

Breaking Dormancy of Shallot (*Allium ascalonicum* L.) Bulb Using Hydrogen Peroxide

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Article History:

Received : 05 September 2023

Revised : 17 January 2024

Accepted : 30 January 2024

Keywords:

Bulb,
Dormancy,
Hydrogen peroxide,
Shallot.

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ABSTRACT

Shallot bulbs have a dormancy period, so they must be stored for 3-4 months. This condition inhibits the acceleration of planting, which has a short time, so efforts are needed to accelerate the dormancy period by using hydrogen peroxide. This research was carried out from June to July 2023 at the Screen House, Teaching Farm, Faculty of Agriculture, Hasanuddin University. The study was arranged in a randomized block design with a two-factor factorial design. The first factor is the variety of Mentas, Rubaru, Violetta 2 Agrihorti, Kramat 1, and Ambassador 3 Agrihorti. The second factor is hydrogen peroxide concentration with three levels, namely 0%, 10% and 20%. The results showed that breaking the dormancy of shallot bulbs using hydrogen peroxide at a concentration of 20% effectively triggered the process of bulb growth in the various shallot varieties tested, marked by an increase in the percentage of rooted and sprouted bulbs. The Rubaru and Mentas varieties had an excellent response to 20% hydrogen peroxide immersion, indicated by a shorter rooting and sprouting time, compared to other varieties and concentrations of hydrogen peroxide. Therefore, hydrogen peroxide with a concentration of 20% can be used to break dormancy in shallot bulbs. However, further studies are needed on growth and production in the field and the quality and safety of shallot bulbs.

1. INTRODUCTION

The need for shallot (*Allium ascalonicum* L.) increases because their role cannot be replaced with other products. The Ministry of Agriculture has determined shallots as one of Indonesia's mainstay commodities; apart from being much needed by the community, they also affect national inflation. Shallot has a strategic role and many benefits as a seasoning, complementary ingredients, medicines, and others. In addition to having many benefits, shallots are also included in the horticultural commodity group, which often experiences price fluctuations every year, so shallots are included in seven essential commodities because they significantly affect inflation if supplies in the community are lacking (Kustiari, 2017). Thus, shallots become the highest contributor to inflation in May 2023, from the food component, with inflation of 7.92%, and shallots contributing 0.03% to national inflation.

Shallots have various benefits. Apart from being used as a spice in the kitchen, they are also beneficial for treating body health (herbs). As an herb, it benefits health because shallots contain anthocyanins, which can protect the body from heart disease, cancer, and diabetes. In addition, shallots are also beneficial for treating skin health because they are rich in antioxidants (Syam'un et al., 2021). The various uses of shallots in everyday life affect the demand, which tends to

increase yearly. Thus, the government launched a multifold production program (PROLIGA) to meet domestic and export needs covering Southeast Asian (ASEAN) countries such as Vietnam, Thailand, Malaysia, and Singapore.

Indonesia's shallot production in 2021 will reach 2,004,590 tons. The harvested area is 194,570 ha, with the largest production area namely Central Java. Shallots are also an Indonesian commodity, with fresh and processed export volumes reaching 47,955 tonnes (BPS, 2022). Household consumption of shallots reached 790,000.63 tons (BPS, 2022). Every year, there is an increase in the consumption of shallots, apart from the result of the increasing population, also due to the increasing variety of processed product industries that require raw materials for shallots.

In July 2022, shallot bulb supplies for seeds became scarce and difficult to find, resulting in very high price spikes ranging from Rp48,000/kg to Rp50,000/kg, once reaching Rp80,000/kg so that many farmers discouraged them from planting and replaced it with other commodities (Ari, 2022). In addition, bulbs that are used as seeds need to be stored for 2-4 months because they experience a dormancy period (Syam'un *et al.*, 2017). During the dormancy period, shallot bulbs cannot grow if planted or can grow but are very diverse. Dormancy can be divided into three stages, namely endodormancy (regulated by physiological factors), ecodormancy (regulated by environmental factors), and paradormancy, which is influenced by growth inhibition from other parts of the plant (Lang *et al.*, 1987).

The standard physical way to break dormancy in shallot bulbs is by cutting the top ends of the bulbs (Arifin *et al.*, 1999). Cutting to break dormancy requires labor, which takes a long time and is expensive. Another alternative that can be used to break the dormancy of shallot bulbs is natural and synthetic growth regulators. Growth regulators are easier to implement, and there is no risk of physical damage from cutting. However, using synthetic growth regulators is not only challenging to obtain, it is also costly. Therefore, it is necessary to look for other ways that are easier to obtain and low cost, namely by using hydrogen peroxide.

Hydrogen peroxide is a reactive oxygen species (ROS) that plays a role in plant biochemical and physiological processes (Nurnaeimah *et al.*, 2020). Furthermore, D'Angelo & Goldman (2019) suggested that using hydrogen peroxide to break dormancy in onion bulbs has a significant effect. In addition, it was found that hydrogen peroxide, with a concentration of 20%, could significantly accelerate the growth of onion shoots and roots. Research conducted by Aguilla *et al.* (2016) also found a positive effect of using hydrogen peroxide in breaking dormancy of bud on vine rootstock. Based on the findings above, this study aims to evaluate and analyze dormancy breaking using various concentrations of hydrogen peroxide on several varieties of shallot bulbs cultivated in Indonesia.

2. MATERIAL AND RESEARCH METHODOLOGY

2.1. Research Location

This research was conducted from June to July 2023, at the Screen House, Teaching Farm, Faculty of Agriculture, Hasanuddin University.

2.2. Experimental Design

The study was arranged in a randomized block design (RBD) with a two-factor factorial design. The first factor was variety (V), which consisted of five varieties, namely: Mentas (v1), Rubaru (v2), Violetta 2 Agrihorti (v3), Kramat 1 (v4), and Ambassador 3 Agrihorti (v5). The second factor is hydrogen peroxide (P), which consists of three concentrations consisting of 0% (p0), 10% (p1), and 20% (p2). From the two treatment factors, 15 treatment combinations were obtained, with three replicates.

2.3. Medium Preparation

The planting medium used is a mixture of soil, compost, and rice husk biochar, with a ratio of 1:1:1 (V/V/V). The media were mixed evenly and then put in a rectangular plastic container (500 cm³) that had been perforated. The weight of the planting medium in each container is made uniform (each container weighs about 500 g).

2.4. Soaking and Planting Process

The bulbs used were one week after harvest. The bulb size ranges from 5 to 7 g. One-third of the top of the bulb is cut using a knife. After that, place the bulbs upside down in a plastic container and pour the hydrogen peroxide solution according to the treatment orders until half of them are submerged. Soaking was done for two hours. After soaking, the bulbs are washed using clean water and then planted in a planting container with planting media. Each planting container contains six bulbs that have been treated (Figure 1).



Figure 1. Soaking bulbs

2.5. Data Collection and Analysis

Observation of various growth parameters was carried out for 30 days. Parameters observed included the percentage of rooted bulbs (%), the percentage of sprouted bulbs (%), time to rooting (d), time to sprouting (d), and time from rooting and sprouting (d). The percentage of sprouted and rooted bulbs was calculated on the 30th day. Time to rooting indicates a certain period for bulbs to grow their roots, while time to sprouting indicates a certain period for bulbs to grow their shoots. Time from rooting and sprouting shows the difference in days between when the roots appear and when the shoots appear. Parameters of time to rooting and sprouting were calculated when 50% of bulbs had grown roots and leaves as long as 1 cm. The data collected was then analyzed using ANOVA, and if there was a significant effect, then tested further with the DMRT test with $\alpha = 0.5$. Processing data using RStudio software version 4.2.1.

3. RESULTS AND DISCUSSION

3.1. Analysis of Variance Results

The application of hydrogen peroxide on several shallot varieties significantly or very significantly affected all observed parameters (Table 1). The interaction between varieties and the concentration of hydrogen peroxide application was affected the time to rooting, time to sprouting, and time from rooting to sprouting. Individually, variety significantly affects the time to sprouting, time from rooting to sprouting and the percentage of rooted bulbs. Then, the concentration of hydrogen peroxide significantly affected the parameters of time to sprouting, time from rooting to sprouting, percentage of sprouted bulbs, and percentage of rooted bulbs.

Table 1. Effect of variety and hydrogen peroxide on various parameters

Parameters	V	HP	V × HP
Time to rooting (d)	tn	tn	**
Time to sprouting (d)	**	**	**
Time from rooting to sprouting (d)	**	**	**
Percentage of rooted bulbs (%)	*	**	tn
Percentage of sprouted bulbs (%)	tn	**	tn

Note: Variety (V), Hydrogen Peroxide (HP), (**) Fvalue>0.01 and (*) Fvalue>0.05 on ANOVA with α 0.05.

3.2. Time to Rooting, Sprouting, and Time from Rooting to Sprouting

Combination between variety and hydrogen peroxide affect the time to rooting, time to sprouting and time from rooting to sprouting (Table 2). In observing the time to rooting, it was noted that the combination of treatments between Rubaru variety and without the application of hydrogen peroxide had the slowest average time to rooting, namely on the 9th day, which was not significantly different from the treatment of Violetta 2 Agrihorti without the application of hydrogen peroxide, Mentas without the application of hydrogen peroxide, and the Ambassador 3 Agrihorti variety with 10% hydrogen peroxide. In contrast, the combination between Mentas and Rubaru varieties combined with 20% hydrogen peroxide had the fastest average time to rooting, namely on day 2.33. Ambassador 3 Agrihorti without applying hydrogen peroxide, it was recorded that not a single bulb had roots during 30 days of observation.

Similar to the observation of the time to rooting, the observation of the time to sprouting was also affected by the two combination treatments. The combination of treatments between Ambassador 3 Agrihorti varieties with 10% hydrogen peroxide had the slowest average time to sprouting, namely on day 21.67, significantly different from all other treatments. Then, the combination of the Rubaru variety with 20% hydrogen peroxide was recorded to have the fastest average time to sprouting, namely on the 11th day. Furthermore, not all treatment combinations succeeded in growing the shoots. The five test varieties without the application of hydrogen peroxide showed no growth symptoms during the 30 days of observation.

The interaction between varieties and hydrogen peroxide affects the time from rooting to sprouting. Ambassador 3 Agrihorti variety with 10% hydrogen peroxide recorded the most prolonged time from rooting to sprouting, namely 17 days, significantly different from all other treatment combinations. The combination of treatments between the Violetta 2 Agrihorti variety with 10% hydrogen peroxide, the Violetta 2 Agrihorti variety with 20% hydrogen peroxide and the

Table 2. Interaction effect between variety and hydrogen peroxide on time to rooting, sprouting, and time from rooting to sprouting

Combination Treatment	TR (d)	TS (d)	TRS (d)
Mentas + 0% H ₂ O ₂	6.33 abc	0.00 h	0.00 f
Mentas + 10% H ₂ O ₂	3.00 bcd	12.33 ef	9.33 e
Mentas + 20% H ₂ O ₂	2.33 cd	11.33 fg	9.00 e
Rubaru + 0% H ₂ O ₂	9.00 a	0.00 h	0.00 f
Rubaru + 10% H ₂ O ₂	3.00 bcd	12.00 efg	9.00 e
Rubaru + 20% H ₂ O ₂	2.33 cd	11.00 g	8.67 e
Violetta 2 Agrihorti + 0% H ₂ O ₂	8.00 ab	0.00 h	0.00 f
Violetta 2 Agrihorti + 10% H ₂ O ₂	4.00 bcd	12.67 e	8.67 e
Violetta 2 Agrihorti + 20% H ₂ O ₂	3.33 bcd	12.00 efg	8.67 e
Kramat 1 + 0% H ₂ O ₂	3.00 bcd	0.00 h	0.00 f
Kramat 1 + 10% H ₂ O ₂	3.67 bcd	17.00 c	13.33 c
Kramat 1 + 20% H ₂ O ₂	3.33 bcd	14.67 d	11.33 d
Ambassador 3 Agrihorti + 0% H ₂ O ₂	0.00 d	0.00 h	0.00 f
Ambassador 3 Agrihorti + 10% H ₂ O ₂	4.67 abcd	21.67 a	17.00 a
Ambassador 3 Agrihorti + 20% H ₂ O ₂	3.67 bcd	19.00 b	15.33 b

Note: means followed by the same letter are not significantly different for $p \leq 0.05$ according to Duncan multiple range test. (TR) time to rooting, (TS) time to sprouting, and (TRS) time from rooting to sprouting.

Rubaru variety with 20% hydrogen peroxide, each had the closest time from rooting to sprouting, namely 8.67 days. Furthermore, not all treatment combinations succeeded in growing roots and shoots, so several treatment combinations had no data.

The findings we obtained from observations were that the five shallot varieties had the potential to take root and sprout when treated with hydrogen peroxide. The fastest growing average age of roots was 2.33 days in the Mentas variety with 20% hydrogen peroxide application and the slowest 9 days in the Rubaru variety without hydrogen peroxide application. Applying hydrogen peroxide with a concentration of 20% can accelerate root growth compared to without the application of hydrogen peroxide. In fact, in untreated bulbs, no growth activity was recorded at all, especially in the Ambassador 3 Agrihorti variety.

It was observed that shoot growth was slower than roots. Several treatments recorded no shoot growth activity, especially in the treatment without hydrogen peroxide, in all varieties tested. The fastest average time to sprouting was 11 days on the Rubaru variety with 20% hydrogen peroxide application, and the slowest was 21.67 days on the Ambassador 3 Agrihorti variety with 10% hydrogen peroxide application. The emergence of these shoots is an essential indicator in observing the breaking of dormancy. Even though it was only 10 days after harvest, the shallot bulbs soaked in 20% hydrogen peroxide were able to show signs of growth. Shallots must be stored for months to be used as seeds. The shallot bulbs of the Lembah Palu variety are stored for at least two months before they can be planted (Maemunah *et al.*, 2015). In addition, the dormancy period of shallot bulbs ranges from 2 to 3 months (Triharyanto & Purnomo, 2020).

3.3. Percentage of Rooted and Sprouted Bulbs

In observing the percentage of rooted bulbs, the interaction between the two treatment factors did not give a significant effect, but individually, each treatment factor provided a significant influence (Table 3). Of the five varieties observed, the Rubaru variety had the highest percentage of rooted bulbs, namely 72.22%, significantly different from the other four varieties. Then, the Ambassador 3 Agrihorti variety had the lowest average percentage of rooted bulbs, namely 48.15%.

Separately, several concentrations of hydrogen peroxide affected the percentage of rooted bulbs. Applying hydrogen peroxide with a concentration of 20% recorded the highest average percentage of rooted bulbs, namely 90%, significantly different from other concentrations. This treatment also had a significant difference from the control, which has the lowest average percentage of rooted bulbs, namely 13.33%. In observing the percentage of bulbs sprouting, the interaction between the two treatment factors did not have a significant effect. However, individually, the hydrogen peroxide treatment had a significant effect, while varieties had no effect. The application of hydrogen peroxide with a concentration of 20% recorded the highest average percentage of bulbs sprouting, namely 60%, which was not significantly different with a concentration of 10%, namely 54.45%. Then, without hydrogen peroxide treatment, only 6.67% of bulbs sprouted.

Table 3. Effect of variety and hydrogen peroxide on percentage of rooted and sprouted bulbs

Variety	PRB (%)	PSB (%)
Mentes	55.56 b	42,59 a
Rubaru	72.22 a	44,44 a
Violetta 2 Agrihorti	51.85 b	38,89 a
Kramat 1	55.56 b	35,19 a
Ambassador 3 Agrihorti	48.15 b	40,74 a
Hydrogen Peroxide	PRB (%)	PSB (%)
0%	13.33 c	6.67 b
10%	66.67 b	54.45 a
20%	90.00 a	60.00 a

Note: means followed by the same letter are not significantly different for $p \leq 0.05$ according to Duncan multiple range test. (PRB) percentage of rooted bulbs and (PSB) percentage of sprouted bulbs.

The provision of hydrogen peroxide can reduce the storage duration of shallot bulbs so that farmers can plant earlier, or the frequency of cultivation can be increased throughout the year. A study by [Sinaga *et al.* \(2021\)](#) found that storing shallot bulbs for 4 to 6 months still showed good growth, where several varieties were tested, namely Bima Brebes, Katumi, Kuning, Pikatan, Trisula, Pancasona, and Mentas. This research shows that the maximum storage of shallot bulbs is five months because their growth potential has decreased at the age of 6 months. [Ansar *et al.* \(2022\)](#) found different things in the storage of shallot bulbs, as seeds with a storage duration of 30 days after harvest could be used as planting material. However, the storage period of 60 days had a shorter average growing time of 3.97 days.

This study also revealed that root growth in dormant shallot bulbs is not always followed by shoot growth; even if it is followed by shoot growth, the difference in days from rooting to sprouting is long. Root growth is not enough to indicate breaking dormancy because shoots that become leaflets are essential organs in the assimilate formation process, so the appearance of these two organs must mark the break-in shallot bulb dormancy. Even so, the emergence of roots will always be faster than the emergence of shoots. Hydrogen peroxide treatment is effective in stimulating the growth of roots and leaves. There is a tendency to increase the growth of roots and shoots due to the increasing concentration of hydrogen peroxide given.

The role of hydrogen peroxide as a dormancy-breaking agent has been demonstrated in plant botanical seeds. Research conducted by [Liu *et al.* \(2010\)](#) found a link between hydrogen peroxide and ABA and GA regulation in *Arabidopsis* seeds. It is known that hydrogen peroxide can regulate the ABA catalytic process and promote GA biosynthesis. It was previously known that ABA and GA have an essential role in the germination and growth of plant seeds ([Ali *et al.*, 2022](#); [Tuan *et al.*, 2018](#)). Hydrogen peroxide is also known to regulate ethylene, jasmonic acid, and salicylic acid in the germination process ([El-Maarouf-Bouteau *et al.*, 2015](#)).

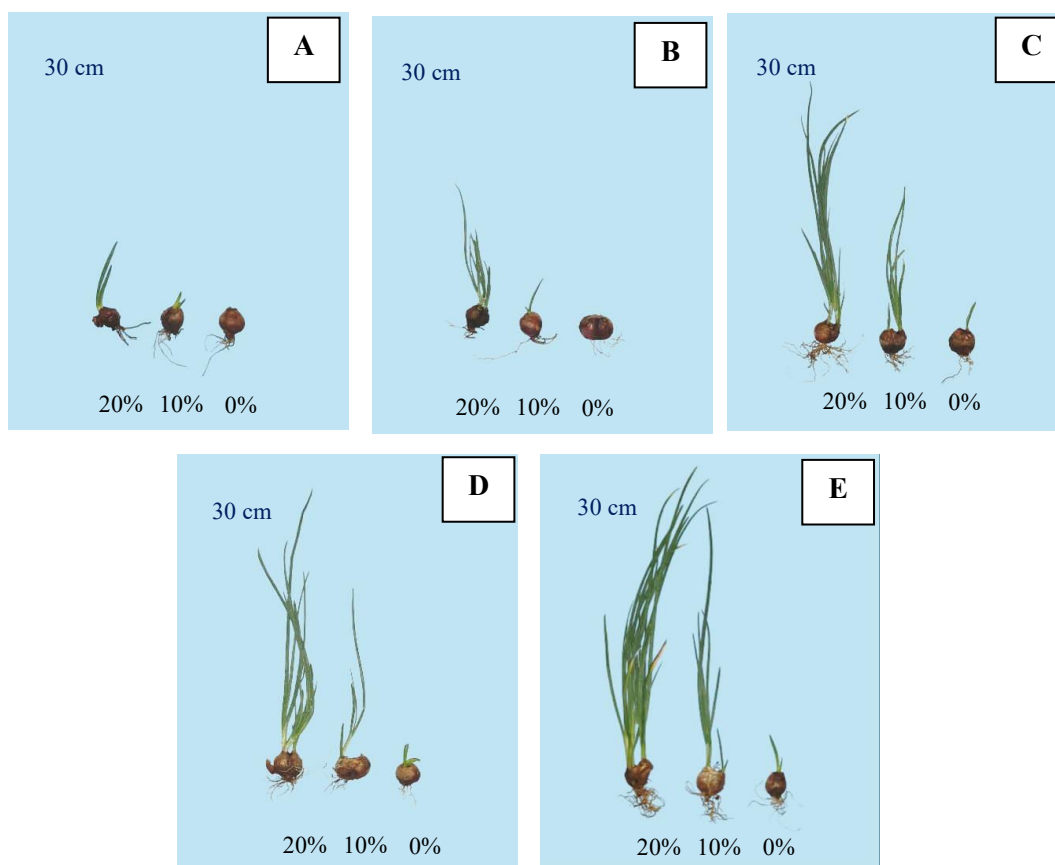


Figure 2. Morphology of bulbs seedlings at 30 days old. (A) Ambassador 3 Agrihorti (B) Kramat 1, (C) Violetta 2 Agrihorti, (D) Rubaru, and (E) Mentes.

In general, the five shallot varieties observed had differences in each observed parameter, but the time to rooting and sprouting could be increased by the application of hydrogen peroxide. The performance of the tested bulbs can be seen in Figure 2. The consequence of bulbs not having enough shelf life is that they cannot grow and are susceptible to soil-borne pathogenic diseases that travel through the bulbs. Tarigan *et al.* (2019) stated that ready-to-use shallot bulbs had been stored for at least 2 to 4 months, depending on the variety. This study also revealed that bulbs without a storage period were more susceptible to pathogens such as *Peronospora destructor* and *Fusarium oxysporum*. Furthermore, research conducted by Comadug & Simon (2002) found that shallot bulbs that were only stored for 5 days had the highest mortality rate of 29.4%, while the bulbs stored for 65 days had the lowest mortality of 2.32%. In addition, the longer the storage time, the faster the plants form bulbs. Furthermore, the economic analysis also favored the bulbs, which had a shelf life of 65 days, because there were many deaths in the bulbs, which had a shelf life of 5 days.

4. CONCLUSIONS

Breaking the dormancy of shallot bulbs using hydrogen peroxide at a concentration of 20% effectively triggers the process of bulb growth in the various shallot varieties tested, marked by an increase in the percentage of bulb rooting and sprouting. The Rubaru and Montes varieties had an excellent response to 20% hydrogen peroxide immersion, indicated by a shorter time from rooting to sprouting, compared to other varieties and concentrations of hydrogen peroxide. Therefore, hydrogen peroxide with a concentration of 20% can be used to break dormancy in shallot bulbs. However, a more in-depth study of growth and production in the field is needed, as well as the quality and safety of the bulbs produced.

ACKNOWLEDGMENT

The author would like to thank the head of the Teaching Farm, Faculty of Agriculture, Hasanuddin University, who had provided research land.

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