Growth of red dragon fruit seedlings (*Hylocereus costaricensis* L.) from two sources of cuttings at various concentrations of shallot solutions

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Abstract. One of the obstacles faced in the expansion of the dragon fruit planting area is limited cutting materials to produce high quality seedlings. This study aimed to study the growth of dragon fruit (*Hylocereus costaricensis* L.) seedlings from two sources of cuttings at various concentrations of shallots. The research was conducted at the Teaching Farm of the Faculty of Agriculture, Universitas Hasanuddin from November 2018 to February 2019. The trial was set based on Split Plot Design with source of cutting materials as the main plots, consisted of two types of sources ie. apical primary branch and basal primary branch, while concentration of shallots solution as sub plots, consisted of five levels, namely 0, 200, 400, and 600 g.L⁻¹ water, and Rooton-F 10 gL⁻¹ water. The results show that the growth of the dragon fruit seedlings from two different sources of cuttings at various concentrations of shallots did not show significant differences. Sources of cuttings from the basal of the primary branch gave the best results on the number of shoots (2.40 shoots). Application of various concentration of shallot solution resulted in the highest percentage of life cuttings (100%) compared to control (75%). The concentration of shallot solution of 600 g.L⁻¹ water showed the highest results in shoot length (28.33 cm), root length (31.09 cm) and root volume (66.67 mL). The use of Rooton-F as a positive control gave the highest results in root length (31.09 cm) and root volume (66.67 mL).

1. Introduction
One of the factors causing the low production of dragon fruit in Indonesia is the use of low-quality seedlings that can reduce the amount of production and longer fruiting time. Increased efforts to develop dragon fruit, resulting in increased demand for seedlings. The availability of good and quality seeds need to be considered, given the number of parent trees that can be used as seed sources is limited in number, so it is necessary to try to use the source of cuttings as efficiently as possible.

Propagation by cuttings has several obstacles, namely non-uniform seedling growth. The choice of cuttings used as cutting materials affects the growth rate of seedlings of a plant. The cutting materials can come from the tip of the branch and the base of the branch, but the growth rate varies in each source of cuttings used because of the availability of auxin at different parts of the cuttings.

Cutting materials derived from young plants will be more easily to form root than older plants. This is due to the ability of the older plants in performing cell division, therefore, cuttings taken from old...
tissue will have difficulty in forming primordial roots. Decreased ability in old plant tissue to form primordial roots is due to reduced phenol content which functions as a cofactor [1].

Vegetative propagation that has been used and proven successful in dragon fruit plants is by branch cuttings. The advantages of this technique include a homogeneous result, can be produced in large quantities and a short time and the seeds are produced uniformly, the same as the parent and a shorter fruiting time and the success rate of seeds surviving in this propagation is quite high [2].

Successful vegetative propagation by cuttings is marked by the emergence of roots in the cuttings. For the formation of roots in cuttings, optimal environmental conditions such as temperature, humidity, and light intentions are needed. The process of root formation begins in the area of stem branch that was sliced resulting in damaged cells, cells surrounding the damaged cells will experience differentiation by holding mitosis (cell multiplication) and then formed parenchymatic cells namely callus [3]. A callus that is formed initiates to form root primordial which eventually forms new roots [4].

One effort that can be done to increase the percentage of growth in dragon cuttings is by adding growth regulators to the cutting material. Synthetic growth regulators are more expensive and sometimes in the market are quite scarce. Another alternative that can be done is to use growth regulators that are sourced from organic matter. Natural growth regulators are growth regulators that are readily available in nature at low prices. Shallots is one of the agricultural products containing allicin compounds. Allicin compound is a compound that if added to plants will facilitate the metabolism of plant tissues and can mobilize food ingredients that exist in the body of the plant [5]. Shallots also produce Indole Acetic Acid (IAA), which is identical to auxin that can stimulate root initiation [6]. Auxin can increase the process of cell elongation, in this case, the root cells [7]. Auxin causes the recipient cells in plants to release hydrogen ions around the cell walls which then will lower the pH and cause the cell wall to loosen, hence induce growth associated with cell elongation [8].

According to Rahayu and Berlian [9], shallot bulbs contain vitamin B1 (Thiamin), riboflavin, allicin, nicotinic acid, and auxin and rhizokalin growth-regulating substances which can stimulate root growth. Purwitasari [10] also stated that the onion juice with a concentration of 80% showed higher chrysanthemum root length compared to other concentrations because it contained auxin at optimum levels so that elongation and development of root cells could be stimulated. The results of Siskawati's research [11] proved that the administration of shallot extract with a concentration of 100% and immersion for 2 hours produced the highest and dry weight of shoots in Jatropha plant cuttings when compared with concentrations of 0%, 40%, 60%, and 80%. The results of Siti's [12] research showed that the application of 400g per liter in dragon fruit cuttings resulted in highest shoot lengths and weights.

2. Methodology

2.1. Experimental methods
This research was carried out in the Experimental Farm of the Faculty of Agriculture, Universitas Hasanuddin from November 2018 to February 2019. This research was conducted in the form of an experiment using Split Plot Design. The first factor set as the main plot was the source of cutting materials of dragon fruit plants (S), consisted of two levels, namely: apical primary branch (s1), and basal primary branch (s2). The second factor set as subplots was the concentration of shallot solution (H), consisting of five levels, namely: 0 gL⁻¹ water (h0) as first control, 200 gL⁻¹ water (h1), 400 gL⁻¹ water (h2), 600 gL⁻¹ water (h3), and Rooton-F 10 gL⁻¹ water (h4) as the second control. From these two factors, 10 treatment combinations were obtained, each of which was repeated 3 times as a group. Each treatment combination used two units of cuttings, resulted in the total number of 60 branch cuttings.
2.2. Preparation of shallot solution and planting media

Treatment of the concentration of shallot solution was prepared by peeling the shallots and weighing according to the treatment (200 g, 400 g, and 600 g). Subsequently, the shallots were blended until smooth then diluted by adding water up to 1,000 mL.

The planting media used consisted of chicken manure, sand, and soil with a ratio of 1: 1: 1. The media were mixed evenly and then put into a 15 cm x 20 cm polybag. Then the media was saturated with water to field capacity.

2.3. Preparation of cutting materials

Cutting materials used were taken from the primary branches based on criteria of free from pests and diseases and have been fruitful (Figure 1). The material was then prepared by cutting the stem with a size of 55 cm, then the apical section was cut as much as 5 cm then the material is cut into 2 parts with the same length of 25 cm. Slice at the top of the cutting was made flat while slice at the bottom was made with angle of 45º to expand the rooting zone of the cuttings. Hence, cutting materials were allowed to stand until the surface of the former piece was dry.

![Figure 1](image1.png)

*Figure 1.* Source of cuttings from the primary branch. (a) The primary branch before being cut; (b) The apical part of the primary branch; (c) The basal part of the primary branch

2.4. Planting

Planting was carried out by immersing the bottom of the cuttings into the planting medium ± 10 cm. After the cuttings were planted, the cuttings were placed in the greenhouse for two months. After two months, roof of the greenhouse was opened to give direct sunlight to the two months old seedlings before planting in the field. Watering was conducted every two days in the morning until the age of 30 days after planting (DAP), then the frequency of watering was reduced to once every five days.
2.5. Observation and data analysis
Observations were made every two weeks starting from 2 DAP until the end of the study. The parameters observed included percentage of life cuttings, number of shoots, root length, and root volume. Data were analyzed using analysis of variance to test the significance of the treatment given. If there is a significant effect then proceed with further tests using the Least Significant Difference (LSD) test at \( \alpha = 0.05 \).

3. Results
Analysis of variance shows that the treatment of the source of cuttings did not significantly affect all parameters except for the number of shots of dragon fruit cuttings. On the other hand, the treatment of the concentration of shallot solution had a significant effect on shoot growth as indicated by the parameters of percentage of life cuttings, shoot length, root length, and root volume.

3.1. Percentage of life cuttings
Pre-planting treatment for dragon fruit cuttings both with a solution of shallots and Rooton-F significantly increased the percentage of life cuttings. There was no significant difference from the source of cuttings used in the parameters of the number of cuttings that had successfully grown. Dragon fruit cuttings that were not given pre-planting treatment showed an average percentage of life cuttings of only 75% compared to cuttings soaked in a solution of shallots and Rooton-F, which showed a 100% success rate at the end of the trial (Figure 2).

![Figure 2](image)

**Figure 2.** Average of life dragon fruit cuttings (%) on different pre-plant treatments. The numbers followed by the different letters on the bars (a, b) means that it is significantly different based on LSD at the level \( \alpha = 0.05 \).

3.2. Number of shoots
Number of shots of the dragon fruit cuttings at 75 and 90 DAP varied significantly with the source of cutting materials while the pre-planting treatment applied either shallot or Rooton-F did not have a significant effect. The use of cutting from the basal section of the dragon fruit stem resulted in higher number of shoots (Table 1). The results of the analysis of variance showed that the treatment of cutting material sources significantly affected the observations at the age of 75 and 90 DAP, while the treatment of shallot solution concentration and the interaction of the two treatments did not significantly affect the number of cuttings.
Table 1. Average of shoot numbers (shoots) of dragon fruit cuttings from different sources of cuttings

| Source of Cuttings  | 75 DAP  | 90 DAP  | Mean |
|---------------------|---------|---------|------|
| Apical section (s1) | 1.27 x  | 1.33 x  |      |
| Basal section (s2)  | 2.17 y  | 2.40 y  |      |
| LSD 0.05            | 0.2     | 0.22    |      |

Numbers followed by the same letters in the same column (x, y) mean that they are not significantly different at the level $\alpha = 0.05$. DAP = Days After Planting.

LSD test results show that at the age of 75 and 90 DAP, the average number of shots of the red dragon fruit cuttings was highest in the source of cuttings at the base of branches (s2), namely 2.17 branches and 2.40 branches and significantly different compared to the source of cuttings of branch tip parts (s1) is 1.27 and 1.33 branches.

3.3. Shoots and roots growth

Analysis of variance shows that the pre-plant treatment significantly improved the growth of shoots and roots of the dragon fruit cuttings from different sources, while a source of cuttings did not affect the shoot and root growth of the cuttings. Average of the shoot and root parameters are shown in Table 2.

Table 2. Average of shoot and root length (cm) and volume of the root (mL) of dragon fruit cuttings on different concentrations of shallot solutions.

| Concentration of shallot solutions | Shoot Length (cm) | Root Length (cm) | Volume of Root (mL) |
|------------------------------------|-------------------|------------------|---------------------|
| Control (0 g.L$^{-1}$)             | 11.58 c           | 23.25 c          | 41.67 b             |
| Shallot extract (200 g.L$^{-1}$)   | 21.33 b           | 26.25 bc         | 50.00 b             |
| Shallot extract (400 g.L$^{-1}$)   | 22.00 ab          | 28.17 ab         | 54.16 ab            |
| Shallot extract (600 g.L$^{-1}$)   | 28.33 ab          | 28.84 ab         | 66.67 a             |
| Rooton-F (10 g.L$^{-1}$)           | 23.08 ab          | 31.09 a          | 66.67 a             |
| LSD$_{\alpha=0.05}$               | 0.73              | 4.14             | 16.28               |

Numbers followed by the same letters in the same column (a, b, c) mean that they are not significantly different at the level $\alpha = 0.05$.

From the results of LSD further test, the level of 0.05 (table 2) on the observation of 90 DAP show that the highest length of cuttings of red dragon fruit was found in the shallot solution concentration of 600 g.L$^{-1}$ (h3) that was 28.33 cm, significantly different from concentration of 0 g.L$^{-1}$ (h0) and 200 g.L$^{-1}$ (h1). The shortest shoot length (11.58 cm) is found at a concentration of 0 g.L$^{-1}$ (h0) and is significantly different from other concentrations.

The observation of root length parameters showed that the longest root length (31.09 cm) was found in the Rooton-F 10 g.L$^{-1}$ (h4) treatment, and it was significantly different from the concentration of shallot solution of 0 g.L$^{-1}$ (h0) which was only 23.25 cm and concentration of 200 g.L$^{-1}$ (h1), which is 26.25 cm. The shortest root length (23.25 cm) is found in the treatment concentration of shallot solution of 0 g.L$^{-1}$ (h0).

From the observation of root volume parameters, it shows that the highest root volume (66.67 mL) is found in the treatment concentration of 600 g.L$^{-1}$ (h3) and 10 g.L$^{-1}$ (h4), significantly different from the concentration of onion 0 g.L$^{-1}$ (h0) is 41.67 mL and the concentration of 200 g.L$^{-1}$ (h1) is only 50.00 mL. The lowest root volume was found in the treatment of 0 g.L$^{-1}$ (h0) shallot solution concentration which was 41.67 ml.
4. Discussion

Application of shallot solution has a significant effect on the percentage of life cuttings and observation of shoot length. This is presumably because the auxin needed by cuttings in growth can be fulfilled. Hardjadinata [2] suggested that the addition of exogenous natural and synthetic auxins in vegetative propagation can stimulate cell division, cell lengthening and can increase the percentage of life cuttings.

The emergence of adventitious roots in vegetative propagation is something that needs attention because the role of roots is very important, one of which is as a support plant and also as an important organ in the process of absorption of nutrients. Application shallot solution in the recent research showed a significant influence on root length and root volume. This is in line with Hardjadinata [2] which stated that the application of natural and synthetic auxins to cuttings can stimulate the growth of adventitious organs such as roots, shoots, and leaves.

Percentage of the number of life cuttings, on the application of 200, 400, and 600 grams per liter of water produced 100% of life cuttings that were significantly different from the control treatments that were only 75% live cuttings. This is in line with Marfirani’s research [13] which stated that the higher the concentration of shallots the better the increase in cutting growth. This is because of the higher the concentration of shallots, the higher the allicin compound obtained by dragon fruit cuttings. The secondary metabolic product of shallots is the allin compound which immediately turns into allicin compounds, allicin and thiamin compounds in onions can form chemical bonds called allithiamin. The existence of these substances can accelerate metabolism in plant tissue and can mobilize food ingredients in plants [9].

The results of the study show that the treatment of 0 grams per liter of water of the shallot solution gave the lowest results on each observation. This is presumably because the auxin content in cuttings is limited so that the growth of cuttings is slightly inhibited. Each plant has growth hormones to stimulate the growth of roots, shoots, and leaves, but the hormones contained in plants are small so that they need to be added from the outside to accelerate growth [14]. The use of cuttings from the basal part of the branch gave better results compared to cuttings from the apical part of the primary branch. Material cuttings from the base of the branch has more food reserves than the tip of the branch, so the cuttings from the base of the branch are able to bring up roots faster than the tip of the branch. Formation of roots and shoots in a plant is influenced by carbohydrate content and balance of the auxin hormone in planting material [15].

In the parameters of shoot length, root length, and root volume, no significant differences were found between the cutting materials taken from apical and basal part of the primary branches. The parameter seems to be influenced by environmental factors and planting media. The environmental conditions greatly influence the growth of shoots, including humidity, fertility of the growing media and sunlight exposure [16]. From the two sources of cuttings, namely the basal branches and the apical branches, better sources for cutting material were cuttings taken from the basal part of the primary branch. This is indicated by the higher number of shoots formed because the mature tissue in the cuttings and the number of carbohydrates from the cuttings at the base can support the growth and development of cuttings.

5. Conclusions

1. There was no significant interaction between the treatment of the shallot solution concentration and the source of the cutting material on the growth of dragon fruit cuttings.
2. The source of cuttings from the basal of the primary branch produced the number of shoots (2.40 shoots) than the cuttings from the apical of the primary branch (1.33 shoots).
3. Cuttings treated in shallot solution concentration of 600 g.L⁻¹ resulted in better growth of the dragon fruit seedlings indicated with the highest average values of shoot length (28.33 cm), root length (31.09 cm) and root volume (66.677 mL).
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