Agro Bali : Agricultural Journal
Vol. 7 No. 3: 906-915, November 2024
e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1831

Efficiency of White Mustard Cooperative Farming Production and Socio-Economic Factors Affecting (Case in Tulungrejo Village, Batu City), Indonesia

Laila Nur Hafiidha♥, Syafrial, Rosihan Asmara
Department of Agricultural Economics, Agriculture Faculty, Universitas Brawijaya, Malang, Indonesia
♥Corresponding author email: lailanurhafiidha@gmail.com

Article history: submitted: May 3, 2024; accepted: October 31, 2024; available online: November 27, 2024

Abstract. The inefficiency of white mustard growers in allocating input might lead to low productivity and, ultimately, lower production. This research aims to analyze the level of technical efficiency, allocative efficiency, economic efficiency and socioeconomic factors that influence the technical inefficiency of white mustard farming. The research location is Tulungrejo Village, Batu City. Respondents totaling 67 farmers were selected using the *simple random sampling method*. Data were analyzed using *Data Envelopment Analysis* (DEA), assuming input-oriented VRS and Tobit Regression. The research results show that the average total technical efficiency is (CRSTE = 0.774), (VRSTE = 0.949), (SE = 0.819), the average allocative efficiency is 0.896, and the average economic efficiency is 0.851. Socioeconomic factors influencing the technical inefficiency of white mustard farming are the number of family members and land ownership.

Keywords: data envelopment analysis; production efficiency; white mustard

INTRODUCTION

East Java is the central province for white mustard production in Indonesia. According to data from the East Java Province Central Statistics Agency, white mustard production has increased from 2017 to 2021, with an average output of 73,710 tons. If we look at it from a productivity perspective, white mustard productivity has fluctuated, with the average white mustard productivity from 2017-2021 being 11,864 tonnes per hectare. Nationally, white mustard production in East Java Province shows good performance, with a moderate white mustard productivity in 2021 of 11.64 tonnes per hectare, the value of white mustard productivity in East Java is above the national average white mustard productivity, namely 10.45 tonnes per hectare (BPS, 2023). However, the level of white mustard productivity in East Java is still lower than other provinces, including North Sulawesi (16.01 tonnes per hectare), West Java (15.84 tonnes per hectare), and Bengkulu (13.60 tonnes per hectare), Jambi (12.27 tonnes per hectare) North Sumatra (12.07 tonnes per hectare), Central Sulawesi (11.65 tonnes per hectare). The incapacity of white mustard farmers to assign unsuitable inputs is the root cause of low productivity, resulting in low production and the use of production factors without considering costs so that farming has not achieved maximum profits. Gaspersz, (2008) It is said that figuring out the maximum output possible given a specific amount of input is the goal of the production function. The production function explains the technical link between production variables and output results in a production process.

Efficiency is using the minimum input possible to produce maximum output (Soekartawi, 1994). Farrell (1957) and Coelli et al. (1998) claimed that technical and allocative efficiency makes up production efficiency. Farmers who can allocate production variables to produce maximum production will achieve technical efficiency (Moehar, 2002). The capacity of producers to use resources as cheaply as possible while maintaining optimal quality is known as allocation efficiency. If these two measurements are combined, a total measurement of economic efficiency will be obtained. Efficiency measurements can be divided into input-oriented and output-oriented. Input-oriented measurement is a condition that reduces the input used where the resulting output is fixed. The output-oriented measurement uses the same input but will *get a* greater output.

Analyses of production efficiency can be done with both parametric and non-parametric

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1831

methods. Stochastic Frontier Analysis (SFA) is used in a parametric manner. Data Envelopment Analysis (DEA), a non-parametric method, is used in this study. The DEA method has been carried out by several researchers, namely Manik et al. (2018), Ayuningtyas, N., Hidayat, N.K., (2022), Chaniago et al. (2019), Wiranda et al. (2018), Adeyonu et al. (2019), Timpanaro et al. (2018), Anang (2021), Miassi et al. (2023), Młynarski et al. (2021), Hesampour et al. (2022) and Abdulai et al. (2018).

Based on the technical efficiency analysis, the effects of technical inefficiency can influence technical efficiency. According to Pitt et al (1981) and Coelli *et al* (1998), technical inefficiency can be caused by respondent characteristics such as land area, age, level of education, and so on. Analysis of factors that influence technical inefficiency can be done using Tobit regression. The Tobit regression model has been carried out by several researchers, namely Firmana et al. (2016), Winarso et al. (2021), Hestina et al. (2017), Asmara (2017), and Arifin et al. (2021).

Research using data envelope analysis (DEA) can be carried out with the variable return to scale (VRS) or constant return to scale (CRS) assumption. Scale efficiency, pure efficiency, and total efficiency are all produced under the VRS assumption. Adeyonu et al (2019) analyzed the efficiency sweet potato production in Nigeria by using the DEA approach with CRS and VRS assumptions. Based on the CRS assumption, the research findings indicate an average value of 0.685 for technical efficiency, 0.445 for allocative efficiency, and 0.310 for economic efficiency. Under the VRS assumption, the average technical efficiency is 0.783, allocative efficiency is 0.604, and economic efficiency is 0.467.

Research by Miassi et al (2023) analyzes the technical efficiency of rice production in West Africa. Using DEA and Tobit regression approaches. The research results show that the technical efficiency value obtained is 51%, and the majority of rice producers experience limited access to agricultural credit and equipment.

A farmer is likely efficient in farming production compared to other farmers because using the same input and input costs can produce higher output. Sometimes, farmers experience technical inefficiencies because, in cultivation, some things become obstacles, such as adverse climatic conditions, the existence of illnesses or pests, and other elements that result in low productivity Coelli et al. (2005). The research results of Puarada et al. (2020) show that only 7 farmers are technically efficient, and 23 other farmers are technically inefficient because the use of inputs is not yet efficient, so the output produced is not optimal. Research by Chatra & Rahayu (2022) shows that three coffee agro-industries have achieved technical efficiency values, and four other coffee agro-industries are still experiencing technical inefficiency due to production capacity factors and other things.

Several previous studies related to white mustard farming have been widely developed in the literature, namely Purnomo (2022), Ma'arif et al. (2022) and Ganul (2022). Purnomo (2022) analyzed the efficiency use of production inputs mustard using the observed Cobb-Douglas function model with multiple linear regression. Ma'arif et al (2021) analyzed efficiency allocative using analysis income, function model Cobb-Douglas production with multiple linear regression and OLS estimation, and efficiency allocative with count mark from (NPMx/Px). Ganul (2022) analyzed the profitability and productivity of white mustard production in Tabanan Regency Batu Village, Batu District.

Different from previous research, the primary purpose of this study is to use a non-parametric data envelope analysis (DEA) method to assess the technical, allocative, and economic efficiency of white mustard farming production in Tulungrejo Village. It is possible to display each farmer's relative efficiency using the DEA technique approach. In order for farmers who utilize inputs most effectively to serve as role models for other farmers who could use inputs more effectively. The second goal of this study is to use Tobit regression to examine the socioeconomic variables that

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1831

affect the technical inefficiency of growing white mustard.

METHODS

This research was conducted in Tulungrejo Village, Batu City, East Java. Tulungrejo Village was determined purposively because it has high white mustard production in the Bumiaji District. The population in this study were white mustard farmers who were members of farmer groups. Sampling used simple random sampling. Researchers used the Slovin formula as a sampling technique for chicory farmers. The number of white mustard farmer respondents was 67 farmers. Data was collected during one planting season, November 2022 to January 2023. The data used in this research are primary and secondary. Preliminary data was obtained by interview method using a questionnaire. Secondary data was obtained from journals, books and related agencies.

Tobit regression and Data Envelopment Analysis (DEA) are the models utilized in this research. Growing white mustard is examined from a technical, allocative, and economic efficiency perspective using the Data Envelopment Analysis (DEA) model. An efficient value equal to one indicates that white mustard farming is relatively efficient, while an efficiency value of less than one indicates that white mustard farming is relatively inefficient. The DEA method used in this research is the BCC model with input-oriented VRS assumptions. The BCC DEA model is systematically explained as follows:

$$Min_{\theta,\lambda}\theta$$
$$\text{Subject to: } -qi + Q\lambda \geq 0,$$
$$\theta xi - x\lambda \geq 0,$$
$$l1'\lambda = 1$$
$$\lambda \geq 0$$

Description:
l1 = Vector lxl
ɵ = Proportional reduction of input for to-i DMU
λ = Weight of to-j DMU

The Data Envelopment Analysis Program (DEAP) ver 2.1 was used to estimate the model. The number of inputs utilized, the output produced, and the costs of the inputs used in the manufacture of white mustard were the data used in the study conducted using the Data Envelopment Analysis Program (DEAP). Socioeconomic factors influencing the technical inefficiency of white mustard growing are analyzed using Tobit regression. The output results from technical efficiency are represented as data between 0 and 1. So, the model used is Tobit regression. (Greene 1991: Hossain 1988) (Asmara, 2017) states that regression Tobit is more appropriate because the mark from the variable no free is index efficiency limited between 0 and 1. The parameters used are the Stata ver 17 program.

RESULTS AND DISCUSSION

Analysis of Technical Efficiency of White Mustard Farming

With the input-oriented Variable Return to Scale (VRS) assumption, the Data Envelopment Analysis (DEA) method was employed in this study's analysis. Nine input variables and one output variable for white mustard growers in Tulungrejo Village made up the variables used in this study. The input variables used in this research are land area, seeds, manure, urea fertilizer, SP-36 fertilizer, KCL fertilizer, liquid pesticides, solid pesticides and labor. The output variable used is white mustard production. **Table 1** displays the results of technical efficiency analysis using Data Envelopment analysis.

The range of the technical efficiency value is 0 to 1. If a farmer's ET value is 1, they are considered technically efficient; if it is less than 1, they are considered technically inefficient. The scale efficiency value determines the production tendencies of farmers. According to the study's findings, there are seven farmers with SE = 1 and 61 farmers with SE < 1. Seven farmers with a SE of 1 indicate a Constant Return to Scale (CRS) tendency. Meanwhile, 60 farmers with SE < 1 are at Increasing Return to Scale (IRS) 12 farmers and Decreasing Return to Scale (DRS) 48 farmers. Based on this, it can be seen that the average white mustard farmer in Tulungrejo Village is in a

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1831

position where the increase in output is smaller than the increase in input (Decreasing Return to Scale).

Table 1. Results of technical efficiency analysis

	Overall Technical Efficiency	**Pure Technical Efficiency**	**Scale Efficiency**
Minimum	0.413	0.558	0.486
Maximum	1.000	1.000	1.000
Mean	0.774	0.949	0.819
SD	0.144	0.094	0.140
Numbers technically efficient	7	38	-
Number CRS farms	-	-	7
Number I RS farms	-	-	12
Number DRS farms	-	-	48

The average value of overall technical efficiency, or assumed CRS, for white mustard is 0.774, based on the findings of the DEA research. This indicates that general white mustard farmers are not technically efficient. One is the maximum efficiency value, and 0.413 is the lowest. There are seven technically proficient white mustard growers and sixty technically inefficient farmers (**Figure 1**). The average efficiency rating is 0.949 based on the findings of the pure technical efficiency analysis or VRS assumptions. There are 38 productive farmers and 29 inefficient farmers (VRSTE < 1). Scale efficiency on average is 0.819 (**Figure 2**). Seven white mustard farmers with SE = 1 and sixty white mustard farmers with SE < 1 are shown in the analysis results.

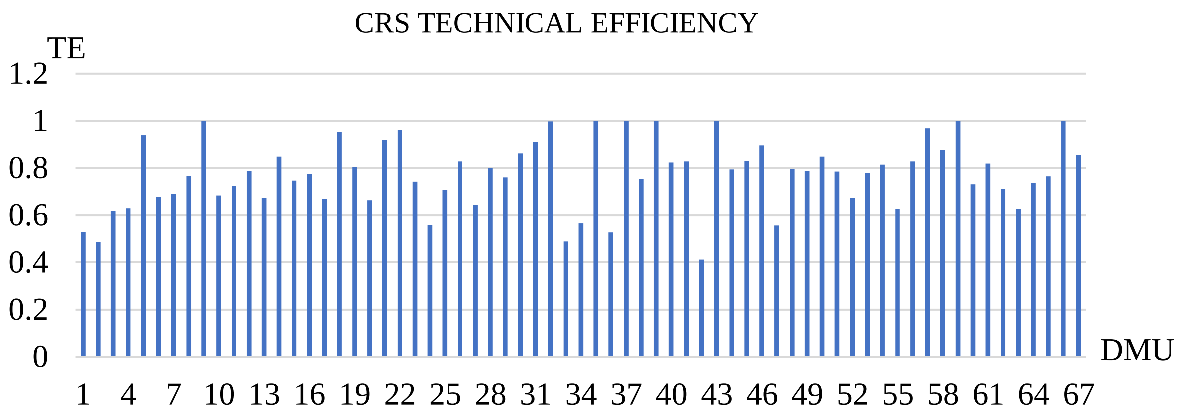

Figure 1. Distribution of total technical efficiency values (CRS assumption)

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1831

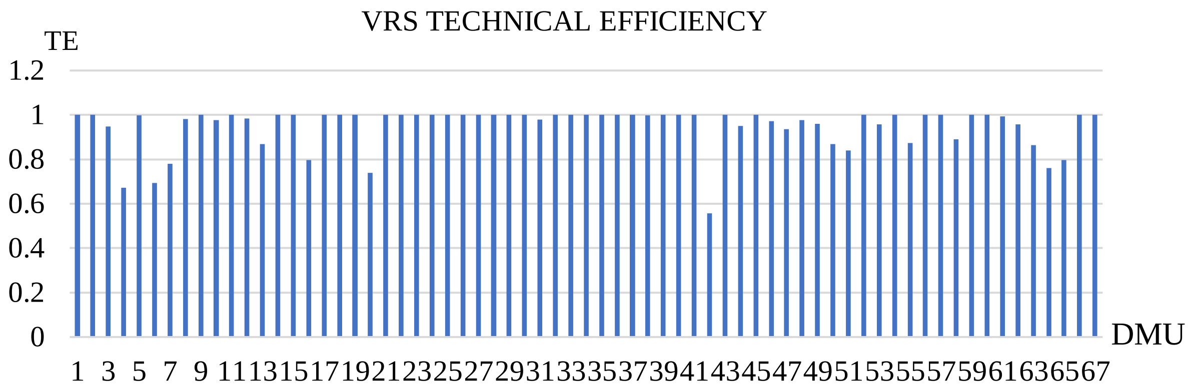

Figure 2. Distribution of pure technical efficiency values (VRS assumption)

Analysis of Allocative Efficiency of White Mustard Farming

The results of data processing analysis using the *Data Envelopment Analysis* (DEA) approach produce allocative efficiency values for each DMU or white mustard farmer in Tulungrejo Village. White mustard farmers allocate input costs in the form of land rent, seeds, manure, urea fertilizer, SP-36 fertilizer, KCL fertilizer, liquid pesticides, solid pesticides and labor so that the input prices prevailing in the market are the costs incurred by white mustard farmers to get that input. **Table 2** displays the results of allocative efficiency analysis using Data Envelopment Analysis.

Table 2. Results of allocative efficiency analysis

No.	Efficiency Value Allocative	Amount Farmer (person)	Percentage (%)
1	0.61 - 0.70	2	2.98
2	0.71 - 0.80	7	10.44
3	0.81 - 0.90	28	41.79
4	0.91 - 0.99	23	34.32
5	1	7	10.44
Total		67	100
Average	0.896		

Based on the allocative efficiency analysis results, an average of 0.896 was obtained. The allocative efficiency value of white mustard farmers in Tulungrejo Village ranges from 0.61-1.00. The efficiency value ranges between 0.81-0.90, namely 28 farmers or 41.79 percent, which is the most common.

The allocative efficiency of white mustard farming in Tulungrejo Village is relatively high, with an efficiency value of (0.81 – 0.90). This is demonstrated by the percentage of farmers in the deficient category with an efficiency value of (< 0.71) and low with an efficiency value of (0.71 – 0.80) of 14 percent compared to the relatively high category with an efficiency value of (0.81 – 0.90) and the high category with an efficiency value (> 0.90) of 86 percent. When compared between the moderately high and high categories, white mustard farmers in Tulungrejo Village are in a reasonably high condition, namely 42 percent (**Figure 3**). This condition shows that the input allocation of white mustard farmers in dealing with the prevailing input prices is inefficient. This means that the inputs used are inadequate based on the input prices faced by white mustard farmers.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1831

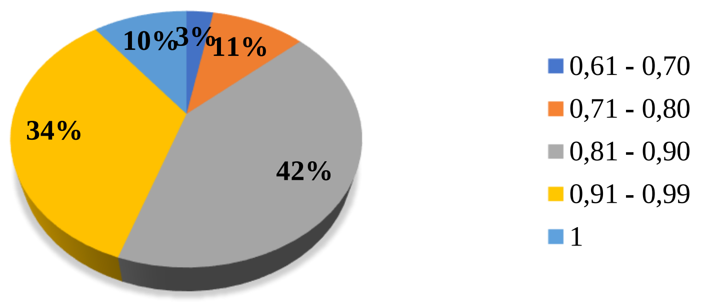

Figure 3. Distribution of allocative efficiency

Analysis of the Economic Efficiency of White Mustard Farming

Economic efficiency can be achieved if the DMU or mustard greens farmers are technically and allocatively efficient. For every DMU or white mustard farmer in Tulungrejo Village, the Data Envelopment Analysis (DEA) approach yields economic efficiency values based on the findings of data processing analysis. **Table 3** displays the results of economic efficiency analysis using Data Envelopment Analysis.

Table 3. Results of economic efficiency analysis

No.	Economic Efficiency Value	Amount Farmer (person)	Percentage (%)
1	0.41 - 0.50	1	1.49
2	0.51 - 0.60	1	1.49
3	0.61 - 0.70	8	11.94
4	0.71 - 0.80	12	17.91
5	0.81 - 0.90	21	31.34
6	0.91 - 0.99	17	25.37
7	1	7	10.44
Total		67	100
Average	0.851		

The economic efficiency value of white mustard greens in Tulungrejo Village ranges from 0.41–1.00. The efficiency value range between 0.81–0.90 is the highest, namely 21 farmers or 31.34 percent. Only 10 percent of white mustard farmers in Tulungrejo Village achieve total economic efficiency. Meanwhile, the other 90 percent are still at an economically inefficient level. Tulungrejo Village's white mustard farming has an average economic efficiency of 0.851, which means the economic efficiency is relatively high. This condition shows that, on average, to produce white mustard production levels, there is an economic inefficiency of 14.9 percent. So, it is necessary to reduce production costs by reducing the use and proportion of production inputs.

Factors Affecting White Mustard Farming Inefficiency

The technical inefficiency of white mustard farming cannot be separated from the factors that influence it. Using Tobit regression, factors influencing farmers' technical inefficiency level can be examined. Technical inefficiency is the dependent variable, and Tobit regression is chosen because it falls between 0 and 0.99. Independent variables include farmer age, number of family members, farming experience, extension participation, farmer education level (dummy), and land ownership (dummy).

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1831

Table 4. Results of Tobit Regression Analysis

Variable	Coefficient	Std. err	t	P>|t|
Age Farmer	0.0008894	0.0040495	0.22	0.827
Amount Member Family	0.0394085	0.024244	1.63	0.109**
Experience Farming	0.0054342	0.0040627	1.34	0.186
Participation Counseling	-0.0241764	0.0306788	-0.79	0.434
Level of education	-0.0620069	0.0571737	-1.08	0.282
Land Ownership	-0.1164052	0.0641098	-1.82	0.074*
Likelihood Log	= -9.08			
Lr Chi² (6)	= 9.83			
Prob > Chi²	= 0.1319			

The results of Tobit regression processing have different significance. Land ownership is a factor that at a fundamental level of 10 percent has a significant effect on the technical inefficiency of white mustard cultivation in Tulungrejo Village. The number of family members has a significant effect on the technical inefficiency of white mustard cultivation at a level of 15 percent is presented in **Table 4**.

a. Age

The Tobit regression test findings indicate that the farmer's age does not significantly influence the degree of inefficiency. The coefficient value for the farmer age variable is 0.0008894. This means that the higher the farmer's age, the more technical inefficiency will decrease by 0.0008894. In other words, if the farmer's age increases by one year, the level of technical efficiency will increase by 0.0008894. Older farmers start farming activities earlier than younger farmers. So older farmers have more experience. This experience will help farmers decide about farming activities, including using inputs. This is in line with the research of (Nurjati et al., 2018), which stated that the age variable does not affect the technical inefficiency of shallot farming.

b. Number of Family Members

According to the Tobit regression test results, the number of family dependents has a positive and significant influence at the 15 percent level. The average number of farming family members in the research location is four. The coefficient value for the variable number of farmer family members is 0.0394085. This coefficient value means that the more family members there are, the more technical inefficiency will increase by 0.0394085. This is in line with research by Hestina et al (2017), with the increasing number of family members, farmers will be more careful in managing finances, including spending on input needs.

c. Farming Experience

Farmers in Tulungrejo Village have an average of 20 years of white mustard farming experience. White mustard farming experience is the basis for farmers making decisions using production inputs. White mustard farming is not significantly impacted by farming experience, according to the findings of the Tobit regression calculation. The farming experience coefficient is 0.0054342, and this means that if a farmer's farming experience increases by one year, technical efficiency will increase by 0.0054342. The results align with the research results of Winarso (2021) and Firmana (2016), where, with farming experience, you can find solutions to farming problems, and farmers can make the right decisions using efficient inputs.

d. Extension Participation

Farmer participation in agricultural extension activities can be seen from the

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1831

frequency of farmers attending extension services in one planting season. The frequency of attending extension is a parameter of farmer activity in farmer groups. The findings of the Tobit regression indicate that there is no significant relationship between the frequency of attendance at extension services and the inefficiency of white mustard cultivation. The extension participation variable's coefficient value is -0.0241764. This implies that the technical efficiency of growing white mustard will be decreased by 0.0241764 for each time a farmer attends counseling once. This is in line with research by Hestina (2017), where in this study, participating in extension services did not affect technical efficiency because some farmers did not participate in extension activities. Farmers' trust in agricultural extension workers is suspected to be relatively low, and some rice farmers are more comfortable with the cultivation techniques that farmers are accustomed to using.

e. Level of education

Most farmers in Tulungrejo Village have a higher level of education (other than elementary school). In the Tobit regression results, the education level variable does not significantly affect the inefficiency of white mustard farming. The technical inefficiency of growing white mustard has a negative coefficient when it comes to education level. The *dummy* coefficient value for education level is -0.0620069. This indicates that farmers with an elementary school (SD) education level and farmers with a higher education level have different levels of technical inefficiency. Farmers with a higher level of education (other than elementary school) will reduce the technical inefficiency in white mustard farming by 0.0620069. This is contrary to research by Winarso (2021), Hestina (2017), and Arifin (2019), where the higher the level of education, the level of efficiency will increase. This is because farmers have a more advanced mindset and can adopt information more accurately to develop their farming business better.

f. Land Ownership

Most farmers in Tulungrejo Village use their land, namely 52 respondents or 77.61 percent. At the 10 percent level, the land ownership variable has a negative and significant impact, according to the findings of the Tobit regression analysis. The coefficient for land ownership status is -0.1164052. This means there is a difference between farmers with rented or owned land, whereas, for farmers with owned land, the level of technical inefficiency will decrease by 0.1164052. This is in line with research by Winarso (2021) and Arifin (2019) that shows most farmers who own their land have land used for cultivation for a long time, so their productivity has decreased. So, farmers with their own land spend more of their budget allocating more inputs. So that farmers with their land increasingly increase the inefficiency of farming.

CONCLUSION

The research results show that white mustard farming in Tulungrejo Village is not technically, allocative, and economically efficient because the average efficiency value is less than 1. This is demonstrated by the average technical efficiency value of 0.949, allocative efficiency of 0.896 and economic efficiency of 0.851. Only 10 percent of white mustard farmers in Tulungrejo Village achieve total economic efficiency. It is evident from the analysis of white mustard farming's production efficiency that there is room for improvement. The number of family members is the factor that actually and positively affects the technical inefficiency of growing white mustard. The factor that has a natural and negative impact on technical inefficiency is land ownership. The farmer's age does not significantly impact the technical inefficiency of growing white mustard, agricultural experience, involvement in extension, or educational attainment.

REFERENCES

Abdulai, S., Nkegbe, P. K., & Donkoh, S. A. (2018). Assessing the technical efficiency of maize production in northern Ghana: The data envelopment analysis approach. *Cogent Food and Agriculture*, *4*(1).

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1831

https://doi.org/10.1080/23311932.2018.1512390

Adeyonu, A. G., Balogun, O. L., Ajiboye, B. O., Oluwatayo, I. B., & Otunaiya, A. O. (2019). Sweet potato production efficiency in Nigeria: Application of data envelopment analysis. *AIMS Agriculture and Food*, *4*(3), 672–684. https://doi.org/10.3934/agrfood.2019.3.672

Anang, B. T. (2021). Assessing technical and scale efficiency of groundnut production in Tolon district of northern Ghana: A nonparametric approach. *Journal of Agriculture and Food Research*, *4*. https://doi.org/10.1016/j.jafr.2021.100149

Arifin, A. M., Fariyanti, A., & Tinaprilla, N. (2021). Efisiensi Teknis Usahatani Kentang di Kabupaten Gowa Sulawesi Selatan. *Forum Agribisnis*, *11*(1), 65–74. https://doi.org/10.29244/fagb.11.1.65-74

Asmara, R. (2017). *Efisiensi Teknis Usahatani Tanaman Pangan dalam Upaya Peningkatan Produksi: Pendekatan Fungsi Produksi Frontier Stokastik dan Data Envelopment Analysis (DEA).* Universitas Brawijaya.

Ayuningtyas, N., & Hidayat, N. K. (2022). *Analisis Efisiensi Produksi Usahatani Kopi Robusta (Studi Kasus: Kelurahan Karang Dalo, Kecamatan Dempo Tengah, Kota Pagar Alam)*. https://bdijournal.bekasikab.go.id/index.php/bdi/article/view/58

BPS. (2023). *Statistik Indonesia 2023*. https://www.bps.go.id/id/publication/2023/02/28/18018f9896f09f03580a614b/statistik-indonesia-2023.html

Chaniago, R. E., Hadi, S., & Yusri, atri. (n.d.). Analisis Efisiensi Produksi Padi Organik Di Desa Kelayang Kecamatan Rakit Kulim Kabupaten Indragiri Hulu - *Efficiency Analysis of Organic Rice Production in Kelayang Village, Rakit Kulim Subdistrict, Indragiri Hulu Regency*. https://doi.org/https://doi.org/10.30606/js.v7i1.1739

Chatra, M. A., & Rahayu, S. (2022). Analisis Efisiensi Kinerja Agroindustri Kopi di Kota Sungai Penuh, Provinsi Jambi, Indonesia. *Agro Bali : Agricultural Journal*, *5*(2), 322–330. https://doi.org/10.37637/ab.v5i2.941

Coelli, T., Rao, D. S. P., & Battese, G. E. (1998). An Introduction to Efficiency and Productivity Analysis. In *An Introduction to Efficiency and Productivity Analysis*. Springer US. https://doi.org/10.1007/978-1-4615-5493-6

Coelli, Tim. (2005). *An introduction to efficiency and productivity analysis*. Springer.

Firmana, F., Nurmalina, R., & Rifin, A. (2016). efisiensi teknis usahatani padi di kabupaten karawang dengan pendekatan data envelopment analysis (DEA). *Forum Agribisnis: Agribusiness Forum*, *6*(2), 213–226. https://doi.org/https://doi.org/10.29244/fagb.6.2.213-226

Ganul, H. E. (2022). *Pendapatan dan Efisiensi Usahatani Sawi Putih (Studi Kasus di Desa Batunya Kecamatan Baturiti Kabupaten Tabanan)* [Universitas Mahasaraswati Denpasar]. https://eprints.unmas.ac.id/id/eprint/699/

Gaspersz, V. (2008). Total quality control. *Jakarta: PT. Gramedia Pustaka Utama*.

Hesampour, R., Hassani, M., Hanafiah, M. M., & Heidarbeigi, K. (2022). Technical efficiency, sensitivity analysis and economic assessment applying data envelopment analysis approach: A case study of date production in Khuzestan State of Iran. *Journal of the Saudi Society of Agricultural Sciences*, *21*(3), 197–207. https://doi.org/10.1016/j.jssas.2021.08.003

Hestina, J., Nurmalina, R., & Suharno, S. (2017). Analisis Efisiensi Teknis Usahatani Padi Di Jawa Dan Luar Jawa: Pendekatan Data Envelopment Analysis (Dea). *Forum Agribisnis: Agribusiness Forum*, *7*(2), 103–120. https://doi.org/https://doi.org/10.29244/fagb.7.2.103-120

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1831

Ma'arif, M. I., Syafrial, S., & Widyawati, W. (2022). Analisis Efisiensi Alokatif Penggunaan Faktor Produksi Dan Pendapatan Usahatani Sawi Putih (Brassica Pekinensis L.). *Jurnal Ekonomi Pertanian Dan Agribisnis*, *6*(4), 1389–1404. https://doi.org/https://doi.org/10.21776/ub.jepa.2022.006.04.16

Manik, G. H., Asmara, R., & Maarthen, N. (2018). Analisis Efisiensi Produksi Usahatani Jagung Menggunakan Data Envelopment Analysis (DEA) di Desa Maindu, Kecamatan Montong, Kabupaten Tuban. *Jurnal Ekonomi Pertanian Dan Agribisnis*, *2*(3), 244–254. https://doi.org/10.21776/ub.jepa.2018.002.03.9

Miassi, Y. E., Akdemir, Ş., Dossa, K. F., & Omotayo, A. O. (2023). Technical efficiency and constraints related to rice production in West Africa: The case of Benin Republic. *Cogent Food and Agriculture*, *9*(1). https://doi.org/10.1080/23311932.2023.2191881

Młynarski, W., Prędki, A., & Kaliszewski, A. (2021). Efficiency and factors influencing it in forest districts in southern Poland: Application of Data Envelopment Analysis. *Forest Policy and Economics*, *130*. https://doi.org/10.1016/j.forpol.2021.102530

Moehar, D. (2002). Metode penelitian sosial ekonomi. *Jakarta: Bumi Aksara*.

Nurjati, E., Fahmi, I., & Jahroh, S. (2018). Analyzing the Efficiency of Shallot Production in Pati Regency Using the Cobb-Douglas Stochastic Frontier Production Function. *Jurnal Agro Ekonomi*, *36*(1), 15–29. https://doi.org/10.21082/jae.v36n1.2018.15-29

Puarada, S. H., Gurning, R. N. S., & Harahap, W. U. (2020). Efisiensi Teknis Rantai Pasok Jagung Tingkat Petani dan Pengumpul dengan Metode Data Envelopment Analysis (DEA) Kecamatan Batang Kuis, Deli Serdang, Sumatera Utara. *Agro Bali: Agricultural Journal*, *3*(2), 234–245. https://doi.org/10.37637/ab.v3i2.629

Purnomo, F. A. (2022). Analisis Efisiensi Teknis Penggunaan Input Produksi Pada Usaha Tani Sawi (Brassica Juncea L.) Di Desa Gunung Putih Kecamatan Tanjung Palas. *Repository. Perpustakaan UBT: Universitas Borneo Tarakan*.

Soekartawi. (1994). *Teori Ekonomi Produksi dengan Pokok Bahasan Analisis Cobb-Duglas*. PT. Raja Grafindo.

Timpanaro, G., Urso, A., & Foti, V. T. (2018). Technical and scale efficiency in nursery enterprises in an area of significant widespread horticulture in Italy. *HortScience*, *53*(2), 208–216. https://doi.org/10.21273/HORTSCI12344-17

Winarso, R. H., Syafrial, S., & Widyawati, W. (2021). Analisis Efisiensi Teknis Multi-Stage Menggunakan Data Envelopment Analysis (DEA) dan Regresi Tobit pada Usahatani Bawang Merah, Studi Kasus di Desa Torongrejo, Kecamatan Junrejo, Kota Batu, Jawa Timur. *Jurnal Ekonomi Pertanian Dan Agribisnis*, *5*(4), 1191–1205. https://jepa.ub.ac.id/index.php/jepa/article/view/805/405

Wiranda, D., Hadi, S., & Bakce, D. (2018). Analysis of Production Efficiency of Vegetable Farming in Kampar Regency. In *Journal of Agricultural Economics* (Vol. 9, Issue 2). https://doi.org/http://dx.doi.org/10.31258/ijae.9.2.%25p