

Comparative Economic Efficiency of Certified Rice Seed Production and Rice Grain Farming: A Case Study in Subak Dlod Sema, Badung Regency, Bali, Indonesia

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ABSTRACT: The expansion of rice harvested area in Badung Regency has increased the demand for certified rice seed. However, rice seed production in Subak Dlod Sema, one of the major seed production centers in the region, currently fulfills only approximately 29.3% of the seed requirement based on the harvested area. This study aimed to compare the economic efficiency of certified rice seed production and rice grain farming and to identify the factors contributing to technical inefficiency in both farming systems. The study involved 53 farmers, consisting of 15 certified rice seed producers and 38 rice grain farmers. Data were analyzed using Stochastic Frontier Analysis (SFA), while Net Profit Margin (NPM) was employed as a complementary indicator of farm profitability. The results showed that both farming systems achieved high levels of technical efficiency but remained inefficient in terms of allocative and economic efficiency. The average technical efficiency scores were 0.954 for certified rice seed production and 0.985 for rice grain farming, while allocative efficiency averaged 0.281 and 0.234, respectively. Economic efficiency values were 0.267 for certified rice seed production and 0.231 for rice grain farming. These findings indicate that farmers were able to produce outputs close to the production frontier; however, the allocation of production inputs relative to their costs had not yet reached the economically optimal level. Farmers' age, formal education, and household size had no significant effect on technical inefficiency in either farming system, whereas farming experience significantly reduced technical inefficiency only in rice grain farming. Furthermore, certified rice seed production generated a higher Net Profit Margin (34.36%) than rice grain farming (22.45%), indicating greater profitability. Overall, the findings suggest that improving allocative efficiency is essential for enhancing economic performance, while the higher profitability of certified rice seed production highlights its potential for expansion to strengthen the availability of certified rice seed in Badung Regency.

KEYWORDS: allocative efficiency; certified rice seed production; economic efficiency; Net Profit Margin; rice grain farming; stochastic frontier analysis; technical efficiency; technical inefficiency.

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for the majority of the Indonesian population and plays a fundamental role in ensuring national food security. Continuous population growth has substantially increased rice demand, requiring a balance between rice supply and demand to prevent shortages that may threaten food security. Rice availability is influenced by several factors, including production levels, consumption patterns, agricultural technologies, and rice market dynamics, while rice imports are commonly used by the government to mitigate production deficits caused by natural disasters or crop failures (Risna et al., 2024; Ilyas et al., 2020). Therefore, maintaining and increasing rice production remains an essential strategy for strengthening national food security.

Badung Regency, Bali Province, is one of the important rice-producing regions in Indonesia. According to Statistics Indonesia (BPS, 2024), the population of Badung Regency reached 526,000 in 2023, with an annual population growth rate of 2.20% over the previous three years. Based on an annual per capita rice consumption of 87.84 kg (Suarni, 2022), the rice requirement in Badung Regency is estimated at 46,203 tons per year, while annual rice production reached 59,052.50 tons (BPS, 2024). Although current production exceeds local demand, continued population growth and the conversion of agricultural land to non-agricultural

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uses may reduce future rice availability (Marhaeni & Yuliarmi, 2018). Consequently, improving rice productivity is necessary to ensure sustainable rice production.

One strategy to increase rice production is through expanding harvested area and improving farm productivity. During 2021–2023, the harvested area in Badung Regency increased from 14,825.85 ha to 15,329.63 ha (BPS, 2024). However, during the same period, the cropping index declined from 2.22 to 1.83, while approximately 473.78 ha of paddy fields were converted to non-agricultural land (Department of Agriculture of Badung Regency, 2024). Despite these constraints, rice production measured as harvested dry grain increased by approximately 5,305 tons in 2023 compared with the previous year (BPS, 2024). These findings indicate that recent increases in rice production have been driven primarily by improvements in farm productivity rather than by land expansion alone.

Farm productivity is strongly influenced by the quality of production inputs, particularly certified rice seed. As harvested areas continue to expand, the demand for certified seed also increases. Farmers generally prefer certified varieties with high germination rates, superior yield potential, resistance to pests and diseases, and good market acceptance (Purba et al., 2022). Certified rice seed also provides greater varietal purity, seed viability, and storage quality, thereby contributing to higher crop productivity (Mayalibit et al., 2017). Consequently, ensuring an adequate supply of certified seed has become an essential component of sustainable rice production (Sayaka & Hidayat, 2015).

Despite the increasing production of certified rice seed in Badung Regency, its availability remains insufficient to satisfy farmers' demand. Certified rice seed production increased from 90.615 tons in 2022 to 112.300 tons in 2023 (BPSBTPHBUN, 2024). Assuming a seed requirement of 25 kg ha⁻¹, this production is sufficient to plant only about 4,492 ha, which is still below the actual planting requirement in the regency (BPSBTPHBUN, 2024). Limited land availability, capital constraints, and inefficient utilization of production inputs have been identified as important factors restricting seed production (Sucahyo & Hutajulu, 2015). These conditions indicate that improving production efficiency is essential for increasing the supply of certified rice seed.

Subak Dlod Sema is one of the major rice-producing areas in Badung Regency where farmers cultivate both certified rice seed and rice grain for consumption. As one of the active certified seed production centers, its current production fulfills only approximately **29.3%** of the certified seed requirement based on the harvested area in Badung Regency. This substantial production gap suggests that the capacity of certified seed production remains far below market demand and highlights the need to improve production efficiency in seed farming systems. At the same time, most farmers in Subak Dlod Sema continue to cultivate rice primarily for grain rather than for certified seed production, raising questions regarding the relative economic performance of the two farming systems.

Economic efficiency provides a comprehensive measure of farm performance because it integrates both technical efficiency and allocative efficiency. A farming system is considered economically efficient when it can maximize output using available resources while simultaneously allocating production inputs according to their economic value. Evaluating economic efficiency also enables the identification of factors contributing to technical inefficiency, thereby providing useful information for improving farm management. In addition, profitability indicators such as **Net Profit Margin (NPM)** complement efficiency analysis by measuring the ability of farming systems to generate net profit from total revenue.

Although numerous studies have investigated the efficiency of rice farming, comparative studies evaluating **certified rice seed production and conventional rice grain farming** remain limited, particularly in Indonesia. Previous research has generally focused on production efficiency or farm profitability separately, whereas studies integrating **technical efficiency, allocative efficiency, economic efficiency, technical inefficiency, and profitability** within a comparative framework are still scarce. This knowledge gap limits understanding of whether certified rice seed production offers greater economic advantages than conventional rice grain farming and whether it provides sufficient incentives for farmers to engage in seed production.

Therefore, this study aimed to compare the economic efficiency of **certified rice seed production and rice grain farming** in Subak Dlod Sema, Badung Regency, Bali, Indonesia. The study employed **Stochastic Frontier Analysis (SFA)** to estimate technical, allocative, and economic efficiency, while **Net Profit Margin (NPM)** was used as a complementary indicator to compare farm profitability. Furthermore, this study identified the factors contributing to technical inefficiency in both farming systems. The findings are expected to provide scientific evidence for improving farm resource allocation, enhancing farm profitability, increasing certified rice seed production, and supporting sustainable rice production and food security.

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RESEARCH METHOD

Research Design

This study employed a quantitative research approach to compare the economic efficiency of **certified rice seed production** and **rice grain farming** in Subak Dlod Sema, Badung Regency, Bali, Indonesia. The objectives of this study were (1) to analyze the levels of technical, allocative, and economic efficiency of certified rice seed production and rice grain farming, and (2) to identify the factors affecting technical inefficiency in both farming systems. Economic efficiency was evaluated through the measurement of technical efficiency and allocative efficiency. Primary data were collected through structured interviews using questionnaires and field observations. Classical assumption tests were performed using **EViews 10**, while efficiency analysis based on the **Stochastic Frontier Analysis (SFA)** approach was conducted using **FRONTIER Version 4.1**. As a complementary analysis, **Net Profit Margin (NPM)** was employed to compare the profitability of the two farming systems.

Research Location and Time

The study was conducted in **Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency, Bali, Indonesia**. The study site was purposively selected because it is one of the major centers of certified rice seed production in Badung Regency. The research was carried out from **June to October 2024**.

Data Sources and Respondents

This study utilized both primary and secondary data. Primary data were collected through direct interviews and structured questionnaires administered to farmers, whereas secondary data were obtained from government agencies, books, scientific journals, and other relevant literature. The secondary data sources included **Statistics Indonesia (BPS)**, the **Ministry of Agriculture of Indonesia**, the **Department of Agriculture and Food Security of Bali Province**, the **Seed Inspection and Certification Center for Food Crops, Horticulture, and Plantation Crops (BPSBTPHBUN)** of Bali Province, and the **Department of Agriculture and Food of Badung Regency**. The study employed both quantitative and qualitative data following the classification proposed by **Sugiyono (2013)**.

The study involved **53 respondents**, consisting of **15 certified rice seed producers** and **38 rice grain farmers**. Because the target population was relatively small and heterogeneous, all members of the population were included as respondents using the census method (**Sugiyono, 2013**). The list of certified seed producers was obtained from **BPSBTPHBUN**, while rice grain farmers were selected based on their farming activities within Subak Dlod Sema.

Research Variables

The stochastic frontier production model consisted of one output variable and six production input variables. Rice production (kg) was used as the output variable (Y), whereas land area (ha), seed quantity (kg), urea fertilizer (kg), NPK fertilizer (kg), pesticides (L), and labor (man-days) were included as production input variables (X_1 – X_6). The technical inefficiency model included four socioeconomic variables, namely farmer age (years), formal education (years), farming experience (years), and household size (persons) (**Sugiyono, 2013**).

Research Instruments

The research instrument consisted of a structured questionnaire designed to obtain information on respondent characteristics, production inputs, production costs, production output, input and output prices, and farm revenues from certified rice seed production and rice grain farming. Field observations and follow-up interviews were also conducted to verify questionnaire responses and obtain additional information regarding farming practices (**Sugiyono, 2013**).

Research Procedure

The research was conducted through the following stages:

1. A structured questionnaire was prepared to collect information regarding farmer characteristics, production inputs, production costs, production output, input and output prices, and farm revenues from certified rice seed production and rice grain farming.
2. Primary data were collected through face-to-face interviews and field observations.
3. The collected data were tabulated using **Microsoft Excel 2013** for preliminary data processing.
4. Classical assumption tests, including normality, homoscedasticity, and multicollinearity tests, were performed using **EViews 10** before estimating the frontier production model.
5. **Stochastic Frontier Analysis (SFA)** was conducted using **FRONTIER Version 4.1** to estimate the stochastic production frontier, technical efficiency, and the determinants of technical inefficiency.

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6. The dual cost function approach was applied to estimate allocative efficiency and economic efficiency.
7. **Net Profit Margin (NPM)** was calculated as a complementary indicator to compare the profitability of certified rice seed production and rice grain farming.
8. The estimated technical efficiency, allocative efficiency, economic efficiency, technical inefficiency, and NPM values were interpreted according to the research objectives, followed by the formulation of conclusions and recommendations.

Data Analysis

This study employed econometric methods to analyze the research variables through mathematical models appropriate to the data. The first objective was addressed by measuring technical efficiency using the Stochastic Frontier Analysis (SFA) approach with a Cobb–Douglas production function, and by measuring allocative and economic efficiency using a dual cost function approach. The second objective was addressed through estimation of the technical inefficiency effects model within the SFA framework. As a supporting analysis, Net Profit Margin (NPM) was used to compare the ability of the two farming systems to generate net profit from their revenues.

Cobb–Douglas Production Function and the Stochastic Frontier Analysis (SFA) Approach

This study applied the Stochastic Frontier Analysis (SFA) method to analyze the economic efficiency of certified seed rice farming and consumption rice farming in the Dlod Sema irrigation subak, Badung Regency, using FRONTIER Version 4.1 for Windows. The stochastic approach assumes that output is a function of production inputs, random error, and technical inefficiency, involving rice output (Y) as the dependent variable and production inputs (X) as independent variables (Aigner et al., 1977).

The Cobb–Douglas production function describes the relationship between inputs and output. Following Coelli et al. (1998), the stochastic frontier specification of the Cobb–Douglas model is written as:

$$\ln(Y_i) = X_i\beta + V_i - U_i, \quad i = 1, 2, \dots, N \quad (1)$$

The production inputs considered in both farming systems were land area, seed quantity, fertilizer (urea and NPK), pesticide, and labor. Based on these inputs, the empirical model is specified as:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + (V_i - U_i) \quad (2)$$

Technical Efficiency and Technical Inefficiency Analysis

Technical efficiency is inversely related to the level of inefficiency: higher technical efficiency corresponds to lower inefficiency. Following Coelli et al. (1998), technical efficiency (TE) for cross-sectional data is formulated as:

$$ET_i = Y_i / \exp(X_i\beta) = \exp(X_i\beta - U_i) / \exp(X_i\beta) = \exp(-U_i) \quad (3)$$

where ET_i is the technical efficiency of the i -th farmer, and $\exp(-U_i)$ is the expected value of U_i , with TE ranging between 0 and 1. When $U_i = 0$, technical efficiency reaches 100 percent; $U_i > 0$ indicates inefficiency in the production process.

U_i is assumed to follow a specific distribution, and its mean parameter is denoted μ_i (Darmawan, 2016). Following Coelli et al. (1998), the inefficiency effects model is specified as:

$$\mu_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \varepsilon_i \quad (4)$$

Parameter estimation was conducted in two stages: first, Ordinary Least Squares (OLS) was used to obtain initial estimates of the production coefficients (β_i); second, Maximum Likelihood Estimation (MLE) was used to jointly estimate the production coefficients (β_i), the intercept (β_0), and the variance components of V_i (σ_v^2) and U_i (σ_u^2). Following Battese and Corra (1977), FRONTIER 4.1 reports the following variance parameters:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \quad (5)$$

$$\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2) \quad (6)$$

where σ^2 is the total variance of the error term and γ (gamma) represents the proportion of total variance attributable to technical inefficiency, ranging between 0 and 1. A γ value approaching 1 indicates that most of the variation in output is due to technical inefficiency, implying that many production units operate below the efficient frontier; conversely, a value approaching 0 indicates that output variation is mainly due to random error or measurement error rather than inefficiency.

Since the OLS stage requires the classical assumptions to hold, normality, homoscedasticity, and multicollinearity tests were performed on the cross-sectional data using EViews 10 to ensure that the regression estimates were valid, unbiased, efficient, and consistent.

Allocative and Economic Efficiency Analysis

To achieve optimal profit, farm households must allocate their inputs cost-efficiently; a decision that satisfies this criterion is termed allocatively efficient. In this study, allocative and economic efficiency were measured through a dual cost function

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derived from the Cobb–Douglas production function. The duality principle implies that a production function describing the input–output relationship can be used to derive a minimum cost function, taking into account the level of output, input prices, and production technology parameters (Darmawan, 2016). Based on this principle, the dual cost function is specified as:

$$C = C(Y_i, P_i, \theta_i) + U_i \quad (7)$$

The dual cost function is used to derive the minimum cost (C^*) required to produce a given level of output at prevailing input prices. Economic efficiency (EE) is then obtained by comparing the minimum cost (C^*) with the actual cost (C) incurred by farmers, following Jondrow et al. (1982) and Ogundari and Ojo (2006):

$$EE = C^* / C = E(C_i | U_i = 0, Y_i, P_i) / E(C_i | U_i, Y_i, P_i) = E[\exp(U_i/\epsilon)] \quad (8)$$

EE ranges between 0 and 1; values closer to 1 indicate that the actual cost incurred is closer to the minimum cost required to produce the given output. Economic efficiency is the product of technical efficiency (TE) and allocative efficiency (AE): $EE = TE \times AE$. Once EE and TE have been estimated, allocative efficiency is derived as:

$$AE = EE / TE \quad (9)$$

AE ranges between 0 and 1; values approaching 1 indicate that input use is closer to the cost-minimizing input combination at prevailing input prices.

Net Profit Margin (NPM) Analysis

As a supporting analysis, Net Profit Margin (NPM) was used to compare the ability of certified seed rice farming and consumption rice farming to generate net profit from revenue. Brigham and Ehrhardt (2011) define net profit margin as the ratio of net income to sales, reflecting the proportion of net profit generated per unit of sales. In this study, the concept was adapted to farm-level analysis, where net income is represented by farm net profit and sales by total farm revenue. NPM is formulated as:

$$NPM = (\text{Net Profit} / \text{Total Revenue}) \times 100\% \quad (10)$$

Net profit is calculated as the difference between total revenue and total production cost, while total revenue is the product of output quantity and selling price. A higher NPM indicates a larger share of revenue retained as net profit after accounting for production costs. In this study, NPM was not used as a measure of economic efficiency, but rather as a supporting analysis to provide information on differences in profit margins between the two farming systems.

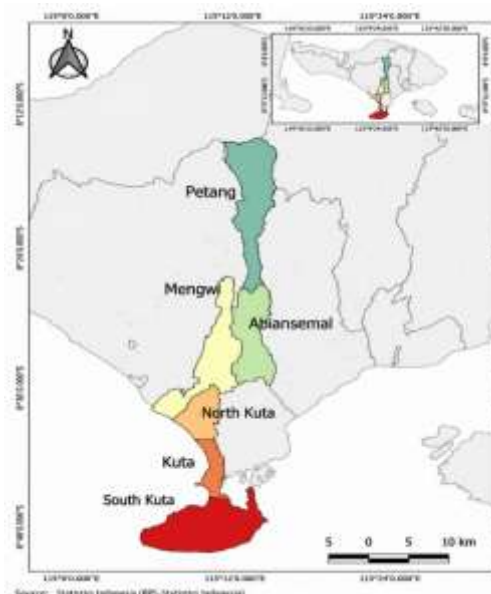
RESULTS AND DISCUSSION

1. General Overview of the Research Location

General Overview of Badung Regency

Badung Regency is one of the regencies in Bali Province, located at coordinates 8°14'–8°50' South Latitude and 115°05'–115°26' East Longitude. Administratively, Badung Regency is bordered by Buleleng Regency and Tabanan Regency to the north, the City of Denpasar and Gianyar Regency to the east, Tabanan Regency to the west, and the Indian Ocean to the south (Figure 1). The seat of the Badung Regency government is located in Mangupura.

Figure 1.



Overview of Badung Regency

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Based on data from the Central Statistics Agency (BPS) of Badung Regency (2025), the area of Badung Regency reaches 398.75 km², divided into six districts: South Kuta, Kuta, North Kuta, Mengwi, Abiansema, and Petang. These six districts each have distinct geographical characteristics. The southern areas, such as Kuta, South Kuta, and part of North Kuta District, are generally lowlands located in coastal areas. Their low to moderate elevation has driven the rapid development of this region into a center of tourism, trade, and settlement activities. Meanwhile, the central and northern parts, covering Mengwi, Abiansema, and Petang Districts, have more varied topography, ranging from undulating plains to hills and mountains, making them suitable for the development of the agricultural sector, particularly food crops, horticulture, and plantations.

This diversity in the physical characteristics of the region has implications for land-use patterns and the economic structure of the community. In the southern region, the development of the tourism sector has driven intensive land-use transformation, whereas the central and northern regions still show a dominance of agricultural activities. This condition makes Badung Regency a region with a development dualism, namely a rapidly growing tourism sector and an agricultural sector that continues to serve as a food provider and source of livelihood for the rural community.

One of the agricultural commodities widely cultivated in Badung Regency is rice. This commodity plays an important role as the community's main food source while also serving as one of the pillars of agricultural activity in Badung Regency. Rice cultivation is generally concentrated in Mengwi, Abiansema, and Petang Districts, which still have relatively extensive irrigated paddy fields supported by the presence of the subak irrigation system. The existence of the subak not only ensures the availability and distribution of water for cultivation activities, but also plays a role in regulating planting patterns and coordination among farmers, thereby supporting the sustainability of rice production.

In addition to producing unhulled rice (gabah) to meet food needs, some farmers in Badung Regency also develop certified rice seed multiplication businesses as part of diversifying their farming activities. This activity has developed in several rice production center areas, particularly in Mengwi District. Mengwi District is one of the main agricultural areas in Badung Regency, with an irrigated paddy field area reaching 3,971.93 ha (Diperpa, 2025). The extensive expanse of paddy fields, the availability of irrigation water sources, and the presence of a still well-functioning subak system make this region conducive to the development of a rice seed business.

General Overview of Subak Dlod Sema

Subak Dlod Sema is one of the subaks located in Sading Village, Mengwi District, Badung Regency. Administratively, the Subak Dlod Sema area lies within an agricultural zone that still maintains its paddy field function amid the rapid development of the non-agricultural sector in Badung Regency. The paddy field area it manages reaches 64 hectares, most of which is used for wetland rice cultivation. The existence of Subak Dlod Sema functions not only as a traditional irrigation management institution, but also as a farmer organization that regulates various aspects of agricultural management, including water distribution, the implementation of planting patterns, maintenance of the irrigation network, and coordination of cultivation activities at the farmer level.

Topographically, the Subak Dlod Sema area lies at an elevation of between 50–100 meters above sea level, with slopes ranging from 0–8 percent, classified as flat to gently sloping. This condition supports the development of paddy field agriculture because it allows irrigation water distribution to occur relatively evenly and facilitates land management by farmers. In addition, the landform, which is dominated by plains, allows for the formation of a relatively uniform expanse of paddy fields, thereby supporting the implementation of coordinated cultivation patterns within a single subak area.

In terms of land resources, the Subak Dlod Sema area is dominated by yellowish-brown latosol soil formed from the weathering of volcanic material from Mount Buyan-Beratan and Mount Batur. This soil has a fairly good effective depth, a relatively stable soil structure, and water-holding capacity that supports rice plant growth. Although its natural fertility level is classified as moderate due to high nutrient leaching, this condition still allows for intensive rice cultivation through appropriate nutrient management. The availability of water sources originating from the Badung River Basin (DAS) system is also an important factor supporting the sustainability of agricultural activities in this area.

Agricultural activity in Subak Dlod Sema is dominated by rice farming with a planting intensity of two to three times per year. Planting patterns are established through agreement among subak members, taking into account the availability of irrigation water, agroclimatic conditions, and cultivation needs. In practice, farmers generally use superior rice varieties adjusted to local environmental conditions and market needs. The existence of a still actively functioning subak system enables collective farm management, thereby supporting efficient resource management and the sustainability of rice production.

In addition to producing rice for consumption, some farmers in Subak Dlod Sema also develop certified rice seed multiplication businesses. The existence of seed multiplication activities indicates a diversification of farming activities undertaken

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by farmers in response to the continuously increasing need for quality seeds. In addition, seed multiplication activities are also seen as an alternative business that can provide added value compared to consumption rice farming. This condition encourages some farmers to become involved in certified rice seed production activities as part of the development of their farming business.

Rice seed multiplication farming activities in Subak Dlod Sema have developed since 2013 and continue to this day. The continuity of this activity indicates that seed multiplication has become one of the agricultural activities pursued by some subak members. Nevertheless, the number of farmers involved in rice seed production is not always the same in each planting season. This dynamic is influenced by various considerations faced by farmers, related to farming conditions, resource availability, and individual decisions in determining the type of business to be run each planting season. Variation in the number of seed-multiplying farmers over time indicates that farmer involvement in the seed multiplication business is a dynamic process influenced by various factors developing at the farmer level and within the business environment.

2. General Characteristics of Respondents

The general characteristics of respondents in this study represent a description of the characteristics of individuals that distinguish them from other individuals. Respondents in this study consisted of seed-multiplying farmers and consumption rice farmers. The general characteristics observed in this study included age, formal education, farming experience, number of family members, main occupation, land ownership status, and land management status.

Age of Respondents

The results of this study show that the average age of seed-multiplying farmers at the research location is 55.87 years, while the average age of consumption rice farmers is 55.18 years. Overall, the average age of respondents in this study is 55.38 years, so it can be said that the age of farmers at the research location generally falls within the range of 55 years. The majority of the ages of both seed-multiplying farmers and consumption rice farmers fall within the 40–65 year range. As can be seen in Table 1, as many as 48 people, or 90.57 percent of respondents, are in the 40–65 year age group, while respondents under 40 years old number 2 people (3.77 percent) and respondents over 65 years old number 3 people (5.66 percent).

This study found that the majority of respondents are of productive age. According to the Central Statistics Agency (BPS, 2024), the population aged 15–64 years is classified within the productive age group. Productive age is the phase in which a person still has optimal physical ability, labor capacity, and work capacity to carry out economic activities. Based on the research data, as many as 50 people, or 94.34 percent of respondents, are within the productive age group (<65 years), while only 3 people, or 5.66 percent, have entered the elderly age group (>65 years). This indicates that most rice farmers in Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency are still of productive working age, so that in terms of physical condition, experience, and managerial capability, they still have adequate capacity to carry out production activities and manage their rice farming businesses.

Table 1. Age of Respondents – Seed-Multiplying Farmers and Consumption Rice Farmers in Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency

No	Age Group (Years)	Seed Multiplier		Consumption Rice Farmer		Total	
		Number	(%)	Number	(%)	Number	(%)
1	< 40	1	6.67	1	2.63	2	3.77
2	40 – 65	13	86.67	35	92.11	48	90.57
3	> 65	1	6.67	2	5.26	3	5.66
	Total	15	100.00	38	100.00	53	100.00
	Average	55.87		55.18		55.38	

Source: Primary Data, processed (2024)

The results show that the age structure of both seed-multiplying farmers and consumption rice farmers is dominated by the 40–65 year age group. Based on Table 1, only 2 people (3.77 percent) of farmers are under 40 years old, consisting of 1 seed-multiplying farmer and 1 consumption rice farmer. This age distribution indicates that the number of young farmers at the research location is still relatively small compared to the number of farmers in the 40–65 year age group. Young farmers are farmers within the 19–39 year age range (Ministry of Agriculture, 2013). The low proportion of farmers under 40 years old indicates that the process of farmer regeneration at the research location is still proceeding slowly. The dominance of farmers in the 40–65 year age group also indicates a tendency toward the aging farmer phenomenon, although most respondents are still within the productive

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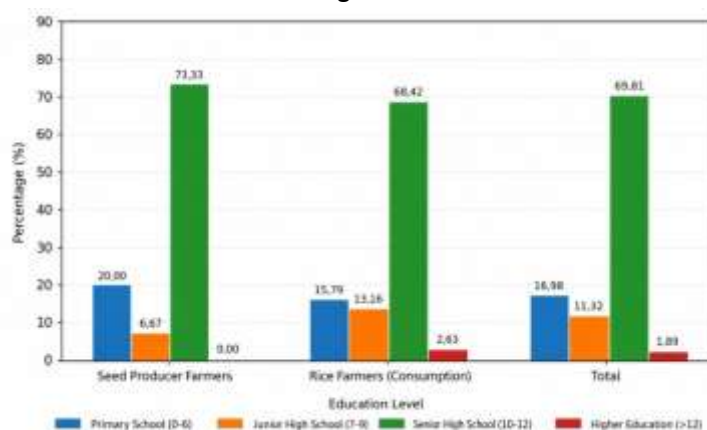
age category. If this condition continues without adequate regeneration over the next 10–20 years, it has the potential to reduce the agricultural labor force, decrease the production capacity of the agricultural sector, and threaten the sustainability of rice farming in the study area. Therefore, various efforts are needed to accelerate farmer regeneration. According to Marpaung and Bangun (2023), such efforts can be carried out through increased educational support, changing perceptions of the economic prospects of the agricultural sector, extension services regarding agricultural production and distribution, and economic support from the government.

Formal Education

The level of formal education of farmers can affect their ability to adopt new innovations and technologies, which is expected to provide benefits in the development of rice farming, both for consumption rice farmers and seed-multiplying farmers. According to Ishaq and Ruswandi (2018), a person's level of formal education influences their mindset and reasoning ability. The higher the level of education a farmer has completed, the more rational and systematic their thinking, and the broader their knowledge and insight compared to farmers with lower levels of education.

The level of formal education in this study is divided into four levels: Elementary School (SD) (0–6 years), Junior High School (SLTP) (7–9 years), Senior High School (SLTA) (10–12 years), and Higher Education (>12 years). The results of this study show that the majority of respondents in both farming groups had completed education up to the Senior High School (SLTA) level. As many as 37 respondents, or 69.81 percent, had completed education up to the SLTA level (Figure 2). Meanwhile, respondents with an elementary school (SD) education numbered 9 people (16.98 percent), SLTP graduates numbered 6 people (11.32 percent), and only 1 person (1.89 percent) had completed education up to the higher education level.

Figure 2.



Percentage of Education Level of Consumption Rice Farmers and Seed-Multiplying Rice Farmers

When examined by farming group, the majority of seed-multiplying farmers are SLTA graduates, at 73.33 percent, followed by SD graduates at 20.00 percent and SLTP graduates at 6.67 percent. Meanwhile, in the consumption rice farmer group, 68.42 percent of respondents are SLTA graduates, 15.79 percent are SD graduates, 13.16 percent are SLTP graduates, and 2.63 percent have completed education up to the higher education level. This condition shows that the education level of farmers at the research location is dominated by secondary education, so that in general farmers already have sufficient basic ability to receive information, understand innovations, and apply technology related to rice farming activities. Education needs to be given attention because it is one of the important factors in shaping farmers' abilities and expanding their knowledge.

Farmers with higher levels of education tend to have better cognitive ability, literacy, and analytical skills, as well as broader access to information, compared to farmers with lower levels of education (Hermawan et al., 2025). This is in line with Rivanda et al. (2015), who state that higher education makes farmers more open and more capable of accepting and adopting new technology. With an open attitude and good analytical ability, farmers will be more able to adopt efficient farming practices.

In efficient consumption rice farming practices, farmers are able to apply fertilization precisely and use water-efficient irrigation systems. Farmers can also carry out pesticide spraying in accordance with the 5T principle (correct type, dose, timing, method, and target). Meanwhile, in seed multiplication farming, efficiency practices are reflected in farmers' thoroughness in following seed certification standards, carrying out roguing to eliminate off-type/CVL plants that do not match the variety, and their ability to determine which varieties to multiply based on economic considerations. Thus, a higher level of education has the potential to improve farmers' managerial ability and decision-making in allocating production inputs more optimally, thereby not

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only encouraging increased technical efficiency and reducing the level of farm inefficiency, but also contributing to increased productivity, both in terms of quality and quantity of yield.

Farming Experience

Work experience describes the length of time a person has carried out a particular job, enabling that individual to understand, master, and complete their work more effectively and efficiently. Experience can also reflect a person's level of ability, skill, and knowledge in their field of work. The results of this study show that the average experience of seed-multiplying farmers in their field of work is 16.40 years, while consumption rice farmers have an average farming experience of 18.47 years. Overall, the average experience of respondents in this study is 17.89 years. The length of experience of seed-multiplying farmers in this study varies, ranging from 4 years to 50 years, while consumption rice farmers have experience ranging from 5 years to 40 years. Based on these results, consumption rice farmers have a longer average farming experience compared to seed-multiplying farmers. This condition is thought to be related to the seed multiplication farming activity in Subak Dlod Sema, which only began to develop in 2013. Thus, some seed-multiplying farmers are relatively newer to seed multiplication activities compared to their experience in rice farming in general, so that the average experience in the seed-multiplying farmer group is lower than in the consumption rice farmer group.

Table 2. Experience of Respondents – Seed-Multiplying Farmers and Consumption Rice Farmers in Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency

No	Farming Experience (Years)	Seed Multiplier		Consumption Rice Farmer		Total	
		Number	(%)	Number	(%)	Number	(%)
1	4 – 19	11	73.33	21	60.00	32	66.38
2	20 – 35	3	20.00	16	40.00	19	35.85
3	36 – 50	1	6.67	1	0.00	2	3.77
Total		15	100.00	38	100.00	53	100.00
Average		16.40		18.47		17.89	

Source: Primary Data, processed (2024)

The results in Table 2 show that 73.33 percent, or 11 people, of seed-multiplying farmers have farming experience ranging from 4–19 years, followed by 20 percent or 3 people with 20–35 years of experience, and 6.67 percent or 1 person with 36–50 years of experience in their field. Meanwhile, in the consumption rice farmer group, 55.26 percent or 21 people have a range of farming experience of 4–19 years, 16 people (42.11 percent) have 20–35 years of experience, and 1 person (2.63 percent) has 36–50 years of experience in their field. Overall, the majority of respondents have farming experience within the 4–19 year range, namely 32 people, or 60.38 percent of total respondents. Furthermore, 19 people (35.85 percent) have 20–35 years of farming experience, and only 2 people (3.77 percent) have more than 35 years of experience. These findings indicate that most respondents already have relatively extensive farming experience.

Farming experience is one of the factors that can affect farmers' level of technical efficiency. Handayani et al. (2023) showed that farming experience is one of the factors affecting technical inefficiency in organic rice farming in Lampung Province. In line with these findings, Firmana et al. (2016) and Hermawan et al. (2025) showed that farming experience is related to the level of technical efficiency of rice farmers. Farmers with longer farming experience tend to have a better understanding of cultivation activities and farm management, which can support decision-making in the use of production factors.

In consumption rice farming practices, experience can help farmers determine the appropriate planting time, manage the use of fertilizers and pesticides more efficiently, and adjust cultivation techniques to local environmental conditions. Meanwhile, in seed multiplication farming, experience plays an important role in maintaining varietal purity, carrying out roguing activities, meeting seed certification standards, and managing the production process to produce seeds that meet quality standards. Thus, farming experience can help farmers anticipate production risks, adjust cultivation techniques to field conditions, and determine a more efficient combination of inputs, thereby having the potential to increase technical efficiency and reduce the level of farm inefficiency.

Number of Family Dependents

The number of family dependents is one indicator of the economic burden borne by the head of the household. The greater the number of dependents, the greater the household expenditure needs, including for food consumption, education, and health. In addition, according to Mita et al. (2018), the number of dependents has a positive effect on farmers' decisions to adopt rice

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seed multiplication farming innovations. This is because the greater the burden of dependents, the more farmers are encouraged to increase their income through the adoption of innovation in order to meet their family's needs.

Table 3. Number of Family Dependents of Respondents – Seed-Multiplying Farmers and Consumption Rice Farmers in Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency

No	Number of Family Dependents (Persons)	Seed Multiplier		Consumption Rice Farmer		Total	
		Number	(%)	Number	(%)	Number	(%)
1	1 – 2	3	20.00	11	28.95	11	26.42
2	3 – 4	7	46.67	21	55.26	28	52.83
3	5 – 7	5	33.33	6	15.79	14	20.75
	Total	15	100.00	38	100.00	53	100.00
	Average	3.60		3.21		3.32	

Source: Primary Data, processed (2024)

The results of this study show that the average number of family dependents for seed-multiplying farmers is 3.60 people, while for consumption rice farmers it is 3.21 people. Overall, the average number of family dependents of respondents in this study is 3.32 people, so it can be said that the number of family dependents of farmers at the research location generally falls within the range of 3–4 people, or is classified as a medium-sized household. As can be seen in Table 3, the majority of respondents have 3–4 family dependents, namely 28 people or 52.83 percent, followed by 14 people or 26.42 percent with 1–2 family dependents, and 11 people or 20.75 percent with 5–7 family dependents.

When examined by type of farming, in the seed-multiplying farmer group, 3 people (20.00 percent) have 1–2 family dependents, 7 people (46.67 percent) have 3–4 family dependents, and 5 people (33.33 percent) have 5–7 family dependents. Thus, most seed-multiplying farmers have medium-sized families, namely 3–4 people (46.67 percent).

Meanwhile, in the consumption rice farmer group, 11 people (28.95 percent) have 1–2 family dependents, 21 people (55.26 percent) have 3–4 family dependents, and 6 people (15.79 percent) have 5–7 family dependents. This distribution shows that the majority of consumption rice farmers also have a medium number of family dependents (3–4 people). In addition, the proportion of consumption rice farmers with 1–2 family dependents is relatively larger compared to seed-multiplying farmers, while the proportion with 5–7 family dependents is more commonly found among seed-multiplying farmers.

The number of family dependents is an important factor that can influence work motivation, economic burden, and the efficiency of household income allocation among farmers. The greater the number of family dependents, the greater the economic needs that must be met, requiring farmers to manage their farming more productively and efficiently in order to maintain household income stability. In the context of rice farming, the number of family dependents can also influence farmers' decisions in allocating production inputs, the use of family labor, and the application of technological innovation to increase farm productivity and income.

Main Occupation, Land Ownership Status, and Land Management Status

Based on Table 4, most respondents, namely 44 people or 83.02 percent, have farming as their main occupation. When examined by type of farming, in the seed-multiplying farmer group, 12 people (80.00 percent) have farming as their main occupation, while 3 people (20.00 percent) have a main occupation outside the agricultural sector. Meanwhile, in the consumption rice farmer group, 32 people (84.21 percent) work as farmers, and 6 people (15.79 percent) have a main occupation outside the agricultural sector. Based on these results, it can be seen that the agricultural sector remains the main source of livelihood for most of the community at the research location. This condition shows that agricultural activity, particularly rice farming, still plays an important role in supporting the household economy of farmers in the study area.

Table 4. Characteristics of Respondents – Seed-Multiplying Farmers and Consumption Rice Farmers in Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency

No.	Farmer Characteristics	Seed Multiplier		Consumption Rice		Total	
		Number	%	Number	%	Number	%
1	Main Occupation						
	Farmer	12	80.00	32	84.21	44	83.02
	Non-Farmer	3	20.00	6	15.79	9	16.98

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No.	Farmer Characteristics	Seed Multiplier		Consumption Rice		Total	
2	Land Ownership Status						
	Owner	7	46.67	21	55.26	28	52.83
	Non-Owner	8	53.33	17	44.74	25	47.17
3	Land Management Status						
	Self-Cultivated	15	100.00	34	89.47	49	92.45
	Cultivated by Others	0	00.00	4	10.53	4	7.55

Source: Primary Data, processed (2024)

Regarding land ownership status, the results show that of the 53 respondents, 28 people (52.83 percent) are landowners, while 25 people (47.17 percent) are respondents who do not own their own land. When examined by type of farming, consumption rice farmers more often own their own land, namely 21 people (55.26 percent), compared to seed-multiplying farmers, of whom 7 people (46.67 percent) own land. Meanwhile, consumption rice farmers who do not own their own land number 17 people (44.74 percent), while in the seed-multiplying farmer group there are 8 people (53.33 percent). Land ownership is an important production asset because it provides farmers with greater flexibility in determining planting patterns, input use, and long-term decision-making in farming.

Based on land management status, it can be seen in Table 4 that of the 53 respondents, 49 people (92.45 percent) cultivate their own land, while 4 people (7.55 percent) have their land cultivated by others. In the seed-multiplying farmer group, all respondents, or 15 people (100.00 percent), cultivate their own land, and there are no respondents whose land is cultivated by others. Meanwhile, in the consumption rice farmer group, 34 people (89.47 percent) cultivate their own land, and 4 people (10.53 percent) have their land cultivated by others. This shows that most farmers in both farming groups are directly involved in managing the land they cultivate. Independent land management generally provides greater control over cultivation activities, from determining planting time and the use of production inputs, to supervising the crop maintenance process. This condition can also support the application of better cultivation technology and increase the efficiency of production factor use.

3. Characteristics of Consumption Rice Farming and Seed Multiplier Farming

In this study, the average production and the amount of input use in consumption rice farming and seed multiplier farming in Subak Dlod Sema can be seen in Table 5. Based on Table 5, there is a difference between consumption rice farming and seed multiplier farming, which shows that the average production of seed multiplier rice farming is higher than that of consumption rice farming.

The average production of consumption rice farming is 7,203.02 kg/ha, while the production of seed multiplier rice farming reaches 8,195.02 kg/ha (Table 5). This shows that the productivity of seed multiplier farming is higher, by 992.00 kg/ha, compared to consumption rice farming. This productivity difference is thought to be related to differences in cultivation management, the use of certified seeds, and the application of stricter production standards in seed multiplier farming. Ernawati et al. (2025) state that seed multiplier rice farming has better economic characteristics because the use of certified superior seeds is able to increase the productivity and quality of the harvest. The use of certified superior seeds not only has an impact on increased production yield, but also has the potential to increase the economic value of the resulting product.

In terms of input use, the average seed use among seed multiplier farmers is 26.43 kg/ha, while for consumption rice farmers it is 30.16 kg/ha (Table 5). Seed use in both types of farming is in accordance with the recommended guideline of 25–30 kg/ha (Irfan et al., 2019). Although seed use among consumption rice farmers is relatively higher, the productivity produced is still lower than that of seed multiplier farming. This condition indicates that high seed use is not always directly proportional to increased production yield, but is also influenced by seed quality. According to Akbar et al. (2023), the use of high-quality, certified superior seeds is able to produce higher productivity compared to non-certified seeds. This increase in productivity can ultimately contribute to increasing the income and profit received by farmers.

In addition, the average use of urea fertilizer among seed multiplier farmers is 240.89 kg/ha and Phonska fertilizer is 399.13 kg/ha, while among consumption rice farmers the average use of urea fertilizer is 226.89 kg/ha and Phonska fertilizer is 394.35 kg/ha. The dosage used by both types of farming shows a different pattern compared to the recommended fertilization dosage. The use of urea fertilizer by both seed multiplier farmers and consumption rice farmers is still slightly below the recommended dosage of 250–300 kg/ha. Conversely, the use of Phonska fertilizer among both groups of farmers far exceeds the recommended dosage range of 150–250 kg/ha (Irfan et al., 2019; Kementan, 2007). This condition indicates that farmers tend to rely on the compound fertilizer Phonska to meet plant nutrient needs, while urea fertilizer use is relatively lower than recommended. In

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addition, it can be seen that seed multiplier farmers tend to use fertilizer in greater amounts compared to consumption rice farmers. This more intensive fertilizer use is thought to be related to the efforts of multiplier farmers to maintain plant growth so as to meet seed production quality standards.

Table 5. Average production and input use in farming in Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency

Description	Unit	Seed Multiplier	Consumption Rice
Production	Kg/Ha	8,195.02	7,203.02
Land Area	Ha	0.48	0.33
Seed	Kg/Ha	26.43	30.16
Urea	Kg/Ha	240.89	226.89
Phonska	Kg/Ha	399.13	394.35
Pesticide	Liter/Ha	6.26	4.70
Labor	HOK/Ha (man-workdays/ha)	72.92	68.24

Source: Primary Data, processed (2024)

In addition to fertilizer use, farmers in both types of farming also use pesticides to control pests and plant diseases in order to minimize harvest loss. The average pesticide use in consumption rice farming is 4.70 liters/ha, while in seed multiplier farming it is 6.26 liters/ha (Table 5). This dosage is higher than the recommended dosage of 3–4 liters/ha (Irfan et al., 2019). The higher pesticide use in seed multiplier farming is thought to be related to efforts to maintain plant health and the quality of the seed produced. In seed multiplication businesses, seed quality is an important aspect because the seed produced must meet quality and certification standards, so that pest and disease control tends to receive greater attention compared to consumption rice farming. Nevertheless, pesticide use that exceeds the recommended dosage needs attention because it does not always result in a comparable increase in production. According to Dhaifulloh et al. (2024), excessive pesticide use can have a negative impact on the agricultural environment and farmers' health. The application of integrated pest management (IPM) principles and the use of pesticides in accordance with recommended dosages is important to improve the efficiency of input use while maintaining the sustainability of farming (Yassin et al., 2026).

Another input used in farming production in this study is labor. The average labor use in consumption rice farming is 68.24 man-workdays/ha (HOK/ha), while in seed multiplier farming it is 72.92 man-workdays/ha (Table 5). These results show that labor use in seed multiplier farming is slightly higher than in consumption rice farming. Although the cultivation stages of the two types of farming are generally relatively similar, seed multiplication activities require additional treatments such as roguing, or plant selection, to maintain varietal purity and the quality of the seed produced. According to Sultana et al. (2019), roguing activity is an important component in rice seed production that requires precision and additional labor.

4. Efficiency Analysis of Consumption Rice Farming and Seed Multiplier Rice Farming

Efficiency analysis in this study was conducted using the Cobb-Douglas production function. Estimation of the production function can be carried out through two approaches, namely the Ordinary Least Squares (OLS) method and the Maximum Likelihood Estimation (MLE) method. The purpose of using the OLS method is to estimate the initial model and identify any violations of classical assumptions before estimating the stochastic frontier model using the MLE method. The classical assumption tests carried out include tests for normality, multicollinearity, and heteroscedasticity. The OLS method is also used to test the feasibility and consistency of the initial model, so that the estimated model can be used at the technical efficiency analysis stage.

In this study, the estimated production function satisfied all classical assumptions, so that the model is feasible to proceed to the stochastic frontier estimation stage using the MLE method. The normality test results for the production function estimation model show that the data are normally distributed. This is indicated by a Jarque-Bera probability value of 0.939845 (>0.05) for the seed multiplier farming model and 0.596271 (>0.05) for the consumption rice farming model. A probability value greater than the 5 percent significance level indicates that the residuals of both models are normally distributed.

Furthermore, based on the multicollinearity test on the production estimation function for both seed multiplier and consumption rice farming, no symptoms of multicollinearity were found among the independent variables. This is indicated by Variance Inflation Factor (VIF) values for all independent variables that are smaller than 10.00, so that it can be concluded that the model satisfies the multicollinearity assumption.

The heteroscedasticity test results using the Glejser test also show that there are no symptoms of heteroscedasticity in the model. Based on the test results, the Prob. Chi-Square (Obs*R-squared) value for the seed multiplier farming model is 0.2305

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(>0.05), while for the consumption rice farming model it is 0.5389 (>0.05). A probability value greater than the 5 percent significance level indicates that the residuals of both models have constant variance (homoscedastic).

With all of the classical assumptions above satisfied, the Cobb-Douglas production function model in this study is considered feasible and consistent to proceed to the stochastic frontier estimation stage using the Maximum Likelihood Estimation (MLE) method, in order to measure the level of technical efficiency of farmers in both seed multiplier and consumption rice farming.

The results of the Cobb-Douglas production function estimation for seed multiplier farming and consumption rice farming using the Ordinary Least Squares (OLS) method are shown in Table 6. This study's model uses six independent variables to measure the effect of input use on production, namely land area (X1), seed (X2), urea fertilizer (X3), Phonska fertilizer (X4), pesticide (X5), and labor (X6). The OLS method is used to estimate the Cobb-Douglas production function and to analyze the effect of each input on production. The estimated coefficients show the production elasticity of each input, while the effect of each variable on production is analyzed based on the t-ratio value.

The results of the production function estimation using the OLS method show a coefficient of determination (R^2) value of 0.964, or 96.4 percent, for seed multiplier farming and 0.996, or 99.6 percent, for consumption rice farming. This means that the variables of land area, seed, urea fertilizer, Phonska fertilizer, pesticide, and labor are able to explain 96.4 percent of the variation in production of seed multiplier farming and 99.6 percent of the variation in production of consumption rice farming in Subak Dlod Sema. Meanwhile, the remaining 3.6 percent and 0.4 percent, respectively, are explained by other factors outside the model that were not included in this study. The high coefficient of determination values in both types of farming indicate that the input variables used in the model have a high ability to explain the variation in production at the research location.

Table 6. Cobb-Douglas Production Function Estimation for Seed Multiplier Farming and Consumption Rice Farming Using the OLS Method in Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency

Variable	Seed Multiplier: Coefficient	Seed Multiplier: t-ratio	Consumption Rice: Coefficient	Consumption Rice: t-ratio
Constant	2.383	5.769	3.884	37.798
Land Area (X1)	0.023	0.093	0.952***	21.48
Seed (X2)	0.262	1.342	0.002	0.068
Urea (X3)	0.201	1.316	-0.013	-0.555
Phonska (X4)	-0.055	-0.443	0.000	0.022
Pesticide (X5)	0.071	1.569	0.011	0.629
Labor (X6)	0.395*	2.256	-0.020	-0.527
R-squared (%)	96.4		99.6	

*** = 99% confidence level (t-table = 3.355); ** = 95% confidence level (t-table = 2.306); * = 90% confidence level (t-table = 1.860)

The land area variable (X1) shows different results between seed multiplier farming and consumption rice farming. In seed multiplier farming, land area has a coefficient value of 0.023 with a t-ratio value of 0.093, so that it has no significant effect on production at the 10 percent significance level. Nevertheless, the positive coefficient direction indicates a positive relationship between land area and seed multiplier production. This finding is consistent with Mohamad et al. (2025), who found that land area has a positive but not significant effect on paddy rice production. The insignificance of the land area variable in seed multiplier farming is thought to be because the respondents' land area is relatively homogeneous, mostly around 0.40 ha, so that the variation among respondents is limited and the effect of land area on production cannot be significantly detected by the model. In contrast, in consumption rice farming, land area has a coefficient value of 0.952 with a t-ratio value of 21.480, so that it has a significant effect on production at the 1 percent significance level. The coefficient value of 0.952 indicates that every 1 percent increase in land area, assuming other input use remains constant (*ceteris paribus*), is associated with a 0.952 percent increase in consumption rice production. The land area coefficient value is also the largest compared to other input variables in consumption rice farming, indicating that changes in land area produce the largest response to changes in production. This finding is consistent with Klau et al. (2025), Ulpah et al. (2018), and Rivanda et al. (2015), who state that land area has a significant effect on rice production. Land area remains the main production factor in rice farming because it determines the production capacity that farmers can achieve. The larger the land cultivated, the greater the farmer's opportunity to increase the amount of production obtained. This finding is also supported by Ardian (2024), who concluded that land area is one of the factors most consistently positively related to rice production across various farming studies.

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The seed variable (X2) has no significant effect on production in either type of farming. In seed multiplier farming, the seed variable has a coefficient value of 0.262 with a t-ratio value of 1.342, while in consumption rice farming it has a coefficient value of 0.002 with a t-ratio value of 0.068. The positive coefficient in both types of farming indicates a positive relationship between seed use and production, although the effect is not statistically significant. This finding is consistent with Rohman et al. (2021), Febrianto et al. (2024), and Neonbota and Kune (2016), who show that seed use has no significant effect on rice production. The insignificance of the seed variable in seed multiplier farming is thought to be because farmers use relatively uniform amounts and types of seed in accordance with certified seed production standards, while in consumption rice farming most farmers use relatively similar amounts of seed based on cultivation habits that have been applied for generations. Although underpinned by different seed use practices, both conditions cause the variation in seed use among farmers to be relatively small, so that its effect on production variation is not significantly detected in the model. Thus, the amount of seed used has not become the main factor explaining the difference in production between the two types of farming. Klau et al. (2025) explain that rice productivity is determined not only by the amount of input used, but also by the proper and efficient management of production factors.

The urea fertilizer variable (X3) has no significant effect on production in either type of farming. In seed multiplier farming, urea fertilizer has a coefficient value of 0.201 with a t-ratio value of 1.316, while in consumption rice farming it has a coefficient value of -0.013 with a t-ratio value of -0.555. These results show a difference in coefficient direction between the two types of farming, although the effect is equally not statistically significant in both. In seed multiplier farming, the positive coefficient indicates a positive relationship between urea fertilizer use and production, while in consumption rice farming the negative coefficient indicates an opposite direction of relationship. However, because the effect is not statistically significant, this negative coefficient is not strong enough to indicate that increased urea fertilizer use would decrease production. This finding is consistent with Agustarini et al. (2022) and Opu et al. (2022), who show that urea fertilizer use has no significant effect on rice production. The insignificance of the urea fertilizer variable in both types of farming is thought to be because fertilizer use among farmers is relatively uniform, so that variation in its use has not been able to significantly explain differences in production in the model.

The Phonska fertilizer variable (X4) has no significant effect on production in either type of farming. In seed multiplier farming, Phonska fertilizer has a coefficient value of -0.055 with a t-ratio value of -0.443, while in consumption rice farming it has a coefficient value of 0.000 with a t-ratio value of 0.022. These results show that Phonska fertilizer use has a different coefficient direction in the two types of farming, but both have no significant effect on production. In seed multiplier farming, the negative coefficient indicates an opposite relationship between Phonska fertilizer use and production, but this relationship is not statistically significant, so it is not strong enough to indicate that increased Phonska fertilizer use would decrease production. Meanwhile, in consumption rice farming, the coefficient value close to zero indicates that changes in Phonska fertilizer use produce a very small response in production. This finding is consistent with Walis et al. (2021) and Lismawati and Isyanto (2021), who found that NPK fertilizer use has no significant effect on rice production. The insignificance of the Phonska fertilizer variable in both types of farming is thought to be because fertilizer use among farmers is relatively uniform, so that variation in its use has not been able to significantly explain differences in production in the model.

The pesticide variable (X5) has no significant effect on production in either type of farming. In seed multiplier farming, pesticide has a coefficient value of 0.071 with a t-ratio value of 1.569, while in consumption rice farming it has a coefficient value of 0.011 with a t-ratio value of 0.629. The positive coefficient in both types of farming indicates a positive relationship between pesticide use and production, although the effect is not statistically significant. This finding is consistent with Walis et al. (2021), Opu et al. (2022), and Lismawati and Isyanto (2021), who show that pesticide use has no significant effect on rice production. The insignificance of the pesticide variable is thought to be because pesticide use among farmers is relatively uniform, so that variation in its use has not been able to significantly explain differences in production in the model. In addition, pesticide use plays more of a role in controlling attacks by plant pest organisms and reducing the risk of yield loss than in directly increasing production.

The labor variable (X6) shows different results between seed multiplier farming and consumption rice farming. In seed multiplier farming, labor has a coefficient value of 0.395 with a t-ratio value of 2.256, so that it has a significant effect on production at the 10 percent significance level. This coefficient value indicates that every 1 percent increase in labor use, assuming other inputs remain constant (*ceteris paribus*), is associated with a 0.395 percent increase in seed multiplier production. This positive and significant effect indicates that labor plays an important role in the seed multiplication production process. This is related to the characteristics of seed multiplication activities, which require more intensive management compared to consumption rice farming. Sayaka and Hidayat (2015) state that seed multiplication activities require additional labor to carry out roguing and more intensive plant care in order to maintain the quality of the seed produced. In contrast, in consumption rice farming, labor has a coefficient value of -0.020 with a t-ratio value of -0.527, so that it has no significant effect on production. The negative coefficient

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indicates an opposite relationship between labor use and production, but because the effect is not statistically significant, this result is not strong enough to indicate that increased labor use would decrease consumption rice production. This finding is consistent with Agustarini et al. (2022), Walis et al. (2021), and Opu et al. (2022), who found that labor has no significant effect on rice production. The difference in results between the two types of farming indicates that the role of labor is more evident in seed multiplication activities, which require more intensive cultivation stages and quality supervision, whereas in consumption rice farming, additional labor use has not shown a significant relationship with increased production.

After analyzing the effect of production factor use through the Cobb-Douglas production function using the OLS method, the next analysis was conducted to estimate the technical efficiency of farming using the stochastic frontier approach. The stochastic frontier model parameters for seed multiplier and consumption rice farming are presented in Table 7.

Table 7. Stochastic Frontier Model Parameters for Seed Multiplier and Consumption Rice Farming in Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency

Parameter	Seed Multiplier	Consumption Rice
Sigma-squared (σ^2)	0.0016	0.0002
Gamma (γ)	0.9999	0.2044
Log likelihood	33.5900	103.7802
LR test	11.5906	11.1363

Source: Primary Data, processed (2024)

In seed multiplier farming, a sigma-squared value of 0.0016 and a gamma value of 0.9999 were obtained. This shows that 99.99 percent of the residual variation in the model comes from technical inefficiency factors, while the remainder comes from random factors (random error, or v_i). The gamma value, which is very close to one, indicates that the residual variation in the seed multiplier farming model is dominated by the technical inefficiency component. Nevertheless, these results need to be interpreted with caution, given that the number of multiplier farmers at the research location is relatively limited, namely 15 people, and comes from a relatively homogeneous production environment. This condition indicates that the variation among respondents is relatively small, which can affect the frontier parameter estimation results.

Meanwhile, in consumption rice farming, a sigma-squared value of 0.0002 and a gamma value of 0.2044 were obtained, meaning that only about 20.44 percent of the residual variation comes from technical inefficiency factors, while the remaining 79.56 percent comes from random factors (random error) or other factors beyond the farmers' control. This condition indicates that consumption rice farmers at the research location have a relatively uniform level of farm management, so that the variation in production that occurs tends to be influenced by factors that cannot be fully controlled by farmers, such as weather conditions, attacks by plant pest organisms, and other environmental factors.

The difference in gamma values between the two farming groups indicates that the sources of production variation occurring in seed multiplier farming and consumption rice farming have different characteristics. In seed multiplier farming, residual variation is estimated to be more related to the technical inefficiency component, which may indicate that farmers' ability to manage the production process is one of the factors that differentiates production achievement among farmers. This condition is thought to be related to the characteristics of the seed multiplication business, which demands the application of more specific cultivation techniques compared to consumption rice farming, so that differences in farmers' managerial and technical abilities have the potential to affect the production yield obtained.

In contrast, in consumption rice farming, most of the residual variation actually comes from random factors and other factors outside the model. This shows that differences in technical ability among farmers are relatively not the main source of production variation. This condition is thought to be related to the relatively uniform cultivation pattern of consumption rice among farmers, both in terms of technology use, irrigation systems, and cultivation practices applied. As a result, the production variation that occurs is more influenced by external factors that cannot be fully controlled by farmers than by differences in the level of technical efficiency among farmers.

The results of this study also show a Likelihood Ratio (LR) value of 11.5906 for seed multiplier farming, while for consumption rice farming it is 11.1363. The LR-test values for both models are smaller than the Kodde-Palm critical value of 12.5915 at the 5 percent significance level. These results indicate that H_0 fails to be rejected, meaning that the stochastic frontier (MLE) production function model does not statistically provide a significant improvement compared to the OLS model. In other words, the existence of a technical inefficiency component in both types of farming cannot be strongly proven by statistical calculation. Therefore, the

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interpretation of the gamma value, especially the very high gamma value in seed multiplier farming, needs to be done carefully and cannot be directly used as evidence that residual variation is dominantly caused by technical inefficiency.

The condition above is thought to be related to the relatively homogeneous characteristics of the respondents, because all farmers are located within a single Subak area with relatively similar agroecological conditions and irrigation systems. Subak is a traditional farmer institution in Bali that plays a role in coordinating the various interests of its members, both those related to agricultural management and to farmers' socio-economic life (Widodo, 1978). One of the main functions of Subak in agricultural activities is to regulate the management and distribution of irrigation water in a coordinated manner to support the farming activities of its members (Resiani and Sunanjaya, 2020). In addition, Subak serves as a space for learning and knowledge exchange processes, both formal and informal, which contributes to the formation of farmers' knowledge, attitudes, and skills (Sukanteri et al., 2021). The Subak institution also serves as a forum for coordinating agricultural activities that supports interaction and cooperation among farmers in farm management (Sedana et al., 2021). In the context of the research location, this institutional function is reflected in the arrangement of water distribution and planting time, the implementation of extension activities, access to subsidized fertilizer, and information exchange among farmers. These various forms of coordination allow farmers who are members of the same Subak to obtain access to information and to apply relatively similar farm management practices.

The uniformity of the production environment and farm management practices is thought to cause the variation among respondents to be relatively limited, so that the technical inefficiency component in the stochastic frontier model becomes more difficult to statistically distinguish from the random error component. This condition may be one of the factors causing the LR-test values in both farming groups to be smaller than the Kodde-Palm critical value, so that the stochastic frontier model has not shown a statistically significant improvement compared to the OLS model. In addition, the limited number of observations, especially in the seed multiplier farmer group, is thought to also affect the model's ability to identify the technical inefficiency component more accurately.

The high coefficient of determination (R^2) value in the OLS model indicates that most of the production variation can be explained by the input variables used in the model. This is consistent with the LR-test results, which show that the stochastic frontier estimation has not provided a statistically significant improvement compared to OLS in explaining the production function. Nevertheless, the stochastic frontier approach was still used in this study to obtain technical efficiency score estimates through the separation of the random error component (v_i) and the technical inefficiency component (u_i). However, the technical efficiency estimation results need to be interpreted with caution, taking into account the non-significant LR-test results.

Based on these estimation results, the following analysis discusses the level of efficiency of seed multiplier and consumption rice farming, which includes technical efficiency, allocative efficiency, and economic efficiency.

Technical Efficiency

Technical efficiency in rice farming is achieved when farmers are able to produce a given level of output using the minimum possible input, or to produce the maximum output from a given level of input. The analysis of technical efficiency in this study was conducted using the stochastic frontier approach, which not only estimates the parameters of the production function but also provides information on the technical efficiency of each farmer and the factors influencing their inefficiency. The stochastic frontier approach is also able to separate the effect of random error from the effect of technical inefficiency in the production process, so that the resulting estimates can more accurately describe the actual condition of the farming enterprise.

The results of the technical efficiency level analysis are presented in Table 8. The efficiency index values in this study were divided into three categories: a technical efficiency (TE) value of $TE < 0.70$ was classified as not yet efficient; a TE value between 0.70 and 0.90 was classified as fairly efficient; and a TE value ≥ 0.90 was classified as efficient (Coelli et al. 1998). The results of this study show that the majority of seed-multiplier farmers were already efficient in their production techniques (86.67%), while 13.33 percent of farmers had efficiency index values in the fairly efficient category ($0.70 < TE < 0.90$). Meanwhile, for consumption rice farming, the entire distribution of technical efficiency index values among respondents was in the efficient category ($TE > 0.90$). This indicates that consumption rice farmers are relatively more homogeneous in their ability to manage production factors compared with seed-multiplier farmers.

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Table 8. Distribution of technical efficiency (TE) index of farming enterprises in Subak Dlod Sema, Sading Village, Mengwi Sub-district, Badung Regency

Technical Efficiency	Seed Multiplier		Consumption Rice	
	Number	%	Number	%
TE < 0.70	0	0.00	0	0.00
0.70 – 0.90	2	13.33	0	0.00
> 0.90	13	86.67	38	100.00
Total	15	100.00	38	100.00
Maximum TE	0.999		0.999	
Minimum TE	0.867		0.956	
Average	0.954		0.985	

Source: Primary Data, processed (2024)

Table 8 shows that seed-multiplier rice farming has an average technical efficiency value of 0.954, with a maximum efficiency value achievable by farmers under the best-practice management conditions of 0.999 and a minimum of 0.867. Based on the stochastic frontier production function model, the technical efficiency (TE) level attained by seed-multiplier rice farming enterprises falls into the efficient category. Likewise, consumption rice farming is also classified as efficient, with an average TE value of 0.985. The maximum technical efficiency index value for consumption rice farming is 0.999, with a minimum value of 0.956. The minimum value, which remains above 0.90, indicates that all consumption rice farmers have reached the technically efficient category. The high average technical efficiency indicates that farmers at the research site have been able to allocate the use of production inputs such as seed, fertilizer, pesticides, and labor in a relatively optimal manner in accordance with the needs of their farming enterprises.

According to Sumaryanto et al. (2003), a high level of technical efficiency can be interpreted from two perspectives. On one hand, this condition indicates that farmers already possess good managerial ability, including in accessing information and making appropriate decisions regarding the use of production factors. On the other hand, high technical efficiency also indicates that opportunities to increase productivity through improved farm management are becoming increasingly limited, because the gap between the productivity already achieved and the maximum (frontier) productivity level is becoming smaller. This condition is reflected in consumption rice farming, which has a higher average technical efficiency than seed-multiplier farming. As opportunities to increase productivity through improvements in cultivation practices that have already been applied become narrower, further increases in production require support from technological innovation, such as the use of superior varieties, the application of more advanced cultivation techniques, and agricultural mechanization. For seed-multiplier farming, the application of such innovations becomes even more important because the seed production process must meet stricter quality standards, so that every stage of cultivation is required to comply with seed certification procedures, unlike consumption rice farming.

The results of this study also show the sources of technical inefficiency derived from the stochastic frontier production model. The factors used to estimate technical inefficiency in this study were farmer's age, farmer's formal education, farming experience, and the number of family dependents. These factors are presumed to influence farmers' ability to make production decisions, adopt technology, and manage the use of inputs efficiently in their farming activities.

Table 9. Estimation results of the technical inefficiency effects of the stochastic frontier production model of farming enterprises in Subak Dlod Sema, Sading Village, Mengwi Sub-district, Badung Regency

Variable	Seed Multiplier		Consumption Rice	
	Coefficient	t-ratio	Coefficient	t-ratio
Constant	-0.1798	-0.2758	-0.0011	-0.0189
Farmer's Age (Z1)	0.0065	0.5839	0.0024	1.7093
Formal Education (Z2)	-0.0053	-0.1971	-0.0063	-1.7362

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Farming Experience (Z3)	-0.0015	-0.2225	-0.0036**	-2.3691
Number of Family Dependents (Z4)	-0.0191	-0.5082	0.0002	0.0679

*** = 99% confidence level (t-table = 3.355)

** = 95% confidence level (t-table = 2.306)

* = 90% confidence level (t-table = 1.860)

Based on Table 9, the variables of farmer's age, formal education, farming experience, and number of family dependents did not have a significant effect on the technical inefficiency effect in seed-multiplier farming. Meanwhile, in consumption rice farming, only the farming experience variable had a significant effect on the technical inefficiency effect at the 95 percent confidence level, while the other variables had no significant effect. This is shown by the t-ratio value of each variable compared with the t-table value at the confidence level used. Thus, most of the socioeconomic variables analyzed were not yet able to significantly explain the variation in technical inefficiency among farmers, except for the farming experience variable in consumption rice farming, which was proven to have a significant effect on the technical inefficiency effect. An explanation of each variable is presented below.

a. Farmer's Age (Z1)

Farmer's age is one of the individual characteristics that can theoretically influence the level of technical inefficiency. Farmers who are of productive age generally have better physical capability, find it easier to receive new information, and adopt innovations in farming activities more quickly. Based on Table 9, the age coefficient for seed-multiplier farming was 0.00655 with a t-ratio of 0.583, while for consumption rice farming it was 0.0024 with a t-ratio of 1.7093. These t-ratio values indicate that farmer's age did not have a significant effect on the technical inefficiency effect in either farming group.

The lack of significance of the age variable indicates that differences in farmers' ages have not become a determining factor for the level of technical efficiency. This can be explained by the fact that most respondents belonged to the productive age group with a relatively homogeneous age range, namely around 45–59 years. This homogeneity means that farmers' ability to manage their farming enterprises, adopt innovations, and make production decisions did not differ significantly among farmers. In addition, the cultivation system applied in Subak Dlod Sema is decided jointly by subak members, such as the arrangement of cropping patterns, irrigation management, and extension activities, so that differences in age did not have a significant effect on the level of technical inefficiency.

b. Formal Education (Z2)

Formal education is expected to improve farmers' ability to understand information, adopt technology, and make decisions related to farming activities. Based on the estimation results, the formal-education coefficient for seed-multiplier farming was -0.0053 with a t-ratio of 0.1971, while for consumption rice farming it was -0.0063 with a t-ratio of 1.7362. The negative sign of the coefficient indicates that the higher the farmer's level of education, the lower the tendency toward a technical inefficiency effect, although this effect was not statistically significant.

The results of this study show that formal education did not have a significant effect on the technical inefficiency effect in either farming group. This finding is in line with the study by Cahyati and Hasan (2021), which stated that formal education has a negative relationship with technical inefficiency, but the effect is not significant. This condition is thought to be caused by the relatively homogeneous education level of the respondents, most of whom were senior high school graduates. In addition, knowledge of cultivation techniques is obtained not only through formal education but also through extension activities, training, and the exchange of experience among farmers within the subak organization. As a result, farmers' ability to understand cultivation technology and manage their farming enterprises became relatively uniform, so that formal education did not become a distinguishing factor for the level of technical inefficiency.

c. Experience (Z3)

Farming experience reflects the length of time a farmer has been engaged in cultivation activities, and thus has the potential to improve technical and managerial ability in managing a farming enterprise. Based on Table 9, the farming-experience coefficient for seed-multiplier farming was -0.0015 with a t-ratio of 0.2225, while for consumption rice farming it was -0.0036 with a t-ratio of 2.3691. The negative sign of the coefficient in both models indicates that the longer the farming experience, the lower the tendency toward a technical inefficiency effect.

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However, this effect was significant only for consumption rice farming. This result indicates that farming experience contributes to improving the technical efficiency of consumption rice farmers. The longer a farmer manages their farming enterprise, the greater the accumulated knowledge and skills in determining the use of production inputs, anticipating farming risks, and making cultivation decisions appropriate to field conditions. Thus, the learning-by-doing process that takes place over many years is able to reduce the level of technical inefficiency. This result is in line with the studies of Fadillah (2022) and Triyono et al. (2016), which stated that farming experience can improve farmers' technical and managerial ability, making the use of production factors more efficient.

In contrast to consumption rice farming, farming experience did not have a significant effect on the technical inefficiency effect in seed-multiplier farming. This condition indicates that the success of seed-multiplier farming is determined not only by the length of a farmer's experience but also by compliance with the technical standards of seed production. Seed-multiplier farmers apply relatively uniform cultivation procedures in accordance with seed certification requirements and receive regular technical guidance. This uniformity in the application of standards means that variation in experience among farmers has not been able to significantly explain differences in the level of technical inefficiency.

d. Number of Family Dependents (Z4)

The number of family dependents is presumed to affect technical efficiency because it relates to the availability of family labor as well as the household's economic burden. The estimation results show that this variable did not have a significant effect on the technical inefficiency effect in either seed-multiplier farming or consumption rice farming. For seed-multiplier farming, the coefficient obtained was -0.0191 with a t-ratio of 0.5082, while for consumption rice farming the coefficient was 0.0002 with a t-ratio of 0.0679.

The negative coefficient for seed-multiplier farming indicates a tendency for an increase in the number of family dependents to reduce the technical inefficiency effect, while the positive coefficient for consumption rice farming indicates the opposite tendency. However, neither effect was statistically significant. This condition is thought to be due to the fact that most respondents had a relatively homogeneous number of family dependents, around three to four people, so that the variation in the data was limited. In addition, the number of family dependents does not always reflect the number of family members actually involved in farming activities. Some family members work outside the agricultural sector, are still in school, or have not yet reached productive age, and therefore do not directly contribute to the production process. This finding is in line with Firmana et al. (2016), who stated that the effect of the number of family dependents on technical efficiency can differ across research locations because it is influenced by socioeconomic characteristics and the farming system applied.

Overall, the results of this study show that farmers' socioeconomic characteristics are not the main determinant of technical inefficiency in either farming group. Most of the variables presumed to influence the technical inefficiency effect did not have a significant effect, in either seed-multiplier farming or consumption rice farming. This finding indicates that the variation in technical efficiency among farmers is relatively small, so that individual farmer characteristics are no longer the main factor distinguishing the level of technical efficiency at the research site. This condition is thought to be related to the homogeneity of respondent characteristics and the uniformity of cultivation technology application within the subak institution.

This interpretation is supported by the high average technical efficiency achieved, namely 0.954 for seed-multiplier farming and 0.985 for consumption rice farming. This high level of technical efficiency is also reflected in the farming productivity in Subak Dlod Sema, where the productivity of seed-multiplier farming reached 8,195 kg/ha and that of consumption rice farming reached 7,203 kg/ha. These values are higher than the average rice productivity of Badung Regency in 2023, at 6,831 kg/ha (BPS, 2024), as well as the national rice productivity in 2024, at 5,287 kg/ha (BPS, 2025). This condition indicates that farmers have been able to utilize the available production factors relatively optimally, so that their farming enterprises are operating close to the production frontier.

According to Sumaryanto et al. (2003), a farming enterprise that has been operating close to the production frontier indicates that the gap between actual production and maximum production is becoming increasingly narrow. This condition reflects that farmers' ability to manage production factors has become relatively good, while at the same time indicating that opportunities to increase productivity through improvements in technical efficiency are becoming increasingly limited. Under these conditions, the high level of technical efficiency already achieved causes the variation in technical efficiency among farmers to become relatively narrow, so that differences in farmers' socioeconomic characteristics become less able to explain the variation in inefficiency that occurs.

The high technical efficiency in both farming groups is also thought to be related to the relatively uniform production environment and farm management practices within the subak institution. As explained previously, the coordination of

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agricultural activities and the exchange of information among farmers within the subak institution enable farmers to face relatively similar production conditions and to apply relatively similar farm management practices. This condition is thought to further reduce the variation in technical ability among farmers. Thus, differences in farmers' individual socioeconomic characteristics, such as age, formal education, farming experience, and number of family dependents, have generally not become factors able to significantly explain differences in the level of technical inefficiency in either farming group.

Based on these findings, improving farm performance in Subak Dlod Sema does not depend solely on efforts to increase technical efficiency, given that farmers' technical efficiency level is already relatively high. The role of the subak institution in maintaining the coordination of agricultural activities, supporting the learning process, and strengthening the exchange of information among farmers remains important for sustaining the technical efficiency achievements already attained. Meanwhile, opportunities for further improvement in farm performance need to take into account other dimensions of efficiency, particularly farmers' ability to allocate production factors economically. This aspect is discussed further through the analysis of allocative efficiency and economic efficiency.

Allocative Efficiency and Economic Efficiency

Allocative efficiency reflects farmers' ability to allocate production inputs at optimal price levels, thereby achieving the least-cost combination of inputs to produce a given level of output. Allocative efficiency relates to farmers' ability to make economic decisions regarding the use of production factors based on prevailing input and output prices. The more precisely farmers allocate production inputs, the higher the level of allocative efficiency that can be achieved.

Table 10. Distribution of allocative efficiency (AE) index of farming in Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency

Allocative Efficiency	Seed Multiplication Number	Seed Multiplication %	Consumption Rice Number	Consumption Rice %
AE <0.20	0	0	0	0.00
0.20 – 0.30	14	93.33	38	100
>0.30	1	6.67	0	0
Total	15	100	38	100
Maximum AE	0.312		0.246	
Minimum AE	0.265		0.225	
Average	0.281		0.234	

Source: Primary Data, processed (2024)

Table 10 shows that all farmers in both farming groups have allocative efficiency values above 0.20. In seed-multiplication farming, no farmers had an allocative efficiency value below 0.20 (0.00%). In addition, 14 farmers (93.33%) fell within the 0.20–0.30 range, while 1 farmer (6.67%) had an allocative efficiency value above 0.30. Meanwhile, for consumption rice farming, all respondents (100%) fell within the 0.20–0.30 range. According to Fadillah (2022), allocative inefficiency can occur because farmers fail to allocate production inputs appropriately. Excessive or insufficient input use, expensive input prices, and low output selling prices can cause allocative inefficiency. This ultimately reduces overall economic efficiency.

Based on the allocative efficiency values, seed-multiplication farming has a maximum AE value of 0.312, a minimum value of 0.265, and an average value of 0.281. Meanwhile, consumption rice farming obtained a maximum AE value of 0.246, a minimum value of 0.225, and an average of 0.234. These results indicate that the average allocative efficiency of seed-multiplication farming is higher than that of consumption rice farming. This condition indicates that seed-multiplier farmers are relatively better at allocating the use of production inputs based on the structure of input and output prices. Nevertheless, the allocative efficiency values for both farming groups are still classified as low, so they cannot yet be considered allocatively efficient. The low allocative efficiency value indicates that farmers have not been able to determine the combination of production factor use that produces the minimum production cost for the same level of output. In other words, there is still an opportunity to save on production costs through more appropriate input allocation without having to reduce the production yield obtained.

The results above also show a difference between technical efficiency and allocative efficiency. In the previous discussion, it was found that most farmers had achieved a high level of technical efficiency, indicating an ability to produce output close to the production frontier. However, this high technical efficiency has not been followed by the ability to allocate inputs optimally based on price considerations. As a result, although farmers have been able to produce relatively high output, the production costs

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incurred are still greater than the minimum costs that should be achievable. This condition is in line with the concept of economic efficiency, which states that success in producing output technically does not necessarily lead to the achievement of cost efficiency. Therefore, improving farm performance at the research location requires not only improvements in technical cultivation aspects, but also an increase in farmers' ability to make economic decisions related to the use of production factors.

According to Fadillah (2022), allocative inefficiency occurs when farmers have not been able to allocate the use of production inputs appropriately in accordance with the prevailing price structure. Inefficiency conditions resulting from improper use of production factors were also found by Setiawan and Bowo (2015), who showed that excessive use of inputs in rice farming can increase production costs without producing optimal output. Thus, the use of inputs that is either too much or too little, high production input prices, and low output prices can cause production costs to become inefficient, thereby reducing the overall economic efficiency of the farm.

Compared with the study by Prasmatiwati et al. (2024), seed-multiplication farming in Central Lampung had a higher AE value of 0.7511 compared to the results of this study. This indicates that farmers in Subak Dlod Sema have not been able to optimally allocate production inputs at the prevailing price level. Conditions in which the use of production factors has not achieved allocative efficiency were also found by Nurwansyah et al. (2023), where the use of seeds, urea fertilizer, Phonska fertilizer, pesticides, and labor in lowland rice farming had not been allocatively efficient. At the research location, the low allocative efficiency is thought to be related to the relatively homogeneous pattern of input use among farmers. The uniformity in the use of seeds, fertilizers, pesticides, and labor causes the variation in input use combinations to be relatively small, thereby limiting the opportunity to obtain a more cost-efficient combination. This condition shows that although the cultivation practices applied are relatively uniform, the combination of input use has not fully taken cost efficiency into account based on the prices of production factors.

Economic efficiency describes a farm's ability to achieve a certain level of production at minimum cost through the attainment of technical efficiency and allocative efficiency (Coelli et al., 1998). According to Ogundari and Ojo (2006), the level of economic efficiency (EE) can be measured by comparing the minimum production cost with the actual production cost incurred by each farmer. Based on this measurement, the level of economic efficiency of seed-multiplication farming and consumption rice farming in Subak Dlod Sema is presented in Table 11.

Table 11. Distribution of economic efficiency (EE) index of farming in Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency

Economic Efficiency	Seed Multiplication Number	Seed Multiplication %	Consumption Rice Number	Consumption Rice %
EE <0.20	0	0	0	0
0.20 – 0.30	15	100	38	100
>0.30	0	0	0	0
Total	15	100	38	100
Maximum EE	0.293		0.241	
Minimum EE	0.257		0.225	
Average	0.268		0.231	

Source: Primary Data, processed (2024)

Table 11 shows that the economic efficiency values for both seed-multiplication farming and consumption rice farming are entirely within the 0.20–0.30 range. Based on average values, seed-multiplier farmers have a higher level of economic efficiency, at 0.268, compared to consumption rice farmers at 0.231. Although seed-multiplication farming has a relatively better level of economic efficiency than consumption rice farming, the average economic efficiency value for both farming groups is still classified as low.

The low economic efficiency in this study is mainly influenced by the low allocative efficiency, even though most farmers already have a high level of technical efficiency. This condition indicates that farmers have been able to manage the cultivation process so as to produce output close to the maximum production level, but have not been able to optimally allocate production factors based on the structure of input and output prices. As a result, the combination of input use applied has not been able to generate maximum profit or minimum production cost, so that the overall economic efficiency of the farm has not yet been achieved. This finding is in line with Asnah et al. (2015), who stated that the allocative efficiency and economic efficiency of food

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crop farming in Indonesia are generally still classified as low due to the not-yet-optimal allocation of production factors. Farmers with limited capital tend to use production inputs below the optimal level, while farmers with larger capital often use inputs excessively, thereby increasing production costs without a proportional increase in output.

A low economic efficiency value in both farming groups does not directly indicate low actual profit obtained by farmers. Economic efficiency describes farmers' ability to use an optimal input combination based on input and output prices, whereas the level of profit reflects the actual financial results obtained from farming activities. Therefore, as a supporting analysis, Net Profit Margin (NPM) is used to provide an overview of the ability of seed-multiplication and consumption rice farming to generate net profit from each revenue obtained. The comparison of NPM between the two types of farming also provides additional information regarding the economic attractiveness of seed-multiplication farming compared to consumption rice farming. The results of the NPM calculation for both types of farming are presented in Table 12.

Table 12. Comparison of Net Profit Margin (NPM) between Seed-Multiplication and Consumption Rice Farming in Subak Dlod Sema, Sading Village, Mengwi District, Badung Regency

Description	Seed Multiplication	Consumption Rice
Total Expenditure (Rp)	14,799,144	12,319,977
Revenue (Rp)	22,547,044	15,885,592
Net Profit (Rp)	7,747,900	3,565,615
Net Profit Margin (%)	34.36	22.45

Source: Primary Data, processed (2026)

Based on Table 12, seed-multiplication farming obtained an average revenue of Rp22,547,044 with a net profit of Rp7,747,900, while consumption rice farming obtained an average revenue of Rp15,885,592 with a net profit of Rp3,565,615. The calculation results show that the Net Profit Margin (NPM) of seed-multiplication farming is 34.36 percent, higher than that of consumption rice farming at 22.45 percent. This value indicates that for every Rp100 of revenue obtained, seed-multiplication farming is able to generate a net profit of approximately Rp34.36, while consumption rice farming generates a net profit of approximately Rp22.45. This difference shows that seed-multiplication farming has a better ability to generate a profit margin from the revenue obtained compared to consumption rice farming. This result is in line with Sinha and Nath (2013), who found that the production of certified rice seed provides a higher benefit-cost ratio compared to the production of consumption grain, so that seed production activities provide a higher economic return for farmers.

A higher benefit-cost ratio in certified rice seed production does not automatically encourage consumption rice farmers to switch to becoming seed multipliers. Seed-multiplication farming has more complex management requirements because farmers are not only oriented toward achieving production but must also meet quality requirements so that the production output can be marketed as seed. Sayaka and Hidayat (2015) state that seed-multiplication activities require more intensive cultivation and management stages to maintain varietal purity and the quality of the seed produced. One of the efforts to maintain this purity is through roguing activities, in which conducting roguing twice can produce a seed purity percentage of up to 99.12 percent (Sultana et al., 2019). Additional activities such as maintaining varietal purity, roguing, quality control, and the certification process mean that seed-multiplication activities require more thoroughness and more intensive management compared to consumption rice farming.

On the other hand, the complexity of the multiplication activities is accompanied by a higher economic value of the product. Grain that meets quality requirements and passes certification can be marketed as seed at a higher selling price compared to consumption grain. This difference in selling price provides added value that further increases the revenue and profit margin of seed-multiplier farmers. However, according to Qadir et al. (2024), seed marketing has more specific characteristics because its production and marketing need to take into account the needs for variety, quantity, location, and timing that match demand, and require linkages among actors in the seed production and distribution system. Nevertheless, Triana et al. (2024) found that prospective seed that is not absorbed or not marketed as seed can still be diverted for sale as consumption grain. This shows that there is a marketing alternative that provides flexibility for seed-multiplier farmers in marketing their production output according to prevailing conditions and market opportunities. Seed-multiplier farmers have the opportunity to obtain a higher selling value when the production output is marketed as seed, while still having the alternative of marketing it as consumption grain.

The advantage in profit margin and the availability of marketing alternatives indicate that seed-multiplication farming has good economic prospects to be developed as an alternative business for consumption rice farmers. The high technical efficiency results also indicate that farmers' ability to manage the production process at the research location has been relatively good.

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However, the low allocative efficiency in both types of farming shows that there is still an opportunity to increase profit through better management of the economic aspects of production. Asnah et al. (2015) showed that low allocative and economic efficiency in food crop farming is related to the not-yet-optimal allocation of production factors, whether due to capital constraints or excessive input use, which increases costs without a proportional increase in output. This finding shows the importance of production cost management that takes into account the cost structure and the prices of production factors in farm decision-making. Nuthall (2001) emphasizes that appropriate decision-making in resource management is an important part of farmers' managerial ability and plays a role in improving farm efficiency. Under conditions of already-high technical efficiency, as found in this study, increasing profit no longer relies solely on the ability to produce output, but also on farmers' ability to control production costs so that the profit margin obtained can be increased.

An increase in profit margin can further strengthen the appeal of seed-multiplication farming for farmers. The higher selling value of seed and the availability of alternative marketing outlets further strengthen the potential of this business as a profitable source of income. In addition, the research results show that farmers at the research location already have relatively good technical cultivation skills, so that the development of seed multiplication has a supportive technical foundation. Improvements in production cost management, combined with the economic value advantage of the product, are expected to further increase the prospects of the seed-multiplication business and encourage greater farmer involvement in seed production activities.

The development of seed-multiplication farming also has strategic significance for meeting the demand for certified rice seed in Badung Regency. This is important considering that rice seed production in Subak Dlod Sema is currently only able to meet about 29.3 percent of seed demand based on the rice harvest area in Badung Regency. An increase in the number of farmers involved in seed multiplication is expected to increase local seed production capacity and gradually narrow the gap between seed production and demand. Thus, the development of seed multiplication farming is oriented not only toward increasing farmers' profits, but also toward strengthening the capacity of local seed multipliers to provide quality rice seed to support the sustainability of rice production in Badung Regency.

CONCLUSION

Based on the results of this study, the following conclusions can be drawn:

1. Based on the efficiency analysis, both **certified rice seed production farming** and **rice grain farming** in Subak Dlod Sema achieved a high level of **technical efficiency**, but neither farming system was allocatively nor economically efficient. The average technical efficiency scores were **0.954** for certified rice seed production and **0.985** for rice grain farming. The average allocative efficiency values were **0.281** and **0.234**, respectively, while the corresponding average economic efficiency values were **0.267** and **0.231**. The failure to achieve economic efficiency indicates that farmers have not yet optimized the allocation of production inputs based on prevailing input prices and production costs.
2. The analysis of the determinants of technical inefficiency showed that, in **certified rice seed production farming**, farmer age, formal education, farming experience, and household size did not have a significant effect on technical inefficiency. In contrast, in **rice grain farming**, only farming experience had a significant negative effect on technical inefficiency, indicating that farmers with longer farming experience tended to exhibit lower levels of technical inefficiency. Meanwhile, farmer age, formal education, and household size had no significant influence on the technical inefficiency of rice grain farming.

ADVICE

Based on the findings and discussion of this study, the following recommendations are proposed:

1. **For farmers**, greater attention should be given to improving the management of production inputs by considering input prices and production costs to enhance allocative and economic efficiency. Farmers are encouraged to optimize the combination and utilization of production inputs so that production costs are used more effectively while maintaining or increasing rice productivity.
2. **For policymakers**, agricultural development programs should not focus solely on improving cultivation techniques but should also strengthen farm management and cost-efficiency practices. Extension programs should emphasize farm financial management, rational use of production inputs, and farmers' capacity to determine the optimal combination of inputs based on prevailing input and output prices. Furthermore, the government should strengthen farmer organizations, improve farmers' access to market information on agricultural input and output prices, and facilitate access to production inputs and agricultural technologies. These measures are expected to improve farmers' ability to allocate production resources more efficiently and enhance the economic performance of rice farming.

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3. **For future research**, studies are recommended to involve a larger sample size and a wider geographical coverage to increase data variability and improve the representativeness of the findings. In the present study, most socioeconomic variables did not significantly influence technical inefficiency, which may be attributed to the relatively homogeneous characteristics of the respondents and the limited sample size, particularly among certified rice seed producers. Future studies should also consider conducting observations across different planting seasons, as the number of farmers engaged in certified rice seed production varies from one season to another. Seasonal changes in farmers' participation in seed production may increase the number of respondents and broaden the diversity of farmer characteristics. Expanding the study area, increasing the number of respondents, and extending the observation period are expected to provide a more comprehensive understanding of the factors influencing farm efficiency and to produce findings that are more robust and broadly applicable.

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