Response of shallots varieties to mulch treatment and the different planting season in the lowlands

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Abstract. The low production of shallots due to low productivity caused mainly by the not suitability of varieties, land and climate. The research aims to study 1) the response of varieties to mulch treatment, 2) the response of varieties to different planting seasons without mulch treatment to productivity shallots in the lowland. The study was conducted in the lowlands, Tapin district, South Kalimantan at the rainy and dry season 2017. Three shallots varieties of Batu Ijo, Bauji and Bima Brebes were planted in the 2017 rainy season which were treated with plastic mulch and without mulch. In the 2017 dry season, the three varieties were planted again without mulch treatment. The results showed that the average use mulch treatment in the rainy season increased the productivity of shallots (8.02 t ha⁻¹) higher than without mulch (6.77 t ha⁻¹). The average yield of Bauji variety (8.28 t ha⁻¹) and Batu Ijo variety (8.28 t ha⁻¹) was higher than Bima Brebes variety (4.52 t ha⁻¹). The average productivity of shallots planted in the dry season was 12.37 t ha⁻¹ higher than the rainy season 6.77 t ha⁻¹. Bauji variety was more adaptive to be planted without mulch in the rainy or dry season than Batu Ijo and Bima Brebes varieties in the lowlands.

1. Introduction
Shallots are a strategic commodity that is always consumed by the public. However, domestic production of this commodity is still insufficient, so some are still imported from other countries. The harvested area for shallots in Indonesia is around 159,195 ha with productivity reaching 9.93 t ha⁻¹ [1], while in South Kalimantan the area of shallot harvest has only reached 186 ha with productivity lower than the national average of 6.15 t ha⁻¹ [2].

South Kalimantan has a large area for agricultural business. Agroecosystems for agricultural business in South Kalimantan are very diverse, including dry land, lowlands consisting of irrigated lowlands, rainfed land and swamps. Of the total area of South Kalimantan, 3.75 million ha of which have the potential for agricultural development covering an area of 2,590,733 ha (69.05%), with a wetland area of 759,776 ha (20.52%) [3].

South Kalimantan has 551,702 ha of lowlands consisting of several rainfed agroecosystems, swamps and irrigated lands covering an area of 55,116 ha with 16,348 ha (29.7%) [4] of land planted with rice twice a year. The area of lowlands in Tapin district is 79,190 ha [5], consisting of rainfed lowlands and part of irrigated lowlands. In irrigated lowlands, besides being planted with rice, shallots are also planted in the dry season with the cropping pattern of Rice-Rice-Shallots, Rice-Shallots, Other Horticulure-Shallots. Irrigated lowlands are planted with rice twice a year, so shallots have the opportunity to be
planted after planting rice in the dry season. Shallots have the potential to be planted 2 to 3 times a year in irrigated lowlands because water allows it to be regulated for shallot crops.

South Kalimantan has a rainfall of around 1,662-3,249 mm year\(^{-1}\) and humidity of 78.90-84.20\% [2]. The rainy season with high rainfall and humidity causes a high incidence of diseases caused by fungi so that the average productivity of shallots in South Kalimantan is still low. Rainfall conditions that are excess or lack in extremes will affect plant growth. According to Widyantara and Yasa [6], climate greatly influences the risk of shallot farming. In the rainy season, the risk of shallot farming is lower than the dry season. According to the research results of [7], high rainfall results in decreased productivity of shallots. Shallot plants do not like very wet soil, so the mulch treatment in the rainy season can serve as a protection from direct exposure to high rainfall, preventing splashing of soil particles on the plant. Very wet and moist soil environments facilitate the development of disease.

Climatic and soil conditions such as rainfall, humidity, soil moisture content and temperature can affect plant growth. The use of plastic mulch can affect the microclimate and soil characteristics such as increasing soil moisture content [8], maintaining temperature [9] and reducing evaporation from the soil surface [9, 10]. The use of mulch can also reduce water consumption in producing shallot tubers [11]. This research aims to study the response of varieties to mulch treatment and the response of varieties to different planting seasons without mulch treatment to shallot productivity in the lowland.

2. Methods
The research was conducted in the lowlands of Harapan Masa village, South Tapin sub-district, Tapin district. In the 2017 rainy season cropping, the research was arranged in 2 factors split with mulch treatment as the main plot (with plastic mulch and without mulch) and shallot varieties (Batu Ijo, Bauji and Bima Brebes) as subplots. Each treatment was repeated four times, with the area of each treatment two beds multiplied by 5 m. In the dry season 2017, research was arranged in Random Complete Block Design (RCBD). The three varieties were planted again without mulch treatment, with an area of 250 m\(^2\) for each variety and repeated six times. Shallots are planted in beds 1-1.5 m wide with 20-30 cm high beds and 20-30 cm wide drains and 20-30 cm deep channels. Manure is given 5.0 t/ha (composted first) and dolomite lime 2 t ha\(^{-1}\) to improve soil fertility. The varieties used in the study were Batu Ijo, Bauji and Bima Brebes varieties, with shallots planted at a spacing of 20 x 15 cm. The fertilizers given were Urea 200 kg ha\(^{-1}\), ZA 250 kg ha\(^{-1}\), SP-36 200 kg ha\(^{-1}\) and KCl 250 kg ha\(^{-1}\).

Observations were made on plant height, number of leaves, number of tubers/clumps, tuber diameter and tuber yield of shallots. Observation parameter data were analyzed statistically using variance analysis and comparison of the average treatment using LSD at the 95\% confidence level. To determine the characteristics of the soil in the research location, analysis of soil samples was carried out in the laboratory.

3. Results and Discussion
3.1. Soil characteristics
The results of the soil analysis of the activity location shows soil conditions is acid (pH 4.52), moderate C-organic content, low total N, medium P availability, low total P and K (reserves), low Ca and Mg exchange bases, moderate K and Na, Cation Exchange Capacity is low, the texture of the soil is classified as silty loam clay (table 1). The soil in the research location is classified as acidic, and the levels of Ca and Mg are also classified as low so that for optimal growth of shallots, it is necessary to add lime. The total nutrient content of P and K are also classified as low, so it is necessary to add sufficiently high P and K fertilizers for shallots.
Table 1. The physical and chemical characteristics of the soil in the research location in Harapan Masa Village, Tapin, South Kalimantan.

| Soil characteristics | Value | Criteria |
|----------------------|-------|---------|
| pH (H$_2$O)          | 4.52  | A       |
| pH (KCl)             | 3.84  | -       |
| C. Organic (%)       | 2.57  | M       |
| N total (%)          | 0.18  | L       |
| P Bray I (ppm P$_2$O$_5$) | 18.49 | M       |
| P total (mg 100g$^{-1}$ P$_2$O$_5$) | 8.5 | L |
| K total (mg 100g$^{-1}$ K$_2$O) | 5.28 | L |
| Exchange Bases (me 100g$^{-1}$): | | |
| Ca                   | 6.4   | L       |
| Mg                   | 1.63  | L       |
| K                    | 0.49  | M       |
| Na                   | 0.32  | M       |
| CEC (me 100g$^{-1}$) | 11.46 | L |
| Al-cc (me 100g$^{-1}$) | 1.06 | - |
| Fe dissolved (ppm)   | 144.91| - |
| Texture (%)          |       |         |
| Clay                 | 51.62 |         |
| Silt                 | 31.01 | Clay    |
| Sand                 | 17.37 |         |

Expl. A = Acid, L = Low, M = Moderate.

3.2. Climate characteristics

The amount of monthly rainfall at the activity location shows that the highest rainfall is in December (427 mm) and the lowest is in August (59 mm). Wet months (≥ 200 mm) are four months (November, December, January and March), while dry months (≤ 100 mm) are four months (June-September) (figure 1). In November-January, the rainfall is quite high and causes the plants to get excess water, so it is necessary to make drainage channels when planting shallots. In the months where the rainfall is high, and the humidity is also high, it will spur the growth of fungi so that the shallot plants are susceptible to disease. In July-September, the rainfall is very low so that the plants are prone to drought, so irrigation is needed to water the plants.

![Figure 1](image-url)
The average humidity in the study area ranged from 74.88-82.0% with the highest humidity in March and the lowest in September. The average temperature ranges from 27.35-33.2 °C, with the highest temperature occurring in February and the lowest in March (figure 2).

Figure 2. Average monthly temperature and humidity at the research location, Tapin, 2017 (Source: BPS Tapin [5]).

3.3. Result on shallots
The treatment of plastic mulch and varieties in the rainy season (RS) affected plant height and number of shallots leaves. In the mulch treatment, plant height was 34.92 cm higher than without mulch which was 32.51 cm, while the number of leaves was 31.68 more than without mulch which was 27.72. Differences did not influence plant height in varieties, but the number of leaves of Bauji variety was higher than that of Batu Ijo and Bima Brebes varieties (table 2).

Table 2. Effect of mulch and variety treatment on the height and number of shallots leaves, Tapin RS. 2017.

| Varieties     | Plant height (cm) | Number of shallot leaves |
|--------------|-------------------|--------------------------|
|              | Mulch | Without mulch | Average | Mulch | Without mulch | Average |
| Batu Ijo     | 35.51 | 36.63         | 36.07<sup>a</sup> | 26.31 | 22.25         | 24.28<sup>c</sup> |
| Bauji        | 35.93 | 28.94         | 32.44<sup>a</sup> | 43.08 | 35.29         | 39.19<sup>a</sup> |
| Bima Brebes  | 33.31 | 31.97         | 32.64<sup>a</sup> | 33.15 | 25.63         | 29.37<sup>b</sup> |
| Average      | 34.92<sup>a</sup> | 32.51<sup>a</sup> | 31.68<sup>b</sup> | 31.18 | 27.72<sup>b</sup> | 29.37<sup>b</sup> |

Values within columns and rows having the same lowercase letters are not significantly different (P<0.05) using LSD test.

Treatment with mulch increased the number of tubers (7.81) compared to without mulch (6.40), but it did not differ from tuber diameter. Bauji variety produced more tubers (8.35) than the other two varieties. The Batu Ijo variety has a larger tuber diameter than the Bauji and Bima Brebes varieties (table 3). In addition, the use of mulch increased the productivity of shallot tubers by 8.02 t ha<sup>-1</sup>, higher than the yield of shallots without mulch treatment of 6.77 t ha<sup>-1</sup> (table 4). The Batu Ijo and Bauji varieties gave higher yields of shallots than the Bima Brebes variety. The Batu Ijo variety gave a yield of 8.38 t ha<sup>-1</sup>, Bauji gave 9.28 t ha<sup>-1</sup>, and the Bima Brebes variety gave 4.52 t ha<sup>-1</sup> (table 4).
Table 3. Effect of mulch and variety treatment on the number of tubers and tuber diameter of shallots, Tapin RS. 2017.

| Varieties     | Number of tubers | Tuber diameter (cm) |
|---------------|------------------|---------------------|
|               | Mulch            | Without mulch       | Average | Mulch          | Without mulch | Average |
| Batu Ijo      | 7.35             | 5.50               | 6.43^b  | 2.48           | 2.28           | 2.38^a  |
| Bauji         | 8.68             | 8.02               | 8.35^a  | 2.03           | 1.96           | 1.99^b  |
| Bima Brebes   | 7.40             | 5.69               | 6.54^b  | 2.15           | 1.87           | 2.01^b  |

Values within columns and rows having the same lowercase letters are not significantly different (P<0.05) using LSD test.

Table 4. Effect of mulch and variety treatment on shallot tuber yield, Tapin RS. 2017.

| Varieties     | Shallot tuber (t ha^-1) |
|---------------|-------------------------|
|               | Mulch | Without mulch | Average |
| Batu Ijo      | 9.67  | 7.10           | 8.38^a  |
| Bauji         | 9.44  | 9.12           | 9.28^a  |
| Bima Brebes   | 4.96  | 4.08           | 4.52^b  |
| Average       | 8.02^a | 6.77^b         |

Values within columns and rows having the same lowercase letters are not significantly different (P<0.05) using LSD test.

The higher treatment yield of shallot tubers with mulch treatment is because the use of plastic mulch can reduce evaporation, maintain moisture, and water content is higher [12]. The research results of Sofiati and Kusuma's [13] showed that mulch treatment could reduce soil content weight, improve soil porosity, increase water retention, and better crop yields than straw mulch.

The results of research in the dry season by [11] indicates that the combination of irrigation water and mulch use affects the yield and quality of shallot tubers. Uncontrolled weed growth can also reduce the production of shallot [14]. Plastic mulch treatment can suppress weed growth and increase the yield of shallot tubers [9,15] although the results of other studies show that the use of plastic mulch, rice straw and water hyacinth does not affect the growth and weight of Dayak tubers planted in March-July [16].

The research results of [17] showed that the use of mulch and soil repairer improved soil physical properties (water retention, soil porosity and aggregation) and soil chemical properties. The use of plastic mulch increased the yield of shallots 57.8% compared to without mulch. The use of organic mulch such as rice straw also improves moisture capacity, releases various nutrients, increases biological activity, and subsequently, better plant growth [18,19].

Bauji variety shallot produced a higher number of tubers (11.12 t ha^-1), while the tuber diameter did not show any difference between the three varieties. The yield of shallot in the dry season (DS) did not show any difference between varieties; the yield of shallot tubers ranged from 11.25-12.97 t ha^-1 (table 5).

Table 5. Yields on shallot tubers, Harapan Masa Village, Tapin, DS. 2017.

| Varieties     | Yield (t ha^-1) | Number of tubers/clump | Tuber diameter (cm) |
|---------------|-----------------|------------------------|---------------------|
| Batu Ijo      | 12.97 a         | 8.1 b                  | 2.33 a              |
| Bauji         | 12.90 a         | 11.2 a                 | 2.15 a              |
| Bima Brebes   | 11.25 a         | 10.5 ab                | 2.03 a              |

Values within columns having the same lowercase letters are not significantly different (P<0.05) using LSD test.

The yield of shallots in irrigated lowlands planted in DS. II (Planted early June 2017) shows that the shallots of Batu Ijo and Bauji varieties produce higher shallots than Bima Brebes varieties, although the differences between the three varieties are not significant. It shows the planting of shallots in MK. II, these three varieties can be used and give quite high yields.
When compared to the yield of shallots without mulch in the rainy season and dry season, the dry season yield is much higher, ranging from 11.25-12.97 t ha\(^{-1}\) (average 12.37 t ha\(^{-1}\)) compared to the rainy season which only produces 4.08-9.12 t ha\(^{-1}\) (average 6.77 t ha\(^{-1}\)). Bauji variety is more adaptive in the rainy season (without mulch) with higher yields (9.12 t ha\(^{-1}\)) higher than Batu Ijo variety (7.10 t ha\(^{-1}\)) and Bima Brebes 4.08 t ha\(^{-1}\) (figure 3).

Figure 3. Comparison of treatment yields on shallots in the rainy season and dry season (without mulch), 2017 in lowlands, Tapin, South Kalimantan.

The use of plastic mulch during the season aims to reduce rainwater splashing and reduce wetting of the soil. The yields on the Batu Ijo (9.67 t ha\(^{-1}\)) and Bauji (9.44 t ha\(^{-1}\)) varieties still yielded better, even though using mulch of the Bima Brebes variety (4.96 t ha\(^{-1}\)) was still not able to be planted in the rainy season to get high yields, and still below the average productivity of shallots in Tapin.

The main obstacle to growing shallots in the rainy season is a disease caused by fungi. Bima Brebes turned out to be more vulnerable than the Bauji and Batu Ijo varieties, so that plant growth was stunted and some plants died so that the tubers produced were also lower. Stunted growth and death of shallot plants caused by fungal disease in the rainy season are quite high [20]. The results of [21] showed that Bima variety was a shallot variety that was very sensitive to environmental changes. The yield of Bima's shallot variety in the rainy season is lower than in the dry season. The use of mulch is thought to reduce the soils too wet and moist, thereby reducing the development of disease caused by fungi.

The average yield of shallot productivity in Tapin in 2017 was around 5.80 t ha\(^{-1}\) with a harvest area of 392 ha [5]. The yield of shallots in Tapin is still lower than the potential yield of the existing shallot varieties around 15-20 t ha\(^{-1}\). It means that there is still an opportunity to increase shallot production with the application of technological innovations, especially controlling pests and diseases and the use of adaptive shallot varieties in high rainfall and soil moisture. Observations in the field show that the main constraint on shallot cultivation is that even though it is planted in the dry season, heavy rain still occurs and this causes the shallot plant to suffer from wilt disease (moler) caused by the *Fusarium* fungus, trotol (caused by *Alternaria porei* spores), anthracnose and caterpillar pests (*Spodoptera exigua*).

*Fusarium* wilt or base rot (in Indonesia known as “moler”) caused by *Fusarium oxysporum* is one of the limiting factors for the production of shallots and onions [22]. Symptoms that appear are dry leaves and twisting (twisting) starting from above because the tubers rot. Apart from planting, this disease can also occur in the tubers of the crop in [23] storage. According to Sastrosiswojo and Rubiati [24], pests on shallot plants that can reduce yields are caterpillars (*S. Exigua*), trips (*Thrips tabaci*) and armyworms (*Spodoptera litura*). Onion yields vary between farmers due to differences in land and crop management. The differences in the manufacture of beds, the technical composting of manure, watering techniques, controlling weeds and pests cause various levels of pest attacks and the yield of shallots to be obtained.
4. Conclusion

In the rainy season mulch treatment on shallots produced shallot tubers 8.02 t ha$^{-1}$ higher than without mulch (6.77 t ha$^{-1}$). The yield of shallot tubers planted without mulch in the dry season is 11.25-12.97 t ha$^{-1}$ higher than in the rainy season 4.08-7.10 t ha$^{-1}$. In the rainy season, the average shallot yield of the Batu Ijo and Bauji varieties gave higher yields than the Bima Brebes variety, while in the dry season there was no difference between the three varieties.

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