



## Elevating Sugarcane Farming: Effects of Certified Seed Adoption on Production and Income in East Java, Indonesia

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### ABSTRACT

The use of certified seed is essential for sugarcane agricultural intensification method, emphasizing input quality improvements. In this context, varietal validity has the potential to increase sugarcane output volumes and ensure quality variations. Therefore, this research aimed to analyze the variables affecting farmers' decisions on seed varieties, output, and revenue. The type of data used was cross-sectional with a sample of 1,763 respondents, consisting of 303 and 1,460 adopter and non-adopter farmers, respectively. Propensity score matching and logistic regression were the analysis methods used. The results showed that farmers' age, number of workers, land ownership status, extension participation, and partnerships significantly influenced the decisions in selecting seed types. Significant variations in output, gross income, total expenses, net income, and net earnings were also reported using statistical test analysis, with certified seed adopters having higher profits. In this context, young farmers should be targeted to promote the use of certified seed, provide sufficient labor support for intensive farming, ease access to land, and enhance persuasive messages about partnership benefits. Moreover, ensuring the continuity of production and distribution was important to maintain reasonable seed prices and facilitate farmers' access.

### INTRODUCTION

In Indonesia, sugarcane production and planted areas showed an increasing trend from 1961 to 2022 (Food and Agriculture Organization, 2022). This directly reports the role of East Java Province as the largest sugarcane producer throughout the history of Indonesian independence. Until the end of 2022,

East Java contributed 49.55% of the supply and 1,19 million tons of sugar from the total national White Crystal Sugar (WCS) production of 2,4 million tons. However, this achievement is insufficient for public sugar consumption, which is 3,21 million tons (Badan Pusat Statistik, 2023). The national WCS deficit forced the government to open the import tap to

maintain price stability and the need for sugar consumption. However, WCS imports from 2019 to 2022 showed an increasing trend and this could threaten the stability of farmers' sugarcane supply (Badan Pusat Statistik, 2023).

The national WCS production is lower than the annual consumption needs due to the lack of supply of sugarcane raw materials. Even though (Food and Agriculture Organization, 2022) stated that sugarcane production tends to increase, the supply is not sufficient to meet the demand for raw materials. This is supported by FAO records where the movement of sugarcane productivity trends decreased from 1961 to 2022. The average productivity in early 1961 could reach 136 tons/ha and decrease to 66 tons/ha in 2022 (Food and Agriculture Organization, 2022). In this context, a significant effort must be made to raise sugarcane farming productivity, particularly in center areas such as East Java. This is a critical first step in addressing the dual problems of rising sugar imports and falling sugarcane productivity. The decline in productivity is caused by the frequency of ratooning that exceeds the recommended threshold of three times (Setyawati & Wibowo, 2019; Xu, Wang, Lu, Zeng, & Que, 2021).

In contrast to other complementary inputs such as fertilizers or pesticides, seed inputs are key to the sustainability of sugarcane farming. This is because sugarcane seed planted continue to be used until the system period is

over before unloading the ratoon. The results of (Xu et al., 2021) showed that the use of superior seed in the initial planting process could increase production and extend the life of the ratoon plants. Differences in the quality of sugarcane seed planted determine the level of production for each harvest period until the ratoon system is completed. This is different from the use of seed in other commodities without applying the ratoon system. Therefore, optimizing sugarcane productivity on existing land by applying high-quality inputs is the best option for supporting the intensification program. Farmers are advised to use high-quality seed of clear genetic purity and meet quality standards in class (Baglan, Zhou, Mwalupaso, & Xianhui, 2020). Some research (Akanbi, Mukaila, & Adebisi, 2022; Kalsa, 2019; Mensah et al., 2021; Sandita, 2023; Suwandari et al., 2020) confirmed that the choice to adopt certified seed was the right step in increasing farm productivity. The yields of farms are recognized as superior and of higher quality compared to other types (Connor, Tuan, DeGuia, & Wehmeyer, 2021; Fadillah, 2022). According to (Setiawan, Rifin, & Harmini, 2023), there was no significant difference in technical efficiency between adaptor and non-adaptor farmers. The results (Setiawan et al., 2023) related to differences in technical efficiency levels are similar to (Suwandari et al., 2020). This occurs because adapter farmers have not been optimal in applying certified seed and other inputs, resulting in less-than-optimal

yields. Research (Fadillah, 2022) also reported interesting results, where farm productivity with newly certified superior varieties was low. According to (Akanbi et al., 2022; Connor et al., 2021; Kalsa, 2019; Lestari, Rukmana, & Munizu, 2021; Mensah et al., 2021; Sandita, 2023; Suwandari et al., 2020) and (Fadillah, 2022; Setiawan et al., 2023), there are contradictory results regarding the impact of certified seed adoption in farming.

Previous research conducted (Baglan, Zhou, et al., 2020; Mensah et al., 2021; Okello et al., 2017; Sandita, 2023; Suwandari et al., 2020) reported that yields are superior in quantity with the potential to increase farm income. However, (Fadillah, 2022; Sandita, 2023) showed that the increase in farm income was due to an increase in the amount of production. There was no significant difference in selling price between the yields from certified and uncertified seed. Differences in results were also reported in research (Akanbi et al., 2022; Sandita, 2023), where production costs were higher. According to (Fadillah, 2022) increased use of some types of inputs can increase farming costs. This is also responded to by increased farming activities and allocations to higher labor costs. In addition, (Astari, Irham, & Utami, 2019; Fadillah, 2022; Mensah et al., 2021; Sandita, 2023) showed that the increase in production costs could be caused by the higher price of certified seed. The lengthy inspection and testing before distribution results in a

gap between the supply and demand by farmers, causing the price in the market to be relatively expensive (Maredia & Bartle, 2023). However, (Baglan, Mwalupaso, et al., 2020) show that farmers who live close to the market are likely to obtain more affordable certified seed prices. Other results (Hidayat et al., 2023) show that farmers feel the average price in the market is affordable.

The local seed varieties used are of high quality and have yielded satisfactory results even though certified seed are of good quality (Krishna Dev Joshi et al., 2016). According to (Mensah et al., 2021), farmers realize that the yield potential will be higher when certified seed is used. However, financial limitations and the inability to implement recommended cultivation practices when adopting certified seed, make farmers use local varieties with simple cultivation practices. The results (Mensah et al., 2021) were comparable to those (Izuogu et al., 2023) where farmers were aware of the benefits of certified seed. However, the difference is that farmers' participation in social organizations can provide greater opportunities to access certified seed. Other results (Zakaria, Alhassan, Kuwornu, & Azumah, 2021) showed that farmers' participation in the subsidy programs can also increase the interest in adopting certified seed and determine a trend toward higher fertilizer use (Baglan, Zhou, et al., 2020; Fadillah, 2022; Gitaningtyas & Widyawati, 2022; Sandita, 2023; Suwandari et al., 2020).

In contrast to (Blekking,

Waldman, & Evans, 2021) who show potential risks in the adoption of certified seed, the discrepancies between yield potential and quality during the certification process with the development of smallholder complaints, present more complex challenges for farmers in selecting seed. Research (Fadillah, 2022; Kalsa, 2019; Munyaka, Mvumi, & Mazarura U. M., 2015) reported that a decrease in the quality of certified seed could occur due to suboptimal maintenance and storage practices at the farm level. In addition, the application by farmers who do not adhere to recommended good agricultural practices also results in less-than-optimal yields (Astari et al., 2019). According to (Melesse, 2018; Yilmaz & Kurt, 2020), most seasoned farmers use certified seed, while others adopt ordinary varieties. Differences in perceptions related to selection were also found in research conducted by (Utoyo & Yolandika, 2018) and the motivation of farmers who use certified seed prioritizes seed quality.

The use of superior seed technology can provide higher profits for farmers. In the adoption process, the choice to adopt certain types is related to the influence of socio-economic factors. The results of (Fadillah, 2022; Mensah et al., 2021) show that older farmers who are more often constrained by physical and non-physical problems have a lower chance of adopting certified seed (Dissanayake, Jayathilake, Wickramasuriya, Dissanayake, & Wasala, 2022; Melesse, 2018; Susanti & Ariyanto, 2023). Other results

(Baglan, Zhou, et al., 2020; Gitaningtyas & Widyawati, 2022) found that additional labor had a positive effect on supporting farm complexity during the adoption but (Connor et al., 2021; Fadillah, 2022) reported the opposite. In addition, (Muraoka, Jin, & Jayne, 2018; Sahara & Kusumowardhani, 2017; Yilmaz & Kurt, 2020) showed that land ownership contributed to increasing farmers' confidence to adopt new technologies. Narrow land ownership reduces farmers' interest in improvising the use of certified seed (Baglan, Zhou, et al., 2020; Fadeyi, Ariyawardana, & Aziz, 2022). Farmers' participation in extension services (Aidoo, Mensah, Omono, & Abankwah, 2014; Baglan, Zhou, et al., 2020; Connor et al., 2021; Melesse, 2018; Silva & Broekel, 2016, 2016) and partnership activities (Lestari et al., 2021) have the potential to increase opportunities in adopting certified seed. Previous results are limited to showing responses and the potential impact in several types of agricultural commodities. There are contradictory results regarding the socio-economic factors influencing farmers' decisions to select seed types and the impact on farm outputs. Therefore, this research intends to examine the factors influencing the adoption of certified seed and the impact on sugarcane farming production and income in East Java.

## **METHODS**

This research used secondary data belonging to the Badan Pusat Statistik (BPS) from the 2013 Indonesian plantation business

household census with the questionnaire code ST2013-SKB.S. In addition, the data was explored through information in secondary data. Cross-sectional data was used with a population of 5,281 sugarcane farmers in East Java but only consisted of 2,109 respondents. The sample selection was based on other complete data information including the variables to be used, and consistent units. Therefore, the number of samples selected was 1,763 sugarcane farmers, consisting of 303 and 1,460 users and non-users of certified seed. The sampled sugarcane farmers in East Java are smallholder sugarcane farmers and about 60% of total production costs are used to purchase farm inputs in the input market. Labor input costs, transportation of products, and purchase of seed have a large contribution to the total cash costs incurred by farmers. Meanwhile, 40% of the total production cost was dominated by the value of land inputs under the farmers' ownership and seedlings from the nursery. The results showed that 59% of sugarcane seedlings used by farmers in East Java come from nurseries.

The association between the independent and the dependent variables was reported using the logistic regression model. The first step was to divide the two observation groups into control and intervention. The second stage is to determine the model and variables to be estimated. The socioeconomic and demographic traits of the respondents are considered while

selecting the appropriate variables. The logit model used in the investigation has the following general form.

$$\text{logit}(P_i) = \ln\left(\frac{P_i}{1 - P_i}\right) = \beta_0 + \dots + \beta_n x_n$$

$P_i$  is a dummy variable explaining the farmer's decision in selecting the type of seed (1 = certified seed, 0 = uncertified seed). Independent variables ( $X_i$ ) as predictors of factors influencing farmers' decision in selecting the type of seed consist ( $X_1$ , farmer age), ( $X_2$ , household size), ( $X_3$ , length of formal education), ( $X_4$ , number of workers), ( $X_5$ , land ownership status), ( $X_6$ , agricultural extension), ( $X_7$ , pest-affected farm), ( $X_8$ , partnership), and ( $X_9$ , planting method). The partnership variable represents information on farmers' participation from State-Owned Enterprises (BUMN), Regionally-Owned Enterprises (BUMD), or private companies. Partnership cooperation aims to meet mutual needs between sugarcane farmers and plantation companies as the main raw material providers and suppliers to sugar factories. Plantation companies render help by providing technical guidance facilities and financial capital assistance for farming.

The odds ratio value from the logistic regression results can be used to interpret the odds of a possibility. The odds ratio value  $>1$  has a positive association or the chances of farmers adopting certified seed are higher. The Propensity Score Matching

(PSM) method is used to ascertain the effects of different seed types on the output and profitability of sugarcane cultivation. Additionally, the Nearest-Neighbor Matching (NNM) matching method was selected to match the observation value between the control and intervention groups in the third stage based on the propensity score. An observation with a propensity score outside the common support area can be excluded from the covariates. The fourth stage interprets the difference of the variables through the Average Treatment Effect on the Treated (ATT) value. The ATT value is used to determine the impact on output ( $D = 1$ ), despite the reality of not using certified seed ( $D = 0$ ). The estimation of PSM analysis through ATT values is free from selection bias. In addition, this research uses marginal effects to determine the change in probability caused by changes in the independent variable. Interpretation is easier when the independent variable is discrete such as a change in probability changing from 0 to 1. The PSM model estimation refers to (Bai & Clark, 2019) and marginal effects are sequential as follows.

$$ATT = E(Y_1 | X, D = 1) - E(Y_2 | X, D = 0)$$

Marginal effect  $X_k =$

$$P_r(Y = 1|X, X_k = 1) - P_r(Y = 1|X, X_k = 0)$$

## RESULTS AND DISCUSSION

### Variable Descriptive Statistics

There are some similarities in characteristics in age, household size, length of formal education, land

ownership status, percentage of farmers affected by pests, and planting methods (**Table 1**). The similarities show the importance of a thorough understanding of the variables driving seed adoption choices in farming community. Even though users of certified seed have younger average ages than those who do not, both groups are considered to be of productive age (15 to 64 years). Productive farmers have a greater interest in accessing and maximizing opportunities to increase farm profits (Melesse, 2018). In contrast, farmers who have entered the non-productive phase become limited and less adaptive in implementing new practices related to agricultural development (Brown, Daigneault, & Dawson, 2019). Another similarity between the two groups is in the average number of household members, which is four people. Generally, family needs tend to be the main priority for farmers, often resulting in suboptimal allocation of income, including the adoption of novel technologies (Apriani, Rachmina, & Rifin, 2018; Okello et al., 2016; Susanti & Ariyanto, 2023). However, the participation of household members can assist farmers in the practice of adopting new technologies (Ali, Rahut, Behera, & Imtiaz, 2015; Jha & Gupta, 2021; Melesse, 2018; Mutanyagwa, Kaliba, & Isinika, 2018).

The average length of formal education of adaptor and non-adopter sugarcane farmers is seven years, equivalent to the junior high school level. The capacity of farmers to comprehend and adapt to the

**Table 1.** Descriptive statistics of sugarcane farmer variables in East Java

Variables	Adopter Farmers				Non-adopter Farmers			
	<i>Means</i>	<i>S.D.</i>	<i>Freq.</i>	<i>%</i>	<i>Means</i>	<i>S.D.</i>	<i>Freq.</i>	<i>%</i>
Farmer age (years)	48	10.33			51	11.58		
Household size	4	1.31			4	1.40		
Length of formal education (years)	7.32	2.73			7.20	2.75		
Number of workers (people)	12	17.28			9	7.34		
Female	5	7.06			3	3.33		
Male	9	14.75			8	5.80		
Land ownership status								
Owned			278	91.75			1,239	84.86
Rent and free rent			25	8.25			221	15.14
Agricultural extension								
Follow			70	23.10			110	7.53
Not following			233	76.90			1,350	92.47
Pest-affected farms								
Affected			44	14.52			229	15.68
Not affected			259	85.48			1,231	84.32
Partnership								
Follow			166	54.79			534	36.58
Not following			137	45.21			926	63.42
Planting method								
Regular method			301	99.34			1,436	98.36
Irregular method			2	0.66			24	1.64

Source: Results of Descriptive Statistical Analysis Using Stata (2023)

advancements in agricultural technology is closely correlated with the duration of schooling, as well as the willingness to accept innovations (Apriani et al., 2018; Susanti & Ariyanto, 2023). According to (Fadeyi et al., 2022), training programs are effective in assisting farmers to provide information and comprehension of adopting agricultural technologies. In addition, the majority of adopter and non-adopter farmers also use land for

farming (Jha & Gupta, 2021). Similar to (Utoyo & Yolandika, 2018) large land holdings make farmers more visionary to increase the efficiency of farms in the long term.

There was no difference between the percentage of adopter and non-adopter farmers affected by pests. Vulnerability to pests is an important reason for purchasing certified seed (Kalsa, 2019). However, (Munyaka et al., 2015) reported that procedural errors in storing and

maintaining have the potential to reduce the quality of seed, resulting in reduced crop resistance to pest attacks. The majority of methods applied between the two groups are regular cropping. Even though the type of regular cropping pattern was not identified in the secondary data, the conclusions (Djumali, Khuluq, & Mulyaningsih, 2016) suggested that sugarcane farming applies a regular planting method with a double-jurying pattern. This planting pattern has the potential to produce more sugarcane stem tillers than single-jurying. The result conducted by (Djumali et al., 2016) was strengthened by (Ouko, Bett, & Dembele, 2018), where there was a positive relationship between consistent cultivation practices and farmers' openness to new technological innovations. Other differences are reported from the higher percentage of labor requirements, participation in agricultural extension, and partnerships among adopter farmers. The adoption may drive adopter farmers to increase workforce due to the complexity of farming activities associated with this decision (Baglan, Mwalupaso, Zhou, & Geng, 2020; Gitaningtyas & Widyawati, 2022). The intensity and continuity of farmers in following extension services can positively influence the decisions to adopt technology (Silva & Broekel, 2016). Similarly, sugarcane farmers who are part of partnerships, benefiting from agricultural extension services, adopt new technologies (Lestari et al., 2021). Plantation

companies play a role in helping farmers provide input assistance, technical guidance facilities, and financial capital to develop farms and produce sugarcane according to the criteria.

### **Factors Influencing Sugarcane Farmers' Decision to Adopt Certified Seed**

The logit model analysis shows that farmer age, number of workers, participation in agricultural extension, partnership, and land ownership status significantly influence sugarcane farmers' decisions in selecting seed types (**Table 2**). In contrast, the variables of household size, length of formal education, pest-affected farms, and planting method were not statistically significant. The probability of using certified seed drops by 0.003 times for each unit increase in farmer age (**Table 2**). The decline in cognitive abilities among older farmers shows an increased need for time and energy to access information and other agricultural resources (Ali et al., 2015; Seok, Moon, Kim, & Reed, 2018). Moreover, the adoption becomes more difficult due to scarcity and high maintenance requirements (Fadillah, 2022; Mensah et al., 2021). Research by (Awotide, Abdoulaye, Alene, & Manyong, 2015) emphasized that difficulties in accessing credit experienced by older farmers add to problems in adopting agricultural technology. Other results show that old farmers are conservative and risk-averse to the adoption of new technology (Brown et al., 2019; Susanti



& Ariyanto, 2023). In contrast to old farmers, young farmers who are more literate in innovation and the development of agricultural technology are more motivated to maximize farm profits by adopting certified seed and focusing on optimizing the potential (Chete, 2021; Susanti & Ariyanto, 2023). The results are not similar to (Dissanayake et al., 2022; Melesse, 2018; Susanti & Ariyanto, 2023) where older farmers are more adaptable in farming. This is because older farmers have experienced and encountered many phases of technological development. The intuition is more sensitive to the potential benefits of technology adoption and drives farmers to excel at improved adoption practices.

The analysis related to increasing the number of workers can improve farmers' chances of adopting certified seed (Bulte, Cecchi, Lensink, Marr, & Asseldonk, 2020). For every one-unit increase in the number of family dependents, the probability of adoption decreases by 0.005 times (**Table 2**). The optimal contribution of labor plays a significant part in the success of sugarcane farming, specifically in Indonesia where the bulk of tasks are completed by humans (Sulaiman, Arsyad, Amiruddin, Teshome, & Nishanta, 2023). In line with (Baglan, Mwalupaso, et al., 2020; Gitaningtyas & Widyawati, 2022), farmers tend to require additional labor for technology adoption due to the crop characteristics of certified seed. The labor demands for harvesting increase the enhanced yields achieved

by farmers (Baglan, Mwalupaso, et al., 2020). According to (Gitaningtyas & Widyawati, 2022) and (Baglan, Mwalupaso, et al., 2020), additional labor can be triggered by the increasing complexity of farming activities. The results differed from (Connor et al., 2021; Fadillah, 2022) where the use of labor was more efficient after the adoption.

Farmers who own land have a greater chance of adopting certified seed (Okello et al., 2016) (Harwoto, Rondhi, Rokhani, & Suwandari, 2022). The probability increases by 0.061 times when land ownership changes to self-owned, as shown in **Table 2**. Land ownership gives farmers a greater sense of security and control over production decisions. Farmers who manage land are more confident in improvising farming methods, resulting in higher productivity compared to those who rent land (Muraoka et al., 2018). These results are consistent with (Sahara & Kusumowardhani, 2017), (Muraoka et al., 2018), and (Yilmaz & Kurt, 2020), where farmers who own land tend to be more motivated to allocate capital for investments. The larger the farmland cultivated for commercial purposes has a favorable impact on increasing farmers' incentives (Yilmaz & Kurt, 2020). Research by (Baglan, Mwalupaso, et al., 2020) and (Fadeyi et al., 2022) reported different results, showing that the incentive to use certified seed is decreased in small land holdings.

Farmers who participate in agricultural extension adopt certified seed (Ullah, Shah, Shaofeng, Khan, &

**Table 2.** Estimation results of the variables influencing the adoption of certified seed

Variables	Coef.	Odds Ratio	S.E.	z	P> z	Marginal Effect
Farmer age	-0.019	0.981***	0.006	-2.93	0.003	-0,003
Household size	-0.040	0.961	0.047	-0.82	0.413	-0,005
Length of formal education	0.004	1.004	0.071	0.05	0.957	0,001
Number of workers	0.020	1.020***	0.007	2.90	0.004	0,003
Land ownership status	0.460	1.584*	0.410	1.78	0.076	0,061
Agricultural extension	1.171	3.225***	0.567	6.66	0.000	0,156
Pest-affected farms	0.009	1.009	0.186	0.05	0.963	0,001
Partnership	0.551	1.735***	0.235	4.07	0.000	0,073
Planting method	0.698	2.010	2.116	0.66	0.507	0,093
Prob>chi2	(0.0000)					
Pseudo R <sup>2</sup>	(0.0627)					

Source: Results of Data Analysis Using Stata (2023)

Information: \* significance level  $\alpha=10\%$  ( $|t\text{-stat}| > t\text{-table: } 1.65$ );

\*\* significance level  $\alpha=5\%$  ( $|t\text{-stat}| > t\text{-table: } 1.96$ );

\*\*\* significance level  $\alpha=1\%$  ( $|t\text{-stat}| > t\text{-table: } 2.58$ )

Ali, 2015). In deciding to follow extension services, the probability increases by 0.156 times (**Table 2**). Farmers who participate in extension tend to have a better understanding of the potential and advantages (Baglan, Mwalupaso, et al., 2020; Connor et al., 2021). The results (Silva & Broekel, 2016) showed that the ability to accept certified seed may be improved more successfully through an extension to include direct technical support. Extension serves as a conduit for the exchange of expertise and experience between extension agents and other farmers (Melesse, 2018). A broader benefit of farmers' participation in extension programs is the ease of obtaining certified seed from extension agents, providing an additional advantage (Aidoo et al., 2014). According to (Ali et al., 2015), extension services can diminish motivation to adopt new technologies. The probability

increases by 0.073 times when selecting to become a partner, as reported in **Table 2**. The loyalty of farmers to the partnership increases with favorable offers. Research by (Lestari et al., 2021) showed that easy access for partner farmers can increase the motivation to use seed. This is because the higher quantity and quality of sugarcane increases the chances of earning a higher income. According to (Susanti & Ariyanto, 2023), farmers who are members of partnerships are quicker to access new technologies to increase productivity and welfare.

### Effects of Adoption of Certified Seed on East Javan Sugarcane Production and Farm Income

The similarity between the two groups of farmers based on the observed socioeconomic characteristics can be seen through the overlapping areas (**Figure 1**). The

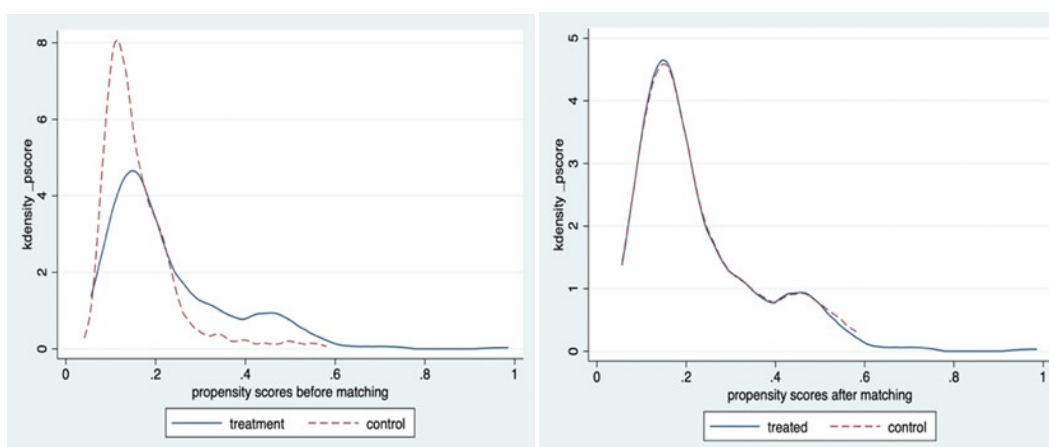
common support area is a propensity score distribution area to show the density conditions between intervention and control groups. This research examined effects of certified seed adoption on farm income and sugarcane output using nearest-neighbor matching and propensity score matching methods to produce an ATT value. Using certified seed has a major impact on raising farm income and sugarcane yield (**Table 3**). The results are consistent with (Baglan, Mwalupaso, et al., 2020; Fadillah, 2022; Mensah et al., 2021; Okello et al., 2017; Suwandari et al., 2020), using certified seed to increase sugarcane yields and enhance total farm revenue. The increase in gross farm income is due to high production, while the selling price of certified and uncertified sugarcane in several distribution sites shows no difference around 401 to 457 IDR per kilogram (Sandita, 2023). Farmers who adopted certified seed experienced an increase in production of 5.85 tonnes/ha and gross farm income of 3,08 million IDR/ha. This is driven by the advantages, namely strong seed vigor and more resistance to pests and diseases (Mastenbroek, Sirutyte, & Sparrow, 2020). Sugarcane plants derived from certified seed have more stem internodes and larger sizes. This provides an advantage for adopter farmers because the sugar contained in the stem is higher (Sandita, 2023; Suwandari et al., 2020). Another advantage is the efficient use reported by (Gitaningtyas & Widyawati, 2022; Sandita, 2023; Suwandari et al.,

2020), where adopter farmers require fewer certified seed per hectare of land. In contrast, non-adopter farmers tend to use more local varieties as an anticipatory measure to face the risk of crop failure due to pest attacks. The risk of failure can be caused by the contamination of other varieties to reduce the quality and productivity of farmers' crops (Fadillah, 2022).

The total farm expenses of farmers who adopted certified seed were higher at 1,29 million IDR per hectare than non-adopters (Fadillah, 2022; Suwandari et al., 2020). The increase in total farm expenses can be triggered by the intensive use of fertilizers on sugarcane plants from certified seed. Farming activities are more complex, specifically in fertilizing, harvesting, and maintenance to promote higher labor needs and wages (Fadillah, 2022; Gitaningtyas & Widyawati, 2022). Another factor affecting the amount of production is higher cost (Aidoo et al., 2014; Maredia & Bartle, 2023). According to (Maredia & Bartle, 2023; Mensah et al., 2021), there is a difference in the price of certified seed which is more expensive at 719 IDR per stem compared to uncertified seed at 489 IDR per stem at a significance level of 1% (**Table 3**). However, (Gitaningtyas & Widyawati, 2022) stated that the purchase price was more expensive and efficient than uncertified. The higher cost of certified seed may be attributed to suboptimal distribution patterns, which affect the accessibility to farmers (Baglan, Mwalupaso, et al., 2020). The disparity

in price triggers a gap in the adoption (Gitaningtyas & Widyawati, 2022). Another interesting result (Fadillah, 2022) showed that repeated use was a potential strategy for reducing the

use of several farm inputs including seed. These results provide a more open view of the different strategies of adopter farmers in allocating farming costs. The analysis showed that the net



**Figure 1.** Common support area

Source: Results of Data Analysis with Nearest-Neighbor Matching Method (2023)

**Table 3.** Effects of certified seed on farm income and sugarcane yield in East Java using the nearest-neighbor matching method

Variable	Sample	Treated	Control	Different	S.E.	T-stat
Production (tonnes/ha)	Unmatched	82.87	80.29	2.58	1,479	1.74*
	ATT	82.87	77.02	5.85	2,114	2.77***
Seedling price (IDR/stem)	Unmatched	719.46	485.78	233.68	51.73	4.52***
	ATT	719.46	488.86	230.60	74.71	3.09***
Gross Farm Income (000 IDR/ha)	Unmatched	38,241	36,059	2,182	744,637	2.93***
	ATT	38,241	35,162	3,079	1,143,456	2.69***
Total Farm Expenses (000 IDR/ha)	Unmatched	23,693	22,882	811	485,183	1.67*
	ATT	23,693	22,404	1,288	697,160	1.85*
Net Farm Income (000 IDR/ha)	Unmatched	14,549	13,177	1,371	601,022	2.28**
	ATT	14,549	12,758	1,791	890,986	2.01**
Net Farm Earning (000 IDR/ha)	Unmatched	14,399	12,789	1,610	598,500	2.69***
	ATT	14,399	12,195	2,204	889,309	2.48**

Source: Results of Data Analysis Using Stata with Propensity Score Matching Method (2023)

Information: \* significance level  $\alpha=10\%$  ( $|t\text{-stat}| > t\text{-table: } 1.65$ );

\*\* significance level  $\alpha=5\%$  ( $|t\text{-stat}| > t\text{-table: } 1.96$ );

\*\*\* significance level  $\alpha=1\%$  ( $|t\text{-stat}| > t\text{-table: } 2.58$ )

farm income and earnings of 1,79 million IDR/ha and 2,20 million IDR/ha of adopter farmers were higher than non-adopters. According to (Akanbi et al., 2022; Baglan, Zhou, et al., 2020; Fadillah, 2022; Mensah et al., 2021; Sandita, 2023), the increase in the cost of certain agricultural inputs shows the financial benefits achieved by the adoption to enhance efficiency and yield. Therefore, the impact of adopting certified sugarcane seed provides the benefits of better cultivation practices and the potential to increase the level of economic welfare of farmers in the long term.

#### CONCLUSION AND SUGGESTION

In conclusion, farmers' decisions to adopt certified seed are influenced by age, number of workers, land ownership status, participation in agricultural extension, and partnerships. Despite an increase in total farm expenses, adopting certified seed had a significantly positive impact on sugarcane yields, gross farm income, net farm income, and net farm earnings compared to non-adopters. The supply of labor was increased to support increasingly intensive farming activities after the adoption of certified seeds, encourage young farmers to use certified seeds, facilitate access to arable land, as well as increase promotions and persuasive appeals regarding the benefits obtained from participating in the partnership. Additionally, the standard of services and frequency of extension programs were elevated to

meet farmers' needs, particularly regarding the recommended use of certified seed. Another significant suggestion was to increase the supply to meet market demand and prevent excessive pricing. Therefore, improvements were needed for the continuity of certified seed production, distribution, and access to increase the easiness of reaching sugarcane farmers.

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