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Feasibility of water-saving technology to improve shallot productivity in dryland of Eastern Indonesia

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Abstract. Increasing productivity of shallot using water saving technology in dryland farming system is recently documented in the literature due to efficient use of water irrigation. However, to what extent of profitabiliy and feasibility of water saving technology in dryland farming system of shallot are limited information. The aim of this study was to determine the feasibility and profitability of water saving technology of shallot farming system in dryand of easten part of Indonesia. Input and output data were obtanied from the experimental research involving three treatments of technology packages tested and laid as Randomized Block Design: (A (Trichoderma, sprinkler irrigation, use of bio-urine); B (same as A but with furrow irrigation); and C (farmer practice), The amount of water used was measured using a water meter. The results showed that package A has achieved the highest shallot yield at 31.6 tons/ha, 14% and 45% higher compared to package B and C, respectively. The total cost of irrigation with package A was less than the other packages, in which there was 15.8% and 30.4% more efficient compared to package B and package C, respectively. The cost of cultivating shallots with water-saving technology was lower than package B and farmer practices. The total profits obtained for package A was IDR 199,475,602 ha^{-1} which was higher than package B and farmers practices which was IDR 162,420,704 ha^{-1} and IDR 108,165,556 ha^{-1}, respectively and with B/C ratios for each package A, package B and package C was 2.88; 2.21 and 1.39 respectively. Thus, water saving technology for shallot farming system in dryland have high feasible to be developed.

1. Introduction

Shallots are one of the most important agricultural commodities in Indonesia. Apart from being the main cooking spice, red onions are also used as medicine by the community. Based on the reported by NTB Bureau of Statistic (BPS) [1], the consumption of shallots in Indonesia reached 27.72 kg/per capita/year. This need will certainly increase along with the increasing population and the increasing variety of culinary types favoured by the community.

Given the high level of consumption of shallots by the population, efforts to increase production are very important and urgent. Shallots are horticultural commodities that are sensitive to heavy rains and fog. This causes shallots to grow optimally in the dry season (April-May or July-August), or in dry climates. Bureau of Statistic data [2] shows that the Province of West Nusa Tenggara (NTB) as a dry climate area is the third largest shallot producer in Indonesia after Central Java and East Java.

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In addition to agro-climatic conditions, to grow optimally shallots require adequate amounts of water at the right time. As stated by Patel and Rajput [3], shallots have a shallow root system and are sensitive to water loss in the topsoil. This causes shallots require an efficient irrigation system that ensures the availability of water according to the growth phase. So far, the practice that is often done by farmers is to provide excess water with the assumption that the more water given, the better the plant growth will be [4]. The consequence of this is the high cost of water supply as well as the labour of watering during growth period. Excessive water at the time of shallot growth is not just high risk to various diseases, it also causes cost inefficiency [5].

One method of irrigation that quite efficient to be used is sprinkler irrigation, because this method can save water, besides the water irrigation can be applied in accordance to the needs of plants growth period accurately [6,7]. Enciso et al. [8] reported that drip irrigation system technology in shallot cultivation can save water use by up to 44% compared to flood irrigation system (leb). In addition, yield and size of the shallot bulbs are also better. The income obtained from drip irrigation was around 119% higher than the leb system.

Kasiran [9] states that the advantages of using drip or sprinkler irrigation technology compared to watering plants manually (using a hose), among others are 1. The equipment used (especially distribution pipes) has been proven to be durable, resistant to all weather, chemicals, pressure from inside and from outside, and anti-rust because it is made of polyethylene. 2. Can work at low pressure, meaning it does not require a large pump engine power. 3. Very efficient in the use of water, because the water is flowed to the plant drop by drop or spread and can be adjusted according to the needs of the plant. 4. Can prevent fertilizer loss in the root zone due to leaching. 5. Can reduce the risk of damage to plants due to watering, such as falling/broken plants due to being hit by hoses, and so on. 6. Cultivation activities no longer depend on the season; land can be planted throughout the year so that the planting index increases. 7. Can reduce the use and cost of labour. Furthermore, Suriadi et al [10] reported that sprinkler irrigation was also able to save water irrigation upto 95.8% and increased shallot yield by 45% compared to flood irrigation (leb).

Water-saving technology of shallot cultivation has been reported elsewhere [11–14]. However, feasibility of the sprinkler irrigation system on the farmer level has not been studied in detail. Thus, it is necessary to study feasibility of irrigation system that is economically profitable, technically applicable and socially acceptable. The purpose of this study was to determine the feasibility and profitability of water saving technology of shallot farming system in dryand of easten part of Indonesia.

2. Material and methods

The experiment was conducted through participatory research approach, where farmers applied the technology and treatments on their land together with researcher and extension agents starting from the planning to evaluating the feasibility of technology applied. The detail of experimental design and treatment of technology packages was explained by Suriadi et al. [10]. In brief, treatments involved in this experiment are presented in Table 1. We used P2AT well to irrigate shallot crop with debits of around 10-20 l s^{-1}. Irrigation costs using P2AT wells vary from Rp. 30,000-35,000 per hour. It required around 20 hours to irrigate the crop for one ha of land. The amount of water consumed during the crop growth period was measured using a water meter.

Table 1. Package of water-saving technologies for shallot cultivation [10].

Components of Package	Packages of Technology		
	Package A	Package B	Package C
Land preparation	Complete tillage	Complete tillage	Complete tillage
Seed quality	Certificated seed	Certificated seed	Certificated seed
Seed treatment	Yes	Yes	No
Fertilizer applied ha^{-1}	Compos=10 t ha^{-1}+SP 36= 150 kg ha^{-1}+ ZA= 250 Kg +NPK =250 kg + Urea=100 kg ha^{-1}	Compos=10 t ha^{-1}+SP 36= 150 kg ha^{-1}+ ZA= 250 Kg +NPK =250 kg + Urea=100 kg ha^{-1}	Farmers practices (SP36=250 kg ha^{-1}+ ZA=350kg ha^{-1}+NPK

Components of Package	Packages of Technology		
	Package A	Package B	Package C
			=300kg ha^{-1}and urea= 100kg ha^{-1}
Bio-pesticide	*Trichoderma* sp.	No bio-pesticide	No bio-pesticide
Weeding	As condition	As condition	As condition
Irrigation	Sprinkler	furrow	Furrow
Time of irrigation	Using soil moisture kit	Using soil moisture kit	When the soil dry
Pest and disease	Integrated pest and diseases control	Integrated pest and diseases control	Every 2 days upto harvest
Bio-urine	12% for 4x applied	12% for 4x applied	No bio-urine

Data collection was conducted through observation, measurement and interviews. Each farmer co-operators recorded all activities on shallot cultivation in the form of a farm record-keeping. This was done to ensure that all of the packages of technology were applied by farmer co-operators including expenditures flow. Types of data collected include type and number of input production, prices of input production, prices of irrigation materials, labour costs, output data and output prices, yield of shallot and amount of water use during shallot growth period. Data were analysed using descriptive method or statistical analysis where possible. To determine the feasibility of the shallot technology of farming on the balance of revenues or costs, the revenue cost ratio (R/C) approach is used [15].

3. Results and discussion

3.1. Productivity of shallot and water used

Yield of shallot at various packages of technology and water used by each treatment at dryland of NTB is shown in Table 2. The productivity of shallots was affected by the implementation of the technology package. Package A technology showed the highest yield of shallots compared to package B and the lowest was package C (farmer practice) probably due to adding bio-pesticide of Trichoderma and optimal irrigation obtained during plant growth period. Package A technology was able to increase the yield of shallots by 10% higher than package B and 42% higher than package C. The result of this experiment was online with reported by Fauziah et al [16] where yield of shallot decreased as volume of irrigation reduced from 100% value of evapotranspiration and yield of shallot increased by 39.28% using sprinkler irrigation compared with conventional (furrow) irrigation. Moreover, Muchtar et al. [17] reported that shallot yield increased by 75.53% compared with non-sprinkler irrigation.

Table 2. Dry yield (14%) of shallot at various packages of technology and water used at dryland NTB.

Treatments	Dry yield (ton.ha-1)	Water used (mm)	Water efficiency (%)	Irrigation water cost (IDR)
Package A	23.12	348.8		3,725,000
Package B	20.93	565.3	62.1	6,037,000
Package C	16.25	683.0	95.8	7,294,000

The amount of water irrigation used during shallot plant growth period (63 days) for each technology package is shown in Table 2. Package A used water irrigation for 348.8 mm which was the lowest use of water irrigation compared to other packages. Based on our measurement, debit of pumping well used to irrigate shallot was 7.9 l s^{-1} and duration required for irrigation was 22.5 hours per hectare. Package A (sprinkler) was able to save water up to 62.1% and 95.8% compared to package B (furrow irrigation) and packages C, respectively. Undang (2004) stated that in coarse-textured soil, the efficiency of water use with the sprinkler method was twice as high as surface water irrigation.

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3.2. Financial analysis and feasibility of water saving technology for shallot production

The cost components of shallot farming that carried out in the dry season in semi-arid climates with sprinkler irrigation is presented in Table 3. The Table shows that the largest cost component comes from the purchase of sprinklers installed at every 10 m distance. The overall cost of sprinkler installation was IDR 27,105,000/ha. If the economic life of the sprinkler irrigation was 10 years assuming the sprinklers were only used twice a year for dry season 1 (DS1) and DS2 with growth period of shallot was about 2 months , then the cost of the sprinkler components for each year was IDR 2,710,500 ha^{-1}. The cost of the sprinkler will be less if it is used to irrigate crops for two seasons in a year, which is IDR 1,355,250 $season^{-1}$. Thus, the sprinkler cost component is the maximum cost for shallots planted in the dry season on dry land. The total cost of irrigation with package A was smaller than the other packages for 15.8% and 30.4% for package B and package C, respectively. Hoang et al [18] reported that sprinkler irrigation required high cost input as infestation but the sprinkler irrigation may be used for long period of time, depending on its quality and the way of used. Furthermore, sprinkler irrigation can reduce labor cost, water saving, time and pumping cost [19].

Table 3. The cost of farming shallot in the dry season in dryland of various technology packages application.

		Cost Description	Package A (IDR)	Package B (IDR)	Package C (IDR)
I		**Labor wages**	**10,100,000**	**10,600,000**	**10,400,000**
	1	Soil tillage	2,000,000	2,000,000	2,000,000
	2	Planting and fertilization	2,100,000	2,300,000	2,400,000
	3	Weed control	2,000,000	2,300,000	2,000,000
	4	Harvesting and transportation	4,000,000	4,000,000	4,000,000
II		**Input Production**	**57,921,000**	**62,933,000**	**67,490,000**
	1	Shallot seed	45,000,000	45,000,000	45,000,000
2		Fertilizers	6,150,000	7,350,000	7,150,000
	3	Pest control	3,046,000	4,546,000	8,046,000
	4	Irrigation cost	3,725,000	6,037,000	7,294,000
III		**Sprinkler cost**	**1,355,250**		
		Sprinkler	4,950,000		
		Pipa 3 "	1,890,000		
		Pipa 2 "	5,880,000		
		Pipa 1"	2,200,000		
		Pipa 3/4"	8,112,500		
		pipa 1/2 "	210,000		
		Inner drat 1/2"	550,000		
		balve 1 "	340,000		
		T 3/4 and L	550,000		
		Pipa glue	180,000		
		over sock 3-2	22,500		
		over sock 2-1	60,000		
		over sock 1-3/4	110,000		
		over sock 3/4-1/2	550,000		
		Installation cost	1,500,000		
		Total cost	**27,105,000**		
		Economic live 10 years			
		Cost per year	2,710,500		
		Cost per season (2x)	1,355,250		
		Total farming cost	**69,376,250**	**73,533,000**	77,890,000

The total revenue, profit, R/C ratio, B/C ratio and BEP of shallot cultivation on several technology packages in dry land are shown in Table 4. In Table 4 indicates that the highest profit was obtained at package A and the lowest profit was at package C due to the yield of shallots in package A was higher than in the other packages. This also was indicated by higher B/C and R/C ratio at Package A than other packages. In addition, irrigation operational costs are also lower than other packages

If the initial investment value for the sprinkler installation is calculated in the season of shallot cultivation, the highest overall cost for package A was IDR 95,126,000 or higher IDR 21,593,000 compared to package B, and IDR 17,236,000 higher than package C. However, the benefit of package A was higher for IDR 37,054,898 compared to package B, and IDR 91,310,046 compared to package C. This shows that the initial investment cost sprinkler irrigation can be covered by the benefits generated by package A.

Table 4. Total revenue, profit, R/C ratio, B/C ratio and BEP of shallot farming on several technology packages in dry land.

Technology Package	Fresh Yield ($t.ha^{-1}$)	Price. kg^{-1}	Farming cost	Revenue (R)	Benefit (B)	R/C	B/C	BEP
A	31,630	8,500	69,376,250	268,851,852	199,475,602	3.88	2.88	2,193
B	27,759	8,500	73,533,000	235,953,704	162,420,704	3.21	2.21	2,649
C	21,889	8,500	77,890,000	186,055,556	108,165,556	2.39	1.39	3,558

4. Conclusion

The application of package A technology is able to save water very significantly compared to other onion cultivation technology packages. The amount of water needed during the growth of shallot plants with package A was much lower than that of package B and package C of 343.8 mm. Package A technology (sprinkler) was able to save 62.1% of water compared to package B and up to 95.8% by farmer practice or package C. The total cost of irrigation with package A is less than the other packages, which is 15 .8% and 30.4% more efficient for package B and package C. The cost of shallot farming with water-saving technology was lower than package B and the farmer practice. The total profit obtained with package A was IDR 199,475,602 higher than package B and the farmer practice for IDR 162,420,704/ha and IDR 108,165,556/ha respectively, with B/C ratios for each package. A, package B and package C of 2.88; 2.21 and 1.39, respectively.

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