Land resources management of shallots farming: a case study in the highlands of Solok Regency, West Sumatera

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Abstract. Solok Regency in West Sumatera Province is one of the new development centers for shallot production in Indonesia. This region has a specific cultivation characteristic that is different from other shallot production centers, where the cultivation is done in the highlands throughout the year. It is estimated that there will be differences in yields and production techniques between the rainy and wet seasons. The purpose of this study was to investigate farming practices of shallot cultivation in the highland of Solok Regency during the dry and wet seasons. Survey on 95 shallot farmers in Solok Regency showed that the use of labour inputs, solid pesticides, leaf fertilizer, and adhesives was significantly different between the rainy season and the dry season. At the same time, the land area inputs, mulch use, organic fertilizer, chemical fertilizer, dolomite, and liquid pesticides were not significantly different. The productivity of each land unit in the rainy season is lower than that of the dry season. The results of this study are expected to be a reference for planning the application of integrated pest and disease management technology according to the appropriate season on the shallot commodity in the highlands of Solok Regency.

1. Introduction
Shallot played an essential role in increasing the inflation rate of food commodities in 2015 [1] and often experiences fluctuations in supply and prices [2,3]. One of the causes of this condition is the production still centralized in Java, which still uses rice fields for cultivation. The main production centers must serve the entire vast territory of Indonesia and consist of many islands. When the rice planting season arrives, the planting area of shallots drastically drop because the land used to grow shallots is used to plant rice [4]. This condition makes shallots as one of the strategic commodities in Indonesia based on the classification by the Ministry of Agriculture.

One of the policies that can be applied to overcome the problems in the supply is to cultivate shallot outside the season [4-6]. However, this effort is limited by the availability of land especially when the available land is used to plant rice. Another alternative is to expand the planting areas that have different seasons from the regular season to guarantee the stability of the food supply. Solok Regency is one of the potential areas as a buffer zone for national shallot production because of its several advantages. Solok Regency has the potential to become a supply area for shallots, mainly when the main production centers are not producing.

One of the considerations for developing new production centers is climatic conditions, especially the rainfall. It is essential in determining the planting time for shallot and plays a role in determining the availability of water for cultivation, or the opposite, too much rain will have a negative impact on plants [7]. Based on the preliminary research conducted, shallot cultivation in Solok Regency is carried out...
throughout the year, which means it is carried out both in the dry and wet season. It might have risks, especially changes in temperature and climatic conditions, which lead to changes in existing pest and disease activity [8,9]. However, it also has some opportunities especially to increase the profit in the wet season [10], as long as the selection varieties [4] and technology used [5] is right for cultivating shallots in the wet season.

The differences that may occur in shallot cultivation in two different seasons will undoubtedly have an impact on productivity and costs [10]. It is necessary to study these differences in new development locations so that policy recommendations can be made to support the expected production stability. The purpose of this study was to compare the input-output and costs of shallot farming in Solok Regency during the rainy and dry seasons. It is hoped that the results of this research can be used for policymaking on shallot cultivation outside the season and support the application of integrated crop management in certain seasons.

2. Materials and methods
This research was conducted in May until December 2017 in Solok Regency, West Sumatera Province. Primary data of farming system were collected by survey. Farmers respondents were selected using cluster stratified random sampling in two sub-districts of Solok Regency, such as Lembah Gumanti and Danau Kembar sub-district. From these sub-districts, several villages were taken as samples, and then 95 farmers were randomly taken to be interviewed.

Secondary data used in this paper are the characteristics of shallot cultivation in Solok Regency which are sourced from the Solok Regency Agriculture Service and the Directorate General of Horticulture as well as data on the description of agro-climatic conditions of shallot production centers in Solok Regency which are sourced from BMKG and Balitklimat. The primary data that were asked was in the form of input and output types as well as farming costs incurred in shallot cultivation during the rainy season and dry season in the previous year.

Primary data in the form of farming are then divided into several groups, such as farmers who only plant during the rainy season, farmers who only plant during the dry season, and farmers who plant either in the dry season or the rainy season. The data obtained from farmers who planted both in the dry and rainy seasons will then be processed using the t-test to determine the differences in the use of the number of inputs in the dry season and the rainy season. In addition, a comparative analysis of the technical efficiency of shallot farming will be carried out in the rainy season and the dry season.

3. Results and discussion
3.1. Average production, harvested area, and monthly productivity of shallots in Solok Regency.
The average production, harvested area, and monthly productivity of shallots in Solok Regency in the period 2012-2017 are shown in table 1. In this period, the highest average harvest area was in December and the lowest in that period was in February. The difference between the highest average monthly harvest area and the lowest average monthly harvest area which is only 106.67 ha or 22% of the highest harvest area shows that there is extreme high fluctuation of the harvested area. The highest average monthly productivity occurred in November, which was 11.39 t ha⁻¹, while the lowest average monthly productivity occurred in January, which was 10.58 t ha⁻¹. The difference between the highest and lowest monthly average productivity shows that throughout the year productivity is relatively stable. However, it is necessary to know the difference in production input during the rainy season and the dry season. There is a possibility that productivity in certain seasons is the same as in other seasons because of different treatment compared to other seasons.

The average productivity between periods of October to March and April to September in 2012-2017 is 11.02 t ha⁻¹ and 11.01 t ha⁻¹. This number shows that there is no significant difference between production in the wet and dry season. The absence of differences in productivity can occur due to several factors, such as climatic conditions and farm inputs. In terms of climate, the average temperature in Solok Regency hardly shows a significant difference throughout the year (figure 1), although in several
sub-districts of shallot production centers in Solok show differences of the average rainfall and the number of rainy days (figure 2).

**Table 1.** Average production, harvested area, and monthly productivity of shallots in Solok Regency in the period 2012-2017.

| Month    | Production (t) | Harvesting Area (ha) | Productivity (t ha\(^{-1}\)) |
|----------|----------------|----------------------|------------------------------|
| January  | 4,023.57       | 378.50               | 10.58                        |
| February | 4,104.15       | 372.50               | 10.95                        |
| March    | 4,279.57       | 394.00               | 10.78                        |
| April    | 4,448.35       | 404.00               | 10.85                        |
| May      | 4,697.92       | 431.00               | 10.78                        |
| June     | 4,797.38       | 428.33               | 10.99                        |
| July     | 4,648.00       | 408.83               | 11.28                        |
| August   | 4,737.48       | 424.50               | 11.08                        |
| September| 4,501.68       | 405.50               | 11.11                        |
| October  | 4,715.23       | 415.17               | 11.38                        |
| November | 4,959.95       | 435.00               | 11.39                        |
| December | 5,239.55       | 479.17               | 11.02                        |

Source: Solok Regency Agricultural Department (2018).

**Figure 1.** The average temperature of Solok Regency in 2012-2017.
Figure 2. The average rainfall and number of rainy days in the period 2012-2017 in several subdistricts in Solok; a. Lembang Jaya, b. Danau Kembar, c. Lembah Gumanti, d. Gunung Talang.

3.2. Comparison of shallot input-output during the rainy season and dry season in the highlands of Solok Regency

Table 2 shows that some farmers only plant shallot in the rainy season and the other ones plant only in the dry season and the others plant both in the rainy and dry seasons. The majority of respondent farmers (86.32%) or 82 people plant shallots both in the rainy and dry seasons, while the others only plant in the rainy season (3.16%) and only plant in the dry season (10.53%).

Table 3 shows the analysis of the differences in input and output of shallot farming in the rainy and dry seasons from farmers who were planting shallot both in the wet and dry season. Farmers who plant shallots in both seasons can plant up to four times a year, adjusting the age of shallot which harvested 90 days from planting. Farmers who only plant shallots in the rainy season have a reason why they do this because of fears of drought and pest attacks in the dry season. Meanwhile, farmers who only plant in the dry season have several reasons, such as concerns about disease attacks in the rainy season and the use of the land they control to cultivate other crops such as chillies, cabbage, potatoes, leeks, and other crops.

Table 2. Comparison of the number of respondent farmers who plant shallots in the rainy season and the dry season.

| Parameter                        | Number | Percentage (%) |
|----------------------------------|--------|----------------|
| Only planting in the rainy season| 10     | 10.53          |
| Only planting in the dry season  | 3      | 3.16           |
| Planting in the rainy and dry season | 82    | 86.32         |

Source: primary data (2017).

The next step is to analyze the difference between input and output use during the wet and dry seasons. The analysis was carried out on 82 respondent farmers who planted shallots in both the rainy and dry seasons.
Table 3. Comparison of the average number of inputs and outputs of shallot farming in Solok Regency during the rainy and dry seasons.

| Parameter      | Unit   | Dry Season | Wet Season | P-value  |
|----------------|--------|------------|------------|----------|
| Land           | ha     | 0.67       | 0.75       | 0.194NS  |
| Mulch          | roll   | 10.48      | 12.19      | 0.153NS  |
| Labour         | labour day | 279.19   | 310.51     | 0.002*   |
| Dolomite       | kg     | 2,169.51   | 5,898.17   | 0.077NS  |
| Organic fertilizer | kg   | 10,594.82  | 10,096.04  | 0.104NS  |
| Seed           | kg     | 640.43     | 715.85     | 0.211NS  |
| Chemical fertilizer | kg | 182.48     | 180.27     | 0.417NS  |
| Solid pesticide | kg   | 11.19      | 13.29      | 0.007*   |
| Liquid pesticide | L   | 10.52      | 8.86       | 0.231NS  |
| Leaf fertilizer | L    | 3.79       | 2.28       | 0.012*   |
| Adhesive       | L      | 3.89       | 4.02       | 0.003*   |
| Harvested      | kg     | 8,034.76   | 7,825.00   | 0.393NS  |
| Productivity   | kg ha⁻¹| 11,992.18  | 10,433.33  |          |

The use of input in shallot farming which is carried out both in the wet season and dry season shows a significant difference in the use of labor, solid pesticides, leaf fertilizers, and the use of adhesives (Table 3). The use of labor in the wet season is 310.51 Man-days, 31.32 man-days higher than the use of labor in the dry season, which is 279.19 man-days. In addition to the land used in the wet season, the greater difference in labor use during the wet season is due to the frequency of spraying of pesticides, especially fungicides, which are more frequent in the wet season than in the dry season.

The same thing happened to solid pesticides where it was used more in the wet season than in the dry season. Solid pesticides that are widely used in the wet season are fungicides used by farmers to minimize disease attacks. Of the 13.29 kg, the average solid pesticide used in the dry season consists of 0.64 kg of solid insecticide and 12.65 kg of solid fungicide. The problem at the growth stage of shallot plants cultivated in the highlands in the rainy season is disease attack [9]. The average use of solid pesticides in the rainy season is more in the wet season. The use of leaf fertilizers is higher in dry season, and the use of adhesive is higher in wet season. In the dry season, the average use of leaf fertilizer is 3.79 L, higher than the use of leaf fertilizer in the dry season of 2.28 L. Meanwhile, in the wet season, an average of 4.02 L was used, where the amount is 0.13 L more than in the dry season where the average usage is 3.89 L. The use of solid pesticides, especially in the wet season, needs to be a concern because excessive pesticide use can have a negative impact on the soil ecosystem and can cause a decrease in the number of beneficial fungi and bacteria in the soil [11].

The input such as land, mulch, dolomite, organic fertilizers, seeds, chemical fertilizers, and liquid pesticides shows no significant difference, although the average use of several input production factors is different in both seasons, indicated by the P-value which is more than 0.05 in the t-test results. Even so, the average area of land use, mulch, lime, and seeds was higher in the wet season, such as 0.75 ha, 12.19 rolls, 5,898.17 kg and 715.85 kg, respectively, compared to use in the dry season. The dry season which uses only 0.67 ha, 10.48 roll, 2,169.51 kg and 640.43 kg. While the average use of organic fertilizers, chemical fertilizers, and liquid pesticides was higher in the dry season, such as 10,594.82 kg, 182.48 kg, and 10.52 L respectively, compared to 10,096.04 kg during the rainy season, 180.27 kg, and 8.86 L during the rainy season. In the use of mulch, differences in use occur because it depends on the size of the land used.

The yields obtained during the dry season and wet season showed the results that were not significantly different even though the average yield during the dry season was 8,034.76 kg, higher than the average yield during the wet season which was 7,825.00 kg. The smaller planting area and the higher
yields obtained during the dry season cause the average productivity of shallots obtained during the dry season to be higher than the productivity of shallot cultivation during the wet season. The productivity of shallots planted in the dry season is 11,992.18 kg ha\(^{-1}\), which is 1,558.85 kg ha\(^{-1}\) higher than the productivity in the wet season.

In general, the productivity of shallots cultivated in the wet season in the highlands will be lower than those cultivated in the dry season in the same location. Previous research mentions the same results at the location of shallot cultivation in the highlands of Tegal Regency [10]. However, the results of shallot cultivation in the highlands of Solok Regency in the rainy season based on the survey results are still in optimal results for shallot cultivation in Indonesia [12], and still higher than off-season shallot cultivation in other locations which reach 7.25 to 8.70 t ha\(^{-1}\) [4, 10].

### 3.3. Comparison of farming costs during the rainy and dry seasons in the highlands of Solok Regency

The difference in the amount of shallot farming input in the dry season and the rainy season which is carried out in the production center of Solok Regency will not only make a difference in the farming costs carried out. This is because there are differences in the price of the types of farm inputs used. The difference in the costs of shallot farming carried out in the dry and rainy seasons in the production centers of Solok Regency are shown in Table 4.

**Table 4.** Comparison of costs and the percentage of input and output of shallot farming in Solok Regency during the rainy and dry seasons.

| Parameter       | Dry season | Wet season | P-value |
|-----------------|------------|------------|---------|
|                 | Costs (Rp) | Percentage | Costs (Rp) | Percentage |         |
| Mulch           | 3,650,000.00 | 7.02       | 4,231,463.41 | 7.38       | 0.152\(^{NS}\) |
| Labour          | 2,075,548.81 | 48.23      | 28,015,548.78 | 48.87      | 0.002*    |
| Dolomite        | 714,707.32  | 1.37       | 1,732,951.22 | 3.02       | 0.068\(^{NS}\) |
| Organic fertilizer | 5,031,524.39 | 9.68       | 4,785,162.60 | 8.35       | 0.099\(^{NS}\) |
| Seed            | 10,420,182.93 | 20.04     | 11,073,719.51 | 19.32      | 0.325\(^{NS}\) |
| Chemical fertilizer | 1,327,405.27 | 2.55       | 1,370,994.20 | 2.39       | 0.301\(^{NS}\) |
| Solid pesticide | 1,920,085.27 | 3.69       | 2,061,403.22 | 3.60       | 0.277\(^{NS}\) |
| Liquid pesticide | 3,112,059.11 | 5.99       | 3,449,566.21 | 6.02       | 0.313\(^{NS}\) |
| Leaf fertilizer | 385,974.09  | 0.74       | 241,858.23  | 0.42       | 0.005*    |
| Adhesive        | 356,207.32  | 0.69       | 367,350.61  | 0.64       | 0.004*    |
| Total           | 51,993,694.50 | 100.00   | 57,330,017.99 | 100.00     |         |

Notes: *Significantly different (\(\alpha\leq0.05\)), \(^{NS}\)Non-significant  
Source: primary data (2017).

The cost of farming in the wet season is higher than the cost of farming in the dry season. The total cost of farming in the dry season is IDR 51,961,304.25 and the total cost during the wet season is IDR 56,716,164.33. The difference between the total farm costs is IDR 4,754,860.08 season\(^{-1}\). The significant differences in farming costs occurred in the cost of labor, leaf fertilizer, and adhesive, based on the results of the t-test, which resulted in a P-value less than 0.05. Land use is not included in the cost calculation because all land used for shallot farming during the rainy and dry seasons is private land.

Based on the results of calculations, both shallot farmings which is carried out in the dry season and rainy season in the highland production centers of Solok Regency, labor is the largest component of farming costs that must be incurred. Expenditures for labor costs during the dry and rainy seasons also show significantly different results with a P-value of 0.002 below 0.05. With these results, a slight difference in the amount of labor input will cause a difference in the amount of costs incurred for labor input.

In the dry season and wet season, the average cost for labor is 48.26% and 49.40%, respectively, of the total farming costs. Based on the results of previous studies, labor is the largest component of
farming costs in shallot farming [10,13]. Based on the survey results, the maximum unit cost for 1 male labor is IDR 150,000 day\(^{-1}\) and a minimum of IDR 60,000 day\(^{-1}\). Meanwhile, the maximum unit cost for 1 female labor is IDR 100,000 day\(^{-1}\) and a minimum of IDR 50,000 day\(^{-1}\).

The second-largest component of farming costs during the wet and dry seasons in the highlands of Solok Regency is the cost of procuring seeds. In the wet season, the cost of procuring seeds reaches 19.52% of the total shallot farming cost, while in the dry season the cost of procuring seeds is 20.05% of the total shallot farming cost. Based on the results of the t-test, the cost of procuring seeds in the dry season and rainy season on shallot cultivation in the highlands of Solok Regency does not show a significant difference with a P-value greater than 0.05. The total cost of procuring seeds during the dry season is IDR 10,420,182.93 for seeds of 640.43 kg, and the total cost of procuring seeds in the rainy season is IDR 11,073,719.51 for seeds of 715.85 kg indicates that the unit price of shallot seeds in the highlands of Solok Regency is low. During the dry season, the farmers buy shallot seeds at a price of IDR 16,270.68 kg\(^{-1}\), while in the rainy season the price of seeds is IDR 15,469.25. The low cost of procuring these seeds is because shallot farmers in Solok Regency are more independent in providing seeds by setting aside previous crops to be planted in the next season. The independence of providing these seeds is the same as what shallot farmers in Brebes did [14].

An interesting thing happened to the farming costs incurred for the procurement of solid pesticides. The amount of solid pesticide input for the dry season is significantly different from the amount of pesticide input during the wet season. However, based on the results of the t-test on the costs for the procurement of solid pesticide, which gives a P-value of 0.277 which is above 0.05, it provides information that the costs incurred for the procurement of solid pesticide are not significantly different between the rainy and dry season. This condition is because farmers have anticipated the arrival of the rainy season, which requires more pesticides in the form of fungicides than the dry season by buying other fungicides at a lower price. In terms of costs incurred, it does not show a real difference even though in terms of the number of inputs, it shows a real difference. The use of chemical pesticides needs to be a concern because so far, shallots are a very intensive commodity using pesticides [15]. Excessive use of pesticides must be avoided to minimize the risk of pest and disease resistance.

The cost of shallot farming for the procurement of adhesives and leaf fertilizer also shows significant differences between the rainy and dry seasons. However, the proportion of costs incurred for these two types of inputs is very small, only between 0.42 and 0.74% from total expenditure both in the wet and dry season.

4. Conclusions
Based on the results of the study, it can be concluded that in general the input-output and farming costs during the rainy and dry seasons do not show any differences except in the amount of input and costs on labor, leaf fertilizers, and adhesives. The use of solid pesticides shows a difference in the number of inputs but does not show a difference in the costs incurred. On the other hand, the costs in the rainy season are higher than during the dry season, resulting in higher production costs per unit of output. The production results that do not differ significantly show that Solok Regency has the potential to produce shallots during the off-season. However, it needs to be concerned that production management which is not interrupted within one year can create a risk of pest and disease outbreaks. Therefore, integrated pest and disease management need to be done to minimize the risk of outbreaks and minimize pest and disease resistance.

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