Jurnal Manajemen & Agribisnis, Vol. 19 No. 3, November 2022
Permalink/DOI: http://dx.doi.org/10.17358/jma.19.3.331

Available online at
http://journal.ipb.ac.id/index.php/jmagr

FACTORS AFFECTING THE TECHNICAL EFFICIENCY OF CASSAVA FARMING IN WONOGIRI REGENCY

Anggi Fitria Cahyaningsih[*)1], Endang Siti Rahayu[*)], Kusnandar[*)]

[*)]Agribusiness Program, Faculty of Agriculture, Universitas Sebelas Maret
Ir. Sutami St 36, Kentingan, Jebres, Surakarta, Central Java 57126, Indonesia

Article history:

Received
13 June 2022

Revised
14 July 2022

Accepted
20 November 2022

Available online
30 November 2022

Abstract: Cassava is a potential commodity to develop because it is used for consumption and industrial raw materials. Wonogiri Regency has the highest harvest and production area in Central Java. Such a high production level is not comparable to a low level of productivity. The productivity of cassava in Wonogiri Regency is only 18.99 tons per hectare lower than the national productivity, which is 25.95 tons per hectare. Therefore, it is necessary to use inputs as an efficient resource to increase productivity. This study analyzed the technical efficiency and factors affecting the efficiency of cassava. Primary data from 75 cassava farmers in Wonogiri Regency. Data Envelopment Analysis (DEA) and regression Tobit were the data analysis methods. DEA results showed efficiency scores ranging from 0.107 to 1.28% of cassava farmers in Wonogiri were technically efficient in carrying variable return to scale, with an average score of 0.580. Cassava farmers in Wonogiri Regency should increase the efficiency value by reducing slack inputs, namely cassava seeds, phonska fertilizer, and urea fertilizer. Tobit regression results show that farmer education and group membership significantly affect the efficiency of cassava. Farmers with higher education have better skills to adopt new technologies and use inputs more efficiently. The farmer group has a positive influence because it can provide information and discussion to overcome the problem of cassava farming.

Keywords: cassava farming, DEA, efficiency, productivity, tobit regression

Abstrak: *Ubi kayu merupakan komoditas potensial untuk dikembangkan karena penggunaannya untuk konsumsi hingga bahan baku industri. Kabupaten Wonogiri memiliki luas panen dan produksi tertinggi di Jawa Tengah. Tingginya tingkat produksi tersebut tidak sebanding dengan tingkat produktivitas yang rendah. Tingkat produktivitas ubi kayu di Kabupaten Wonogiri hanya 18,99 ton/Ha, lebih rendah dari tingkat produktivitas nasional yaitu 25,95 ton/Ha. Oleh karena itu, diperlukan penggunaan input sebagai sumber daya yang efisien untuk meningkatkan produktivitas. Penelitian ini menganalisis efisiensi teknis dan faktor-faktor yang memengaruhi efisiensi ubi kayu di Kabupaten Wonogiri. Data primer dari 75 petani ubi kayu di Kabupaten Wonogiri. Metode analisis data yang digunakan yaitu Data Envelopment Analysis (DEA) dan regresi Tobit. Hasil DEA menunjukkan skor efisiensi berkisar antara 0,107 hingga 1,00 untuk VRS. 28% petani ubi kayu di Wonogiri secara teknis efisien di bawah variable return to scale, dengan skor rata-rata 0,580. Petani ubi kayu di Kabupaten Wonogiri sebaiknya meningkatkan nilai efisiensi dengan mengurangi penggunaan input slack, yaitu bibit ubi kayu, pupuk phonska, dan pupuk urea. Hasil regresi Tobit menunjukkan bahwa pendidikan petani dan keanggotaan kelompok tani secara signifikan mempengaruhi efisiensi ubi kayu di Kabupaten Wonogiri. Petani dengan pendidikan tinggi memiliki keterampilan yang lebih baik untuk mengadopsi teknologi dan inovasi baru dan menggunakan input dengan lebih efisien. Kelompok tani memiliki pengaruh positif karena dapat memberikan informasi dan diskusi untuk mengatasi permasalahan usahatani ubi kayu.*

Kata kunci*: petani ubi kayu, DEA, efisiensi, produktivitas, regresi tobit*

[1] Corresponding author:
Email: anggifitria16@gmail.com

INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is a tropical plant in Asia, Africa, and South America (Burns et al. 2012). Cassava is a commodity with great potential to support agricultural growth in Indonesia because of its wide use ranging from consumption to industry. Cassavas have characteristics that attract farmers to cultivate them. Cassava commodities are available throughout the year, more tolerant to soils with low fertility and resistant to drought, pests, and diseases (Aboki et al. 2013). Based on theIndonesian Ministry of Agriculture Database (2019), national cassava production in 2015-2019 was relatively declining. In 2019, cassava production decreased compared to 2018 from 19.34 million tons to 16.35 million tons. The decrease in production resulted in the demand for national cassava that has not been fulfilled (Anggraini, 2016).

Based on data on the development of cassava production in Indonesia in 2018, there are eight provinces with high-production cassava centers, three provinces including Lampung, with production reaching 6,683,758 tons. Central Java province ranks second with a production of 3,267,417 tons. While East Java province is third with a production of 2,551,840 tons (Central Bureau of Statistics Indonesia, 2019). Nationally, the productivity rate of cassava in 2018 decreased compared to 2017, which amounted to 246.50 quintals per hectare.

Wonogiri regency has the highest harvest and production area among ten other districts in Central Java (Table 1). The soil conditions and climate of the region that support growing crops make Wonogiri Regency an agricultural area with cassava as a superior commodity. The cassava production in Wonogiri Regency amounted to 890,438 tons with a harvest area of 46,873 hectares. Although the amount of production and harvest area in Wonogiri Regency is the highest, cassava productivity is the lowest among other regions that rank the tenth highest in cassava production in Central Java. The level of productivity of cassava in Wonogiri Regency is only 18.99 tons per hectare, lower than the national productivity level in 2019, which is 25.95 tons per hectare. Productivity is vital for the future of humanity to meet its basic needs of food, fiber, and shelter (Khuda et al. 2006). According to Kumbhakar (2004), the decrease in productivity is due to technical inefficiencies, while the more efficient a company is, the higher its productivity. Efforts to increase cassava production through extensive (land expansion) in the current conditions are incrasingly difficult to pursue because agricultural land is increasingly limited, primarily due to the increasing conversion of agricultural to non-agricultural land. As a result, efforts to overcome the decline in cassava production are to increase productivity through efficiency improvements.

According to Bakhshoodeh and Thomson (2001), technically efficient farmers use less input than other farmers to produce a certain amount of output at a certain level or farmers who produce greater output than other farmers using a certain number of inputs. Farmers' low productivity can be sourced from various problems encountered in the field or on the farm. According to Ardhiana and Riani (2019), issues range from limited resources to be used, low productivity, and opportunities for developing agriculture and management or cultivation techniques that are still traditional. According to Anggraini (2016), some of the socioeconomic characteristics of farmers who are sources of inefficiency are age, business experience, household size, education level, membership in peasant groups, extension, credit access, and others. The socioeconomic characteristics of farmers will affect the managerial abilityof farmers in the production of cassavas, affecting the level of efficiency of cassava farming. Belete et al. (2016) suggest socioeconomic factors influence technical efficiency scores. Efficiency can be achieved by minimizing the required resources or inputs used to produce a particular output or maximizing the output generated from a specific resource. Therefore, an effort to increase productivity must be accompanied by the efficient use of resources. Therefore, this study aims to (1) analyze the efficiency of cassava farming in Wonogiri Regency and (2) analyze the factors that affect the efficiency of cassava farming in Wonogiri Regency.

Analysis related to farming efficiency, especially cassava in Wonogiri Regency, needs to be carried out considering that cassava is one of the leading commodities in the regency and is the highest production center in Central Java Province. Problems related to the low productivity of cassava farming can be analyzed with the efficiency of farming through the Data Envelopment Analysis (DEA). With the DEA method, it can be identified whether excessive use of production inputs (slack) causes inefficiency. Research on the efficiency of farming for cassava commodities in Central Java Province, especially in Wonogiri Regency, has never been carried out as the area with the highest production in 2019. Previous research from Lasmini et al. (2016) used DEA to analyze the technical efficiency of rice farming, research by Hakim et al. (2021), to analyze technical efficiency among agricultural households in East Java, and research by Ajayi et al. (2018), with the DEA method and Heckman probit model to analyze the technical efficiency of cassava farmers in Ondo State, Nigeria. The results of this study are then used to provide recommendations for both farmers and the government on how to increase efficiency by allocating appropriate production inputs. Thus, it will affect increasing production and productivity of cassava farming Wonogiri Regency.

METHODS

The primary method used in this study is quantitative descriptive. This research was conducted in three sub-districts of Wonogiri Regency, Central Java: Ngadirojo Subdistrict, Jatipurno Subdistrict, and Girimarto Subdistrict in 2021. The determination of the location of the study was chosen deliberately (purposive sampling), considering that the three sub-districts are areas with high cassava production and a center for cassava production in Wonogiri Regency. The data used in this study are primary data and secondary data. Data collection techniques are carried out by observation and surveys following the distribution area of cassava management and interviews of cassava farmers with structured questionnaires. Primary data is obtained from the mechanism of interviews and observations with farmers, and secondary data is obtained from the Database of the Indonesian Ministry of Agriculture, Central Bureau of Statistics Indonesia (Badan Pusat Statistik) of Central Java Province and Wonogiri District.

The method of determining samples using purposive sampling, which is selected based on specific criteria, cassava farmers who are still actively conducting cassava farming activities. There is no sampling frame at the research site, so the number of populations cannot be known. Ramanathan (2003) suggests that the number of samples for DEA analysis should betwo or three times greater than the number of inputs and outputs used. Cohen et al. (2007)stated that the minimum number of samples is as many as 30. This study determined the sample number of 75 cassava farmers because it was considered to have been able to qualify to conduct a data analysis test.

Data Envelopment Analysis (DEA)

Technical efficiency measurements use non-parametric methods, namely Data Envelopment Analysis (DEA), to determine the technical efficiency of cassava farmers in the Wonogiri Regency. DEA is a widely accepted methodological approach for assessing productive efficiency or quantifying relative deficiencies (Bournaris et al. 2019).

Table 1. The Harvest area, production, and productivity of cassava according to the ten highest productions in Central Java in 2019

Regency	Harvest Area (Ha)	Production (Ton)	Productivity
Cilacap	3,840	98,187	25.57
Purbalingga	1,754	52,659	30.02
Banjarnegara	3,417	112,625	32.96
Wonosobo	4,404	156,300	35.49
Boyolali	3,342	91,721	27.44
Wonogiri	46,873	890,438	18.99
Karanganyar	2,165	54,997	25.40
Pati	14,184	746,516	52.63
Jepara	6,759	245,074	36.25
Semarang	1,685	53,218	31.58

Source: Central Bureau of Statistics (Badan Pusat Statistik) Central Java, 2020

The study used the variable return to scale model concept in DEA to perform technical efficiency analysis. The assumption of variable return to scale (VRS) is different from CRS, where VRS does not require changes in input and output of a DMU to take place linearly. Hence, it is permissible to increase (increasing return to scale) and decrease (decreasing return to scale) efficiency value (Charnes et al. 1978). An efficiency score of ≤ 1 with a value of 1 indicates a point at the border, showing a decision making unit (DMU) is technically efficient.

Mathematically, the calculation of technical efficiency with the VRS model is written as follows:

$$\text{Min } \theta, \lambda, \theta$$

Subject to: $-yi + Y\lambda \geq 0$, $\theta\, xi - X\lambda \geq 0$, $N1\lambda=1$, $\lambda \geq 0$, Where θ is the technical efficiency score, where the value is used to measure the efficiency of the cassava farm, yi is the vector of the amount of cassava production, and xi is the vector of the number of production inputs. Y is the output of the amount of production. X is the production input, and λ is the Nx1 vector of weights. Input variables in this study are land area, cassava seedlings, organic fertilizer, urea fertilizer, and phonska fertilizer, while the output variable is cassava production.

Tobit Regression

Factors that affect technical efficiency in these researchers were analyzed using Tobit regression. Therefore, estimation with an ordinary least squares (OLS) regression of DEA scores would lead to a biased parameter estimate since OLS assumes a normal and homoscedastic distribution of the disturbance and the dependent variable (Charnes et al. 1987). Tobit regression of variables is not accessible or dependent limited in value (Censored), while free variables (Independent) are not limited in value (non-censored). The technical efficiency value is the sensor value used in this study, limited between 0.00 and 1.00. Variable factors that are suspected to affect technical efficiency based on various previous studies and adjusted to the conditions at the research site are the age of farmers, farmer education, farming experience, and the participation of farmers in the farmer group. Farmers are the main actors in the cassava farming business. Therefore the self-capacity of farmers is a factor that can support the success of the farming business. Factors of the farmer himself include age, level of education, and experience in farming which are free variables in this study. Self-identification is an effort to increase productivity, business efficiency, income and welfare, and awareness of the importance of sustainable agriculture (Fardanan, 2017). Factors outside the farmer can be seen in farmer participation in farmer groups (poktan). According to Parissing (2019), a farmer group is formed based on similar environmental conditions and familiarity for improving business development. As the main actors, farmer groups become one of the agricultural institutions that play an important role and become the spearhead in agricultural development. Farmer groups have several activities, one of which is the Farmer Extension Agency (BPP) counseling. Therefore, the participation of farmers in farmer groups is one of the variables in this study. Meanwhile, other variables such as climatic conditions, government policies, and internet access are fixed. Most farmers are more than 50 years old and have limitations in accessing the internet; not all areas where farmers live reach the internet smoothly. Tobit regression model of the following form was specified:

$$Y = \alpha + \beta 1\ X1 + \beta 2X2 + \beta 3X3 + \beta 4\ X4 + e$$

where: Y (Technical efficiency score) ;x1(Farmer's age (year)); x2 (Farmer education (year)); x3 (Experience in farming (year)); x4 (Dummy variable to determine whether farmers participate in farmer's group (1) or not (0)); α (Constant); β1-β4 (Regression Coefficient)

The hypotheses used for technical efficiency analysis in this study are:

1. Age
   The older the age, it is suspected that it will negatively affect technical efficiency. The older the age, the smaller the technical efficiency of farming (inefficient).
2. Education Level
   The level of education is expected to have a positive effect on technical efficiency. The longer the level of education taken by farmers, the more efficient farmers are (the value of technical efficiency is higher).
3. Experience
   The growth of farmers in carrying out cassava farming is suspected of having a positive effect on technical efficiency. The higher the experience of cassava farming, the more technically efficient

the farmer (the higher the technical efficiency value).

4. Participation of farmers in farming groups.
   The participation of farmers or membership in the farming group is thought to positively affect cassava's technical efficiency. Farmers who follow or participate in farmer groups are more efficient than those who do not participate in farmer groups.

Wonogiri Regency is the area with the highest level of cassava production in Central Java. However, the level of cassava productivity in the Wonogiri Regency is low. The low level of productivity needs to be pursued through the allocation of production factors that input the cassava farming business so that the use of production factors is efficient. Technical efficiency shows the ability to produce maximum output with a number of existing inputs. Technical efficiency analysis of cassava farming in Wonogiri Regency using DEA analysis tools with input variables land area, cassava seedlings, organic fertilizer, urea fertilizer, and phonska fertilizer and variable output, cassava production. Factors that are suspected to affect the level of efficiency of cassava farming in Wonogiri Regency are the age of farmers, farmer education, farming experience, and the participation of farmers in the farmer group. Such efficiency factors are analyzed by regression of the Tobit model. The framework for answering the problems in this research is presented in Figure 1.

RESULTS

The Efficiency of Cassava Farming in Wonogiri Regency

The variables used are input variables and output variables. Input variables consist of land area, seed use, organic fertilizer, urea fertilizer, and phonska fertilizer, while variable output is cassava production. Farmers who can be technically efficient are farmers who have a technical efficiency valueof 1,000, while farmers who have a technical efficiency value below the value of 1,000 cannot be said to be technically efficient. The results of technical efficiency analysis with DEA is presented in Table 2.

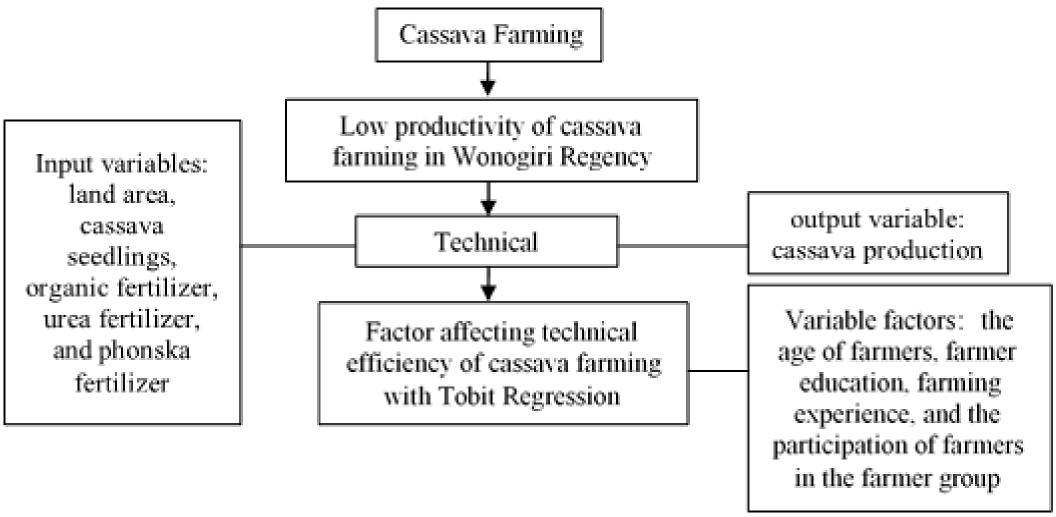

Figure 1. Research framework

Table 2. Technical efficiency score of cassava farming in Wonogiri Regency

Items	VRSTE
Average value (Mean)	0.580
Minimum efficiency value	0.107
Maximum efficiency value	1.000
Total farmers with an efficiency value 1	21 (28%)
Total farmers with an efficiency value of <1	54 (72%)

Table 2 shows that based on the results of DEA calculations assuming Variable Return to Scale Technical Efficiency (VRSTE), 21 farmers (28 percent) are technically efficient, and54 (72 percent) are not technically efficient. A cassava farmer's average technical efficiency value is 0.580, with an efficiency value of 0.107 and a top value of 1.000. The technical efficiency value of farmers in Wonogiri Regency is lower than the results of Anggraeni et al. (2016) research on cassava farmers in Central Lampung Regency, with an average technical efficiency value of 0.69. The results of DEA research from Ajayi and Olotumise (2018) indicated that about 80% of the respondents had an efficiency above 0.50, with an average efficiency of 0.83. The DEA results could be deduced from the average technical efficiency that cassava producers in Wonogiri Regency could increase their efficiency by 42% through the better and appropriate use of resources. The technical efficiency levels ranged from a minimum of about 10.7% to a maximum of 100%. Akpaeti and Frank (2021), in their research, also said that the DEA result implies that an average cassava farmer has some room for productivity increase through increased efficiency. There is a tremendous opportunity to improve technical efficiency among the cassava farmers in the study area.

Input *Slack*

Slack is an inefficient level of inefficiency in DMU. The inefficient use of inputs on DMU is referred to as slack input. Slack input values is presented in Table 3. Managing the cultivation business efficiently using appropriate production inputs will determine the productivity achieved (Susanti et al. 2017). As one of the resources used in cassava farming in the Wonogiri Regency, land has a slack value input of 0.038 ha. These advantages can result in technical inefficiencies due to improper planting distance arrangements from farmers. Erwin et al. (2015) said that setting planting distance and providing growing space for plants to obtain nutrients and find out the needs of seeds or seeds needed. Following GAP or cultivation guidelines from the Ministry of Agriculture, the optimal cassava planting distance is 100x100cm for monoculture planting systems. However, some farmers still apply planting distance less than GAP, which is about 50-60 cm x 70-80 cm. The planting distance will affect the level of seed needs needed in farming. With the planting distance getting tighter, the number of seeds needed increases, and these factors can cause inefficiencies.

Seed inputs had an average slack value of 354.184 stems with 18.67 percent of respondents. This value indicates that some farmers use excess seedlings in cassava farming activities. The use of extra inputs carried out by farmers in Wonogiri Regency can be caused by the habits of farmers in conducting their farming activities based on experience only. The use of seedlings is done using a comparison between land area and seed needs, such as previous farmers, even though the land's condition will change in quantity and soil quality. Research results related to excess inputs were also found in Shahnavazi's research (2018) which found that the largest gap was from seeds.

Chemical fertilizers in the form of Phonska fertilizer and Urea fertilizer also have slack input with respondents of 17.33 percent and 40 percent, consecutively. This slack input is because many farmers consider that the high fertilizer used can increase the amount of production. The average farmer should reduce Phonska fertilizer by 38,078 kg and 11.168 kg for Urea fertilizer. Raheli et al. (2017) suggest that chemical fertilizers cause a real difference between efficient and inefficient farmers. The type of slack input with the largest number ofrespondents is urea fertilizer, with 30 respondents (40 percent) of the respondents studied.The average use of Phonska fertilizer farmers in Wonogiri Regency is 52.96 kg per hectare, while urea fertilizer is 142.90 kg per hectare. Farmers may increase efficiency by reducing urea fertilizer inputs following GAP or cultivation guidelines from the Ministry of Agriculture, where the optimal fertilizer dose is 30 kg per hectare for Phonska fertilizer and 135 kg per hactare for urea fertilizer. Arifin et al. (2021), technical efficiency is the ability to reduce waste by maximizing output and minimizing inputs. Farmers can increase the amount of output by implementing good and correct GoodAgricultural Practices (GAP), including using seedlings and inputs as recommended.

Factors that Affect the Technical Efficiency of Cassava Farmingin Wonogiri Regency

Socioeconomic variables used in Tobit regression in this study are age (year), education (year), the experience of farming cassava (year), and participation in the farmer group (dummy). The characteristics of respondent farmers in Wonogiri Regency averaged 56 years, with an education level of 8 years and learning experience of 31 years. Sixteen farmers do not join the farming group, and 59 farmers are members of the farmer group. Based on the Tobit regression analysis results, factors that affect the technical efficiency of cassava farming in the Wonogiri Regency is presented in Table 4.

Variables of education, farming experience, and dummy membership of farmer's groups positively affect the technical efficiency of cassava farming in the Wonogiri Regency. The positive coefficient value of education variables 0.0474 indicates that the farmers with higher education have higher technical efficiency than those with low education. The results of this study are in line with the results of Arifin et al. (2021) and Susanti et al. (2017), where farmers who have a higher level of education have a more comprehensive network. ,Therefore access to information obtained can be broader and faster compared to farmers who have a lower level of education. Farmers are considered able to improve their managerial ability and assist farmers in making decisions related to farming, including inputs to be used. Farmers with higher levels of education are easier to accept and implement innovations and new technologies in agriculture. The research results from Amandasari (2014) and Lawalata et al. (2015) showed that education would affect farmers' ability in agricultural management and more easily receive new information and technology.

Table 3. Average slack input value of cassava farming in Wonogiri Regency

Items	Average Slack Value	Respondent	Percentage
Land (Ha)	0.038	16	21.33%
Seedlings (stems)	354.184	14	18.67%
Organic Fertilizer (kg)	4.000	1	1.33%
Phonska Fertilizer (kg)	38.078	13	17.33%
Urea Fertilizer (kg)	11.168	30	40.00%

Table 4. Results of Tobit Regression

Variable	Coefficient	Probability (P> |t|)
Age (year)	0.0063	0.285
Farmer's education (year)	0.0474*	0.000
Farmer's experience (year)	0.0120*	0.008
Participation in the farmer group (Dummy)	0.1922*	0.035
Prob > chi2 = 0.0000		
Pseudo R2 = 0.6591		

Description: *) Significant at 5%

Variable experience trying to farm cassava has a positive effect on the technical efficiency of cassava. Research Arifin et al. (2021) and Ademiluyi et al. (2013) also stated that experience affects technical efficiency. The experience of trying to farm can help farmers in decision making. Farmers with extended farming experience can make better decisions, so they have higher technical efficiency than those with low experience because they learn from previous farming experiences. Farmers' decisions based on experience will make farmers more efficient because they have better skills, knowledge, and technology adoption capabilities to minimize the productivity decline that affects farmers' efficiency due to resource degradation. The dummy variable of farmer group membership has a value of 1 if farmers follow the activities of the farmer group, both as administrators and members. Meanwhile, if farmers do not follow the farmer group, the value is 0. This variable positively affects the technical efficiency of cassava farming in the Wonogiri Regency. The farmer who follows the farmer's group has a higher value of technical efficiency than the farmer who doesn't follow the farmer group. Lubis et al. (2014) and Che Soh et al. (2021) also had similar results. The existence of farmer groups is very important because it can help farmers overcome various problems experienced related to cassava farming. Through the farmer group, they offer and exchange ideas and technologies with other members, training, and information from extensionists. Che Soh et al. (2021) stated that the activation of farmer participation of farmer's groups or associations is very important to receive assistance from the government and improve farmers' bargaining position in obtaining quality production inputs at affordable prices.

Manajerial Implication

The managerial implication of the results of this study for cassava farmers in the Wonogiri Regency is that farmers can improve the technical efficiency of cassava farming by using efficient production inputs. Farmers can increase their experience and knowledge about cassava farming through non-formal education such as training and assistance from farmer groups (poktan) and information from various media. Therefore, for the government, these results can be used as policy material in increasing farmers' access to agricultural extension services that can assist in farmer training programs related to the appropriate combination of inputs. Policies on fertilizer distribution also need to be improved so that farmers' access to fertilizer needs, especially subsidized fertilizers, can be available according to farmer needs. The role of farmer groups (poktan) is very important for farmers in accessing information, and counseling is needed, especially regarding production inputs for good cassava farming. The approach in conveying information on the use of inputs, especially optimal fertilizers, to farmers must be able to provide an overview through cassava farmers who are already efficient regarding the benefits of using optimal fertilizers so that it is expected to be a motivation for farmers to apply it and is also expected to affect production and increase the technical efficiency of cassava farming.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The average technical efficiency rate of cassava farmers in Wonogiri Regency is 0.580 (58%), with 72% of farmers not technically efficient. Cassava farmer could increase their efficiency by 42% through the better and appropriate use of input variables as resources. Variables that significantly affect the efficiency of cassava in the Wonogiri Regency are farmer education, farmer experience, and the participation of farmers in farmers' groups

Recommendations

Cassava farmers in Wonogiri Regency can increase their farmers' efficiency by reducing the use of excess input (input slack), especially in the use of cassava seedlings, phonska fertilizer, and urea fertilizer. Determination of seedling needs can be adjusted to the quantity and quality of the land. According to Good Agricultural Practices (GAP) or the guidelines for cassava cultivation with optimal fertilizer doses, farmers can increase efficiency by reducing the amount of urea fertilizer inputs, according to Good Agricultural Practices (GAP) or the guidelines for cassava cultivation from the Ministry of Agriculture with optimal fertilizer doses. Recommendation to increased participation of farmers to join the farmer group needs to be done because it has various benefits in the management of cassava farming to be more efficient. The role of extensionists in the farming group is also important to socialize the importance of using appropriate inputs. Recommendations for further research are expected to be able to analyze farmers' efforts to increase the efficiency of cassava farming by utilizing the application of technology in cassava farming.

FUNDING STATEMENT: This research was supported and funded by PNBP and LPPM (Lembaga Penelitian dan Pengabdian kepada Masyarakat), Universitas Sebelas Maret Surakarta.

CONFLICTS OF INTEREST: The authors declare no conflict of interest.

REFERENCES

Aboki E, Jongur AAU, Onuand JI, Umaru II. 2013. Analysis of technical, economic, and allocative efficiencies of cassava production in Taraba State, Nigeria. *Journal of Agriculture and Veterinary Science* 5(3):19-26. https://doi. org/10.9790/2380-0531926

Ademiluyi IO, Adepujo SO, Andokeke AK. 2013. Technical efficiency of sustainable cassava farming in Kogi State, Nigeria. *Journal of Sustainable Development* 10(1):56–60.

Ajayi CO, Olutumise AI. 2018. Determinants of food security and technical efficiency of cassava farmers in Ondo State, Nigeria. *International Food and Agribusiness Management Review* 21(7): 915–928. https://doi.org/10.22434/ IFAMR2016.0151

Akpaeti AJ, Frank NN. 2021. Technical efficiency of cassava cooperative farmers in south- south, Nigeria: a comparative analysis. *Nigerian Agriculture Journal* 52(2):8-14.

Amandasari M. 2014. Efisiensi teknis usahatani jagung manis di Kecamatan Tenjolaya Kabupaten Bogor: Pendekatan data envelopment analysis [tesis]. Bogor: Sekolah Progam Pascasarjana, Institut Pertanian Bogor.

Anggraini, N, Harianto, Lukytawati A. 2016. Efisiensi teknis, alokatif dan ekonomi pada usahatani ubikayu di Kabupaten Lampung Tengah, Provinsi Lampung. *Jurnal Agribisnis Indonesia* 4(1):43-56. https://doi. org/10.29244/jai.2016.4.1.43-56

Ardhiana, Riani. 2019. *Analisis Efisiensi Ekonomi Usahatani: Pendekatan Stochastic Production Frontier.* Aceh: Sefa Bumi Persada.

Arifin AM, Anna F, Netti T. 2021. Efisiensi teknis usahatani kentang di Kabupaten Gowa Sulawesi Selatan. *Forum Agribisnis (Agribusiness Forum)* 11(1):65-74. https:// doi.org/10.29244/fagb.11.1.65-74

Bakhshoodeh M, Thomson KJ. 2001. Input and output technical efficiencies of wheat production in Kerman, Iran. *Agricultural Economics* 24(3): 307-313. https://doi.org/10.1016/S0169-5150(00)00074-8

Belete A, Setuno MP, Laurie SM, Senyolo MP. 2016. A stochastic frontier approach to technical efficiency and marketing of orange fleshed sweet potato (OFSP) at farm level: A case study of Kwazulu-Natal Province, South Africa. *Journal of Human Ecology* 53(3):257-265. https://doi.org/10.1080/09709274.2016.1 1906979

Bournaris T, George V, Christina M. 2019. The efficiency of vegetables produced in glasshouses: The impact of data envelopment analysis (DEA) in land management decision making. *MDPI Journal: Land* 8(17): 1-11. https://doi.org/10.3390/land8010017

Burns AE, Bradbury, JH, Cavagnaro, TR, Gleadow, RM. 2012. Total cyanide content of cassava food Products in Australia. *Journal of Food Composition and Analysis* 25:79–82. https:// doi.org/10.1016/j.jfca.2011.06.005

[BPS] Central Bureau of Statistics Indonesia (Badan Pusat Statistik). 2019. Luas panen, produksi dan produktivitas ubi kayu di Indonesia 2019. www.bps.go.id. [20 Jul 2021].

[BPS] Central Bureau of Statistics Indonesia (Badan Pusat Statistik). 2020. Luas panen, produksi dan produktivitas ubi kayu dan ubi jalar menurut kabupaten/kota di Provinsi Jawa Tengah. www.jateng.bps.go.id. [20 Jul 2021].

Charnes A, WW Cooper and E Rhodes. 1978. Measuring the efficiency of decision making units. *European Journal of Operational Research* 2:429-444. https://doi. org/10.1016/0377-2217(78)90138-8

Che Soh N, Nur SS, Mohd M. 2021. Economic efficiency of stingless bee farms in peninsular Malaysia estimated by data envelopment analysis (DEA). *PERTANIKA Journal of Social Sciences & Humanities* 29(1):617–633. https://doi. org/10.47836/pjssh.29.1.34

Cohen L, Manion L, Morrison K. 2007. *Research Methods in Education Sixth Edition.* New York: Routledge Taylor and Francis Group.

https://doi.org/10.4324/9780203029053

Erwin S, Ramli, Adianton. 2015. Pengaruh berbagai jarak tanam pada pertumbuhan dan produksi kubis (Brassica oleracea L.) di Dataran Menengah Desa Bobo Kecamatan Palolo Kabupaten Sigi. *Jurnal Agrotekbis* 3(4):491-497.

Fardanan AG. 2017. The effect of the role of agricultural extension workers on changes in the behavior of coconut farmers in Oba District, Tidore Islands City. Seminar Nasional Hasil Penelitian dan Pengabdian Masyarakat UNIMUS 2017.

Indonesian Ministry of Agriculture. 2019. Database (basis data kementrian pertanian). www.pertanian.go.id. [20 Jul 2021]

Khuda B, Ahmad B, Sarfraz H. 2006. Food security through increasing technical efficiency. *Asian Journal of Plant Sciences* 5: 970-976. https://doi.org/10.3923/ajps.2006.970.976

Kumbhakar SC. 2004. *Productivity and Efficiency Measurement Using Parametric Econometric Methods.* Binghamton: Working Paper, State University of New York.

Lasmini F, Nurmalina R, Rifin A. 2016. Technical efficiency of rice farming business of participating farmers and non-participating farmers of the SL-PTT Program in Sukabumi Regency. *Jurnal Manajemen & Agribisnis* 13(1):59-68. https://doi.org/10.17358/JMA.13.1.59

Lawalata M, Dwidjono HD, Slamet H. 2015. Relative efficiency of red onion farming in Bantul Regency with data envelopment analysis (DEA) Approach. *Jurnal Ilmu Pertanian* 18(1):1-8. https://doi.org/10.22146/ipas.6169

Lubis RRB, Arief D, Mangara T, Handewi PS. 2014. Analisis efisiensi teknis produksi nanas: Studi kasus di Kabupaten Subang, Jawa Barat. *Jurnal Agro Ekonomi* 32(2):91-106. https://doi.org/10.21082/jae.v32n2.2014.91-106

Parissing CS. 2019. Kelompok tani (fungsi dan peran kelompok tani). http://cybex.pertanian.go.id/mobile/artikel/85489/KELOMPOK-TANI--FUNGSI-DAN-PERAN-KELOMPOK-TANI/. [20 Jul 2021].

Raheli H, Rezaei RM, Jadidi MR, Mobtaker HG. 2017. A two stage DEA model to evaluate sustainability and energy efficiency of tomato production. *Journal Information Processingin Agriculture* 4:342-350. https://doi.org/10.1016/j.inpa.2017.02.004

Ramanathan R. 2003. *An Introduction to Data Envelopment Analysis, A Tool for Performance Measurement.* London: Sage Publication.

Shahnavazi A. 2018. Technical, allocative, and economic efficiencies of potato production in Iran. *International Journal of Farming and Allied Sciences* 7(3):73-77.

Susanti ENS. 2017. efisiensiteknis usaha pembesaran lobster di Pulau Lombok, Nusa Tenggara Barat. *Jurnal Manajemen dan Agribisnis* 14(3):230-239. http://dx.doi.org/10.17358/jma.14.3.230