Effect of mulch application and watering frequency on growth and production of chilli (*Capsicum annuum* L)

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Abstract. Red chilli is one of vegetable that has a high economic value in Indonesia. One of the factors that influence the growth of chilli is the availability of water which is a limiting factor for chilli plants. The purpose of this study was to determine the effect of mulch use and frequency of watering on the growth and yield of chilli plants. The research was conducted in Lampoko Village, Barebbo District, Bone Regency, in Mei-July 2017, used factorial randomized block design with two factors. The first factor was the application mulch (without mulch, organic mulch, and plastic mulch) and the second factor was the frequency of watering (once a day, two times a day, and once in two days). The data obtained were then analyzed for variance and continued with Duncan's Multiple Range Test (DMRT). The results showed that the treatment of mulch utilization significantly affected plant height 30 and 60 DAP, number of fruit, weight fruit, and fresh plant weight. The treatment of the frequency of watering significant effect on plant height 30 and 60 DAP, number of fruit, weight fruit, and fresh plant weight. In general, the best growth and production of chilli were obtained in the treatment of the application of plastic mulch with a frequency of watering once a day namely 13,03 t ha⁻¹.

1. Introduction

Red chilli (*Capsicum annuum* L.) is a type of commercial vegetable that has been cultivated in Indonesia for a long time because this product has high economic value. In addition to meeting daily household needs, chilli is widely used as raw material for industry, food and pharmaceuticals. According to Utami [1], chillies also have many health benefits because of the nutritional content in them. Chilli fruit contains capsaicin, vitamin C, beta-carotene, calcium and phosphorus. The content in chillies can cure several diseases such as relieving colds and nasal congestion.

Loizzo et al. [2] reported that chillies have antioxidant activity, high phenol and capsaicinoid content. There are two types of chilli plants that are generally cultivated in Indonesia, namely, large red chillies (*Capsicum annuum* L.) and cayenne pepper (*Capsicum frutescens* L.). According to FAOSTAT [3], Indonesia is ranked fourth as the country with the highest chilli production in the world after China, Mexico and Turkey, while the productivity rate is still lower than China, which reached 21.89 tonnes ha⁻¹.

The production of chilli in South Sulawesi Province in 2018 was 26,944 tons, and in 2019 it decreased to 21,055 tons or around 21.86% [4]. The low production of chilli plants is caused, among others, by the application of cultivation techniques that have not been implemented. One of the factors that influence the growth of chilli plants is the availability of water.

Water is one of the most critical physical components and is needed in large quantities for plant growth and development [5]. About 85-90% of the fresh weight of cells and tall plant tissue is Water
functions as a nutrient solvent, constituent of protoplasm, photosynthetic raw material and so on. Three factors, namely influence watering: replacing water that has evaporated, providing additional water needed by plants, and restoring plant strength to grow straight up without branches [6].

The availability of water determines the success of plant production, both vegetatively and generatively because water is a basic need for plants. Water demand increases with increasing groundwater content, but the highest water use efficiency is at groundwater content between 55–70% of field capacity [7]. Excess or lack of water will result in decreased production and quality of plants [8]. According to Gonzalez et al. [9], chilli plants are sensitive to water shortages because their root system is shallow. Providing too much or too little water will result in less than optimum plant height growth, while water content that is close to normal limits will produce optimal plant growth. Given the importance of the role of water, plants that experience water shortages can result in disruption of the metabolic process of plants, which ultimately affects the rate of plant growth and development [10].

In areas with high rainfall and few rainy days, it was resulting in increased rainfall fluctuations. This affects the availability of water in the soil, which automatically affects soil temperature and humidity. The use of mulch to cover the soil is one way to change the soil climate or microclimate near the soil surface [11].

The use of mulch to cover the soil will affect plant growth and production. The use of mulch in the cultivation of red chillies as a cover for the surface of beds/mounds is essential because it provides benefits, including reducing the rate of evaporation from the land surface, thereby saving water use, reducing soil temperature fluctuations, and reducing energy and costs for weeds control [12]. The research objective was to determine the effect of using mulch and watering frequency on the growth and yield of chillies and to determine the interaction between the use of mulch types and the appropriate watering frequency to increase the yield of chilli plants.

2. Materials and methods

2.1. Experimental site
The research was conducted in Lampoko Village, Barebbo District, Bone Regency, South Sulawesi, with an altitude of 10 m above sea level, an alluvial soil type with a pH of 5.5 - 7.0. It was carried out from Mei to July 2017.

2.2. Materials
The materials used in this study were chilli seeds chiko variety, manure and liquid organic fertilizer (LOF), and an organic fertilizer. The tools used in this study were straw mulch, silver plastic mulch, mulch hole, watering device, stake, sprayer, ruler, scale, oven and stationery.

2.3. Implementation in the field
The research was conducted in several stages, namely the research preparation stage, treatment, data collection and processing. The preparation stage is in the form of land cultivation on the land to be used for research. Land processing is carried out two weeks before the chilli plants are ready for planting. Processing is done using a hoe two times. First, the soil is processed coarsely, and then the soil is processed again until it is loose so that when planting the soil does not clump. Soak the seeds to be used first in warm water for two days to accelerate germination. Seedlings are maintained until the seeds are four weeks old after sowing. Installation of plastic mulch is adjusted to the experimental plot.

Rice straw mulch that has been cut into pieces with a length of 10 cm is spread over the surface of the bed, while black silver plastic mulch is installed on the surface of the bed with the left and right sides tied with bamboo and installed one day before planting. Chilli plants that are four weeks old and have 5-6 leaves are transferred to cultivated land. The chilli plants are planted in holes 60 cm x 60 cm apart. Plant maintenance includes activities such as embroidery, watering, weeding, fertilizing and controlling pests and diseases. Fertilization is carried out using Urea 250 kg ha⁻¹ + NPK fertilizer 300 kg ha⁻¹, which is given at planting time and liquid organic fertilizer (LOF) which is given every 7 days until just before
harvest. Pest and disease control is carried out by spraying pesticides on chilli plants every week. Harvesting is done when the chillies reach physiological maturity.

2.4. Experimental design, data collection, and analysis
This study used a 3x3 factorial randomized block design (RBD) with three replications. The first factor is the application of mulch (M) with three levels: M0 = no mulch, M1 = straw mulch (thickness ±3 cm or about one ton), M2 = silver plastic mulch. The second factor is the frequency of watering, which consists of three levels P1 = watering once a day, P2 = watering every other day, and P3 = watering twice a day (50 liters per plot). From the combination of the two research factors, nine treatments were obtained, each of which was repeated three times to get 27 experimental units.

Observation and data collection was carried out in the vegetative phase and the generative phase. Data collected included plant height (cm), number of leaves (strands), flowering age (days), Number of fruits per plant (fruit), and fruit weight per plant (t ha⁻¹). Analysis of observational data using ANOVA, followed by Duncan's Significant Difference Test (DMRT 5%) [13].

3. Results and discussion
Analysis of variance on the effect of treatment on plant growth and production parameters is shown in table 1.

| Variable                      | Mulch (M) | Watering frequency (W) | Interaction (MxW) |
|-------------------------------|-----------|------------------------|-------------------|
| Plant height 30 DAP (cm)      | *         | *                      | ns                |
| The number of leaves 30 DAP   | ns        | ns                     | ns                |
| Plant height 60 DAP (cm)      | **        | **                     | **                |
| The number of leaves 60 DAP   | ns        | ns                     | ns                |
| Plant height 90 DAP (cm)      | ns        | ns                     | ns                |
| The number of leaves 90 DAP   | ns        | ns                     | ns                |
| Age of flower family (days)   | **        | **                     | ns                |
| Number of fruit               | **        | **                     | **                |
| Fruit weight (gr)             | *         | *                      | *                 |
| Fresh fruit yield (t ha⁻¹)    | *         | *                      | *                 |

** and * each significantly different at an error rate of 1% and 5%, ns = not significant. DAP=Days after planting.

3.1. Chili plant growth factors

3.1.1. Plant height. One thing that is often observed to be used as a growth indicator or parameter to measure the influence of the environment or the treatment applied is plant height. This is based on the fact that the plant's height is the most comfortable measure to see. The results of the analysis of variance showed that mulch treatment had a significant effect on plant height 30 days after sowing (DAS) and 60 DAS, as well as the frequency of water treatment, had a significant impact on plant height at 30 and 60 DAS. Analysis of variance showed that there was an interaction between the use of mulch and the frequency of giving water, namely the variable height of the plants at 60 DAS (table 2).

The significant interaction effect of mulch and the frequency of water application indicated that the mulch treatment was different for each treatment, the frequency of giving water to plant height. The highest height of chilli plants at the age of 30 DAS was obtained in the treatment using plastic mulch with a frequency of giving water once a day and significantly different from the treatment without mulch and the use of straw mulch with the frequency of providing water twice a day and giving twice a day.
Furthermore, after the chilli plants were 90 DAS, the mulch treatment did not significantly affect the plant height, as well as the frequency of water distribution, where the frequency of giving water once a day was not a significant difference in plant height compared to the frequency of providing water two times a day and one time two days. This shows that the treatment has reached the right soil conditions for plant height growth. The available water in these conditions is sufficient for the water needs of the chillies so that their growth is optimal. According to Gonzalez et al. [9], chilli plants are sensitive to water deficiency because of their shallow root system.

The appropriate amount of water accelerates the growth to the formation of fruit size. When the amount of water supplied increases, the excess water becomes useless or inefficient. This is because the provision of water in the right amount according to their needs will result in optimal plant growth and increase the efficiency of providing water to plants [14] as shown in table 2.

The highest plant heights at 30 and 60 DAS were obtained in the treatment of using plastic mulch with the frequency of giving water once a day, respectively 41.15 cm and 61.41 cm. While the highest plant height at 90 DAS was obtained in the treatment of using organic mulch with a frequency of giving water one time two days. The results of research conducted by Anisuzzaman et al. [15] showed that the use of black plastic mulch on shallot plants showed higher plant height and crop yield than white plastic mulch, water hyacinth and without mulch.

The application of black silver plastic mulch can increase water availability, maintain soil temperature and suppress weed growth so that the roots of red chilli plants can optimally absorb water and nutrients to support high growth of plants. This is in line with Kusumaswi et al. [16] which states that the use of black plastic mulch and silver plastic mulch will be able to modify the balance of nutrients and water needed by plants so that growth from roots will be good. The results of Barus' research [17] stated that the use of silver, black plastic mulch had a significant effect on plant height, stem diameter, number of branches, crop production and production of chilli plants. The application of black silver mulch can increase the growth of chilli plants, and this is because black silver plastic mulch can improve the content of organic matter and the ability of water resistance.

3.1.2. Number of leaves. The results of the analysis of variance showed that the mulch treatment and the frequency of giving water to chillies did not show a significant effect on the number of leaves at the age of 30, 60 or 90 DAS plants.

Table 2. Effect of mulch use and watering frequency on plant height and number of leaves per hill age 30 DAP, 60 DAP, and 90 DAP on chilli.

| Mulch and watering frequency | Watering frequency once a day | Watering frequency two times a day | Watering frequency once two days | Average |
|-----------------------------|-------------------------------|-----------------------------------|-------------------------------|---------|
|                            | Plant height 30 DAP (cm)      |                                   |                               |         |
| Without mulch              | 34.14                         | 36.45                             | 32.36                         | 34.32 a |
| Organic mulch              | 38.80                         | 35.40                             | 34.40                         | 36.20 a |
| Plastic mulch              | 41.15                         | 38.14                             | 34.75                         | 38.01 a |
| Average                    | 38.03 a                       | 36.67 b                           | 33.84 c                       |         |
|                            | Number of leaves 30 DAP (hill)|                                   |                               |         |
| Without mulch              | 22.75                         | 23.10                             | 22.32                         | 22.72 a |
| Organic mulch              | 23.17                         | 23.35                             | 23.03                         | 23.18 a |
| Plastic mulch              | 23.50                         | 23.21                             | 23.25                         | 23.32 a |
| Average                    | 43.14 a                       | 43.22 a                           | 42.87 a                       |         |
|                            | Plant height 60 DAP (cm)      |                                   |                               |         |
| Without mulch              | 57.25 c                       | 56.78 bc                          | 56.45 bc                      | 56.83   |
| Organic mulch              | 59.25 ab                      | 58.24 b                           | 58.36 b                       | 58.62   |
| Plastic mulch              | 61.41 a                       | 58.60 b                           | 60.24 ab                      | 60.08   |
This is following the results of research by Novayana, et al. [18], that mulch does not affect the number of chili. Limbongan and Monde [19] stated that the number of leaves is closely related to the number of tubers produced because a large number of leaves will produce a lot of photosynthates. According to Noorhadi and Sudadi [20], plants that lack water can cause death, on the other hand, if plants with excess water can cause damage to plant roots, this is caused by lack of oxygen in the inundated soil.

Table 2 shows the highest number of leaves at 30, 60, and 90 DAS in the mulch application treatment obtained in the use of plastic mulch, namely 43.32 and at the frequency of giving the highest number of leaves obtained in the treatment of providing water two times a day, namely 43.22. It is assumed that mulch can increase water availability, maintain soil moisture and suppress weed growth [21].

Furthermore, at the age of 90 DAP, the plant had the highest number of leaves in the application of straw mulch, namely 73.03 and the frequency of giving water once a day, namely 72.93. The number of leaves in straw mulch with the highest frequency of watering once a day because straw mulch can provide a microclimate that supports the activity of microorganisms in the soil and can increase nutrients so that it affects the number of leaves of chili plants. Damaiyanti et al. [22] stated that straw mulch could reduce weed growth and can maintain moisture stability in the soil so that microorganisms are active in decomposing organic matter needed by plants in the growth of plant.

3.2. Plant production factors

3.2.1. Flowering age. The results of the analysis of variance showed that the treatment of mulch application had a significant effect on the age at which flowering began, as well as the treatment of the frequency of giving water significantly affected the flowering period of chili plants. However, there was no interaction between the application of mulch and the frequency of providing water at the flowering age of chili plants (table 3). Water has main functions, among others, as a raw material in the photosynthesis process, a constituent of proplasm which simultaneously maintains cell turgor, as a medium in the process of transpiration.

The fastest flowering age of chillies was obtained in the treatment of application plastic mulch, namely, 41.38 days, while in the treatment of giving water the most immediate flowering period was obtained in the treatment of providing water once a day, namely 41.08.

Gonzalez et al. [9] stated that water is vital for chilli production because it is one of the most vulnerable horticultural crops to water shortages. In the phase of flowering and fruit development is the
phase most sensitive to lack of water. At the time of fruit ripening until harvest, the chilli plants must be sufficiently watered to produce maximum production. Furthermore, Nugraha et al. [23] stated that the water factor is essential because it will affect the growth process. The need for water will increase along with the increasing age of the plant. The highest water requirements occur during the flowering period.

**Table 3.** Effect of mulch use and watering frequency on the age of flower, number of fruit, fruit weight and fresh fruit weight on chilli.

| Mulch and watering frequency | Watering frequency once a day | Watering frequency two times a day | Watering frequency once two days | Average |
|-----------------------------|-------------------------------|-----------------------------------|---------------------------------|---------|
| Age of flower               |                               |                                   |                                 |         |
| Without mulch               | 42.56                         | 43.25                             | 44.01                           | 43.27 a |
| Organic mulch               | 41.24                         | 42.12                             | 43.24                           | 42.20 a |
| Plastic mulch               | 39.45                         | 41.34                             | 43.36                           | 41.38 a |
| Average                     | 41.08 a                       | 42.24 a                           | 43.53 a                         |         |
| Number of fruit             |                               |                                   |                                 |         |
| Without mulch               | 50.32 c                       | 48.12 d                           | 48.32 cd                        | 48.92 b |
| Organic mulch               | 58.12 ab                      | 52.09 bc                          | 49.68 cd                        | 53.30 b |
| Plastic mulch               | 61.40 a                       | 57.23 ab                          | 54.65 b                         | 57.76 b |
| Average                     | 56.61                         | 52.48                             | 50.88                           |         |
| Fruit weight (g)            |                               |                                   |                                 |         |
| Without mulch               | 212.10 c                      | 214.36 b                          | 210.32 c                        | 212.26  |
| Organic mulch               | 218.21 a                      | 212.18 c                          | 211.81 c                        | 214.07  |
| Plastic mulch               | 220.03 a                      | 216.45 b                          | 208.24 c                        | 214.90  |
| Average                     | 216.78                        | 214.33                            | 210.12                          |         |
| Fresh fruit weight (t ha⁻¹) |                               |                                   |                                 |         |
| Without mulch               | 10.56 b                       | 10.12 b                           | 9.51 c                          | 10.06 b |
| Organic mulch               | 10.30 b                       | 9.56 c                            | 12.30 a                         | 10.72 b |
| Plastic mulch               | 13.03 a                       | 11.24 b                           | 10.45 b                         | 11.57 b |
| Average                     | 11.30                         | 10.31                             | 10.75                           |         |

*Note: The numbers followed by the same letter in the same column are not significantly different from the DMRT at the level of 5% (DAP = days after planting).*

3.2.2. **Number of fruits per plant.** The fruit is the result of horticultural cultivation so that the fresh weight of the fruit dramatically affects crop production. The results of the analysis of variance showed that the number of fruits per plant on the application of mulch and the frequency of giving water had a significant effect, as well as the interaction between the application of mulch and the frequency of providing water has a significant impact on the number of fruits per plant. It is suspected that the use of silver, black plastic mulch increases photosynthetic in plants so that it has a good effect on the formation of chillies [24].

According to Kadarso [5], the application of black and silver plastic mulch is better for plant growth, because the silver colour on the upper surface can reflect radiation from the sun that comes so that it can increase photosynthesis, while the black colour of the pulse will cause solar radiation which is transmitted into the soil to be small even. This is what causes the soil temperature to remain low so that it provides good results for plant growth. The highest number of fruit per plant was obtained from the application of plastic mulch and water provision once a day, namely 61.40.

With the application of plastic mulch has a higher number of fruits than straw mulch treatment and without mulch. It is suspected that the application of plastic mulch by giving water once a day increases the photosynthetic in plants so that it has a good effect on the formation of chillies. Mulching is beneficial for plants in terms of reducing weed growth and increasing the number of higher fruits due to more
efficient use of soil nutrients [25, 26]. Gonzalez et al. [9] stated that irrigation is crucial for chilli production because it is one of the most vulnerable horticultural crops to water shortages. In the phase of flowering and fruit development is the phase most sensitive to lack of water.

3.2.3. Fruit weight per plant and fresh fruit weight. The results of the analysis of variance showed that the application of mulch and the frequency of giving water and its interactions had a significant effect on the weight of the chillies in the plantations and the weight of the fresh fruit. The highest yields of fruit weight per plant and fresh fruit weight were obtained in the treatment of using plastic mulch and giving water once a day, namely 220.03 g and 13.03 t ha\(^{-1}\).

In observing the total fruit weight per real chilli plant, mulching was better than without pulsing. This is thought to be because the mulching can maintain the stability of the microclimate in the soil, where the silver colour on the surface of the plastic mulch can reflect incoming solar radiation so that it can increase photosynthesis. In contrast, the black colour of the mulch will keep the soil temperature low so that it gives good results.

At the time of fruit ripening until harvest, the chilli plants must be sufficiently watered to produce maximum production. This is presumably because the use of black and silver plastic mulch can improve the physical, chemical and biological properties of the soil which will facilitate the supply of nutrients needed by plants for fruit formation and development [27]. Fresh weight and dry weight of chillies have a positive correlation with the amount of water given. Plants can carry out a perfect fertilization process with a sufficient amount of water to support the yield of fresh fruit weight [28]. Several studies reported that the total yield of chillies was reduced under drought conditions [29].

4. Conclusion
Based on the results of the study, it can be concluded that:

- The application of mulch has a significant effect on plant height 30 and 60 DAS, flowering age, number of fruits per plant, fruit weight per plant, and fresh fruit yield
- The frequency of giving water had a significant effect on plant height 30 and 60 DAS, flowering age, number of fruits per plant, fruit weight per plant, and fresh fruit yield
- Interaction between the application of mulch and the frequency of giving water has a significant effect on the number of fruits, fruit weight, and fresh fruit yield
- The application of plastic mulch with a frequency of giving water once a day gives the highest fresh fruits yield compared to other treatments, namely 13.03 t ha\(^{-1}\)

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