross patchouli revenue. Both values were substantially above the break-even threshold of one. Nevertheless, the aggregate R/C values describe the overall financial accounting of each group and should not be treated as observations for statistical comparison. When R/C ratios were calculated separately for each farmer, the mean values were 4.42 for intercropping and 4.18 for mixed gardens, and no significant difference was detected between the two systems (p = 0.741).

This finding changes the interpretation of the descriptive R/C difference. The higher R/C ratio observed under intercropping indicates a modest descriptive advantage in the conversion of recorded production costs into patchouli revenue, but the farmer-level evidence does not establish that intercropping consistently generated higher financial returns than mixed-garden cultivation. Thus, the results support the financial feasibility of both systems rather than statistical superiority of one system.

Table 1. Financial performance of patchouli farming under intercropping and mixed-garden systems

Indicator	Intercropping (n = 10)	Mixed garden (n = 20)	p-value
Land area (ha/farm)	0.70 ± 0.26	0.75 ± 0.30	0.742
Production (kg/farm/7 months)	63.00 ± 21.49	59.10 ± 26.04	0.788
Production (kg/ha/7 months)	93.50 ± 30.82	80.43 ± 15.33	0.874
Production cost (IDR million/farm)	17.20 ± 5.24	16.92 ± 6.88	0.344
Revenue (IDR million/farm)	75.60 ± 25.79	70.92 ± 31.25	0.788
Income (IDR million/farm)	58.40 ± 22.01	54.00 ± 24.67	0.676
Income (IDR million/ha)	87.00 ± 35.18	73.56 ± 15.89	1.000
R/C ratio	4.42 ± 1.05	4.18 ± 0.48	0.741

Note: Values are presented as mean ± standard deviation. p-values were obtained using two-sided Mann–Whitney U tests based on individual-farmer observations. Aggregate R/C ratios, calculated as total group revenue divided by total group production cost, were 4.40 for intercropping and 4.19 for mixed gardens.

Land-Standardized Financial Performance

A direct comparison of income per farm can be influenced by differences in cultivated land area. Therefore, financial performance was additionally standardized on a per-hectare basis. Mean cultivated area did not differ significantly between intercropping and mixed-garden farmers (p = 0.742), suggesting that the difference in average farm size between the two groups was relatively limited.

Mean patchouli-oil production per hectare was 93.50 kg/ha under intercropping and 80.43 kg/ha under mixed-garden cultivation. Despite the higher arithmetic mean under intercropping, the difference was not statistically significant (p = 0.874). A similar pattern was observed for income per hectare. Intercropping generated an average income of IDR 87.00 million/ha, compared with IDR 73.56 million/ha under the mixed-garden system.

The apparently substantial difference between these arithmetic means must be interpreted carefully. Variation in income per hectare was considerably greater among intercropping farmers, as indicated by a standard deviation of IDR 35.18 million/ha compared with IDR 15.89 million/ha among mixed-garden farmers. Moreover, the median values were much closer, at approximately IDR 78.20 million/ha for intercropping and IDR 76.86 million/ha for mixed gardens. Consistent with this distribution, the Mann–Whitney U test detected no significant difference in income per hectare between the two systems (p = 1.000).

These results demonstrate why land standardization and farmer-level statistical analysis are important. A comparison based solely on arithmetic averages would suggest a relatively large advantage for intercropping, whereas the distribution of individual-farm outcomes indicates substantial overlap between the two groups. Consequently, the present evidence does not support the conclusion that intercropping systematically generates higher patchouli income per hectare.

Break-Even Performance

Break-even analysis was used to evaluate the minimum price, production level, and land requirement at which patchouli revenue would cover the recorded production costs. The results are presented in Table 2.

Table 2. Break-even indicators of patchouli farming systems

Indicator	Intercropping (n = 10)	Mixed garden (n = 20)	p-value
BEP price (IDR thousand/kg)	281.54 ± 47.91	290.86 ± 35.03	0.741
BEP production (kg/farm)	14.33 ± 4.37	14.10 ± 5.73	0.344
BEP land (ha)	0.165 ± 0.067	0.183 ± 0.081	0.878

Note: Values are presented as mean ± standard deviation. p-values were obtained using two-sided Mann–Whitney U tests.

The mean break-even price was IDR 281.54 thousand/kg under intercropping and IDR 290.86 thousand/kg under mixed-garden cultivation. Descriptively, the lower BEP price for intercropping indicates that intercropping farms required a slightly lower patchouli-oil selling price to recover their recorded production costs. However, the difference was not statistically significant (p = 0.741).

Mean BEP production was nearly identical between the two farming systems, at 14.33 kg/farm for intercropping and 14.10 kg/farm for mixed gardens, with no significant difference (p = 0.344). The mean BEP land requirement was also slightly lower for intercropping, at 0.165 ha compared with 0.183 ha for mixed gardens, but this difference was not significant (p = 0.878).

Therefore, the break-even results do not support a general claim that intercropping has substantially stronger financial resilience than mixed-garden cultivation. Intercropping exhibited slightly more favorable BEP price and land values descriptively, whereas BEP production was almost identical between systems. The considerable overlap in farmer-level values indicates that break-even performance was broadly comparable under the observed production and market conditions.

Comparison with Previous Studies and Economic Interpretation

The absence of a statistically significant difference between the two systems does not imply that cropping-system design is economically irrelevant. Rather, it indicates that cropping-system category alone was insufficient to explain the variation in financial performance among the farmers observed in this study. Individual differences in productivity, production costs, crop arrangement, labor management, and other farm-management characteristics may contribute substantially to the heterogeneity of financial outcomes (Amrin et al., 2024; Halimursyadah et al., 2024; Mukhlis et al., 2024).

Previous research on patchouli-based intercropping has shown that appropriately selected combinations of patchouli and food crop can improve land-use and resource-use efficiency and generate favorable economic returns (Jaya et al., 2024; Prakhyath et al., 2024; Li et al., 2020; Zhu et al., 2023). This provides an agronomic and economic basis for the relatively favorable descriptive performance observed among some intercropping farmers in the present study. However, the benefits of intercropping depend on crop compatibility, spatial arrangement, and competition for light, nutrients, and water (Li et al., 2020). Intercropping should therefore not be interpreted as inherently superior irrespective of local management conditions.

The results should also be considered alongside evidence from mixed-garden systems. Nisa et al. (2024) reported that mixed-garden patchouli systems in Aceh Barat exhibited favorable soil-quality characteristics, biomass production, and patchouli alcohol content compared with other cropping systems. This indicates that the ranking of cropping systems may differ depending on whether the evaluation emphasizes short-term financial performance, land productivity, soil quality, product quality, or longer-term ecological functions (Morugán-Coronado et al., 2020; Thiesmeier & Zander, 2023). The present study evaluates financial performance of the patchouli enterprise and therefore does not provide sufficient evidence to rank the two systems in terms of overall sustainability.

The R/C ratios observed in Aceh Jaya were also higher than the R/C ratio of 2.64 reported by Harita et al. (2024) for patchouli farming in Kluet Timur, Aceh Selatan. This comparison confirms that patchouli farming can be financially feasible across different production locations, but the magnitude of the R/C ratio should be compared cautiously because differences in selling prices, yields, production practices, cost components, and analytical periods can influence the calculated ratio. Consequently, a higher R/C ratio across locations does not necessarily indicate superior technical or allocative efficiency (Cordanis et al., 2023; Danasari et al., 2023).

An important boundary of the present analysis is that farm revenue was calculated exclusively from patchouli-oil production. The economic value generated by companion crops was not included in the revenue calculation. Therefore, the current results cannot be used to conclude that intercropping or mixed gardens provide higher total household income through crop diversification. Companion crops may generate additional income, spread production risk, or contribute other ecological and livelihood functions, but these potential benefits were outside the financial accounting boundary of this study (Muthuri et al., 2023; Raseduzzaman & Jensen, 2017). A whole-farm analysis incorporating the costs and revenues of all component crops would be required to evaluate those benefits directly.

Research Implications

The findings suggest that agricultural extension and patchouli-development programs should avoid recommending one cropping system solely because of a small difference in average R/C ratio. Both intercropping and mixed-garden systems were financially feasible, and no statistically significant differences were detected in the principal financial and break-even indicators. Management interventions may therefore generate greater practical benefits when they focus on the factors that directly influence farm performance, including crop compatibility, spatial arrangement, production-cost control, labor organization, harvesting practices, and post-harvest handling (Febrianti et al., 2024; Mukhtar & Abubakar, 2020; Tambarta et al., 2021).

For intercropping farmers, extension support should emphasize the selection and arrangement of companion crops so that competition for light, water, and nutrients does not reduce patchouli productivity. For mixed-garden farmers, greater attention should be given to spatial organization, shade management, and synchronization of management activities among annual and perennial crops. Such recommendations are more consistent with the present evidence than promoting intercropping as universally superior. Beyond farm-level production management, patchouli development also requires stronger market access, institutional support, and partnerships between farmers and agroindustry actors (Dzulkarnain et al., 2020).

From a land-use perspective, the results also demonstrate that increasing patchouli financial performance does not necessarily require expansion of cultivated area. Mean farm sizes were relatively small in both systems, yet both generated R/C ratios well above one. Improving productivity and cost management on existing land may therefore be a more appropriate development strategy than recommending land expansion solely on the basis of patchouli market opportunities (Kaunang et al., 2024; Wibisono et al., 2024).

The findings should nevertheless be interpreted within the scope of the study. The census included all 30 patchouli farmers who met the study criteria in the observed location, but the relatively small number of eligible farmers, particularly in the intercropping group, limits statistical power and broader generalization. In addition, the financial analysis did not incorporate companion-crop revenues, oil-quality differences, labor opportunity costs, market-channel variation, or ecological indicators. Future research should integrate these components using a larger multi-location dataset to evaluate the broader economic and sustainability trade-offs between patchouli-based cropping systems.

Conclusion

Patchouli farming under both intercropping and mixed-garden systems was financially feasible under the observed conditions in Aceh Jaya, while farmer-level statistical comparisons showed no significant differences in the principal financial and break-even indicators between the two systems. Although intercropping exhibited slightly more favorable descriptive performance for several indicators, the results do not provide sufficient evidence to conclude that it is financially superior to the mixed-garden system. Instead, the findings indicate that farm management, land-use organization, crop compatibility, and cost control may be as important as the choice of cropping system itself in determining patchouli farm performance. The main contribution of this study is the integration of farm-level financial, land-standardized, break-even, and inferential analyses in comparing two patchouli-based land-use systems, providing a more balanced basis for farm-management and extension decisions. For agricultural development in Aceh Jaya, interventions should therefore prioritize improved crop arrangement, efficient input use, production-cost management, and productivity enhancement on existing farmland rather than promoting a single cropping system as universally superior. Future research should involve larger and multi-location samples and incorporate companion-crop revenues, labor opportunity costs, patchouli-oil yield and quality, market channels, and ecological indicators to provide a more comprehensive assessment of the economic and sustainability trade-offs of patchouli-based farming systems.

Acknowledgments
The author thanks the patchouli farmers in Aceh Jaya Regency who provided the farm data used in this study. Appreciation is also extended to all parties who supported data processing and manuscript preparation.

Author Contributions
Conceptualization, methodology, writing—original draft preparation, K.N.; formal analysis, validation, Z.M.; investigation, data curation, writing—review and editing, K.N. and Z.M. All authors have read and approved the published version of the manuscript.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

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