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THE EFFECT OF SHALLOT EXTRACT AS NATURAL PLANT GROWTH REGULATOR AND CUTTINGS MATERIALS ON THE GROWTH OF WATER APPLE (*Syzygium aqueum* (Burm. fil.) Alston) STEM CUTTINGS

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ABSTRACT

The propagation of Syzygium aqueum by cuttings can meet the needs of the seeds in a short time and in large quantities. This study aimed to examine the effect of shallot extract as a natural plant growth regulator (PGR) and cutting material on the growth of Syzygium aqueum stem cuttings. The research was carried out from July to September 2022 at the Greenhouse and the Physiology and Plant Breeding Laboratory, Faculty of Animal Husbandry and Agriculture, Diponegoro University. This study used a factorial Completely Randomized Design (CRD) with two factors. The first factor was the PGR concentration of the shallots at four levels : K0 = 0%, K1 = 30%, K2 = 60%, and K3 = 90%. The second factor is the material of Syzygium aqueum cuttings, with three levels: A1 = tip, A2 = middle, and A3 = base. The results of this study showed that the PGR concentration of shallots had significant effect on the age of shoots. The cutting material had a significant effect on the age and number of shoots. The natural growth regulator concentration of shallots 30% (v/v) in the shoots gave the best results for the growth of Syzygium aqueum cuttings.

INTRODUCTION

Water apple (*Syzygium aqueum* (Burm. fil.) Alston) is a typical fruit of Demak because it is considered to have a different taste from other regions, so the demand for *S. aqueum* increases because it is often used as a souvenir. *S. aqueum* are widely produced in Demak because many farmers cultivate them (Arizqi et al., 2020). *S. aqueum* production in Indonesia in 2014 was 919,749 quintals, which increased to 983, 156 quintals in 2017. Demak Regency, especially Tempuran Village, has high production, reaching 7,930 quintals with a total of 8,274 trees per year (Nurnimah et al., 2020). The *S. aqueum* cultivated in Demak consist of various varieties, such as delima, citra, and deli hijau; however, citra is the most popular. This is because the *S. aqueum* variety Citra has a large fruit and is easy to care for (Hanifa dan Haryanti, 2016). The cultivation of *S. aqueum* is determined by the propagation of plants. *S. aqueum* plants can be propagated generatively and vegetatively. Generative propagation of *S. aqueum* plant is mediated by seeds, while vegetative propagation of *S. aqueum* plant can be vegetative propagated by cuttings, grafting, side grafting, and shoot grafting (Dule and Murdaningsih, 2017).

Cuttings are a method for vegetative propagation of plants that utilize plant parts. The process of cutting involves the separation of plant parts from the parent stem so that these plant parts can form roots and then grow into new individuals (Al Ayyubi et al., 2019). Each part of stem used in cutting has a different ability to form roots. Factors of plant age and cutting growth environment also influence the formation of roots on cuttings (Rokhani et al., 2016). The cutting material used affects the formation and growth of cutting roots. This is because each part of the cuttings has a different auxin content; for example, the tip has a higher auxin content than the center and base. (Putri et al., 2017). The provision of growth regulators from the outside is an effort to support root formation in plant cuttings. Growth regulators can help in root formation so that the nutrient absorption process becomes more effective (Tambunan et al., 2019).

Shallot is a natural plant growth regulator (PGR) from the auxin group that can stimulate root growth in cuttings. 100 g of shallot bulbs consists of 0.04 mg of riboflavin, which plays a role in stimulating the process of root initiation in stem cuttings and lateral roots; 30 mg of thiamin, which plays a role in accelerating cell division that occurs in root meristems and reducing the risk of failure in the growth of seedling cuttings; and other ingredients such as 80 – 85 g water; 1.5 g protein, 0.3 g fat, 9.3 g carbohydrates, and 20 mg niacin (Dule dan Murdaningsih, 2017). Shallots, which are natural PGR, contain various hormones that can stimulate root growth. The hormone content in shallot extract includes Indole-3-Acetic Acid (IAA) at 0.75 ppm; 2,4-Dichlorophenoxy Acetic Acid (2,4 D) at 2,82 ppm; a-Naphthalene Acetic Acid (NAA) at 0.77 ppm; and a 6-Benzyl Amino Purine (BAP) at 0.84 ppm (Nabila et al., 2020).

The use of shallot extracts can increase the growth of *S. aqueum* cuttings. According to Dule and Murdaningsih (2017), the use of 90% + 10% shallot extract has the best effect on stimulating root growth in water apple cuttings. According to Tambunan *et al*. (2018), application of natural PGR of shallot extract increased the root growth of water apple madu cuttings. According to Pradani *et al*. (2018), a shallot filtrate concentration of 87.30% gave the highest yield on the dry weight of water apple variety Citra shoots. This research was conducted with the aim to examine the effect of shallot extract as a natural plant growth regulator and cuttings material on the growth of water apple stem cuttings.

MATERIALS AND METHODS

Subjects

This research used water apple (*S. aqueum*) stems of the Citra variety obtained from the Katonsari Horticultural Seed Garden, Demak, Central Java, Indonesia.

Place and Time of Research

The research was carried out from July – September 2022 at the Greenhouse and the Physiology and Plant Breeding Laboratory, Faculty of Animal Husbandry and Agriculture, Diponegoro University

Tools and Materials

The tools used included pruning shears, blender juicers, measuring cups, cup glasses, plastic covers, envelopes, rulers, analytical balances, and ovens. The material used is the stem cuttings of the S. aqueum var. Citra, soil, husk, manure, shallots, and distilled water.

Research Procedures

This study used a factorial Completely Randomized Design (CRD) with two factors. The first factor was the natural growth regulator concentration of the shallots at four levels: K0 = 0%, K1 = 30%, K2 = 60%, and K3 = 90%. The second factor is the material of the *S. aqueum* cuttings with three levels: A1 = tip, A2 = middle, and A3 = base. The experiment consisted of 12 treatment combinations with 3 replications, and each polybag consisted of 5 plants.

The research stages included the preparatory stage, in which cuttings were taken from the main tree and then cut to a length of 15 cm according to the parts, namely the shoot, middle, and base. The base was cut at an angle of 45^o to provide a wider root area.

The PGR natural shallot solution was prepared by blending the shallots and filtering, and the resulting juice was dissolved in distilled water at different concentrations. *S. aqueum* stem cuttings were soaked in the PGR solution for 6 hours and then planted in the planting medium to a depth of 3 cm. Maintenance includes watering 1-2 times a day and weeding. Observations were made after the plants were 9 WAP, followed by processing the observed data.

The linear additive method that takes into account the value of each influence in this study is as follows:

$$\mathbf{Y_{ijk} = \mu + K_i + A_j + (KA)_{ij} + \varepsilon_{ijk}}$$

Note:

Y_{ijk} : observed values due to the influence of the i-th PGR concentration and the materials of the j-th cuttings and the k-th replicates

i : 1,2,3,4 (many variations of PGR concentration)

j : 1,2,3 (many variations of the materials of cuttings)

μ : common median (population mean) of the total treatment

K_i : additive effect of the i-th PGR concentration

A_j : additive effect of the materials of the j-th cuttings

$(KA)_{ij}$: the effect of the interaction between the i-th PGR concentration and the materials of the j-th cuttings

ε_{ijk} **:** the effect of experimental error caused by the influence of the concentration of the i-th natural PGR, the materials of the j-th cutting material, and the k-th replicate

The data obtained from the research results were analyzed statistically using Analysis of Variance (ANOVA) at a 5% level to determine whether there was a treatment effect, followed by an honest significant difference test (HSD) to determine differences in treatment.

RESULTS AND DISCUSSION

Percentage of live cuttings

The results of the 5% analysis of variance on the survival percentage of *S. aqueum* cuttings can be seen in **Table 1**.

Table 1. Percentage of live *S. aqueum* cuttings at 4 WAP and 9 WAP

The Materials of The Cuttings	Natural PGR Concentration of Shallot				Average
	0%	30%	60%	90%	
	4 WAP (%)				
Tip	53.33	86.67	46.67	86.67	68.33^{ab}
Middle	53.33	73.33	60.00	53.33	60.00^{a}
Base	100.00	93.33	80.00	73.33	86.67^{b}
Average	68.89	84.44	62.22	71.11	
	9 WAP (%)				
Tip	40.00	20.00	53.33	0.00	28.33
Middle	13.33	6.67	20.00	0.00	10.00
Base	20.00	6.67	0.00	0.00	6.67
Average	24.44	11.11	24.44	0.00	

Cuttings at the base had the most hight percentage at 4 WAP at 0% concentration. This was presumably because the base had a higher carbohydrate content. This is in accordance with Lesmana *et al*. (2018), who stated that the base has food reserves in the form of carbohydrates required for leaf growth and root formation in cuttings. A low percentage of surviving cuttings was found at natural PGR concentrations of shallots 90%, all cuttings died at 9 WAP. The death of cuttings occurs because the growing shoots use existing food reserves as photosynthetic material; however, until the food reserves run out, roots have not yet been formed. This is in accordance with the statement by Masli *et al*. (2019) that cuttings that grow shoots without growing roots cannot survive because the existing food reserves run out and cannot absorb nutrients. The condition of death of cuttings begins with the yellowing of the shoots until they dry out and then fall, and the stems also dry out. This is in accordance with Cahyadi *et al*. (2017), who stated that cutting death is characterized by dry leaves and stems.

Age of shoots appear

The results of the HSD test at the 5% level at the age of emergence of shoots of *S. aqueum* cuttings can be seen in **Table 2**.

Table 2. Age of shoots appear of *S. aqueum* cuttings

The Materials of The Cuttings	Natural PGR Concentration of Shallot				Average
	0%	30%	60%	90%	
Tip	3.67 [c]	4.67 [bc]	6.00 [abc]	9.00 [a]	5.83[b]
Middle	8.00 [ab]	7.67 [ab]	6.00 [abc]	8.00 [ab]	7.42[a]
Base	5.67 [abc]	6.67 [abc]	6.33 [abc]	5.33 [bc]	6.00[b]
Average	5.78[b]	6.33[ab]	6.11[ab]	7.44[a]	

Note: Different superscripts in average rows and columns show significant differences

Based on **Table 2**, natural PGR concentrations of shallots were significantly different from the material of the shoot cuttings but were not significantly different in the middle and base. The application of shallot ZPT concentrations to higher shoots causes the cuttings to appear longer. Based on Table 2, the fastest shoot emergence was found in the treatment with 0% natural ZPT concentration of shallots (K0), which interacted with the materials of the shoot cuttings, which was 3.67 DAP. This is presumably because endogenous hormones in the form of auxins are abundant in the shoots. Shoots have meristem tissue that is actively dividing and contains the hormone auxin, which plays a role in plant growth. This is in accordance with Sakti (2020), who stated that shoot cuttings have tissues that are still actively dividing and actively producing phytohormones in the form of auxins, which play a role in plant growth.

Number of shoots

The results of the 5% HSD test on the number of shoots of *S. aqueum* cuttings are shown in Table 3. Natural PGR concentrations in shallots did not significantly affect the number of shoots in *S. aqueum* cuttings. This is presumably because the concentration of auxin in the shallot extract was not optimal while the endogenous auxin content was already high; thus, the application of exogenous PGR did not significantly affect shoot growth.

Table 3. Number of shoots of S. aqueum cuttings in 4 WAP

The Materials of The Cuttings	Natural PGR Concentration of Shallot				Average
	0%	30%	60%	90%	
Tip	7.67	10.33	9.67	8.67	9.08[a]
Middle	13.00	12.67	11.33	8.00	11.25[b]
Base	32.67	22.33	14.33	13.33	20.67[b]
Average	17.78	15.11	11.78	10.00	

Note: Different superscripts in average columns show significant differences

Based on Table 3 the cutting material had a significant effect on the number of shoots of *S. aqueum* cuttings. This was presumably because the number of shoots at the base of the cuttings was greater than at the middle or tip. Shoots grow through buds; therefore, a large number of buds can produce buds in large quantities. This is in accordance with the opinion of Mayanti *et al*. (2021), which states that the number of shoots affects the growth of cuttings because shoots emerge from the buds; therefore, the more buds, the more shoots that appear. The concentration of auxin in the shallot extract is not optimal, and the endogenous auxin content is already high; thus, the application of exogenous growth regulators does not have a significant effect on shoot growth. This is in accordance with the opinion of Pujaningrum dan Simanjuntak (2020) that shoots continue to grow even though the concentration is not optimal because the high endogenous auxin content is sufficient for the growth and formation of plant organs.

Shoot length

The results of the 5% analysis of variance on the shoot length of *S. aqueum* cuttings can be seen in **Table 4**.

Table 4. Shoot length of S. aqueum cuttings in 4 WAP

The Materials of The Cuttings	Natural PGR Concentration of Shallot				Average
	0%	30%	60%	90%	
Tip	1.03	0.90	1.03	0.59	0.89
Middle	0.39	0.99	0.54	0.80	0.68
Base	0.71	0.82	0.70	0.65	0.72
Average	0.71	0.90	0.76	0.68	

Table 4 shows that the natural PGR concentrations of shallots and the materials of cuttings did not significantly affect the shoot length of *S. aqueum* cuttings. This is presumably because the auxin content in the absorbed shallots does not function optimally, as it does not interact with other growth regulators. Advinda *et al*. (2018) stated that a balanced auxin and cytokinin will promote growth, but if each move is not optimal. The absence of a significant effect on shoot length is also suspected, because the cuttings have not yet formed roots that function to absorb the water and nutrients used for plant metabolism.

Number of roots

The results of observations of *S. aqueum* cuttings on the number of roots are presented in a bar chart (**Figure 1**). Data on the number of roots are presented at the age of 9 WAP. The data is presented descriptively because there are many dead cuttings so that analysis of variance cannot be carried out.

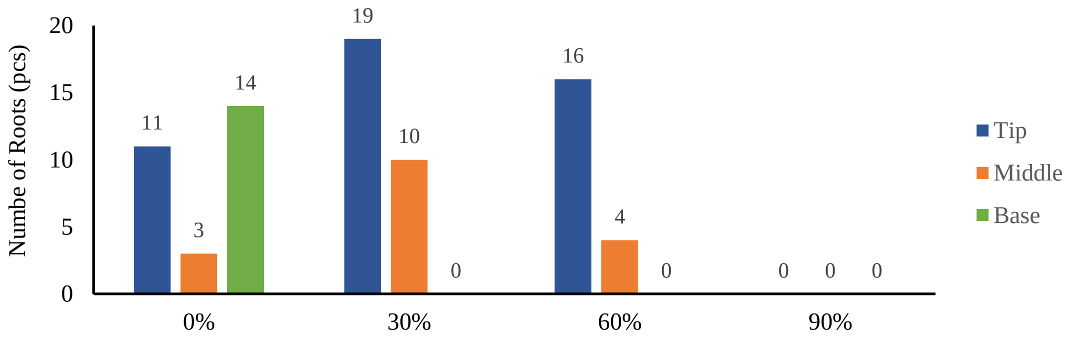

Figure 1. Number of Roots of *S. aqueum* Cuttings in 9 WAP

The highest number of roots is produced by natural PGR concentrations of 30% shallots in the shoots. This is presumably because the auxin content in 30% natural PGR of shallots is optimal for root growth in shoot cuttings. The application of optimal auxin concentrations can affect the ability of stems to grow roots, but concentrations that are too high can inhibit plant growth. The success of cuttings is characterized by the growth of roots and shoots. Cuttings that only grow shoots without growing roots will not last long because they do not have roots that absorb nutrients and water in the soil. This is in accordance with the statement of Masli *et al*. (2019), who stated that if cuttings only grow shoots and do not grow roots, they will not survive long because they run out of food reserves and are not matched by nutrient absorption.

Root length

The results of observations of *S. aqueum* cuttings on root length are presented in a bar chart (**Figure 2**). Data on root length are presented at the age of 9 WAP. The data is presented descriptively because there are many dead cuttings so that analysis of variance cannot be carried out. The longest root length was produced in the middle section, with a natural PGR concentration of 60%. This is presumably because the natural PGR concentration in shallots is 60%, containing auxin, which is optimal for root growth in the middle. The middle cuttings had a lower growth rate than did the shoots. The addition of auxin at higher concentrations is appropriate for application to parts of plants with lower growth rates. This is in accordance with the statement by Rokhani *et al*. (2016) that the addition of high concentrations of ZPT to parts with lower growth can help stimulate root growth.

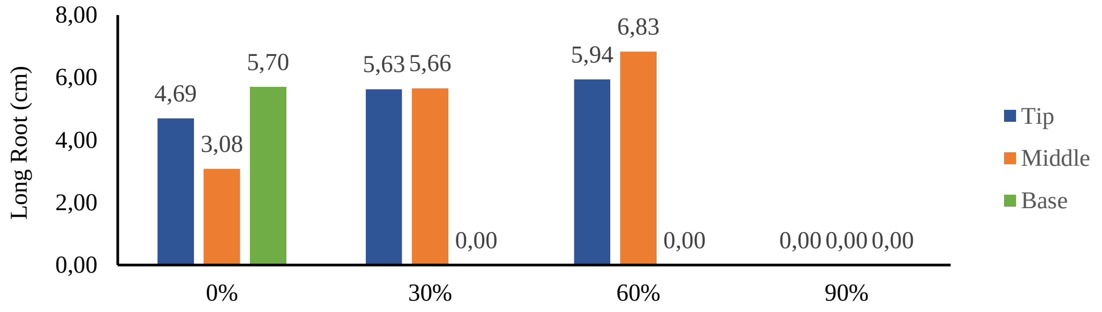

Figure 2. Root Lenght of *S. aqueum* Cuttings in 9 WAP

The process of root elongation is supported by environmental factors such as high and low temperatures. Pamungkas dan Puspitasari (2019) stated that temperatures that are too high can result in an uneven distribution of nutrients in plants, so that cell elongation and enlargement do not occur in a balanced way.

Shoot dry weight

The results of observations of *S. aqueum* cuttings on shoot dry weight are presented in a bar chart (**Figure 3**). Data on shoot dry weight are presented at the age of 9 WAP. The data is presented descriptively because there are many dead cuttings so that analysis of variance cannot be carried out.

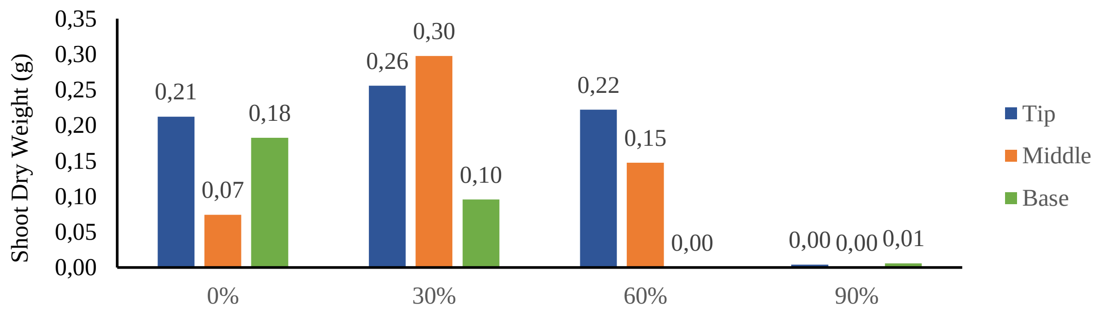

Figure 3. Shoots Dry Weight of *S. aqueum* Cuttings

The highest shoot dry weight was produced by the application of 30% shallot natural PGR in the middle (Figure 3). Shoot dry weight indicates the amount of organic compounds absorbed from the soil into the shoots. The heavier the dry weight of the shoots, the more organic compounds are absorbed; if the dry weight of the shoots is light, the absorbed organic compounds are small. This is in accordance with the opinion of Wiraswati dan Badami (2018), who stated that the dry weight of plants reflects the number of organic compounds in the form of water and carbon dioxide that are absorbed. The large number of leaves and long roots can increase the absorption of nutrients, so that the plant's wet weight and dry weight increase. Appropriate application of auxin can encourage xylem and phloem differentiation processes that affect the growth of roots and shoots. Murdaningsih *et al*. (2019) stated that auxin plays a role in the process of differentiation of xylem and phloem tissues, but if its application exceeds the capacity limit it will be negative and result in low growth capacity. Nutrient absorption is influenced by the presence of shoots and roots. Shoots play a role in photosynthesis during plant growth, while roots play a role in absorb nutrients as raw materials for photosynthesis. A large number of shoots and long roots can increase nutrient absorption and increase the wet and dry weights of the plant. This is in accordance with the statement of Suyanti *et al*. (2013) in Mayanti *et al*. (2021) that the photosynthesis process is supported by the large number of shoots as well as the number and length of roots which play a role in the absorption of nutrients thereby increasing the wet weight and dry weight of the plant.

Root dry weight

The results of observations of *S. aqueum* cuttings on root dry weight are presented in a bar chart (**Figure 4**). Data on root dry weight are presented at the age of 9 WAP. The data is presented descriptively because there are many dead cuttings so that analysis of variance cannot be carried out.

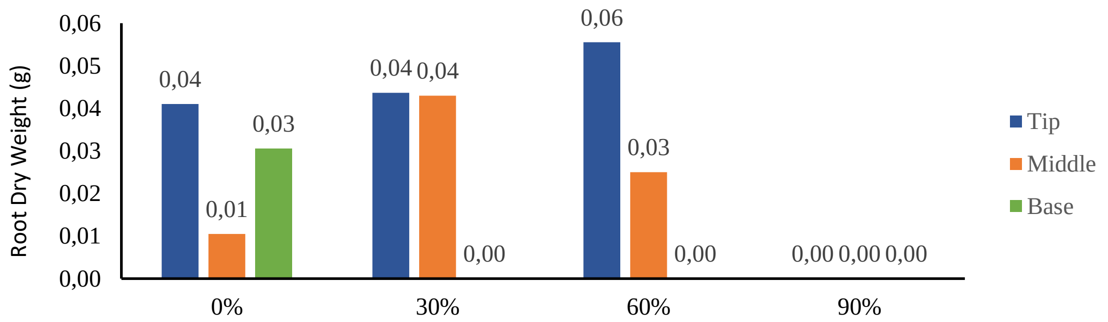

Figure 4. Root Dry Weight of *S. aqueum* Cuttings in 9 WAP

The highest root dry weight was obtained when a natural PGR concentration of 60% shallot was applied to the shoots (Figure 4). Plant growth occurs because the process of absorbing and transporting nutrients from the roots to the leaves proceeds well. Nutrients are used as photosynthetic materials to produce photosynthates as root growth materials that affect root dry weight. This is in accordance with the statement of Handayani *et al*. (2020) that an indication of a smooth photosynthetic process is the production of photosynthate, which affects the dry weight of the roots. The root growth on stems is influenced by the presence of growth regulators. Shallot regulatory substances contain auxins, which play a role in cell elongation and root formation in cuttings. Sofwan *et al*.

(2018) stated that red onion is a natural PGR with auxin content, which plays an important role in cell elongation and root growth in cuttings. The dry weight of the roots was also affected by the number of roots formed on the cuttings. A small number of roots causes little nutrients to be absorbed, so that the dry weight of the roots is low. This is in accordance with the statement of Siskawati *et al*. (2013) in Rahmadani *et al*. (2017)which states that the absorption of nutrients and water content in roots is influenced by the number of roots, when the number of roots is small then only a small amount can be absorbed.

CONCLUSION

The results of this study, it was shown that a natural PGR concentration of 60% shallots could help in the growth of *S. aqueum* cuttings and cuttings materials that are suitable for use as shoot tips.

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