

Valuation of costs and change in returns of seedling technology and shallot planting distance: A case study in Grobogan Regency, Central Java, Indonesia

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ABSTRACT

The increasing rate of shallot production of Central Java Province for the last ten years was lower than the national rate, indicated the need for new technology development. The study aims to determine the economic feasibility of the newly seedling planting technique in three planting distances (10 x 10 cm, 10 x 15 cm, and 15 x 15 cm). In that case, farmers use seed bulbs. The research was carried out in Padang Village, Tanggungharjo Subdistrict, Grobogan Regency, from August to October 2018. Financial analysis, consisting of BCR, MBCR, break-even point of both production and price, and competitive advantage of the techniques were analyzed. The results showed that the newly seedling technologies and planting distance were able to increase the productivity of shallots ranging from 12,685 to 21,088 kg. At the price of shallot bulbs at IDR 10,000 per kg, 10x10 cm planting distance resulted in the highest profit (IDR 180,790,100/ha). It was much higher compared to the farmers' technology (IDR 9,299,000/ha). Based on break-even point analysis, seedling planting technology has a tolerance limit of production and prices decreasing between 67.24% to 71.44% compared to existing technology (16.03%). Seedling planting technology has a competitive advantage with a net profit ratio of 13.76 to 19.44 and a minimum selling price of IDR 3,239 to IDR 3,622 to obtain the same profit as existing technology. Thus, the technology of planting shallot seedlings at a spacing of 10 x 10 cm is recommended to increase the production and profits of shallot farming.

Keywords: shallot, seedling technology, planting distance

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1. Introduction

Central Java Province is the largest shallot production center in Indonesia, with a production of 445,585 tons and contribute nationally as much as 29.64% (Indonesian Central Bureau of Statistic, 2019). Moreover, Brebes Regency produces most of the commodities. In 2018 65.21% (290,564 tons) of the commodity were produced in the region (Central Java Province Central Bureau of Statistic)[1]. As in other regencies in the province, shallot has spread in Grobogan Regency. Grobogan Regency produced as many as 12,328 tons and contributed 2.77% of the shallots production in Central Java. The contribution of Central Java in the last ten years decreased by an average of 3.96% per year despite an average increasing production rate of 1.91% per year. The increasing production rate was lower compare to the national level (5.87% per year). The conventional technologies application at the farm level causes a low increasing production rate. In further, shallot farmers in Central Java usually use shallot tubers rather than botanical seeds (true shallot seed/TSS). Farmers prefer bulbs since it is

more practical than TSS. Farmers do not expect that planting bulbs continuously using the same shallot varieties hinders the opportunity to improve the quality of shallots, thereby reducing the level of shallot production [2-4]. The government intensively promotes TSS through a demonstration plot in Grobogan Regency. TSS has several advantages over the seed bulbs, namely: the amount of TSS requirements is lower (3 to 4 kg/ha) compared to the seed bulbs (1 to 1.5 tons/ha), TSS transportation is more comfortable and cheaper, producing more healthy plants because TSS is pathogen-free, and produces better tuber quality[5-9]. However, the following are disadvantages of TSS using, farmers firstly need to seed TSS, use more labor, and longer harvest time of TSS (19 to 26 days longer than seed bulbs)[10]. Farmers were able to use seedlings as planting material[11-13] to minimize the disadvantages of TSS. Research on shallots using shallot seeds has not been widely carried out by farmers and researchers because it is the introduction of new technology. Therefore, not many research results have revealed the economic value of shallot farming using seeds at varying spacing. Taking into consideration the change of planting material for shallots from seed bulbs to shallot seed (True Shallot Seeds/TSS), the study on the costs and revenue from shallot farming has been undertaken to know the economic importance and profitability. Besides, the study also determined the changes in profits after farmers changed planting material from seed bulbs to shallot seeds and the profit ratio. Finally, the results of this study are expected to serve as guidelines for farmers and suggested policy guidelines based on study findings.

2. Material and methods

The study was carried out in Padang Village, Tanggunharjo Subdistrict, Grobogan Regency, from August to October 2018. The study used a demonstration plot method. Seedling as planting material of TSS was cultivated in one hectare of farmer's land. There were three planting distance, namely (1) 10 x 10 cm, (2) 10 x 15 cm, and (3) 15 x 15 cm. As a control, the study also observed existing farmers, using seed bulbs. The new and existing cultivation technology were as follows (Table 1).

Table 1. The technology of shallot farming study

No	Items	Seedling Technology	Farmers' Technology
1.	Planting materials	TSS	Seed bulbs
2.	Varieties	Bima Brebes	Bima Brebes
3.	Numbers of seedling	2-3 seeds per clump	One bulb per clump
4.	Days of transplanting	45 days after sowing	Direct planting
5.	Spacing	10 x 10 cm, 10 x 15 cm, and 15 x 15 cm	15 x 15 cm
6.	Fertilization	Based on soil analysis	Farmers' practice
7.	Pest and disease control	Selective chemicals' pesticides	Chemical pesticides

In the study, the transplanting age of seedlings from TSS was 45 days after sowing. Based on the laboratory analysis of soil samples, dosage fertilization per hectare of land were 20 tons of organic fertilizer, 200 kg of ZA, 111 kg of SP36, 533 kg of Phonska, 66 kg of KCl, 200 kg of KNO₃, and 400 kg of NPK Mutiara. Primary data from each shallot farming technology included the amount and price of both production inputs and the output produced. There were a series of data analysis. The performance of each shallot farming technology was analyzed descriptively using average value, while the economic feasibility of shallot farmings was financial analysis adapted from[14-16]:

$$\pi = TR - TC$$

$$B/C = \pi/TC$$

where:

π = profits (IDR/ha)

TR = total revenue (IDR/ha)

TC = total cost (IDR/ha)

B/C = benefit-cost ratio

The feasibility level of farming due to technological changes from seed bulbs to seedling with certain planting distance, using losses and gains analysis through marginal benefit costs ratio[17] :

$$MBCR_i = \frac{\pi_i - \pi_j}{TC_i - TC_j}$$

where:

MBCR_i = Marginal benefit-cost ratio of TSS with a planting distance of i over farmers' technology

i = TSS with planting distance of i

j = farmers' technology (existing)

Break-even analyzed the tolerate point of the declining in production or product prices to a certain extent where farming still provides a reasonable rate of profit [18]:

$$BEP-Y = TC/P_y$$

$$BEP-P = TC/Y$$

where:

BEP-Y = break-even point of production

BEP-P = break-even point of price

P_y = price of shallot (IDR)

Y = yield of shallot (tons)

Following Simatupang et al. [19], the level of profitability of TSS with certain planting distance compare to the existing farmers' practice was measured by competitive advantage analysis and Net Profit Enhancement Ratio (NPER):

$$MSP_i = (TC_i + \pi_j)/Y_i$$

$$NPER_i = \pi_i/\pi_j \times 100 \%$$

where:

MSP_i = minimum selling price of TSS with i-planting distance (IDR)

TC_i = total cost of TSS with i-planting distance

Y_i = Yield of TSS with i-planting distance

3. Results and discussions

3.1. Farming technology performances

Farmers utilize narrow agricultural land. On average, the land ownership of farmers is only 0.57 ha. Therefore farmers should apply proper technology to get optimal results [20-23]. Table 2 presents the production inputs used in shallot farming. On average, farmers used 1,200 kg of seed bulbs. This amount was higher compare to Sumenep District (977 kg per hectare as reported by[24-26], but lower than in the Brebes, Tegal, and Cirebon Districts, which was an average of 1.64 tons per hectare [27]. Several factors determined the differences, namely bulb size, planting methods, and varieties. Farmers rarely use seedling technology because of the limited shallot seeds (TSS) in the market. Shallot will grow and optimally produce if proper fertilization is applied, either of organic fertilizer (manure) and inorganic fertilizer (Urea, SP36, and Phonska). Sumarni et al. [11] stated that fertilization must be appropriate and insufficient and balanced quantities. Research by Teang & Sulaeman found that fertilizer use significantly affected onion production. Several pests and diseases attacked the shallot cultivation, namely caterpillars (*Spodoptera exigua*), thrips (*Thrips tabaci*), Fusarium wilt (*Fusarium oxysporum*), and purple spots (*Alternaria pores*). Most types of pests and diseases accord with the results found by Maftukin et al. [28] in Wanasari Subdistrict, Brebes Regency, in which *Spodoptera exigua*, trips, *Agrotis ipsilon*, purple spots diseases, and root-knot nematode (*Meloidogyne* spp.). The pest and disease management on new technology is selective pesticides.

Table 2. The use of production inputs of shallot farming (per hectare)

No	Inputs	Planting Distance in Seedling Technology
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	10 x 10 cm	10 x 15 cm	15 x 15 cm	Farmers' Technology
1. Planting materials:				
a. Seedling (plant)	510,000	340,000	226,666	-
b. Seed bulbs (kg)	-	-	-	1,200
2. Fertilizers (kg) :				
a. Urea	-	-	-	70
b. SP-36	111	111	111	300
c. KCl	66	66	66	-
d. Phonska	533	533	533	500
e. ZA	200	200	200	-
f. KNO ₃	200	200	200	-
g. NPK Mutiara	400	400	400	-
h. Organic/manure	20,000	20,000	20,000	300
3. Pesticides :				
a. Liquid (liter)	10	10	10	14
b. Powder (kg)	5	5	5	2.5
4. Labor (man days) :	225	190	167	155

Total labor used in shallot farming, which came from inside and outside of the family, ranges from 145 to 225 working days. The total labor was lower compared to the labor in Demak District, which varied from 211 to 268 man-days (Sahara et al. 2019). The difference related to the differences in the planting distance used, where the denser planting distance used more labor, mainly for planting, fertilizing, weeding, and harvesting activities.

3.2. Financial Feasibility

Farming costs are all the expenses of farmers to carry out the production process. Although farmers do not pay labor in the family in cash, in this analysis, labor from the family is calculated as part of farming costs (Table 3). The highest production cost of shallot farming, in general, was the cost of purchasing planting materials, which contributed as much as 57.90%, 49.03%, 39.87%, and 73.92% respectively for the planting distance of 10 x 10 cm, 10 x 15 cm, 15 x 15 cm and farmers technology. Purchase of planting materials at the highest cost, either in the form of seed bulbs or seedlings, was typical in shallot farming as being reported by many researches [29, 30]. In seedling technology, fertilizers' purchasing was the second largest proportion of production cost. On the contrary, in farmers' technology, the second largest was for labor cost, which contributed as much as 14.89% of the total production cost, while the cost of fertilizers was the smallest or ranked fourth with the proportion of 4.16%. Farmers have not yet applied recommendations of fertilizers' dosage. Labor cost in seedling technology ranks third largest with a proportion of 12 to 15%. The percentage of labor costs was lower than in other locations. In [17], the author reported that the proportion of labor costs in Demak District was 18.55 to 19.84% of the total cost of shallot farming. Aldila et al. reported that the proportion of labor costs for shallot farming ranged from 36 to 42% in Brebes District and 34 to 35% in Tegal District.

Table 3. Financial feasibility of shallot farming (per hectare)

No	Inputs	Planting Distance in Seedling Technology			Farmers' Technology
		10 x 10 cm	10 x 15 cm	15 x 15 cm	
A.	Production cost (IDR):				
	1. Planting materials:				
	a. Seedlings				
	b. Seed bulbs	51,000,000	34,000,000	22,666,600	-
		-	-	-	36,000,000
	2. Fertilizers:				
	a. Inorganic	12,589,900	12,589,900	12,589,900	1,876,000
	b. Organic	10,000,000	10,000,000	10,000,000	150,000
	3. Pesticides:				
	a. Liquid	2,000,000	2,000,000	2,000,000	2,800,000

No	Inputs	Planting Distance in Seedling Technology			Farmers' Technology
		10 x 10 cm	10 x 15 cm	15 x 15 cm	
	b. Powder	1,250,000	1,250,000	1,250,000	625,000
	4. Labor	11,250,000	9,500,000	8,350,000	7,250,000
	Total cost	88,089,900	69,339,900	56,856,500	48,701,000
B.	Production :				
	1. Yield (kg)	26,888	24,277	18,485	5,800
	2. Return (IDR)	268,880,000	242,770,000	184,850,000	58,000,000
	3. Profit (IDR)	180,790,100	173,430,100	127,993,500	9,299,000
C.	BCR	2.05	2.50	2.25	0.19

The cost of pest control in seedling technology was as much as IDR 3,250,000 or 3.69 to 5.72% of the total cost. The cost was lower than the purchase of pesticides on existing technology (IDR 3,425,000 or 7.03% of the total cost). The pest control costs of the two technologies were not significantly different. Pest control in seedling technology used selective pesticides, so it was cheaper even though the difference was not significantly from farmers' technology. The yield of shallot farming ranged from 5,800 to 26,888 kg. Seedling technology with denser planting distance or the most planting population resulted in the highest yield. Assuming each plant produces shallot bulbs, the higher the population (narrower spacing), the higher the yield gained in the respective area. Deviana et al. [31] found that the highest dry weight of shallot bulbs tubers was obtained at a denser planting distance of 10 x 15 cm (7.3 ton per hectare) although it was not significantly different from 15 x 15 cm (6.4 ton per hectare) and significantly different from a spacing of 20 x 15 cm (4.9 ton per hectare). In contrast to the study of Ademe et al. [32], the highest yield of shallots was 36.39 tonnes/ha at a spacing of 15 x 30 cm. Likewise, the study of Biru [33] which combined spacing and N fertilization obtained the highest shallot yield of 30.26 tonnes/ha obtained at 15 x 50 cm spacing and N fertilization of 150 kg/ha. Based on the analysis of financial feasibility, shallot farming with both planting technology benefited farmers as indicated by the profits received by farmers, which ranged from IDR 127,993,500 to IDR 180,790,100. Moreover, from the BCR value, seedling technologies were benefited (2.05 to 2.50) than existing technology (0.19). Besides, shallot farming in Bantul District and in Kota Gajah, Central Lampung (0.45) [34] and Tanggamus District (0.73) resulted in BCR < 1 [35]. Therefore based on data, seedling technology was able to provide a higher profit compared to existing technologies.

3.3. Changes in shallot farming technology

Changes in shallot farming technology from using seed bulbs to seedling require additional costs-however, the changes made it possible for farmers to receive higher profits (Table 4).

Table 4. Losses and gains due to changes in shallot farming technology from seed bulbs to seedling technology

No.	Items	Planting Distance in Seedling Technology		
		10 x 10 cm	10 x 15 cm	15 x 15 cm
1.	Losses-additional cost (IDR):			
	a. Planting material	15,000,000	-2,000,000	-13,333,400
	b. Fertilizer	20,563,900	20,563,900	20,563,900
	c. Pesticide	-175,000	-175,000	-175,000
	d. Labor	4,000,000	2,250,000	1,100,000
	Total	39,388,900	20,638,900	8,155,500
2.	Gains-additional return (IDR)	210,880,000	184,770,000	126,850,000
3.	Additional profit (IDR)	171,491,100	164,131,100	118,694,500
4.	MBCR	4.35	7.95	14.55

MBCR of planting materials changes technology from seed bulbs to seedling in shallot farming ranged from 4.35 to 14.55. Additional cost as much as IDR 100,000 provides an additional profit between IDR 435,000 - 1,455,000. Therefore additional benefits received by farmers are still higher than the additional cost. Farmers

economically applied the seedling planting technology of shallots at a planting distance of 10 x 10 cm, 10 x 15 cm, and 15 x 15 cm.

3.4. Break-even point of price and production

The break-even point is the minimum of price and production to return farm capital (Novita et al. 2019). Table 5 presents the break-even point of price and production of shallots farming. Breakeven point of production (BEP-Y) of shallot farming with seedling planting technology ranges from 5,685.65 kg to 8,808.99 kg, indicating that at a price level of IDR 10,000 per kg farmers were able to harvest 5,685.65 kg to 8,808.99 kg depending on the spacing used. In terms of prices, farmers obtain a minimum price of IDR 2,856.20 to IDR 3,276.18 per kg at a yield level of 18,485 to 26,888 kg. Tolerance limits for decreasing production and prices that do not cause losses are 67.24%, 71.44%, and 69.24% of production and actual prices for planting distance of 10 x 10 cm, 10 x 15 cm, and 15 x 15 cm, respectively.

Table 5. Break-even point of price and production in shallots farming

No.	Items	Planting Distance in Seedling Technology			Farmers' Technology
		10 x 10 cm	10 x 15 cm	15 x 15 cm	
1.	Total cost (IDR)	88,089,900	69,339,900	56,856,500	48,701,000
2.	Total production (kg)	26,888	24,277	18,485	5,800
3.	BEP-Y (kg)	8,808.99	6,933.99	5,685.60	4,870.10
4.	BEP-P (IDR)	3,276.18	2,856.20	3,075.80	8,396.72
5.	Tolerance for decreased (%)	67.24	71.44	69.24	16.03

The breakeven point of production in this study is almost the same as the Breakeven point of production obtained by Astuti et al.[36] in Cirebon Regency, namely 9.932 kg for farmers who used the right technology (Good Agriculture Practices) and 5.995 kg for farmers who do not use technology. The breakeven point of prices for the two technologies is almost the same, namely IDR 7,333/kg and IDR 17,556/kg, respectively. The indications obtained in both studies are that the use of appropriate technology can increase shallot production thereby increasing farmers' income.

3.5. Performance of competitive advantages of farming

The competitive advantage of seedling technology resulted in a Net Profit Enhancement Ratio (NPER) between 13.76 - 19.44 (Table 6), meaning that each production cost expenditure per-unit price can increase profits by the value obtained. Normatively, the technological advantage of shallot farming with seedling technology compared to planting with seed bulbs increased between IDR 118,694,500 to 171,491,100 per hectare. The NPER value in this study is higher than the results of Simatupang et al. [19], in which getting an NPER value of 7.29 between Good Agriculture Practices and farmers' technology in Simalungun Regency, North Sumatra.

Table 6. Competitive advantages of shallot farming technology

No	Items	Planting Distance in Seedling Technology			Farmers' Technology
		10 x 10 cm	10 x 15 cm	15 x 15 cm	
1.	Cost of farming (IDR/ha)	88,089,900	69,339,900	56,856,500	48,701,000
	Benefits of existing technology (IDR/ha)	9,299,000	9,299,000	9,299,000	9,299,000
	Total (IDR/ha)	97,304,900	78,554,900	66,071,500	58,000,000
2.	Production (kg/ha)	26,888	24,277	18,485	5,800
3.	MSP (IDR/kg)	3,619	3,236	3,574	10,000
4.	Return (IDR/ha)	97,388,900	78,638,900	66,155,500	58,000,000
5.	NPER	19.44	18.65	13.76	-

The minimum selling price is the selling price, where seedling technology gets the same profit as the existing technology. With a minimum price below the actual price, the seedling planting technology has the competitive advantage of existing shallot farming. Simatupang et al. [19] stated that the competitive advantage of both production and price showed the competitiveness level of a particular technology to other technologies. This

value describes the minimum level of production and price of a particular technology that can provide a competitive advantage.

4. Conclusion

The newly planting technology by seedling and planting distance had a positive impact on shallot farming. The new technologies increased shallot farming productivity between 12,685 to 21,088 kg per hectare and gave additional benefits from IDR 118,694,500 to 171,491,100 than the existing technology. Seedling and planting distance technology had competitive advantages as indicated by a net profit ratio between 13.76 to 19.44, and a minimum selling price ranged from IDR 3,239 to 3,622 per kg at the same profit rate of existing technology. Thus, shallot farming technology with nursery technology and a spacing of 10 x 10 cm is feasible to be widely developed in Grobogan Regency and can be tried in other areas.

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Conflict of interest

We declare that there is no conflict of interest dealing with authors and Indonesian Agency for Agriculture Research and Development that facilitated and funded the research activity.

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