

Prospects of Dwarf Coconut (*Cocos nucifera* L. var. genjah) as a Cultivar for Coconut Sugar Production in East Lampung

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Abstract

Coconut sugar is emerging as a promising natural sweetener to reduce Indonesia's dependency on imported refined sugar. Among various coconut cultivars, *Cocos nucifera* L. var. genjah (dwarf coconut) offers advantages for sap production due to its short trunk, early maturity, and high sugar content. This study aimed to examine the prospects of dwarf coconut as a productive cultivar for coconut sugar development in East Lampung Regency, based on field-level adoption indicators. A total of 41 respondents were selected using Slovin's formula. Primary data were collected through structured interviews and analyzed using descriptive statistics, T-tests, and multiple linear regression with SPSS version 27. The findings show that factors such as landholding size, formal education exposure, and income levels significantly ($P < 0.05$) influence the practical use of dwarf coconut for coconut sugar production. These results highlight the potential of dwarf coconut as a strategic cultivar to support local coconut sugar initiatives in Indonesia.

Keywords: Coconut sugar; dwarf coconut; East Lampung.

INTRODUCTION

Sugar is a strategic food commodity that plays a vital role in the daily lives of Indonesians. At present Currently, national sugar needs are predominantly met by cane sugar. However, domestic sugar production remains insufficient to fulfill both household and industrial demands. In 2023, Indonesia's sugar production was estimated at only 2.27 million tons, significantly lower than the national requirement of approximately 7 million tons. Consequently, the government has had to rely heavily on imported refined sugar, with imports reaching 5 million tons in 2023, up from 4.4 million tons in 2017 (Central Statistics Agency, 2024).

This high volume of imports reflects not only economic vulnerability but also a growing public health concern. Refined sugar, commonly found in processed foods, sweetened beverages, and baked goods, is linked to several non-communicable diseases, including obesity, diabetes, metabolic syndrome, hypertension, dental caries, and certain types of cancer (Arshad et al., 2022). Therefore, the development of alternative, locally sourced sweeteners with improved nutritional and health profiles is essential.

One such alternative is coconut sugar, derived from the sap of coconut inflorescences and processed through evaporation until it solidifies. Coconut sugar is

recognized for its lower glycemic index (approximately 35), making it safer for consumption by individuals with diabetes (Trinidad et al., 2010). It also contains beneficial nutrients such as proteins, calcium, magnesium, potassium, iron, zinc, and B-complex vitamins (Hebbbar et al., 2015; Jati et al., 2015), which are not present in refined sugar. Furthermore, one hectare of coconut trees has the potential to yield up to 19 tons of coconut sugar annually, significantly outperforming sugarcane, which yields only 5–10 tons per hectare. This highlights the potential of coconut sugar to contribute to sustainable sweetener production, particularly in tropical countries like Indonesia, one of the world's largest coconut producers.

Despite this potential, the productivity of coconut sugar in Indonesia remains relatively low. For example, in Cilacap Regency, productivity only reaches 8 tons per hectare per year. Contributing factors include the prevalence of aging and unproductive coconut trees, declining interest among the younger generation in becoming coconut tappers, limited technological adoption, and a lack of replanting efforts. According to the Ministry of Agriculture (2022), the area of smallholder coconut plantations has declined by an average of 0.99% per year over the past decade.

One promising approach to address this issue is through the introduction and expansion of dwarf coconut

(*Cocos nucifera* L. var. *genjah*) cultivation. Dwarf coconuts are characterized by shorter trunks, earlier sap production (within 3–4 years), and high sugar content in the sap (13.51–14.56%) (Mashud & Matana, 2014). Additionally, their compact growth habit allows for denser planting, which can potentially increase sap yield per hectare and enhance overall productivity.

East Lampung Regency presents significant opportunities for the development of dwarf coconut-based sugar production. It is the second-largest coconut-producing region in Lampung Province after South Lampung (Central Statistics Agency Lampung, 2021). Since 2019, several farmers in East Lampung have initiated dwarf coconut cultivation through partnerships with private sector stakeholders, including PT Unilever Indonesia. Farmers have noted that the short stature of dwarf coconut trees simplifies the tapping process, improves safety, and increases labor efficiency. However, despite this potential, adoption remains limited. Of an estimated 35,714 potential coconut farmers (most with landholdings of approximately 0.5 hectares), only about 560 have adopted dwarf coconut cultivation.

This low adoption rate highlights the need for a deeper understanding of the underlying factors influencing the utilization of dwarf coconut as a productive cultivar for coconut sugar production. While agronomic characteristics are favorable, successful implementation also depends on various contextual elements, including land availability, economic feasibility, and access to institutional support and information. Thus, this study aims to assess the prospects of dwarf coconut as a strategic cultivar for coconut sugar production in East Lampung by analyzing factors influencing its utilization at the field level. The findings are expected to inform future strategies for improving adoption and scaling up coconut sugar production in Indonesia.

MATERIALS AND METHODS

Study Area

This study was conducted from January to June 2025 in East Lampung Regency, one of the central regions for coconut production in Lampung Province, Indonesia. The area was selected due to its significant potential for coconut cultivation and its role as a center for the development of dwarf coconut (*Cocos nucifera* L. var. *genjah*) plantations, particularly under private sector initiatives.

Sampling was conducted using a purposive sampling technique, targeting individuals with the following criteria: (1) male gender, (2) cultivating dwarf coconut plants, and (3) producing coconut sugar from dwarf coconut. From a total population of 560 coconut sugar producers, a sample size of 41 respondents was

determined using the Slovin formula with a 15% margin of error.

Data Collection

Primary data were collected through field observations and structured interviews using the validated questionnaire. Secondary data were sourced from institutional reports, scientific literature, and other relevant documentation. Data collection employed a structured questionnaire using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The questionnaire consisted of statements designed to measure influencing factors associated with the utilization of dwarf coconut for sugar production. Prior to field deployment, the questionnaire underwent validity and reliability testing using a pilot group of 20 respondents. Validity was assessed using Pearson's Bivariate Correlation with a minimum threshold of $r > 0.5$, while reliability was determined using Cronbach's Alpha with a threshold of >0.6 . The results confirmed that all questionnaire components were both valid and reliable.

Data Analysis

Data analysis was divided into two stages: descriptive and inferential. Descriptive statistics were used to describe the characteristics and response tendencies of the respondents. The Likert scale scores from the questionnaire were summed and averaged. The resulting values were interpreted using an interval class formula to categorize responses (e.g., strongly agree, agree, neutral, etc.), allowing for the assessment of overall trends among the farmers' responses.

Inferential analysis was conducted using multiple linear regression to examine the relationship between five independent variables—age (X_1), formal education (X_2), non-formal education (X_3), land area (X_4), and income (X_5)—and the dependent variable, which is farmer attitude (Y). The regression model is expressed as follows:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon$$

where:

- Y is the dependent variable (attitude toward dwarf coconut cultivation for sugar production),
- α is the intercept,
- β_1 to β_5 are regression coefficients for each independent variable, and
- ε is the error term.

To ensure the validity of the regression model, classical assumption tests were conducted, including the normality test (to confirm that residuals are normally distributed), the heteroscedasticity test (to check for constant variance of residuals), and the multicollinearity test (to detect intercorrelations among predictors). The

strength and significance of the regression model were evaluated using the coefficient of determination (R^2), the F-test (to assess model fit), and the t-test (to evaluate the significance of each independent variable).

RESULTS AND DISCUSSION

Characteristics of Farmers and Their Role in Supporting Dwarf Coconut Sugar Production

The characteristics of dwarf coconut farmers include age, last education, occupation, income, land area, land status,

farming experience, number of trees, tree age, sap production, sugar production, and number of extension sessions attended during one year, as presented in Table 1. These characteristics are closely related to the current condition and prospects of utilizing *Cocos nucifera* L. var. genjah (dwarf coconut) as a primary cultivar for coconut sugar production in East Lampung.

Table 1. Characteristics of dwarf coconut farmers (n=41)

Profile	Description	Number of respondents	Percentage (%)
Age	31 – 40 years old	9	21.95
	41 – 50 years old	17	41.46
	51 – 60 years	13	31.71
	61 – 70 years old	2	4.88
Education	Primary School	14	34.15
	Middle school	15	36.59
	High school	9	21.95
	Higher Education	3	7.32
Work Income	Coconut Sugar Farmers	41	100
	< Rp. 2,000,000	6	14.63
	Rp. 2,000,000 – Rp. 4,000,000	15	36.59
	Rp. 4,000,000 – Rp. 6,000,000	13	31.71
	> Rp. 6,000,000	7	17.07
Land area	0.25 Ha	26	4.88
	0.5 Ha	24	58.54
	0.75 Ha	1	2.44
	> 1 Ha	14	34.15
Land Status	Personal	38	92.68
	Rent	3	7.32
Farming Experience	1 – 13 years	10	24.39
	14 – 26 years	21	51.22
	>27 years	10	24.39
Number of Trees	1 - 50 trees	21	51.22
	> 50 trees	20	47.88
Age of the tree	15 years	29	70.73
	6 – 10 years	12	29.27
Palm Oil Production	1-1.5 liters/stick	15	29.27
	1.6-2 liters/stick	26	63.41
Sugar Production	≤ 300 Kg/month	21	51.22
	> 300 kg/month	20	47.88
Frequency Following Counseling	>4 times	4	9.76
	4 times	30	73.17
	3 times	7	17.07

Table 1 shows that the majority of the 41 respondents in this study were farmers aged 41–50 years, most of whom had a junior high school education, worked as coconut sugar farmers, and earned a monthly income ranging from IDR 2,000,000 to IDR 4,000,000 (average IDR 4,318,536). Most dwarf coconut farmers cultivated land areas of 0.5 hectares (average 0.67 hectares) with private land ownership status. Their farming experience ranged from 14 to 26 years (average 21.19 years), and they owned 1–50 dwarf coconut trees (average 63.65 trees) with tree ages between 1–5 years (average 5.14

years). In terms of productivity, most farmers produced 1.6–2 liters of sap per day per tree (average 1.76 liters/day/tree), resulting in ≤ 300 kg/month of coconut sugar (average 359.87 kg/month). Additionally, they had participated in agricultural extension activities four times within a year.

This demographic and technical profile reflects the adaptive potential of smallholder farmers in East Lampung in developing coconut sugar agribusinesses based on dwarf coconut varieties. Each variable is discussed further below in the context of its relevance to

the sustainability and scalability of coconut sugar production using *Cocos nucifera* L. var. *genjah*.

Age

The majority of the 41 respondents in this study were aged 41–50 years. This age group is categorized as productive adults, generally considered to be at the peak of physical and mental abilities for optimal work. These farmers typically have over 20 years of farming experience, which contributes to their skills in managing farming activities and making informed decisions. The dominance of this age group also reflects the slow regeneration of farmers, with younger generations less inclined to enter agriculture due to economic concerns. These findings are consistent with Manyamsari & Mujiburrahmad (2014) and Marlina et al. (2013), who also found that farmers in this age range dominate the agricultural workforce and play key roles in agricultural development.

Education

Most early-maturing coconut sugar farmers had a junior high school education. While there has been a shift from elementary to secondary school (Nazaruddin & Anwaruddin, 2019), farming is still viewed as a hereditary livelihood that does not demand formal education. Children are often involved as labor (Oktafiani et al., 2021), acquiring farming skills informally. Budiningsih & Watemin (2014) emphasized the traditional lifestyle of coconut sugar farmers, where knowledge is passed from parent to child. In this context, the education level of farmers does not hinder coconut sugar production, particularly from dwarf coconut varieties, as long as they acquire practical knowledge and skills. Moreover, Harsanto et al. (2024) found that dwarf coconut farmers are more receptive to practical training than theoretical instruction, supporting the effectiveness of hands-on learning.

Income

The average monthly income of dwarf coconut farmers is IDR 4,318,536, with most farmers earning between IDR 2,000,000 and IDR 4,000,000. This places them in the lower-middle income category, which, according to Nata et al. (2020), is economically vulnerable. Previous studies such as Muhroil et al. (2015) have shown even lower income levels (IDR 1,332,896/month), although with a positive R/C ratio of 2.18. Ramadhan et al. (2023) reported that daily production of 2.36 kg of sugar could generate IDR 4,367,750/month, suggesting that improved production consistency can lead to better outcomes. However, challenges such as limited market access and dependence on middlemen still hinder profits. Therefore, increasing income requires improved production efficiency, better access to capital, and stronger farmer institutions to support marketing.

Land Area

Most farmers cultivate around 0.5 hectares of land, with an average of 0.67 hectares per farm. This size classifies them as smallholder or household-scale producers. According to Utomo et al. (2022), coconut farmers commonly manage land smaller than 0.5 ha, yet find strong economic motivation in doing so. Dwarf coconut varieties are suitable for these settings due to their low stature and early fruiting (3–4 years), enabling efficient use of space. Ghosh et al. (2023) also noted that moderate income levels can be achieved even with land sizes of 0.21–0.6 ha. The ability to intensify planting in limited areas further supports the appropriateness of dwarf coconut varieties for sugar production among smallholder farmers.

Land Status

The majority of dwarf coconut farmers own their land, typically through inheritance or independent purchase. Private ownership provides security and freedom in managing land, making long-term investments in coconut sugar production more feasible. Harsanto et al. (2024) emphasized that dwarf coconut is often planted in family gardens or yards, reducing dependency on rental systems. Singha et al. (2012) also found that land ownership is positively correlated with higher income and motivation to adopt technology, suggesting that secure tenure enhances the sustainability of the coconut sugar business.

Farming Experience

With experience ranging from 14 to 26 years (average 21.19 years), farmers fall into the experienced category. Aisyah et al. (2023) classify farmers with over 10 years of experience as having mature technical skills and better adaptability. Experience in sap tapping and sugar processing, which are manual and skill-intensive tasks, is often gained through long-term practice rather than formal education. Manyamsari & Mujiburrahmad (2014) also highlighted experience as a key success factor in agricultural management. This long tenure supports the sustainability of dwarf coconut farming systems and opens up opportunities for gradual modernization.

Number of Trees

Farmers own 1–50 dwarf coconut trees, with an average of 63.65 trees. Although limited by land area and capital, this number still classifies them as small to medium-scale commercial farmers (Kusumo et al., 2018). Dwarf coconut's compact size and fast maturity allow them to be planted in yards or intercropped. Utomo et al. (2022) found similar patterns in Karimunjawa, where limited land availability constrained the number of trees. Labor availability also influences planting decisions, as sap tapping is labor-intensive. Hence, the number of trees reflects a practical adaptation to resource constraints.

Tree Age

Most trees are 1–5 years old, with an average of 5.14 years, placing them in the early productive phase. Dwarf coconut varieties start fruiting around 3–4 years (Tulalo & Mawardi, 2018). This suggests that farmers have recently adopted these cultivars, possibly due to government support or increased awareness of their benefits. Harsanto et al. (2024) confirmed that many farmers began planting dwarf coconuts within the past five years due to their superior traits and suitability for small plots. Since sap yield becomes more stable around year five, the current tree age indicates future potential for increased sugar production.

Sap Production

The sap yield ranges from 1.6 to 2 liters per day per tree, with an average of 1.76 liters—considered medium to high productivity. Tulalo & Mawardi (2018) noted that some dwarf varieties can produce 1.2–2.0 liters per day, depending on tree age, tapping method, and environmental conditions. Farmers practicing good maintenance, sanitation, and proper tapping timing tend to achieve higher yields. Mashud & Matana (2014) observed similar productivity in a plantation of 138 trees on 1 hectare using a rectangular planting system. Thus, current sap production levels confirm the agronomic feasibility of dwarf coconut as a source of sap for sugar production.

Sugar Production

Farmers produce ≤ 300 kg/month of coconut sugar, with an average of 359.87 kg/month, indicating small to medium-scale production. Based on sap volumes and typical conversion rates (15–20%), this output is consistent with household-level operations using 30–50 trees per year. Ramadhan et al. (2023) found that 2.36 kg/day of production yields approximately 218.39 kg/month. Although modest, these figures underscore the economic potential of dwarf coconut sap, particularly when combined with effective processing and consistent tapping. These trees offer strong potential as a raw material source for small-scale but scalable coconut sugar enterprises.

Frequency of Attending Extension Sessions

The majority of farmers attended four extension sessions annually, reflecting moderate to high engagement in capacity building. Harsanto et al. (2024) noted that farmers who participate regularly in extension activities show improved practices. Maretya & Sudrajat (2017) also found that higher participation correlates with better land management. This participation demonstrates farmers' willingness to improve their skills related to dwarf coconut cultivation and coconut sugar production, although more frequent and targeted training could further enhance both yield and quality.

Descriptive Analysis

This study employed three scoring categories: Disagree (1.00–2.33), Agree (2.34–3.67), and Strongly Agree (3.68–5.00). Table 2 presents the descriptive statistics for each variable related to farmer characteristics and their attitudes toward using dwarf coconut (*Cocos nucifera* L. var. genjah) for coconut sugar production in East Lampung.

Table 2. Descriptive analysis.

Variables	Mean	Std	Information
Age	3.99	0.63	Strongly agree
Formal education	3.86	0.67	Strongly agree
Non-formal education	4.59	0.50	Strongly agree
Land area	3.76	0.91	Strongly agree
Income	4.14	0.38	Strongly agree
Attitude	3.66	1.04	Agree

Source: Primary data (2025)

The results indicate that most farmers strongly agree that variables such as age, formal education, non-formal education, land area, and income play important roles in shaping their attitudes toward cultivating dwarf coconuts for coconut sugar production. These variables reflect a readiness and optimism among local farmers to adopt dwarf coconut as a sustainable and productive cultivar. Farmers also expressed that cultivating dwarf coconuts brings enthusiasm, interest, and satisfaction, which supports the economic potential of this variety in East Lampung.

Classical Assumption Test

The normality test (Kolmogorov-Smirnov) is used to test whether the dependent and independent variables have a normal distribution or not, as seen from the Asymp Sig. (2-tailed) value > 0.05 , which means the data is normally distributed. The results of the normality test are shown in Table 3.

Table 3. Normality Test.

Asymp. Sig. (2-tailed)	0.200
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In Table 3, it can be seen that the Asymp Sig. (2-tailed) The values are $0.200 > 0.05$, which means that the model of the regression equation is normally distributed.

The multicollinearity test is used to detect whether independent variables in a regression model are correlated with each other. To meet this test, there must be no correlation between each independent variable, as seen from the tolerance value > 0.1 and VIF < 10 , then there are no symptoms of multicollinearity. The results of the multicollinearity test are shown in Table 4.

Table 4. Multicollinearity Test.

Variables	Tolerance	VIF
Age (X1)	0.433	2,311
Formal Education (X2)	0.569	1,756
Non-Formal Education (X3)	0.860	1,163
Land Area (X4)	0.813	1,230
Income (X5)	0.566	1,765

In Table 4, it can be seen that all variables have a tolerance value > 0.1 and a VIF value < 10 , which means there are no symptoms of multicollinearity between the variables in this study.

The heteroscedasticity test (Gleiser) is a test that aims to detect whether there is inequality in residual variations from one observation to another in a regression model. To fulfil this test, there must be no symptoms of heteroscedasticity in the regression model as indicated by the Sig. value > 0.05 so that there are no symptoms of heteroscedasticity. The results of the heteroscedasticity test are shown in Table 5.

Table 5. Heteroscedasticity Test.

Variables	Sig.
Age (X1)	0.794
Formal Education (X2)	0.322
Non-Formal Education (X3)	0.938
Land Area (X4)	0.052
Income (X5)	0.082

Table 6. Results of Multiple Linear Regression Analysis.

Variables	Regression Coefficient	Standard Error	t-count	p-value
Age (X1)	-0.041	0.136	-0.304	0.763
Formal Education (X2)	0.396	0.185	2,147	0.039**
Non-Formal Education (X3)	-0.270	0.135	-1,995	0.054
Land Area (X4)	0.374	0.144	2,592	0.014**
Income (X5)	0.705	0.271	2,604	0.013**
Constant	3,242	4,477	0.724	0.474
F count				6,187
Sigh F				< 0.001
Adjusted R ²				0.530
N				41

Source: Primary data (2025).

Based on the analysis results, the regression equation obtained for the research results is

$$Y = 3,242 - 0,041X_1 + 0,396X_2 - 0,270X_3 + 0,374X_4 + 0,705X_5 + \varepsilon$$

It is clear that age and non-formal education do not influence the attitudes of dwarf coconut farmers toward coconut sugar production. However, formal education,

In Table 6, it can be seen that each variable has a Sig. value > 0.05 , which means that the resulting regression equation does not exhibit symptoms of heteroscedasticity.

Hypothesis Testing

Hypothesis testing was conducted using the T test, F test, and coefficient of determination. The F test was used to simultaneously test the level of significance of the influence of independent variables on the dependent variable by looking at the Sig. < 0.05 value in the ANOVA analysis model. The T test was used to partially test the level of significance of the influence of independent variables on the dependent variable by looking at the Sig. < 0.05 value in the Coefficients model. The coefficient of determination is the proportion of the influence of all independent variables on the dependent variable by looking at the value of R Square. The predictive factors identified in this study were age, formal education, non-formal education, land area, and income that can influence the attitude of dwarf coconut farmers for coconut sugar production. The results of the hypothesis test analysis are shown in Table 6.

land area, and income significantly influence the variables.

Formal Education Influences Farmers' Attitudes Toward the Prospects of Dwarf Coconut for Coconut Sugar Production

Farmers' perceptions of formal education significantly influence their attitudes toward the potential of dwarf coconut cultivation for coconut sugar production ($p = 0.039 < 0.05$). In East Lampung Regency, dwarf coconut farmers possess educational backgrounds ranging from

elementary to tertiary levels. While most farmers have substantial farming experience—averaging 21.19 years—their level of formal education contributes to differentiated attitudes, especially in their receptiveness to innovations in dwarf coconut cultivation and its viability for coconut sugar production.

Studies have shown that formal education enhances farmers' understanding of modern agricultural practices and technologies, thereby improving productivity. According to Mohith & Narayanaswamy (2019), better-educated farmers are more inclined to adopt innovative techniques, including those related to coconut sugar processing. Asfaw et al. (2012) similarly asserted that formal education significantly increases the probability of adopting agricultural innovations in developing countries. Education allows farmers to interpret technical knowledge, access reliable sources of information, and respond to market demands more flexibly.

Faizah et al. (2024) emphasized that formal education equips farmers with better capacity to assess both the benefits and risks of innovation, thereby fostering a stronger readiness for change. Moreover, while formal education is crucial, farming experience remains a vital factor. Experienced farmers possess a deep practical understanding, allowing them to be rational yet selective in adopting new agricultural technologies. Thus, formal education plays a strategic role not only in encouraging the adoption of dwarf coconut cultivation practices but also in enhancing the production of coconut sugar. It is therefore crucial that empowerment strategies emphasize education—both formal and informal (e.g., training and agricultural extension)—to sustainably increase the productivity and quality of coconut sugar derived from dwarf coconut cultivars.

Land Area Influences Farmers' Attitudes Toward Dwarf Coconut as a Coconut Sugar Source

Farmers' perceptions of land area significantly affect their attitudes toward adopting dwarf coconut cultivation for coconut sugar production ($p = 0.014 < 0.05$). Landholding size is a key factor in determining a farmer's production capacity, resource allocation, and motivation. The analysis revealed that farmers with larger land areas tend to exhibit a more proactive and positive attitude toward utilizing dwarf coconuts for sap production. This implies that larger landholdings offer greater economic potential, motivating farmers to optimize their yields through more intensive and innovative cultivation. Rahman et al. (2025) highlighted that larger land size is positively associated with the adoption of agricultural technology, primarily due to better financial capacity and higher risk tolerance. Similarly, Mwangi & Kariuki (2015) noted that the land area plays a pivotal role for farmers' decisions to adopt agricultural innovations, including in plantation crops such as coconuts. Farmers with expansive land resources are more economically capable, which encourages them to pursue technological improvements

and develop new products. Manwan et al. (2022) emphasized that larger land areas enable economies of scale, facilitating greater investment in resources and technologies needed for efficient coconut sugar production. Consequently, land area serves not only as a physical production factor but also as a psychological and economic driver in shaping farmers' attitudes toward dwarf coconut utilization. Therefore, policy initiatives should address land-related disparities by supporting smallholders through intensification programs and providing incentives that enable efficient adoption of technology even on smaller plots.

Income Influences Farmers' Attitudes Toward Dwarf Coconut-Based Coconut Sugar Business

Farmers' perceptions of income levels significantly influence their attitudes toward developing dwarf coconut cultivation for coconut sugar production ($p = 0.013 < 0.05$). The findings suggest that income is a significant determinant of positive farmer attitudes, particularly regarding the adoption of innovation and the establishment of sustainable coconut sugar enterprises based on dwarf coconut varieties. This observation aligns with Oladele (2005), who found that income has a significant impact on farmers' participation in agricultural extension services and their willingness to adopt new technologies. Higher income allows farmers to take calculated risks, access high-quality inputs, and participate in capacity-building programs. Similarly, Ayinde & Obalola (2017) noted that higher income levels enhance farmers' risk tolerance, investment in new technologies, and business diversification. Setiyowati et al. (2022) also found a positive correlation between income and innovation adoption. Wongkar et al. (2016) further emphasized that farmers with greater capital tend to be more confident in experimenting with agricultural innovations. Dwarf coconut, with its short gestation period (approximately 3–4 years), daily sap production, and high market demand—especially in the export-oriented coconut sugar sector—is seen as a promising investment. Farmers' attitudes are shaped not only by income level but also by their perceptions of business stability and long-term profitability.

Therefore, farmer income plays a crucial role in shaping attitudes toward dwarf coconut cultivation. Policy interventions must focus on improving income-generating opportunities for smallholder farmers, such as by expanding market access, promoting rural economic development, and offering financial support like People's Business Credit (KUR), to scale up and enhance the quality of coconut sugar production from dwarf coconut varieties.

Age and Non-Formal Education Do Not Significantly Influence Farmers' Attitudes

Farmers' perceptions regarding age ($p = 0.763 > 0.05$) and non-formal education ($p = 0.054 > 0.05$) do not significantly influence their attitudes toward dwarf

coconut cultivation for coconut sugar production. Although the p-value for non-formal education was close to the significance threshold, neither variable showed a statistically meaningful impact. Non-formal education—comprising training, extension, farmer group discussions, and field assistance—is ideally designed to enhance farmer knowledge and practical skills. However, the study revealed that participation in these activities did not result in significant changes in attitudes. This finding is consistent with Hardinah et al. (2022), who stated that despite frequent agricultural training, its impact on farmers' attitudinal development remains limited. Sulaiman et al. (2005) explained that when extension services are not tailored to farmers' actual needs, they fail to effectively influence behavior. Nugroho et al. (2023) similarly noted that factors such as land access and household economic conditions have greater influence than age or non-formal education. A potential explanation is the quality and relevance of the training: village-level programs often lack practical application, are not problem-driven, and are sometimes conducted as mere formalities. Additionally, ineffective delivery methods—such as one-way lectures without hands-on practice—limit knowledge retention and attitude change. Sinaga & Sudarko (2024) highlighted that non-formal training without follow-up mentoring or field demonstrations risks being superficial and non-transformative.

Regarding age, most farmers in the study were in the 41–50 age bracket, yet age did not significantly influence their receptiveness to adopting dwarf coconut innovations. This aligns with Satriawan et al. (2023), who found that age does not influence farmers' perceptions in the context of agro-tourism development. Hardinah et al. (2022) similarly observed that age is not a major factor in shaping perceptions. These findings suggest that modifying farmers' attitudes cannot rely solely on training or demographic segmentation. More comprehensive and contextual strategies—such as strengthening market access, forming business partnerships, and developing farmer economic institutions—are required to drive sustainable behavioral change.

Combined Farmer Perceptions Influence Attitudes Toward Dwarf Coconut for Coconut Sugar

Collectively, farmers' perceptions significantly influence their attitudes toward utilizing dwarf coconut for coconut sugar production ($p = 0.001 < 0.05$), with a coefficient of determination (R^2) of 0.53. This indicates that 53% of the variability in farmer attitudes can be explained by the combined effects of five independent variables: age, formal education, non-formal education, land area, and income. The remaining 47% is attributed to factors outside the scope of this model. This finding underscores that farmers' attitudes toward dwarf coconut as a sap-producing cultivar are shaped by the interplay of

sociodemographic and economic characteristics. Such insights underscore the need for a multidimensional approach in analyzing and transforming farmer behavior. Satriawan et al. (2023) found that characteristics such as age, education, and income significantly affect perceptions in agrotourism development. Kielbasa (2017) also noted that combinations of demographic and socioeconomic factors influence willingness to adopt agricultural technology. Similarly, Ghosh et al. (2023) emphasized that land area and income are particularly influential in shaping farmer attitudes toward innovation.

Given these findings, empowerment strategies must adopt an integrative approach that considers the specific characteristics of individual farmers. Initiatives such as targeted training, access to capital, and agribusiness mentoring can foster more favorable attitudes toward adopting the dwarf coconut cultivars and improving the value-added potential of coconut sugar production.

CONCLUSIONS

The findings indicate that key factors such as formal education, land area, and income significantly influence the acceptance and utilization of dwarf coconut for coconut sugar production. When assessed simultaneously, the five examined variables—age, formal education, non-formal education, land area, and income—collectively account for 53% of the variance in attitudes toward adopting dwarf coconut. These results underscore the importance of underlying socioeconomic characteristics in shaping decisions related to the cultivation and development of dwarf coconut as a potential cultivar for coconut sugar. To enhance the adoption of dwarf coconut cultivation, it is essential to strengthen farmers' access to both formal and non-formal education, particularly technical training that supports improved cultivation practices. Additionally, further research is recommended to explore the specific role of non-formal education and to identify effective policy interventions—especially those aimed at land expansion and income improvement—that can support the sustainable development of dwarf coconut as a valuable resource for coconut sugar production in East Lampung.

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