Performance of Shallot (Allium cepa L. Var. Aggregatum) Seed Farming With Environmentally Friendly Shallot Cultivation Technology Pattern: The Stochastic Frontier Model Approach

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Abstract

The general purpose of this study is to analyze the technical efficiency of shallot seed farming using production factors in producing superior seeds in East Java. The selection of sample locations is based on the largest shallot production center in East Java, namely Nganjuk Regency, which has 62 farmer groups. Data collection techniques include interview techniques, observation techniques, free interviews with key informants and documentation. The data analysis method uses the Stochastic Production Frontiers method (V.4.1.C). The results of the study using Stochastic Frontier Analysis/SFA are efficiency of shallot seed farming production factors or DMU (Decision Making Unit) namely in the category (0.91-1) technical efficiency of 38.3 percent, category (0.86-0.90) is 21.1 percent, category (0.66-0.85) is 33.7 percent and category (0.41-0.65) is 6.9 percent. Excessive distribution of herbicide input use can increase production costs. Labor production input, superior variety tubers as the raw material, organic fertilizer, land area and insecticides have been distributed appropriately. The compilation of recommendations for the future in improving the performance of seed farming in Nganjuk Regency by using superior varieties, namely Tajuk varieties which have good environmental adaptation capabilities even outside Nganjuk Regency area and can grow well in lowlands and highlands. So that the goal of maximizing the production results of shallot seed farming can be achieved. This study found empirical conditions that efficient seed farming is able to support increased shallot productivity in supporting domestic shallot consumption needs and supporting increased exports. The relationship between environmentally friendly cultivation patterns adopting the agropolitan concept so that this

study is expected to be a tool for policy makers, the government in improving the welfare of shallot farming communities and improving the regional economy.

Keywords: *farm performance, partnership, breeding, shallot seeds, stochastic production frontiers*

1. Introduction

Shallots are a horticultural plant in the form of bulbs that are used as a spice group that is difficult to replace for household consumption. The distinctive aroma and many uses of shallots cause demand for this commodity to continue to increase, despite price fluctuations [1,2]. East Java Province has the largest shallot production, which is 484,670 tons compared to other provinces. In 2023, the shallot harvest area in East Java province reached 51,020 hectares with a productivity of 24.41 tons per hectare, making it the province with the highest shallot production in Indonesia. The development of shallot production from 2018 to 2023 showed fluctuations with periods of increase and decrease. A significant increase occurred from 2019 to 2020 of 46,707 tons, while a sharp decrease occurred from 2021 to 2022 of 22,599 tons. This fluctuation is influenced by several production factors including the use of fertilizers, seeds, labor, agricultural medicines. In addition, there are problems that are often experienced by farmer groups, namely the limited availability of quality seeds, increasing seed prices, and potential pest attacks [3,4,5]. Nganjuk Regency is a center for shallot production and seeds in East Java province, the following is data on the harvested area of shallots [6].

Table 1. Harvested Area of Shallots in East Java (quintals) in 2023

No	Regency	2022	2023
1	Nganjuk	16.780	17.345
2	Probolinggo	9.267	9.038
3	Malang	4.574	4.679
4	Sampang	4.213	4.420
5	Bojonegoro	3.703	3.949

Source : Badan Pusat Statistik, 2024

The existence of shallot seed farming is also faced with challenges including the inhibiting factor of shallot production, namely the availability of seeds. The need for seeds at the national level is always increasing, and in the period 2010-2011 only about 20% to 30% per year of national seed needs were met [7,8,9]. Other needs are met by farmers' own seeds from shallot bulbs for consumption that are stored for seeds from generation to generation. This causes the level of productivity to decrease. The use of bulbs as seeds has several disadvantages, including the short shelf life of the bulbs, requiring a large storage warehouse and high bulb needs (reaching 1-1.2 tons/Ha), resulting in high transportation costs. So it is necessary to find alternative shallot seed propagation technology that is able

to meet the shortage of national seed needs. Several shallot seed propagation technologies that are currently being and continue to be developed are at least 3 types [10,11]. The three types of shallot seed propagation technologies are seed propagation with seeds (TSS), seed propagation with mini bulbs and seed propagation with tissue culture technology.

Environmentally friendly agriculture can be viewed as alternative agriculture, namely agricultural practices that are different from those usually carried out in conventional agriculture, due to the green revolution, so that environmentally friendly agriculture can avoid the negative impacts of the green revolution, namely: (1) land damage due to soil erosion; (2) dependence on the use of high chemical/inorganic fertilizers and high costs to increase soil fertility; (3) dependence on the use of high chemical pesticides and high costs to control OPT; (4) a decrease in biodiversity; (5) excessive use of irrigation water; and (6) decreasing farmer welfare and income [12,13].

Efficiency is one of the main indicators in measuring the ability of farming businesses to survive and be competitive, in this context careful and efficient allocation of resources can produce optimal production levels from limited existing resources. This is as emphasized by [14,15] is defined as how a business can produce at the lowest possible cost to produce optimal output. However, what often happens in the field is the difficulty of achieving efficient farming conditions both technically. So it is necessary to analyze the efficiency (production factors on the productivity of shallot seed farming with environmentally friendly shallot cultivation technology patterns owned by farmer groups so that the level of efficiency can be known and the results can be used as a guideline for farmers in developing and increasing the productivity of shallot seeds in Nganjuk Regency, East Java Province [4,16]. Based on the background description, the assumption developed is that if farmer groups can manage input and output factors efficiently, it will lead to increased performance of shallot seed farming.

2. Research Method

This research was conducted in Nganjuk Regency. The object of this study was shallot seeds owned by farmer groups in Nganjuk Regency. The decline in seed production is related to the use of production factors consisting of shallot bulbs (seeds), organic fertilizers, land area, labor and insecticides [17,18]. The use of these production factors will have a significant effect on the production of shallot seeds. The location and object of the study were carried out intentionally (purposive method) based on certain considerations [19,20,21]. Nganjuk Regency is the largest center of shallot production in East Java Province. Nganjuk Regency has 400 horticultural farmer groups with land ownership of 0.25 hectares. However, there are still some shallot seed farmer groups in Bagor District, there are 10 shallot seed farmer groups, while Sukomoro District has 7 farmer groups. Ngluyu District has 5 farmer groups, while Wilangan District has 8 farmer groups, Gondang District has 10 farmer groups, Rejoso has 14 farmer groups and Nganjuk District has 8 farmer groups. has the largest shallot land in East Java of 14,505 hectares (ha) and has five farmer groups that carry out shallot seed farming. and Some farmers also

plant other horticultural crops. The total number of shallot farmer groups is 62 (each farmer group has 10 members). Previously, there had been no research conducted related to the performance of farming businesses in shallot seed farmer groups in Nganjuk Regency, Indonesia. The calculation of the number of respondents using the Slovin formula, there were 86 farmers who carried out shallot seed farming with environmentally friendly shallot cultivation technology patterns. Each farmer respondent will be asked using an instrument in the form of a list of structured questions based on the indicators used such as questionnaires or direct interviews. Technical Efficiency Measurement Using the Stochastic Production Frontiers (41.C) Production Function Approach in Shallot Seed Farming. This approach aims to analyze inputs that affect the level of shallot seed farming and measure the level of efficiency of farmer groups in Nganjuk Regency. The stochastic frontier production function equation [22] is briefly written as follows:

$$\text{Ln } yit = \beta xit + (vit - uit) \quad i = 1,2,3,\ldots n$$

Description:
yit = production produced by farmers at time -t
xit = input vector used by farmer i at time t
βi = vector of parameters to be estimated
vit = random variable related to external factors (climate, pests) whose distribution is symmetrical and normally distributed.
uit = non-negative random variable, and is assumed to affect the level of technical inefficiency and is related to internal factors and the distribution of uit is half normal [22].

The application in this study can be written with a mathematical formula:

$$TE = \frac{Yi}{Yi*}$$

Description:
TE = Technical Efficiency of Shallot Seed Farming
Yi = Actual production of Shallot Seeds i (output size)
Yi* = Potential production of Shallot Seeds/frontier i

Terms of Technical Efficiency of Shallot Seed Farming ($0 \leq TE \leq 1$):
TE is getting closer to (1) = more efficient Shallot Seed Farming
TE is getting closer to (0) = more inefficient Shallot Seed Farming

The error component which is internal (can be controlled by farmers) and is usually related to the managerial capability of farmers in managing shallot seed farming is reflected by ui. This component is distributed asymmetrically (one sided) namely ui > 0. If the production process is efficient (perfect) then the output produced coincides with its maximum potential, meaning ui = 0. Conversely, if ui > 0 is below its

maximum potential. The distribution is semi-normal (uit ~ | N(0,σu 2 |) and uses the Maximum Likelihood estimation method [23].

3. Result and Discussion

Table 2. Stochastic Frontier Production Function Estimation Results

Variable	Coefficient	D-error Standard	t-ratio
Intercept	5,835	0,364	15,772*
Land Area (X1)	0,582	0,061	8,610*
Labor (X2)	0,544	0,107	4,875*
Superior Variety Tubers (X3)	0,463	0,043	4,151*
Organic Fertilizer (X4)	0,411	0,058	4,029*
Herbicide (X5)	-0,087	0,033	-1,345
Insecticide (X6)	0,062	0,029	3,709**
Sigma-squared	0,052	0,009	5,118*
Gamma	0,999	0,001	622,02*
Log-likelihood	45,68		
OLS			
Log-likelihood	31,22		
MLE			
LR	22,47		

Description:
* = Significant at α 1%
** = Significant at α 5%
*** = Significant at α 10%

Technical efficiency is a condition where the input materials used during the production process by farmers can produce maximum productivity. Technical efficiency is related to the ability of farmer groups to avoid waste when producing output with minimal input. Based on the results of the production function estimation using Stochastic Frontier. Shallot seed farming in Nganjuk Regency, East Java Province, produces the following results.

Regression Equation Model:

Y = 5.835 + 0.582LnX1 + 0.544LnX2 + 0.453LnX3 – 0.411LnX4 – 0.087LnX8 + 0.062LnX9

Based on the table above shows the results of the production function estimation using frontier stochastic 4.1c software with a 1% t-table of 2.75, a 5% t-table of 2.04 and a 10% t-table of 1.70%. All variables studied are known to have their respective coefficients as follows:

1. The Gamma value is obtained at 0.999 and is significant at 1% t-table because t-count> t-table, namely 668.42> 2.75. This shows that 99.9% of the technical efficiency level of shallot seed farming in Nganjuk Regency is due to variations in production inputs and the remaining 1% is influenced by external factors that cannot be controlled by farmer groups such as climate, weather, pests and diseases.
2. Land area input has a significant effect on shallot seed farming production by 0.582 and is significant to t table by 1% where t-count (8.61)> t-table (2.75). This shows that if there is a 1% increase in land area, the shallot seed production will increase by 58.2%. So if the shallot seed land area increases, the production will increase.
3. Labor input has a significant effect on shallot seed production by 0.544 and is significant to t table by 1% where t-count (4.87)> t-table (2.75). This shows that if there is an increase in the number of workers by 1%, the shallot production will increase by 54.4%. So if there is an increase in labor, there will be an increase in the amount of shallot seed production [6,24].
4. Input of superior variety bulbs (shallots) has a significant effect on shallot seed production of 0.463 and is significant to the t-table of 1% where t-count (4.15)> t-table (2.75). This shows that, if there is a 1% increase in seeds, the production of shallot seeds will increase by 46.3%. Therefore, if the number of superior variety bulbs is increased, the amount of production produced will increase.
5. Organic fertilizer has a significant effect on shallot seed production of 0.411 and is significant to the t-table of 1%, namely t-count (4.02)> t-table (2.75). This means that if there is a 1% increase in organic fertilizer, there will be an increase in production of 41.1%. So if the amount of organic fertilizer is increased, the amount of shallot seed production will increase, this is because organic fertilizer is one of the environmentally friendly production factors [19,25,26,27]. Organic fertilizer can increase soil fertility, improve soil structure to be loose which can make shallot roots grow well, increase microorganisms in the soil, the use of organic fertilizers according to the number of plants can produce maximum shallot seed production.
6. Herbicides have no significant effect on shallot production, because t-count (-1.345) <t-table (1.70). Excessive use of herbicides can cause weed resistance which results in the herbicide reaction being less effective.
7. Insecticides have a significant effect on shallot production of 0.062 and are significant to the t-table of 5%, namely t-count (3.70) > t-table (2.04). This shows that if there is an increase in insecticide of 5%, there will be an increase in production of 6.2%. So if the amount of insecticide is increased, the amount of shallot seed production will increase.

Table 3. Results of Technical Efficiency Analysis of Shallot Seed Farming Business

Efficiency Rate	Farmer (person)	Percentage (%)
0,41-0,65	6	6,9%
0,66-0,85	29	33,7%
0,86-0,90	18	21,1%
0,91-1,00	33	38,3%
Total	**86**	**100%**
ET Average	**0.899**	
Maksimum	**0.998**	
Minimum	**0.452**	

Based on the table above, it can be seen that most shallot farmers in Nganjuk Regency have a technical efficiency level between 0.91-1.00, namely 33 farmers or 38% of the total number of respondents of 86 farmers who specifically carry out superior shallot seed varieties. Based on the results of data processing using Frontier software (V.4.1c), the lowest technical efficiency level is 0.45 and the highest is 0.99 with an average technical efficiency of 0.899. This shows that the average level of technical efficiency in the use of production inputs in shallot seed farming in Nganjuk Regency is 89.98%. 4. Conclusion The shallot production sector in the Regency remains superior, it is possible to present a realistic perspective on what is anticipated and the optimal approach to strengthening shallot seed farming. Instability in seed supply reduces the production capacity of shallots in East Java and may threaten the existence of shallot processing industries in various regions in East Java and outside East Java as suppliers of shallot seeds and bulbs as raw materials for processed industries that use shallots as one of the main raw materials or supporting raw materials.

The shallot seed farming carried out by farmer groups in Nganjuk Regency adopts agricultural innovation, many farmers tend not to hesitate in implementing innovations in improving the performance of shallot seed farming. Farmers are of the view that the application of certain technological innovations will be more effective in helping to improve the quality of seed harvests and supporting farmer welfare [10,19,28,29]. The application of a combination of organic fertilizers and herbicides and fungicides can reduce production costs and is an implementation of environmentally friendly shallot seed cultivation technology.

The environmentally friendly farming pattern is an agropolitan concept with a focus on the efficient use of natural resources, prioritizing environmental impact control, farmer welfare and improving the economy of a region. Thus, the implementation of environmentally friendly shallot cultivation can be a real example of the agropolitan concept in sustainable agricultural development. The suitability in the distribution of shallot seed production inputs is expected to be implemented continuously so as to support

the potential of Nganjuk Regency as a buffer for the supply of shallot stock and does not require the possibility that Nganjuk Regency is the largest national supply of shallot seeds.

References

[1] *P. Puryantoro and F. Wardiyanto, "Analysis of Production Factors and Allocative Efficiency of Shallot Farming in Situbondo Regency", Jurnal Pertanian Cemara. vol. 19, no. 1,* ***(2022)****, pp. 20-29.*

[2] *P. Yousefvand, Y. Sohrabi, A. Mastinu, G. Heidari and W. Weisany, "Salicylic Acid Altered The Fatty Acids Compositions and Nutrient Status Of Shallot (Allium Hirtifolium) Grown Under Drought Stress", Journal of Agriculture and Food Research. 18 (Special),* ***(2024)****, pp. 101502.*

[3] *R. Girsang, L. D. Andriani Luta and H. A. Syahfitri, "Increasing Shallot Seed Germination (Allium ascalonicum L.) due to H2SO4 Soaking Interval And Several Planting Media", Journal of Animal Science and Agronomy Panca Budi, vol. 4, no 1,* ***(2019)****, pp. 24-28.*

[4] *J. Julyadi, Y. Amir and T. H. A. P. Putra, "The Use of Two Varieties of Shallot Seeds and the Dosage of Manure for Laying Hens on the Growth and Yield of Shallot Plants (Allium ascalonicum L.)", Jurnal Agroteknologi Jagur, Unand, vol. 7, no. 1,* ***(2025)****, pp. 57-66.*

[5] *M. Rizqy, T. Setyadi and G. I. Harya, "Determination of Leading Fruit Commodities in the Horticulture Subsector in Gresik Regency", Asian Journal of Applied Research for Community Development and Empowerment, vol. 9, no. 1,* ***(2025)****, pp. 54-57.*

[6] *J. Ratseewo, T. Chumroenphat, H. Li and S. Siriamornpun, "Changes In Chemical Composition, Volatile Compound, And Bioactive Compounds Retention In Shallots (Allium Ascalonicum L.) Under Different Drying Methods", Food Chemistry: X, vol. 27,* ***(2025)****, pp. 102419.*

[7] *Y. Hajar and A. Krisanti, " Analysis of the Competitiveness of Shallot (Allium Cepa L.) Agribusiness in Tulungagung Regency", Jurnal Agribisnis Fakultas Pertanian Unita,* ***(2018)****, pp. 1-10.*

[8] *W. Priyo, R. Anindita and S. Maulidah, "Competitiveness Analysis of Shallot Commodities in Kediri Regency", JEPA-Jurnal Ekonomi Pertanian dan Agribisnis, vol. 1 no. 1,* ***(2017)****, pp. 1-7.*

[9] *M. Fharid, "Efficiency of the Supply Chain of Red Onion Commodity in Modern Markets in Makassar City (Case Study of the ea-frul Supplier Institution in Makassar City)", Thesis, Agribusiness Study Program, Agriculture Faculty, Universitas Muhammadiyah Makassar,* ***(2017)****.*

[10] *R. Rosliani, T. Handayani, M. Prathama, R. Murtiningsih, I. Sulastrini, A. Sembiring, R. Pangestuti, A. D. Santosa, and M. P. Yufdy, "Enhancing Botanical Seed Yields Via Seed-To-Seed Techniques And Understanding Botanical Seed Phenology In Shallots", Journal of the Saudi Society of Agricultural Sciences, In Press, Corrected Proof,* ***(2024)****.*

[11] *Sudiyarto, P. R. Destiarni and G. I. Harya, "Analysis of Factors That Affect Consumer Preference on Coffee Consumption in Surabaya", Proceedings of the International Conference on Science and Technology (ICST 2018), pp. 587-593.*

[12] *G. I Harya, A. Salsabila, and L. Nurohmah, "Optimization of Melon Cultivation with the Drft Hydroponic System (Dynamic Floating Technique, Jurnal Pemasaran Bisnis. Jurnal Pemasaran Agribisnis, vol. 6, no. 3, **(2024)**, pp. 416-423.*

[13] *R. Pangestuti, T. Cahyo, M. Retno, E. Eman and S. Chanifah, "Environmentally Friendly Shallot Cultivation Technology in Tegal Regency", Technical Instructions for Environmentally Friendly Shallot Cultivation Technology in Tegal Regency, **(2015)**.*

[14] *G. I. Harya, A. Fauzi, N. Hanani, R. Asmara, A. W. Muhaimin, H. Herjanto, and G. S. Budiwitjaksono, "Analysis of the relationship among technical efficiency, competitive strategy, and export performance in the cocoa agroindustry in Indonesia", Journal of International Food & Agribusiness Marketing, vol. 18, **(2024)**.*

[15] *G. I. Harya, K. Kuswanto, R. Asmara, J. T. Tarik, S. Maulidah, and G. S. Budiwitjaksono, "Taking a Deeper Look at the Priority of Agricultural Industry Efficiency Through the Use Data Envelopment Approach", Agroalimentaria Journal - Revista Agroalimentaria, vol. 29, no. 57, **(2023)**, pp. 167-177.*

[16] *N. M. Sunariadi, P. K. Intan, D. C. R. Novitasari and Y. Hariningsih, "Prediction of Shallot Production in Nganjuk Regency Using the Arima Seasonal Method (Sarima)", Transformasi Jurnal Pendidikan Matematika dan Matematika, vol. 6, no. 1, **(2022)**, pp. 49-60.*

[17] *G. I. Harya, Sudiyarto, G. S. Budiwitjaksono, and P. Markus, "Competitiveness and Processing of Processed Cocoa Industry in Improving the Welfare of People's Cocoa Farmers in East Java", 4th International Seminar of Research Month, **(2020)**, pp. 302-310.*

[18] *G. I. Harya, W. Mindari, T. Setyadi, A. Pratama, S. Mukaromah and C. Fadil, "Application of the Agropolitan Concept through Digital Marketing Training and Environmental Implications for MSMEs in Gunung Anyar District , Surabaya City", Asian Journal of Applied Research for Community Development and Empowerment, vol. 9, no. 1. **(2025)**, pp. 33-39.*

[19] *G. I Harya, N. Hanani, R. Asmara and A. W. Muhaimin, "Study of Technical Efficiency of The Cocoa Industry Using Data Envelopment Analysis", Revista Iberoamericana de Viticultura Agroindustria y Ruralidad, vol. 11, no. 33, **(2024)**, pp. 130-145.*

[20] *I. Harya and W. G. Wahyuningrum, "Feasibility Analysis of Turmeric Farming Business of Petiken Village Farmers Who Are Members of the BPP Driyorejo Farmers Group, Gresik Regency", Jurnal Ilmiah Manajemen Agribisnis, vol. 11, no. 2, **(2023)**, pp. 112-120.*

[21] *P. N. Indah, G. I. Harya, L. Fatma, L. Pratiwi and S. Widayanti, "Analysis of Factors Influencing Processed Cocoa Industry in East Java Indonesia. In A. PRESS (Ed.), International Conference on Science and Technology, vol. 1, **(2023)**, pp. 652–656.*

[22] *T. Coelli, "Estimators And Hypothesis Tests For A Stochastic Frontier Function: A Monte Carlo Analysis", Journal of Productivity Analysis 6,* ***(1995)****, pp. 247-268.*

[23] *Greene, W. H. "Maximum Likelihood Estimation Of Stochastic Frontier Production Models", Journal of Econometrics, vol. 18, no. 2,* ***(1982)****, pp. 285-289.*

[24] *O. S. Omoba, A. I. Olagunju, T. D. Oluwajuyitan, and O. F. Akinrinlola, "Functional Extruded Snacks From Amaranth, Soycake And Shallot Flours: Nutritional Composition, Physicochemical And Antioxidant Properties", Measurement: Food, vol. 15,* ***(2024)****, 100194.*

[25] *G. I. Harya, W. Mindari, T. Setyadi, S. Mukaromah, and C. Fadil, "Implementation of urban farming through integrated training in Gunung Anyar District. 9 th International Seminar of Research Month 2024,* ***(2025)****.*

[26] *M. Patiung, "Analysis Of Feasibility of Development Of Agropolitan Area Probolinggo District", Agricultural Social Economic Journal, vol. 21, no. 2,* ***(2021)****, pp. 79-86.*

[27] *A. Ramadhani, N. C. Putri, S. Widayanti and G. I. Harya, "Technical and Economic Efficiency of Production Factors in Javanese Tobacco Farming: A Case Study of Belun Village, East Java", Journal of Agricultural Socioeconomics and Business, vol. 7,* ***(2024)****, 108–117.*

[28] *M. Taki, M. Noshad, M. M. Jasemi and F. Isvandi, "Application of Even Span Greenhouse Solar Dryer (ESGSD) for drying Persian shallot; Kinetic analysis, machine learning modeling and quality evaluation", Case Studies in Thermal Engineering, pp. 68.*

[29] *Wahyudin, M., Maksum, and H. Yuliando, "The Shallot Pricing in the View of Import Restriction and Price Reference", Agriculture and Agricultural Science Procedia, vol. 3, vol. 2024, pp. 132-136.*