Shallot’s growth and production under sub-surface irrigation in vertical agriculture (verticulture) system

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Abstract. One way to increase yields production of shallot plant can be done by planting in vertical agriculture (verticulture) system. The research aimed were to observe water consumption, to observe leaf length, to observe shallot weight, and to observe bulb quality of shallot. The research was done by experimental design that used sub-surface irrigation with emitter spacing P1 (15 cm), P2 (30 cm), and P3 (45 cm) that immersed in verticulture container with distance among holes 15 cm for each container. Shallot’s seed was planted in each hole that has 33 seeds in a verticulture container. The result shows that the least water consumption, the longest leaf length, the highest shallot weight, and the biggest bulb quality showed in verticulture container that contains irrigation tube with emitter spacing 15 cm. The conclusion that can be interpreted were sub-surface irrigation can be applied as irrigation system in vertical agriculture, where emitter spacing in irrigation tube as same as hole spacing in verticulture container.

1. Introduction
Shallot is one of the horticultural products that more demand by the community, especially in the North Sumatra province. Shallot cultivation requires enough of water for its growth. In shallot cultivation, the community still uses conventional methods. One way can be done to increase shallot productivity is cultivating with vertical agriculture (verticulture) system. Water supply based on water requirements can be done by sub-surface irrigation where water will move from tube to soil because evapotranspiration process. The research aimed were to observe water consumption, to observe leaf length, to observe shallot weight, and to observe bulb quality of shallot.
2. **Material and method**

This research was conducted in April until July 2019 at Semangat Village, Sub-district Merdeka, Karo District, North Sumatera, Indonesia. In this research, shallot’s seed was planted in a container of vertical agriculture (verticulture) which have a spacing of holes were 15 cm and each container consist of 33 holes. Sub-surface irrigation was used in this research which irrigation tube was made with emitter spacing 15 cm as known P1, 30 cm as P2 and 45 cm as P3 (can be shown in Fig. 1). Irrigation tube immersed in verticulture container, and emitter was matched with holes that have shallot’s seed was planted. The parameters observed were:

1. Observation of the amount of water consumption, done by giving water to verticulture container based on water requirement every day
2. Observation the leaf length, measure every three days, starting from leaf base until leaf tips
3. Observation the weight of shallot plant, measure wet and dry weight of shallot
4. Observation of bulb quality, measure bulb diameter before planting and after harvesting

![Figure 1](image-url)  
**Figure 1.** Design experimental

3. **Result and discussion**

3.1. **Water consumption**

Water consumption since shallot seed planted until harvesting can be seen in Figure 2. Fig 2 shows that water consumption increasing until harvesting time. In first fifteen days after planting, water consumption in P1 treatment was 128 ml per a container, and then increase in second fifteen days, and increased dramatically in fifth fifteen days, as same as P2 and P3. Its caused by the bulb was getting bigger, the number of bulbs increasing, and the leaves are getting longer. Increasing the leaf length also causes a greater evapotranspiration value, so the water demand will also increase. From Fig 1 can be seen that irrigation tube with emitter spacing 15 cm has the least water consumption, however, it illustrates smaller water requirement [1] as same as deficit irrigation [3] for shallot cultivation in verticulture system.
3.2. Leaf length

From Fig. 3 can be seen that leaf length growth on P1 was higher than P2 and P3 where get 46.9 cm in 75 days after planting. This shows that water supply with sub-surface irrigation in verticulture container affect shallot’s leaf growth also. Although water consumption in P1 more lest than P2 and P3, however, leaf growth in P1 longer from the others. Provision of water or emitter spacing that same with plant hole will facilitate the plant to absorpt water more easier, therefore, energy for shallot growing more maximal than the energy needed for water absorption. The proportion of soil that divided into 7:3 comparison of soil and organic matter [5] also affect shallot easier to absorpt water, also given enough nutrition for shallot’s growth, even though P1 shows deficit irrigation [3] for water consumption in verticulture system.

3.3. The weight of shallot plant

The weight of shallot plant can be seen in Table 1. Table 1 shows that yield production of shallot both wet and dry weight. The highest weight of yield contained in P1 was 45.52 g for wet weight and 15.30 g for dry weight. The data describes that even though P1 have a least of water consumption, but it produces the highest yield of shallot.
Table 1. Wet and dry weight of shallot plant

| Treatment | Seed weight (g) | The total weight (g) | Bulbs weight (g) | Leaf weight (g) | Root weight (g) |
|-----------|----------------|---------------------|------------------|----------------|---------------|
|           | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry |
| P1        | 4.59 | 45.52 | 15.30 | 19.01 | 11.22 | 24.55 | 3.73 | 1.96 | 0.36 |
| P2        | 4.08 | 38.59 | 12.87 | 17.67 | 9.83 | 19.37 | 2.72 | 1.55 | 0.31 |
| P3        | 4.05 | 38.08 | 12.82 | 18.31 | 9.68 | 17.98 | 2.81 | 1.79 | 0.33 |

Each hole on verticulture container has 5-6 bulb. In P1, each bulb has a weight of 3.16 g for wet weight, and 1.87 g for dry weight. P1 yield higher than P2 and P3, and P3 higher than P2. It indicates emitter spacing also affect yield of shallot [3] in verticulture system. Even though P1 and P3 have least of water consumption, yield of shallot was higher.

3.4 Bulb quality
Shallot bulb quality can be interpreted with bulb diameter. Comparison bulb diameter both before planting and after harvesting can be seen in Table 2.

Table 2. Bulb diameter before planting and after harvesting

| Treatment | Bulb diameter (cm) |
|-----------|--------------------|
|           | before planting | after harvesting |
| P1        | 1.73              | 1.82              |
| P2        | 1.62              | 1.68              |
| P3        | 1.66              | 1.74              |

Table 2 shows that there was a variation of bulb quality were bulbs diameter increase each other. The largest diameter increase occurred in P1, grow up 0.09 cm per each bulb. Whereas in P2 grow up just 0.06 cm and in P3 higher than P2 were grow up 0.08 cm per each bulb. Fig 2 shows that water consumption in P1 as almost same as P3. The proportion of water and air in soil was needed for plant growth, hence, aerated zone towards root growth of plants to absorb water or nutrition easily. Increased bulb diameter also indicates higher yield production in verticulture system, hence, emitter spacing in irrigation tube affect yield [3] of shallot in verticulture system.

4. Conclusion
The least of water consumption shown by P1 (emitter spacing 15 cm) than P2 (30 cm) and P3 (45 cm). The longest leaf length shown by P1, get 46.9 cm in 75 days after planting. The highest shallot weight is shown by P1, 19.01 g for wet weight and 11.22 for a dry weight of bulb per a hole. The biggest bulb quality is shown by P1 where 1.73 cm bulb diameter before planting and get 1.82 cm after harvesting.

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