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Effect of Seed Bulb Cutting Size and Planting Media Volume on the Growth and Yield of Shallot (*Allium ascalonicum* L.) under a Hydroponic Wick System

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ABSTRACT

Shallots (Allium ascalonicum L.) are cultivated as a high economic value agricultural business. Cutting the tip of the seed bulb can stimulate, accelerate and synchronize plant growth. In hydroponic cultivation, the volume of planting media is an important component that needs to be considered. This research was conducted at the Greenhouse Hydroponic Farm Lamongan, Lamongan District, Lamongan Regency, East Java. Split plot design (RPT) or split plot design in a Completely Randomized Design (CRD) with the main plot (main plot) the volume of planting media (U) with 3 levels: 10cm (U1), 15cm (U2), 20cm (U3) and sub plots (sub plots) are the size of the cutting of the seed bulbs (P) with 4 levels: not cut (P0), cut 1/4 (P1), cut 1/3 (P2), cut 1/2 (P3). It was found that the treatment of the size of the cutting of the seed bulbs affected the vegetative and generative variables. Meanwhile, the treatment of planting media volume affects generative variables, especially on the number of harvested bulbs per box and the weight of harvested bulbs per box. The most optimal interaction between the combination of the size of cutting seed bulbs and the volume of planting media occurs at the size of cutting seed bulbs of 1/4 part and the volume of planting media of 10 cm, which is able to increase the weight of harvested bulbs per clump.

1. INTRODUCTION

Shallots (*Allium ascalonicum* L.) are cultivated as an agricultural business with high economic value. Household shallot consumption in 2023 has been 2.86 kg/capita/year, with an average annual growth rate of 0.85%. Meanwhile, shallot consumption per capita in 2024 is predicted to reach 3 kg/year, a 4.93% increase compared to the previous year. From 2024 to 2028, shallot consumption is projected to increase by 1.84% per year, or an average of 3.06 kg/capita/year (Pusdatin, 2024). Over the five-year period (2019-2023), the average harvested area for shallots was 181,467 hectares and continued to grow at 3.27% per year. During the same period, national shallot production averaged 1,873,574 tons, growing at 5.89% per year (Pusdatin, 2024). Although there has been an increase in shallot production, to meet domestic demand for shallots, Indonesia still imports shallots from other countries. The inability of farmers to apply appropriate and effective cultivation techniques results in low shallot productivity.

Hydroponics is taken from Greek, namely *Hydroponous*, *hydro* means water and *ponous* means work. Hydroponics is a farming technology that uses water, nutrients, and oxygen as the growing medium (Wirawati, 2021). The hydroponic method is a cultivation method that utilizes the availability of water and nutrients that are constant, does not use a large area of land, and produces good quality bulbs (Kahar *et al*., 2021). Seasonal uncertainty is one of the most common obstacles, so that the cultivation of shallots using the hydroponic method in a greenhouse is considered capable of overcoming this problem. The wick system is a system in hydroponic cultivation where this system uses a

wick that connects the nutrient tank with the planting medium used in hydroponic cultivation (Masduki, 2018). Shallots can produce maximum yields if they absorb sufficient nutrients to support their growth and development, as each plant species has different nutrient requirements. Nutrients in hydroponic cultivation are provided in a solution containing macro and micronutrients (Rizal, 2017).

Success in shallot cultivation is largely determined by the initial action (pre-treatment) on the seed bulbs (Suriana, 2022). Cutting the tip of the seed bulb can stimulate, accelerate and synchronize the growth of the shallot plant. Cutting the tip of the bulb 1/3 or 1/4 can stimulate faster shoot growth with even growth and encourage the growth of side bulbs. If cutting is not done at the tip of the seed bulb, the growth of the shallot plant will be slightly inhibited and the harvest will decrease (Widiastuti & Khairudin, 2017). In hydroponic shallot cultivation, the volume of the planting medium is a component that must be considered. The volume of the planting medium or analogous to the size of the pot is a factor that influences the growth and yield of shallot plants, considering that the harvest of shallots is in the form of bulbs that develop in the planting medium container (Nabisa & Muchtar, 2019). Therefore, the provision of nutrients for plants cultivated hydroponically must be appropriate in quantity and type and provided continuously (Renaldi *et al*., 2021).Differences in the various sizes of cutting bulbs and the volume of planting media are expected to provide different responses. Plants will reduce the number and size of both all parts and certain parts if the planting density is made denser (Yuniarti *et al*., 2022). Therefore, this research is purposed to evaluate the effect of the size of cutting seed bulbs and the volume of planting media on the growth and yield of shallot plants. The results of this research are expected to be used as a reference in developing shallots hydroponically, especially in Lamongan area, East Java.

2. RESEARCH MATERIALS AND METHODS

2.1. Research Location

This research was conducted at the Greenhouse Hydroponic Farm Lamongan, Lamongan District, Lamongan Regency, East Java. The location is located at an altitude of 7.70 meters above sea level with an average temperature of 27 °C and humidity of 37–80%. This research was conducted in February to April 2024.

2.2. Tools and Materials

The tools included styrofoam box, pH meter, TDS meter, duct tape, flannel cloth, rice husk charcoal, bucket, analytical scale, and netpot. The materials included shallot seed bulbs of Bauji variety, liquid AB mix fertilizer, and water.

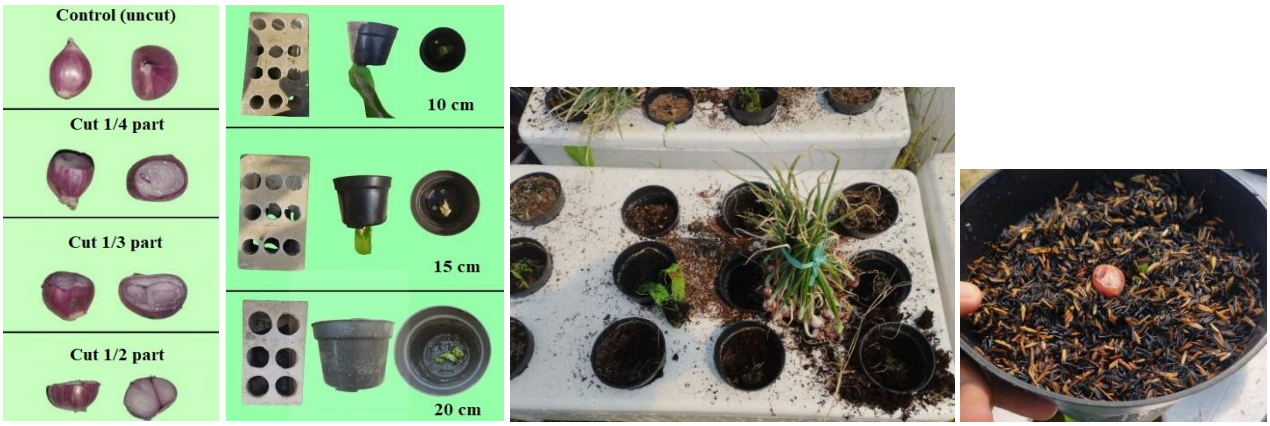
2.3. Experimental Design

Factorial experiment with two factors designed based on Split Plot Design in Completely Randomized Design (CRD). The main plot is the volume of planting media (U) and the sub plot is the size of the cutting of the bulb seeds. The main plot was the volume of planting media, which is equivalent to the size of net pot (U), consisted 3 levels, namely: U1 (10 cm diameter, 8 cm height, volume 456.67 cm^3, 12 pots/box), U2 (15 cm diameter, 10 cm height, volume 1243.55 cm^3, 9 pots/box), and U3 (20 cm diameter, 14 cm height, volume 3210.71 cm^3, 6 pots/box).

The subplot is cutting the tip of bulb seeds (P) consisted of 4 levels, namely: P0 (not cut or control), P1 (cut 1/4 part), P2 (cut 1/3 part), and P3 (cut 1/2 part). The combination of these 2 factors produces 12 treatments and was repeated three times to produce 36 experimental units. Figure 1 shows seed cutting, net pot size, and seed planting.

2.4. Implementation

The implementation of the research began with the selection of bulb seeds. For hydroponic of wick system, a wick from flannel cloth around 15 cm length was hanged in the bottom of the net pot. The wick function to absorb nutrition solution. Planting media (rice husk charcoal) was filled into the net pot until it was almost full. Planting was carried out by cutting the shallot bulbs according to the treatment and placing them on the planting media. The maintenance activity included irrigation, checking pH, providing nutrients, weeding, and controlling pests and diseases. The final stage was harvesting the shallot plants.



(a) (b) (c) (d)

Figure 1. (a) Shallot seed cutting, (b) Net pot diameter size (with wick installed), (c) hydroponic box with net pot size 10 cm diameter, (d) Seed planted in the growing media (rice husk charcoal)

2.5. Observation Variables and Data Analysis

The observation variables of this study included age of shoot emergence (day), plant length (cm), number of leaves, number of harvested bulbs per clump, number of bulbs per plot, bulb weight per clump, bulb weight per plot, total wet weight of the stover, harvest index, and harvest age.

The data analysis carried out was using analysis of variance (ANOVA) in accordance with the split plot design using linear model presented in Equation (1).

$$Y_{mnl} = \mu + \alpha_m + \delta_{ml} + \beta_n + (\alpha\beta)_{mn} + \varepsilon_{mnl} \quad (1)$$

where Y_{mn} is number of observations from the l^{th} group that received the m^{th} level seed cutting treatment and the n^{th} level pot planting media volume treatment; μ is general mean or average value, α_m is effect of the size of the m^{th} level seed cutting, β_n is effect of the n^{th} level planting media volume, $(\alpha\beta)_{mn}$ is effect of the interaction of the m^{th} level seed cutting treatment and the n^{th} level planting media volume treatment, δ_{ml} is random effect for the main plot, and ε_{mnl} is random effect for the subplot.

If ANOVA implies significant difference among treatments, a HSD test from Tukey was carried out with a level of 5%. The HSD test model is given by Equation (2) if the interaction of the two factors is significant. If only one factor is significant, the HSD test model was presented by Equation (3).

$$\text{HSD } (\alpha) \text{ Interaction} = q(\text{p; df; } 0.05) \times \sqrt{\frac{MSE}{r}} \quad (1)$$

$$\text{HSD } (\alpha) \text{ Factor U} = q(\text{p; df U}) \times \sqrt{\frac{MSE}{r \times n_P}} \quad (2)$$

where q is standard value q, MSE is mean square error, r is replication, n_P is number of treatments P.

3. RESULTS AND DISCUSSION

3.1. Age of Shoot Emergence

Table 1 shows the effect of treatment factors on the shoot emergence age of shallots. The combination of seed bulb cutting size and planting media size treatments did not show any significant effect with F-count = 1.00 < F-5% = 2.66. The seed bulb cutting size showed a very significant effect (F-count = 146.19 > F-5% = 3.16), but net pot size did not significant (F-count = 3.55 < F-5% = 5.14). Cutting the seed bulbs at their tips resulted in a faster shoot emergence age and was significantly different from uncut seed bulbs (control). This is in accordance with Haloho *et al.* (2019) who

Table 1. Average of shoot emergence age (day) of shallot due to seed bulb cutting size and planting media size treatments

Net Pot Size	Seed Cutting				Average
	0 (Control)	1/4 part	1/3 part	1/2 part	
10 cm					5.50 A
15 cm					4.92 A
20 cm					5.08 A
Average	9.00c	2.78a	3.33a	5.56b	

Note: Values followed by the same letter imply not significant based on the 5% HSD test. [Uppercases for net pot size, lowercases for seed cutting]

reported that cutting 1/3 of the tip of the seed bulb produced the highest fresh stalk weight for the Tajuk variety of shallots, namely 1126.67 g/plot or equivalent to 23.47 tons/ha. Meanwhile, the planting media volume treatment did not have a significant effect on the age of shoot emergence.

3.2. Vegetative Growth

Results of ANOVA reveal there was no significant effect on the combination of the size of the bulb cutting and the volume of the planting media on the vegetative growth (plant length and number of leaves), at all observation ages (21–49 DAP). The cutting of the seed bulbs showed a very significant effect on the vegetative growth (plant length and number of leaves) at 21–49 DAP (Table 2). The treatment of the size of the cutting of the seed bulbs of 1/4 part (P1) produced the longest length of the shallot plant aged 49 DAP and was significantly different from the treatment of the cutting of the seed bulbs of 1/3 part (P2), while the treatment of the size of the cutting of the seed bulbs of 1/4 part (P1) produced the largest number of leaves of the shallot plant aged 49 DAP and was significantly different from other treatments of the size of the cutting of the seed bulbs. Meanwhile, the treatment of the volume of the planting media did not show a significant effect except for the parameter of the length of the plant aged 49 DAP. Treatment without cutting the seed bulbs/control resulted in a slowdown in shoot growth due to the high levels of abscisic acid hormone (Meli, 2023). According to Purba *et al*. (2018), the treatment of cutting the bulbs by 1/3 of the shoot and with a planting density of 20 x 20 cm is the best treatment, which has a real effect on the parameters of plant height, number of leaves per clump, number of tillers per clump, production per sample and production per plot.

Table 2. Average vegetative growth of shallot plants in the treatment of seed bulb cutting size and planting media volume

Seed Cutting	Plant Length (cm)					Number of Leaves				
	21 DAP	28 DAP	35 DAP	42 DAP	49 DAP	21 DAP	28 DAP	35 DAP	42 DAP	49 DAP
P0 (No Cut)	12.8a	20.3a	25.1a	28.4a	32.5b	2.56a	3.33a	4.67a	5.33a	7.78a
P1 (1/4 Part)	18.3c	24.8d	29.3d	32.4d	32.6b	4.00b	5.11b	6.67b	7.56b	11.00b
P2 (1/3 Part)	17.2c	23.3c	27.7c	31.2c	31.2a	3.22ab	4.33ab	5.56ab	6.33a	9.44a
P3 (1/2 Part)	15.1b	21.7b	26.1b	29.8b	32.2ab	2.44a	3.44a	4.89a	6.00a	8.22a
HSD 5%	1.09	1.08	0.96	0.94	0.99	0.92	1.20	1.16	1.09	1.33
Net Pot Size										
U1 (10 cm)	15.6	22.3	27.3	30.2	31.5a	3.00	4.08	5.58	6.42	8.83
U2 (15 cm)	16.2	23.0	27.0	30.5	32.0b	3.17	4.08	5.42	6.42	9.33
U3 (20 cm)	15.7	22.3	26.9	30.6	31.4a	3.00	4.00	5.33	6.08	9.17
HSD 5%	tn	tn	tn	tn	0.53	tn	tn	tn	tn	tn

Note: Mean values followed by the same letter in the same treatment are not significant based on the 5% HSD test. tn = not significantly different.

3.3. Generative Growth

Based on the results of the 5% HSD analysis in the generative phase, the combination of seed tuber cutting size treatment and planting media volume gave a very significant effect on the parameters of harvested tuber weight per clump (Table 3). The combination of seed tuber cutting size treatment of 1/4 part with a planting media volume of 10 cm (P1U1) produced the highest tuber weight per clump and was significantly different from other treatment combinations, except for P1U2, P1U3, and P2U3. The treatment of seed tuber cutting size gave a very significant

effect on all generative phase parameters (Table 4). The treatment of seed tuber cutting size of 1/4 part was significantly different from the control in all generative phase parameters. The treatment of planting media volume gave a very significant effect on the parameters of the number of harvested tubers per box and the weight of harvested tubers per box. The treatment of 10 cm planting media volume was significantly different from the volume of other planting media in the parameters of the number of harvested tubers per box and the weight of harvested tubers per box. Furthermore, Beja (2020) stated that planting distance had a significant effect on the number of leaves, the number of bulbs per plant, the wet weight and dry weight of bulbs per plant, and the wet weight of bulbs per hectare.

Table 3. Effect of seed cutting size and net pot size on the weight (g) of harvested shallot bulbs per clump

Seed Cutting	Planting Media Volume		
	10 cm (U_1)	15 cm (U_2)	20 cm (U_3)
Uncut (Control) (P0)	29.75a	30.47ab	28.34a
1/4 Part (P1)	40.11d	39.48d	37.61cd
1/3 Part (P2)	35.82bc	36.22c	36.78cd
1/2 Part (P3)	33.35bc	33.09b	34.81bc
HSD 5%		3.04	

Note: Mean values followed by the same letter in the same treatment imply no significant difference based on the 5% HSD test. tn = not significantly different.

Table 4. Effect of seed cutting size and net pot size on the yield of shallots

Seed Cutting	Yield1	Yield2	Yield3	Yield4	Index Harvest	Age Harvest
P0 (uncut, Control)	4.44a	30.22a	323.24a	36.08a	0.81a	60.56d
P1 (1/4 Part)	7.67b	38.33c	345.55c	46.04d	0.85b	56.33a
P2 (1/3 Part)	6.44b	35.22bc	339.07bc	43.23c	0.84b	57.33b
P3 (1/2 Part)	5.78ab	34.00b	335.29b	40.48b	0.83ab	58.56c
BNJ 5%	1.73	2.64	4.37	1.64	0.02	0.69
Net Pot Size						
10 cm	6.00	45.50c	393.36c	41.87	0.83	58.00
15 cm	6.08	33.42b	348.89b	41.22	0.85	58.33
20 cm	6.17	24.42a	263.60a	41.28	0.83	58.25
BNJ 5%	tn	1.97	3.22	tn	tn	tn

Note: Mean values followed by the same letter in the same treatment are not significant difference based on the 5% HSD test. tn = not significantly different. Yield1 = bulbs/clump, Yield2 = bulbs/box, Yield3 = weight bulb harvest (g/box), Yield4 = weight above ground biomass (g/box)

The combination of 1/4 part bulb cutting size treatment and 10 cm planting media volume produced the highest harvest bulb weight per clump. Cutting seed bulbs is a planting technique to stimulate and accelerate plant growth. Cutting seed bulbs is essential in shallot cultivation because the function of cutting seed bulbs is to accelerate shoot growth, encourage the growth of side bulbs and shoots. Treatment without cutting seed bulbs/control resulted in slowing shoot growth due to the effect of high abscisic acid hormone content (Millah *et al*., 2024). The 1/4 part bulb cutting size treatment is the most effective size for cutting seed bulbs because the remaining food reserves are not reduced much so that the growth of shallot shoots that occurs is faster. This is supported by the opinion of Adnan *et al*. (2019), who stated that cutting the seed bulbs by 1/4 can speed up the harvest period of shallots. Cutting seed bulbs can cause plants to become stressed, this happens because there is injury to the bulbs so that the bulb cutting treatment can have an impact on the early growth of shallot plants (Wiliodorus, *et al*., 2020). Proper cutting of seed bulbs is considered to be able to influence the acceleration of the initial emergence of shoots and encourage the growth of shoots and side bulbs. Adnan (2019) stated that cutting 1/4 of the bulb can stimulate the synthesis of plant growth regulators without disturbing the shoot eyes so that it does not trigger slow growth and development of shallot plants.

The purpose of regulating the volume of the planting medium is to provide each plant with its own growing space so that it can grow well (Permana, 2021). In a hydroponic system, the volume of the planting medium is considered to have an influence in terms of competition for water and nutrients, which has an impact on the production of shallots.

High yields are supported by good generative growth. Prasetyo (2022) stated that the increase in the productivity of shallots is due to the density of plant leaves which produce high levels of plant photosynthesis and an increase in the amount of energy that can be used to help plant generative growth. The volume of the planting medium affects the plant population per box. The smaller or denser the volume of the planting medium used, the higher the level of plant population produced and vice versa, the larger/wider the volume of the planting medium used, the lower the level of plant population produced. This statement is in accordance with the results of this study on the parameter of bulb weight per box, where the net pot size of 10 cm produces a bulb weight per box of 393.36 g or an increase of 49.22% when compared to the treatment of a volume of planting media 20 cm. Using a small volume of planting media will provide a greater harvest of red onions, so that the harvest will be more profitable when compared to using a large volume of planting media. According to Karomah *et al*. (2024), it is produced in the roots and functions to stimulate the formation of lateral shoots on the apical shoot and regulate cell division, cell differentiation and apical dominance.

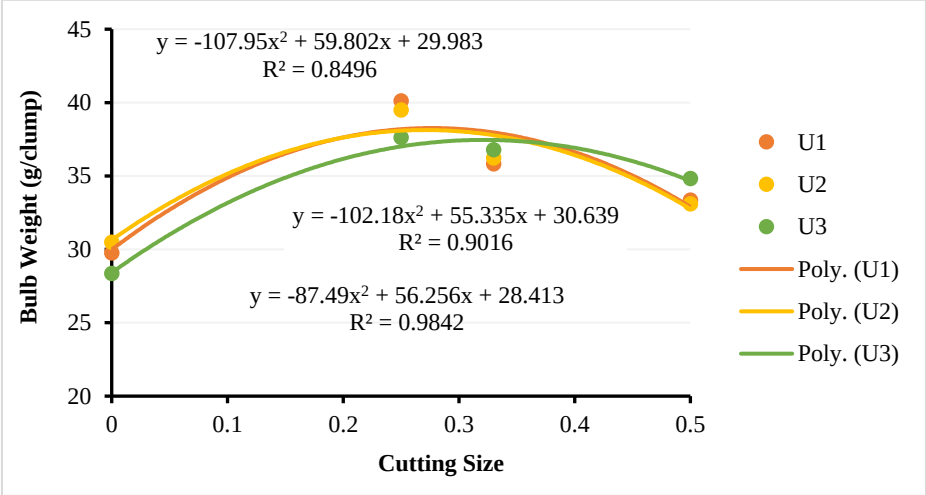


Figure 1. Quadratic relationship between seed cutting size and harvest weight per clump for each net pot size

Based on the quadratic regression analysis of the relationship between each treatment of planting media volume and the weight of harvested bulbs per clump in the treatment of seed bulb cutting size, it shows that the treatment of planting media volume U1 produces a line equation Y = -107.95x^2 + 59.802x + 29.983 (R^2 = 0.8496) with the highest seed bulb cutting size is 0.28 parts (between 1/4 to 1/3 part). This is supported by Haloho *et al*. (2019) where highest yield of shallots of Tajuk variety was found by using seed bulb cutting 1/3 part. If the cutting of seed bulbs is more than 0.28 parts, there will be a decrease in the weight of harvested bulbs per clump. The R^2 value in the line equation of 0.8496 indicates that around 85% of the variability in the size of seed bulb cutting in the quadratic regression model, it can be estimated that the maximum seed bulb cutting size that can be used in each treatment of planting media volume against the weight of harvested bulbs per clump of shallots.

4. CONCLUSION

The combination of 1/4 bulb cutting size treatment and 10 cm planting media volume resulted in the highest harvest bulb weight per clump. The 1/4 bulb cutting size treatment gave the highest value for all research parameters. The 10 cm planting media volume treatment gave the highest value for the number of harvest bulbs per box and the harvest bulb weight per box. The results of this study suggest using a 1/4 part cutting size for seed bulbs and a planting media volume of 10 cm or equivalent to 456.67 cm^3 to increase plant growth and yield.

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