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The Impact of Certified Seeds Adoption on Cost Efficiency of Horticultural Cultivation

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ABSTRACT

This study aims to analyze empirically the impact of adoption of certified seeds on household cost efficiency of seasonal horticultural cultivation. This study uses data from Cost Structure of Horticultural Cultivation Household Survey (SOUH) 2018, Statistics Indonesia. The cost inefficiency variable is estimated using a one-step stochastic frontier. The results of the descriptive data show that labor costs are the biggest costs in the seasonal horticultural cultivation. On average, the proportion of households that adopt certified seed is still lower than households that do not adopt certified seed. In addition, the cost composition between adopters and non-adopters is different. The results of the stochastic frontier analysis show that the adoption of certified seeds has a positive effect on cost inefficiency, meaning that the adoption of certified seeds actually increases cost inefficiency/reduces cost efficiency. The impact of adopting certified seeds has not yet been felt by farmers because it has not lasted long.

Keywords: Adoption of Certified Seeds, Cost Efficiency, Horticultural Cultivation, Stochastic Frontier Analysis

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INTRODUCTION

The welfare of farmers is the final goal of agricultural development, but the welfare of farmers in agricultural sector has a different movement pattern. Nurpalina, Noer, and Kurniawan (2022) suggested that their farmers could be influenced by the added value of the product the enjoy. Based on Figure 1, the farmer's term of trade, which describes the welfare of farmers in the horticulture sub-sector, has been decreasing since 2021, when the welfare of farmers in other sub-sectors is increasing (BPS, 2022). To improve the welfare of horticultural farmers, horticultural farmers need to make it efficient.

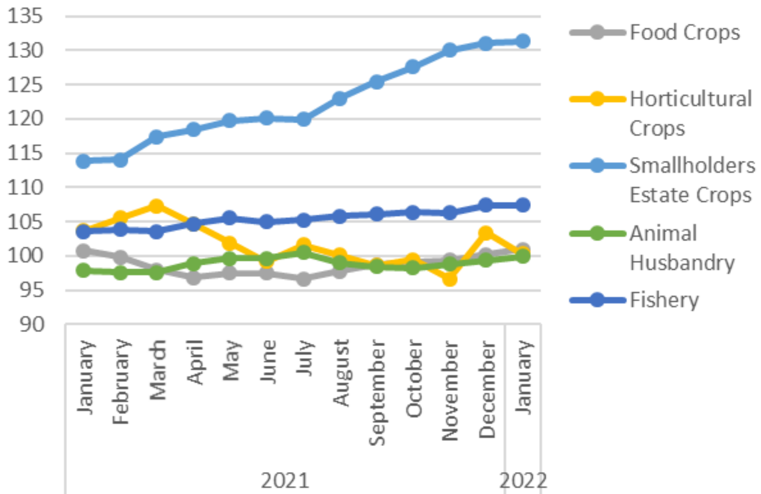

Figure 1. Farmer's Term of Trade
Source: Statistics Indonesia

Based on the results of previous studies, horticulture in Indonesia still has a low level of technical efficiency compared to other subsectors. Wulandari, Meuwissen, Karmana, and Oude Lansink (2017) said that the level of technical efficiency of shallots is 0.59, chili is 0.37, mango is 0.45, and mangosteen is 0.56. These values are still low compared to other sub-sectors. For example, in the food crops sub-sector, Triyono, Rahmawati, and Isnawan (2020) conducted research to determine the level of technical efficiency of rice farming by distinguishing the dry and rainy seasons. From the research, it was found that the level of technical efficiency in the dry season was higher than the level of technical efficiency in the rainy season. The level of technical efficiency in the dry season reaches 0.725, while the level of technical efficiency in the rainy season reaches 0.722. Istiyanti, Rahayu, and Sriyadi (2018) also conducted research in Bantul Regency, but it is in the context of organic rice. The level of technical efficiency of organic rice in Bantul is 0.71. In the plantation sub-sector, Effendy et al. (2019) also looked at the level of technical efficiency in cocoa plants in Indonesia and found that the average technical efficiency in cocoa plants was 0.82.

Adoption of technology, especially in adoption of superior seeds can give benefit to farmers because it can save costs and can also increase income. Mensah et al. (2021) show that the adoption of technology in the form of seeds contributes the most to reducing production costs compared to other inputs, such as fertilizers, irrigation, and herbicides. The other research by Mensah et al. (2021) said that the use of certified seeds in maize farming provides a higher income than seeds developed by farmers themselves. Besides that, Shita, Kumar, and Singh (2020) in their research also said that farmers who adopt technology, both in the form of fertilizer technology and fertilizer technology along with improved seeds, both increase their profits.

Technology adoption in the form of certified seed adoption in the horticulture sub-sector is still lower than in other sub-sectors. Based on data from BPS (2018), the use of certified seeds in seasonal horticultural crops has only reached 38.3%, which means that certified seeds are a proxy for superior variety seeds because they are processed through several stages of activity and supervised by a designated quality control agency and meet the requirements of certain quality standards for seeds or seed producers that are certified. It has obtained a certificate of seed quality system. In contrast to the horticulture sub-sector, the use of superior varietal seeds in the food crops sub-sector has reached 63.2% in rice plants (consisting of hybrid lowland rice, inbred lowland rice Ciherang varieties, and IR-64) and 88.97% in maize (BPS, 2017b, 2017a). Therefore, it is important to conduct a study of technology adoption in the horticulture sub-sector and its relation to efficiency to improve the welfare of horticultural farmers.

This study aims to see whether farmers who adopt certified seeds have different cost inefficiencies compared to farmers who do not adopt certified seeds. Research on technology adoption and linking it to efficiency has been done before (Anang, Alhassan, Danso-abbeam, & Yildiz, 2020; Baglan, Mwalupaso, Zhou, & Geng, 2020; Baglan, Zhou, Mwalupaso, & Xianhui, 2020; Dokyi, Anang, & Owusu, 2021; Funk & Bergtold, 2014; Mariyono, 2020; Sulistyowati, Natawidjaja, & Saefudin, 2015; Suwandari et al., 2020; Winata, Rondhi, Mori, & Kondo, 2020). However, what the distinguishes that makes this research different from previous research is that this research uses a form of adoption of certified seed technology, which to the researcher's knowledge, has never been carried out in the horticulture subsector. In addition, so far, the adoption of seeds has only been associated with technical efficiency issues, where technical efficiency only focuses on production. In fact, farmers who are efficient in using inputs (efficient in terms of production) are not necessarily efficient in terms of costs because they cannot allocate inputs effectively. It is important to consider the ability of farmers to reduce production costs because cost reduction is one component that can provide higher profits for farmers (Siagian & Soetjipto, 2020; Tu & Trang, 2016).

LITERATURE REVIEW

Previous studies linking seed adoption with cost efficiency used the form of seed adoption in the form of Biotechnology Enhanced Soybeans (BES) (Funk & Bergtold, 2014) and improved maize seeds (Zavale, Mabaya, & Christy, 2005). Funk and Bergtold (2014) research were conducted in Kansas which is a state of the US. BES seed is a seed technology developed and promoted in the US. While research by Zavale et al. (2005) conducted in Mozambique using seed adoption in the form of improved seeds where improved seeds are seeds/varieties whose quality is improved to obtain higher productivity than conventional seeds. In Indonesia, especially in the horticulture sub-sector, the available data describing the adoption of seeds are certified seeds.

In previous studies, two methods can be used to estimate cost efficiency, namely Data Envelopment Analysis (DEA) and stochastic frontier. DEA is a non-parametric method that allows the use of multiple inputs and outputs. For DEA to be applicable, DMUs must be in similar activities and environments so that the same set of input costs and production costs can be determined. The advantage of this method depends on its statistical power when compared to other conventional methods, but it is less sensitive to misspecification errors and does not include heteroscedasticity and multicollinearity (Dzeng & Wu in Makuya, Ndyetabula, & Mpenda, 2018). In addition, DEA is more sensitive to outliers and cannot measure random error.

In contrast to DEA, the stochastic frontier is a parametric method that takes into account unobservable random variables associated with inefficiency (which can be technical inefficiency or cost efficiency) (Mendes & Silva, 2013). This method has the disadvantage of imposing special assumptions on the functional form of the frontier and distribution error terms. However, it also has the advantage that it takes into account noise (random error) and has the ability to test conventional hypotheses. This study uses stochastic frontier analysis to estimate cost efficiency because horticultural farming is a risky business due to unpredictable weather shocks and plant pests that can have a large effect on horticultural crop production.

RESEARCH METHOD

This study uses data from the Cost Structure of Horticultural Cultivation Household Survey (SOUH2018) by Statistics Indonesia (BPS). The unit of analysis in this study is a horticultural business household that cultivates seasonal crops (seasonal vegetables such as shallots, chilies, etc.; seasonal fruits such as strawberries, melons, watermelons, etc.; ornamental plants such as orchids, chrysanthemums, and medicinal plants such as ginger), turmeric, etc.) during the past year, with the aim that some or all of the results are sold/exchanged or earn income/profit on business risks. The variable are:

a. Total cost: Total costs are measured by production costs/costs incurred by farmers per area per growing season (Rupiah)/area
b. Production: Production is measured by self-harvested/slashed production divided by land area
c. Seed price: Seed price is the price per unit of seed/seedling (Rupiah)
d. Fertilizer price: The price of fertilizer is a weighted price of urea, ZA, NPK, other chemical fertilizers (TSP/SP36, KCL, etc.), and manure/compost by weighing the amount of fertilizer used
e. Pesticide price: Pesticide prices are weighted prices of chemical, vegetable and biological pesticides by weighing the number of pesticides used
f. Labor wages: Labor wages are costs incurred for labor (Rupiah) per area
g. Land rent: Land rent is the cost incurred for land rental (Rupiah) per area
h. Age: Due to the availability of data, the age of the head of the household was proxied with the age of the selected horticultural crop farmer, i.e., the age of the farmer in the household (10 years of household member) at the time of enumeration, calculated in years based on the last birthday
i. Age squared: The age of the household head squared is measured by the age of the farmer squared
j. Education: The level of education is categorized into 3, namely low, intermediate, and high. This is based on the 1997 International Standard Classification of Education (ISCED-97).
   1) Low: if the respondent has a high school diploma or equivalent or below
   2) Intermediate: if the respondent has a high school diploma or equivalent, code 1
   3) High: if the respondent has a university diploma (Diploma, S1, S2, or S3)
k. Gender: Categorical variable, 1 for male and 0 for female
l. Assistance: Assistance is a categorical variable that is measured by the question of whether to receive assistance (free/subsidized) for the selected horticultural cultivation
m. Credit access: Access to credit is a categorical variable that is measured by the question of whether farmers use loan capital for business.
n. Farmers Group: Farmer group is a categorical variable that is measured by the question of whether there are household members who become farmer groups at the time of enumeration
o. Training: Training is a categorical variable that is measured by the question of whether any household members receive counseling/guidance regarding the management of the selected plant business

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p. Land ownership: Land ownership is a categorical variable that is measured by the question of whether the land tenure status is used

The purpose of the study was to determine the effect of adoption of certified seeds on the cost efficiency of horticultural farming so that the empirical model refers to the cost function generated from the cost minimization model. For the first model, we adopt the translog cost frontier to obtain the cost efficiency parameter according to the study by Parikh et al. (1995) by adjusting the inputs used in horticultural farming.

$$\ln tc = \alpha_0 + \alpha_Q \ln prod + \sum_{i=1}^{n} \alpha_i \ln price_i + \frac{1}{2}\gamma_{yy}(\ln prod)^2 + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\gamma_{ij} \ln price_i \ln price_j + \sum_{i=1}^{n}\gamma_{yi} \ln prod \ln price_i + \varepsilon_i \quad (1)$$

where is the total cost, is the total output (production), is the price of the input variable, and is the disturbance term which consists of 2 components:

$$\varepsilon_i = V_i + U_i \quad (2)$$

$V_i$measure random variation in costs caused by factors beyond the control of the farmer, such as plant diseases, natural disasters, bad weather. While measuring cost inefficiency relative to the stochastic frontier. indicates that the cost of farming is right in the frontier (minimum cost) and indicates that the cost of farming is above the frontier (minimum cost). Cost efficiency is measured by U_i.

Next, we compare the first model with the second model with the cost function *Cobb Douglas,* as used by Siagian & Soetjipto (2020).

$$\ln tc = \alpha_0 + \alpha_Q \ln prod + \sum_{i=1}^{n} \alpha_i \ln price_i + \varepsilon_i \quad (3)$$

After the estimation, a model selection will be made to determine a more appropriate model in estimating the cost function. Selection of the best model is done by the likelihood ratio test and by comparing the likelihood values, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

RESULTS

Seasonal Horticultural Farming Cost Structure

Labor costs are the largest cost component, overall, in the adopter and non-adopter groups. Almost half of the expenditure is used for labor costs. The cost components between adopters and non-adopters are different. In the adopter group, the second largest cost is the cost of fertilizer, followed by land rent, pesticides, and the last is the cost of seeds. Meanwhile, in the non-adopter group, the second largest cost is the cost of seeds, followed by land rent, fertilizer, and the last is the cost of pesticides. This illustrates that although certified seeds are expensive, they use less per hectare than uncertified seeds.

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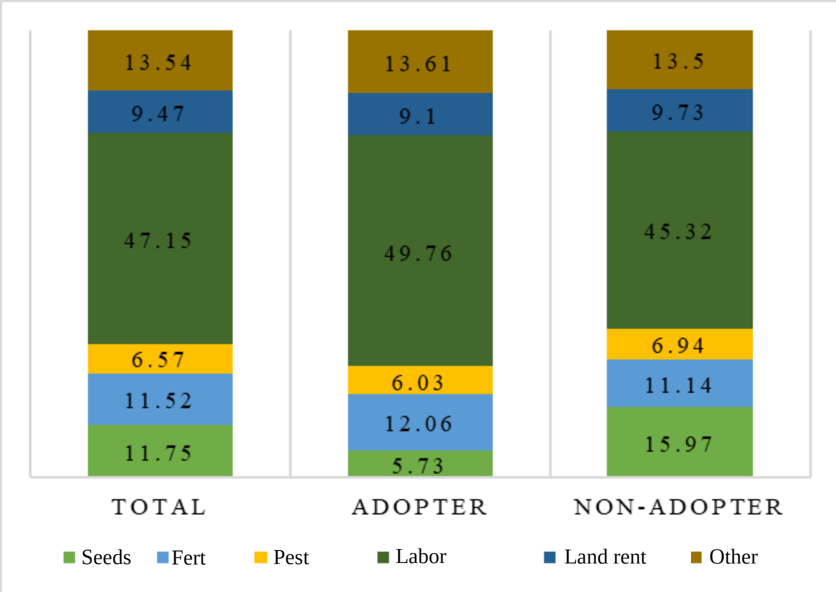

Figure 2. Cost Structure of Seasonal Horticultural Crops
Source: SOUH2018, processed using a weight

Before performing the inferential analysis, a skewness test is first performed to prove whether the function used in this study is a cost function or a production function. Based on the skewness test, the result is that the skewness value is 1.0228. This value is positive and significant at α=0.001 [Pr(skewness)=0.000], which means that the function used in this study is a true cost function. Then, the cost function properties were tested. Homogeneity is satisfied by normalizing the cost function to its input prices. Meanwhile, monotonicity is seen from the estimated cost share of each input and production price. In this study, the cost share is positive for each household.

This study compares the models that will be used in estimating cost inefficiency. The models compared in this study are translog and Cobb-Douglass on the cost function. For comparing the two models, there are several model selection criteria, including log-likelihood, AIC, and BIC. A larger log-likelihood value indicates an estimator is better than an estimator with a smaller log likelihood (Sudrajat, Rahayu, Supriyadi, & Kusnandar, 2018). In addition, to compare the two models, a likelihood ratio test was also carried out by assuming the Cobb Douglas model was nested within the translog (H0 : Because Prob > chi2 = 0.0000 less than the 1% confidence level, the decision to reject H0 can be taken. From the test and the log-likelihood value of the translog model is greater, AIC, and BIC are smaller than the Cobb-Douglas model, then the model chosen to estimate cost inefficiency is the translog model. $\gamma_{yy} = \gamma_{ij} = \gamma_{yi} = 0$).

Table 1. Result of Regression

Variable	Translog	Robust Translog	Average of Marginal Effect
Adopt seeds	1.149*** (0.3306)	1.149*** (0.2229)	0.0112
Cost function	Yes	Yes	Yes
Characteristics of farmers	Yes	Yes	Yes
Characteristics of farm households	Yes	Yes	Yes
Observation	26.097	26.097	26.097

Note:), **), ***) significant at =10%, =5%, and =1%*
Source: Processed from SOUH2018

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After selecting the translog model, a robustness standard error is performed, namely by comparing the standard error between the translog model and the robust translog model. Based on the table below, it can be seen that the standard error of certified seed variables in the robust model is smaller than the translog model, so the model used can be said to be robust and consistent.

DISCUSSION

Before analyzing the results of the estimation of the effect of certified seeds, farmer characteristics, and farm household characteristics on cost inefficiency, we first look at the description of the cost inefficiency data estimated using a one-step stochastic frontier. From a sample of 26,097 households, the average sample has an inefficiency of 0.0672 (Table 2). If viewed based on the value of cost efficiency, the average household efficiency is 0.9372. Based on this value, on average, households are very cost-efficient in producing seasonal horticultural crops (Ogundari & Ojo, 2005).

Table 2. Description of cost inefficiency

Variable	Observation	Average	Standard Deviation	Minimum	Maximum
Cost Inefficiency	26.097	0.0672	0.0262	0.0151	0.3808

Source: Processed from SOUH2018

Next, we will look at the differences in cost inefficiencies according to the adoption of certified seeds, farmer characteristics, and farm household characteristics. Table 5 shows that the value of cost inefficiency between adopter and non-adopter farmers is significantly different on average. Farmers who adopt certified seeds have a higher average cost inefficiency than farmers who do not adopt certified seeds, which is 0.0711, which means that, on average, farmers who do not adopt certified seeds are more cost-efficient than farmers adopting certified seeds. However, when viewed from the standard deviation, the standard deviation of households that adopt certified seeds is greater than the standard deviation of households that do not adopt certified seeds. This implies that the value of inefficiency in households that adopt certified seeds is more diverse than in households that do not adopt certified seeds. Adopting certified seeds does not necessarily provide higher cost efficiency than ordinary seeds because it requires a learning process by farmers about new seed cultivation techniques.

Table 3. Average Cost Inefficiency Differences by Certified Seed Adopters (Seed Adoption=1) and Certified Seed Non-Adopters (Seed Adoption=0)

Variable	Seed adoption=0		Seed adoption=1		Mean differences
	mean	Std. Dev.	mean	Std. Dev.	
Cost Inefficiency	0.0615	0.0223	0.0711	0.0279	-0.0095***
Number of observations	10,655		15,442		

Note:), **), ***) significant at =10%, =5%, and =1%*
Source: Processed from SOUH2018

In Table 1, we can see that the variable adoption of certified seeds is significantly positive in influencing cost inefficiency. However, the magnitude of the effect cannot be seen. Therefore, to see the effect, it is necessary to calculate the marginal effect. Farmers who adopt certified seeds, on average, have a higher cost inefficiency of 0.0112 (more cost inefficient) than farmers who do not adopt certified seeds. Adoption of certified seeds will not succeed if it is not accompanied by the ability to cultivate according to the characteristics of new seeds, it can reduce cost efficiency. In addition, the existence of fake certified seeds circulating in the community makes farmers' expenditures swell, but the seeds they get are seeds that are not of guaranteed quality (Erawati, 2019; Humas Jabar, 2020). In addition, this study uses cross-sectional data, where the adoption decision and its application have not lasted long, it is possible that the adoption process is still in the trial stage, where farmers are still trying to use certified seeds, so that optimal results have not been achieved. Furthermore, horticultural farmers actually use other technologies, besides the use of certified seeds. In seed technology, apart from certified seeds, there are also other technologies such as superior seeds created by farmers themselves.

CONCLUSION

Based on the results of descriptive analysis, this study found that the largest cost component in the seasonal horticultural cultivation is the cost of labor. On average, the proportion of households that adopt certified seed is still lower than that of households that do not adopt certified seed. Furthermore, after using stochastic frontier estimation, it was found that adopting certified seeds can increase cost inefficiencies.

LIMITATION

Our limitation is this study focuses on aggregates seasonal horticultural plants, which in the group of seasonal horticultural plants there are variations in the characteristics of each plant. In addition, this study uses the use of certified seeds as a proxy for seed adoption. In fact, many farmers use superior seeds from their own innovations without being certified.

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DECLARATION OF CONFLICTING INTERESTS

Author have no potential conflict of interest.

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