The effect of sprinkler irrigation system on shallot growth and yields in dry land of Sigi district

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Abstract. Shallot (Allium ascalonicum L.) cultivation is conducted on dry land and requires irrigation. A pressurized irrigation system which is highly water efficiency was suitable in on dry land. The study purpose is to determined irrigation system effect on the growth and yield of shallot. The study used a Randomized Block Design (RBD) in 3 (three) treatment of irrigation systems (I1 = permanent sprinkler irrigation, I2 = portable sprinkler irrigation and I3 = conventional irrigation) in 5 (five) repetitions. The shallot variety is Tajuk. Observations were plant height, tillers, plants and tubers in fresh weight, plants and tubers in dry weight, and yields. Data were analyzed using variance at 5% and DMRT test. The results showed that the application of permanent sprinkler irrigation systems (except plant height and number of tillers) gave the best results when compared to portable sprinkler watering systems and conventional irrigation.

1. Introduction

Shallot cultivated intensively by farmers is a leading vegetable commodity. The economic contribution is quite high on regional economic development and farmers income so that the cultivation of shallot has spread in almost all provinces in Indonesia. Even though the farmers' interest in shallot is quite strong, various constraints, both technical and economic, are still found in the business process.

Based on statistics [1], Indonesian shallot production in 2017 was 1.47 million tons, increased 1.6% from the previous year. In 2016, the total export of shallots was 735.7 tons and there were no imports (zero). Thailand, followed by Vietnam, Taiwan, Malaysia, Singapore, Timor Leste were destination countries for Indonesian shallots exports [2]. In Central Sulawesi, shallot production in 2018 was 8,362 tons, decreased by 3.3% from 2017. Sigi district contributed 1,864 tons [3] which was second-ranked in shallot production after Poso.

Sigi district, covering an area of 519,602 ha consisting 15 sub-districts, is a potential area for the development of crops and horticulture. However, the main limiting factors in cultivation are water availability, low rainfall (<600 mm /yr), short period and erratic climate [4]. After huge earthquake of 7.9 Richter scale in 2018, The Gumbasa irrigation channel was damaged and caused water scarcity in farmer’s land. Some farmers used water from wells and bore wells as an alternative.

In a dry land, water was a limited factor for plant growth. Irrigation technology using a sprinkler is an alternative to the efficiency of resource. Samson and Tilahun's research [5] showed that using sprinkler irrigation increases the efficiency of water in shallot from 6% to 13% under the condition of...
75% ETc water requirements. According to Kumar et al. [6], the advantage of sprinkler irrigation technology was the reduced use of water up to 50% compared to the flush method. The Sprinkler modification is necessary to reduce investment costs incurred by farmers due to lack of capital. This research is conducted to determine the effect of several sprinkler irrigation systems on the growth and yield of shallots (*Allium ascalonicum* L.).

2. Methodology
The study was conducted in the farmers’ land of Kotarindau Village, Dolo Sub-district, Sigi District, Central Sulawesi Province (an altitude of + 87 m) from April to June 2019.

2.1. Material and equipment.
Material: Tajuk variety Shallot seed, NPK Mutiara inorganic fertilizer (16:16:16), High Nitrogen Fertilizer (Urea), SP36 and KCL Fertilizer, Cow Manure, Insecticides, and herbicide.
Equipment: Water pumps, hose, permanent sprinkler irrigation networks, portable sprinkler irrigation networks, hoe and hand sprayers.

2.2. Research design
The study used a Randomized Block Design with 3 (three) treatments in the irrigation system and 5 (five) replications. Each irrigation system was carried out in every 2 days.
- **Permanent Sprinkler Irrigation:** an irrigation system where pipelines and sprinklers are permanently placed on the land. The distance between the pipes is the same as the distance between the sprinklers (a square).
- **Portable Sprinkler Irrigation:** an irrigation system that is easy to move. The equipment is one pump, main pipe, and hose equipped with a rotary sprinkler with a distance of 4 m each section. A diameter hose of 1/2 inch to 5/8 inches. These hoses will move after the planting site has sufficient water (field capacity) by removing the connection on the main pipe. Switching interval depends on set time.
- **Conventional Irrigation:** the LEB system, water will flow through a network/irrigation hose to each plant bed. Leave it for a while until the beds appear wet. If there is enough water, it is automatically drained out through a channel.

The study used 2,500 m$^2$ area for each treatment then made bed with of 100 cm. Drainage ditches are made with a distance between beds 50 cm with a depth of 30 cm. Onion planting spacing was 15cm x 15cm.

2.3. Data analysis
Variables observed included plant growth (plant height, number of leaves and number of tillers) and yield components (number of tubers per clump, fresh weight of tubers per clump, and tuber dry weight per clump). The data obtained were analyzed by F test and differences between treatments were carried out further tests with Duncan Multiple Range Test (DMRT) at 5% level.

3. Results and discussion

3.1. Technology applied in location
Kotarindau Village in the Dolo Subdistrict, Sigi Regency, Central Sulawesi has more than 75% of farmers who cultivate horticultural plants, including shallots. The vital need for horticultural crops is water, so it needs a good provision system. Farmers from Kotarindau village supply water using surface irrigation well. Plant watering systems are used manually by flowing water directly to cropping plots from irrigation channels or using water pumps. This method requires more time, energy and water so it is inefficient.

After huge earthquake 7.9 Richter scale in 2018, The Gumbasa irrigation channel was damaged and caused water scarcity in farmer’s land. Some farmers used water from wells and bore wells as an
alternative. Then the water was collected into a reservoir using a water pump and applied to the plant using a bulk planting system (sprinkler). Sprinkler Systems can be either permanent or non-permanent (portable) or conventional (from wells pumped directly to the field). Bulk irrigation/overhead irrigation is a way of providing water from the top of the plant and adjusting rainfall so that in addition to meeting the water needs of plants, it can also make micro-facilities throughout the plant [7]. According to Iman [8], although initially it requires a relatively high investment, with the calculation and determination of accurate design, proper operation and maintenance, the use of water with a pressurized irrigation system will give benefit. Sprinkler irrigation technology can provide high efficiency and effectiveness in meeting water needs for plants. This can be realized if the sprinkler irrigation system is designed appropriately, regularly used, and follows the number of plant needs and the time of water supply.

3.2 Growth of shallot plants

Plant growth and development is an important process in the life cycle of plants. The process takes place throughout the life cycle of plants and depends on the availability of water, nutrients, and other growth substances and the supporting environment. The observations result of the growth and development of shallot include plant height, number of leaves, and number of tillers are presented in table 1.

| Treatment                          | Plant Height (cm) | Number of Leaves (strands) | Amount of Tiller |
|------------------------------------|-------------------|---------------------------|-----------------|
| **Permanent Sprinkler Irrigation** | 35.95 a           | 25.75 a                   | 10.45 a         |
| **Portable Sprinkler Irrigation**  | 35.66 a           | 24.36 a                   | 9.98 a          |
| **Conventional Irrigation**        | 33.57 b           | 23.30 a                   | 7.90 b          |

Note: The numbers followed by the same letters in the same column are not significantly different according to DNMRT advanced tests of 5%

The analysis of variance in various plant irrigation systems shows a significant influence on the growth of shallots except on a number of leaves. Table 1 shows that the permanent sprinkler irrigation treatment provides the highest plant height and is not significantly different from the portable sprinkler irrigation treatment, and conventional irrigation systems provide the lowest plant height. The conventional irrigation system is the most widely used system by farmers. This system requires large amounts of water, but the efficiency is low.

The increase in shallot height is thought to be from the influence of the irrigation system. In the growth phase, water supply is needed for growth so that the water needs are large. That sufficient water availability at the time of growth results in more active photosynthesis, so that the process of elongation, division, and differentitation of cells occurs better and encourages plant height growth [9]. In the sprinkler irrigation system, the need for water for the vegetative phase of plants is sufficiently available. The area of cell enlargement is just behind the growing point. When these cells are enlarged, the vacuole will suck up large amounts of water. As a result, cells will experience lengthening and thickening in the cell wall. If the availability of water is not enough, it will inhibit the cell elongation process [10].

The addition of the number of leaves in the shallot follows the increasing plant height and age. The rate of leaf formation increases with the age of the plant but determined by how many primordial leaves are formed on the plant. Although the treatment of water supply is with a different irrigation system, the number of leaves formed in each treatment is relatively the same. However, the analysis
shows that even though the effect is not significant, permanent sprinkler irrigation treatment gives the greatest number of leaves when compared to portable sprinkler irrigation and conventional irrigation. The number of leaves of shallot decreases along with the reduced volume of water received by plants. In conventional, 50% of the water supply can be utilized by plants. The effects of drought on the growth of shallot will reduce the number of leaves, the diameter of the umbilicus (flower shape), the number of flowers in the umbilicus, and the number of flowering seeds [11].

The number of shallot tillers is related to the number of leaves. The optimum leaves quantity causes the distribution of light to support photosynthesis. It will deposit and piled up on stems and roots before affecting the number of tillers. High photosynthesis results support the growth results. Table 1 shows that permanent sprinkler irrigation provides the highest number of tillers but is not significantly different from portable sprinkler irrigation. The conventional irrigation systems produce the fewest yield. Plants in its morphological adaptation can take the form of inhibition of stem growth [12]. Water is the main component making up cells and tissues including plant cells. Besides water, shallot tillers height is also influenced by day length and temperature. Shallots are long-day plants, the process of forming tubers requires a longer number of days compared to short-day plants [13]. Shallot bulbs can continue to grow and then form saplings if the minimum length of the day is reached.

Shallot plants can be harvested after 60-70 days which are 60% visible signs of soft stem necks, fallen plants, and yellowed leaves. Harvesting should be carried out in dry soil conditions and sunny weather to prevent tuber rot disease in the warehouse. Harvested shallots are then tied to the stem to facilitate handling [14]. Observation data on the components of the shallot yield including the number of tubers, fresh and dry weights of the bulbs are presented in table 2.

Table 2. Average of bulbs, fresh weight and dry weight of shallot plant 10 days after planting.

| Treatment                | Bulbs Quantity | Fresh weight bulbs (gram) | Dry Weight Bulbs (gram) |
|--------------------------|----------------|---------------------------|-------------------------|
| Permanent Sprinkler      | 10.45 a        | 82.15 a                   | 73.83 a                 |
| Irrigation               |                |                           |                         |
| Portable Sprinkler       | 9.10 a         | 79.30 a                   | 67.21 a                 |
| Irrigation               |                |                           |                         |
| Conventional Irrigation  | 8.98 a         | 46.80 b                   | 40.59 b                 |

Note: The numbers followed by the same letters in the same column are not significantly different according to DNMRT advanced tests of 5%.

The formation of shallot tubers comes from the enlargement of leaf layers which then develops bulbs [15]. The formation of perfect and abundant chlorophyll in the leaves will increase the absorption of sunlight energy in photosynthesis. The photosynthesis is useful for a plant to develop body formation and stored in bulb layers.

The treatment of plant irrigation systems has a significantly different effect on crop yields of shallots except for the tuber number (table 2). The results show that although the effect is not significant, the permanent sprinkler irrigation treatment provide the highest number of tubers when compared to portable sprinkler irrigation and conventional irrigation. It is assumed that in conventional irrigation treatment, the percolation rate is greater than the infiltration rate, so that water that can be absorbed by plants is less than that of sprinkler irrigation. The available water that can be absorbed by plants on shallots has a critical period during the formation of tubers, thereby reducing production. In addition to these factors, the number of crop tubers is also influenced by the density or variety of plants [16].

Shallot bulbs are part of an enlarged plant as a storage place for food reserves. The weight of the tuber is largely determined by the content of the water content contained in the cells making up the tuber layer. Observations of fresh tuber weights were made after the plants were harvested and separated from the leaves and roots of the plants. The irrigation treatment has a significantly different
effect on the fresh weight of tubers per clump and the dry weight of tubers per clump of shallots. The permanent sprinkler irrigation treatment gives the freshest tuber weight per clump and the heaviest tuber dry weight per tuber and was not significantly different from the portable sprinkler irrigation. The conventional irrigation systems provide lightest weights.

Increased tuber weight is influenced by the amount of water and the accumulation of photosynthesis in leaves transplanted for tuber formation. Water supply has an effect on soil moisture for each phase of growth and plant type [17]. The low tuber weights in conventional watering systems are thought to be caused by an uneven distribution of water. If the plant gets excess water, it will be susceptible to rot disease, thereby reducing yield. Conversely, if there is water stress, it will disrupt growth regulators, so that plants grow stunted and newly formed leaves do not develop fully. Drought stress can reduce the level of productivity (biomass) of plants, due to decreased primary metabolism, shrinkage of leaf area and photosynthetic activity.

The ratio of root dry weight and canopy dry weight (stems and leaves) is used to explain root efficiency supporting plant biomass formation [18]. The root dry weight will decrease if water availability decreases [19]. Irrigation frequency is very important to encourage growth. The root formation will stop along with the start of tuber formation [20].

4. Conclusion

Provision of water with a sprinkler irrigation system gives a better effect on all components of growth and yield of shallots compared to water supply with a conventional irrigation system by far. Permanent sprinkler irrigation systems do not make a real difference to the growth and yield components of shallots with a portable sprinkler irrigation system.

5. References

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