The Effect of 1-Methylcyclopropene Treatment on Shallot Physiological Process and Weight Loss

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Abstract. Fresh-handling treatment using 1-Methylcyclopropene (1-MCP) has been proven effective in controlling respiration process of various horticultural commodities, helping to extend shelf-life for storage and transportation purpose. The effect of 1-MCP treatment on shallot (Allium ascalonicum L.) had yet been studied. It was expected to delay maturity, prevent negative effects of ethylene, and inhibit senescence by blocking ethylene receptor. The objective of this research was to study the effects of 1-MCP on the physiological process and weight loss of shallot. The research was preceded by the determination of 1-MCP dosage, i.e. 0.5, 1, 1.5, 2, and 2.5 g. The best dosage was then used in the 1-MCP treatment on shallot. The duration of treatment was 0, 6, 18, 30, and 42 hours. Observation of physiological process was done to respiration rate (CO2) and ethylene production rate. Weight loss was also observed. The best dosage of 1-MCP was 2.5g with the content of 437.78 ppm. On the main experiment, 18 hours of treatment had the lowest but statistically the same respiration rate compared to other duration, and statistically different with the shallot without treatment. For ethylene production rate, 18 hours of treatment had the best effect and statistically different with the ones without treatment. Shallot with different treatments also showed insignificant different on weight loss, but were significantly different with shallot without treatment. Without treatment, the quality of shallot was dropped after 70 days of storage, while all the quality of treated shallot was maintained up to 84 days. It was concluded that 1-MCP treatment was effective in controlling respiration rate and ethylene production rate. However, different duration of 1-MCP treatment had not showed different effects on shallot physiological process and weight loss.

1. Introduction

Shallot (Allium ascalonicum) is a strategic commodity with high economic value in Indonesia. It is consumed as cooking ingredients, vegetable and herbs for health [1]. The active compounds of shallot had been reported in modern epidemiological research that proved its health benefits in large scale [2]. However, it is mainly used as cooking spice due to its unique aroma and flavour, which is brought by its volatile flavour compounds [3]. Allium sp is a group of onions that is rich in sulfur compounds in its essential oil and produces unique organoleptic characteristics [4].

The high utilization of shallot in daily consumption causes its high demand throughout the year in nearly all areas in Indonesia. The perishable property of shallot is a challenge in maintaining its postharvest quality. This challenge has caused low availability of shallot during certain seasons or events. This leads to drastic increase of shallot price which further influences the economic inflation.
Moreover, according to Directorate General of Horticulture in 2017, the production of shallot is localized in only several provinces, more than 70% in Java, 10% in Nusa Tenggara and only less than 20% is spread in Sumatera and other provinces. This uneven distribution causes the needs to extend the shelf-life of shallot, in order to allow it to be transported to far areas with less or no production of shallot.

1-Methylcyclopropene (1-MCP) is an ethylene inhibitor that has been studied extensively over the years [5, 6, 7, 8, 9, 10, 11]. These studies use 1-MCP as single treatment and/or combination treatment with other treatments such as temperature and atmosphere modification/control. The results were promising for the use of 1-MCP in modifying ethylene production behaviour in various horticultural produces. It was proven effective in controlling respiration process, therefore extending shelf-life [12] and may be beneficial for long storage and transportation purpose. However, while these studies had focused on climacteric and non-climacteric fruits and vegetables, research on the effect of 1-MCP on shallot is still lacking.

The objective of this research was to study the effects of 1-MCP on the physiological process and weight loss of shallot.

2. Method

2.1 Materials

Shallot was obtained from one of the largest shallot production center, Brebes, West Java. The shallot was harvested a day before the treatments were applied. The harvesting age was approximately 70 days after planting. The shallot was sorted to separate the damaged ones. Sorted shallot was cleaned from dirt and soil before treatment.

The 1-Methylcyclopropene used was commercially available (EthylBloc™), with concentration of 1-MCP of 0.014% in a 2.5 g packaging. Exposure of 1-MCP was carried out in air-tight glass chambers (250 ml), one for each treatment.

2.2 Determination of 1-MCP dosage and treatment on shallot

The research was preceded by the determination of 1-MCP dosage, i.e. 0.5, 1, 1.5, 2, and 2.5 g. Each dose of 1-MCP was put in the glass chamber, which bottom had been layered with wet cotton (modification of Watkins, 2006). The samples were left for 0, 6, 18, 30, and 42 hours with three repetition. The gas was then injected into Gas Chromatography for observation. The significantly highest peak showed on the graph was then used as the treatment dosage for shallot. Results were statistically analyzed with Analysis of Variance and followed by Duncan’s Multiple Range Test using SAS 9.1.3 software.

The same application was done with shallot. 3 kg of shallot was put in the glass chamber and was exposed with 1-MCP for 0, 6, 18, 30, and 42 hours, with controlled temperature of 21-25°C. All treatments were done in two repetition. Afterwards, shallot was displayed in storage shelves with the same temperature.

2.3 Analyses

Weight loss, respiration rate (CO₂) and ethylene production rate were observed every week. The formulation used in weight loss calculation was:

\[
\text{Weight loss} = \frac{W_{\text{initial}} - W_{\text{final}}}{W_{\text{initial}}} \times 100\%
\]

where:

- \( W_{\text{initial}} \) = weight of shallot before treatment
- \( W_{\text{final}} \) = weight of shallot after treatment

The analysis of respiration rate (CO₂) was done using CO₂ GCH-2018. The analysis was preceded by measuring the standard of respiration using CO₂ meter working in open air in the storage room for 5
minutes. Afterwards, shallot was weighed for 500 g, put into a jar. CO₂ was measured by injecting the CO₂ meter into the jar through a hole corked with a rubber stopper. CO₂ was observed for 5 minutes.

For the determination of ethylene production (AOAC 2005), 3 cloves of shallot were weighed, put in the glass chamber with 1 ml of acetylene. The chamber was then closed tightly and left for 1 week. Ethylene was obtained using syringe through a rubber stopper on the chamber lid. Ethylene production was analyzed using Gas Chromatography (GC).

\[
\text{Ethylene production} = \frac{\text{sample area}}{\text{standard area}} \times 8 \text{ ppm} \times \frac{V \text{ bottle}}{W \text{ sample}}
\]

where:
- sample area = area of samples shown by GC
- standard area = area of standard sample shown by GC
- \( V \text{ bottle} \) = volume of bottle used in analysis
- \( W \text{ sample} \) = weight of sample

3. Results and Discussion

3.1 Determination of 1-MCP dosage and treatment on shallot

In the experiment it was shown that 2.5 g of EthylBloc™ in the glass chamber gave the significantly highest 1-MCP compared with other dosages (Figure 1). On the other hand, 2 g of EthylBloc™ was significantly different compared with 1 g, but not significantly different with 0.5 and 1.5 g. This result was then used in the determination of 1-MCP dosage for treatment on shallot, where 2.5 g of EthylBloc™ was selected.

![Figure 1](image_url)

Figure 1. The average of 1-methylcyclopropene measured from different weight of EthylBloc™.

The range of dosage used in ethylene inhibition studies is considerably wide. More or less \( 10^{-1} \) ppm of 1-MCP was used in this study, while only \( 10^{-4} \) to \( 10^{-3} \) ppm was used in [13] and [14] for grape, in [15] and [16] for cherry, and in [17] for pomegranate. Meanwhile, [18] used approximately \( 10^{-1} \) ppm of 1-MCP and [19] used 100 ppm for pitaya or dragon fruit. Because the dose of 1-MCP for treatment on shallot had not been reported in our knowledge, and considering the small amount of shallot and the small size of glass chamber being used in this study, it was decided to apply a rather high dosage of 1-MCP to allow more accurate calculation and measurement.

3.2 Shallot physiological process and weight loss after 1-MCP exposure

It was reported in previous studies that biochemical changes occur in plants after harvest, which in the case of onions group, changes were found in hormone levels, carbohydrates, polyphenols and organic acid contents. The physiology of the bulbs is influenced by these changes, causing sprouting,
respiration rate and weight loss, which further will affect the quality of the bulbs. It is important that these changes are minimised to maintain the bulbs quality, flavour and health benefiting properties [20]. Hormone levels, carbohydrates, polyphenols and organic acid contents were not observed in this study. However, it was expected to be detected from the influence of these changes to respiration rate and weight loss.

3.2.1 Respiration rate (CO$_2$)

Respiration rate of onions group in storage is very dependent on temperature. Onions group have a very low respiration rate during storage compared to other fruit and vegetables [21], although may vary between species and cultivars [22].

![Figure 2. Respiration rate (measured as CO$_2$) of shallot during storage after different duration of 1-MCP exposure.](image)

As shown in Figure 2, shallots with 1-MCP exposure were observed to have relatively suppressed respiration rates, especially during the last weeks of storage. On the other hand, the trend of respiration rate of untreated shallot in the study showed to be slightly increasing during storage. This observation was confirmed statistically, where untreated shallot had a significantly higher respiration rate average during storage compared to the treated shallot, and the lowest respiration rate was shown by shallot with 18 hours exposure of 1-MCP (Table 1). This finding is in line with the observation reported by Chope et al. [22], which stated that onion respiration is increasing during storage due to the metabolic rate of the bulbs.

| Duration of 1-MCP Exposure (hours) | Total Respiration Rate Average ± SD (ppm) |
|-----------------------------------|--------------------------------------------|
| 0                                 | 523.12 ± 113.65                             |
| 6                                 | 452.07 ± 86.94                              |
| 18                                | 426.62 ± 66.99                              |
| 30                                | 495.34 ± 73.37                              |
| 42                                | 502.62 ± 69.67                              |

Note: numbers followed by different letter(s) show significant difference at $\alpha = 0.05$. 

Table 1. Respiration rate (CO$_2$) of shallot during storage.
3.2.2 Ethylene production

Ethylene is a hormone which modulates plant development and growth, and involves in many aspects of plant development from seed germination to ripening [23]. Ethylene is reported to be produced in response to many triggers, i.e. biotic pathogen attack and abiotic stresses such as wounding, drought stress, hypoxia, ozone and cold temperatures [24].

During observation on storage, sample of untreated shallot showed high increase during 5th to 7th week and started to decrease afterwards (Figure 3). This trend occurred in all the treated samples, but with less amount of ethylene production. Sample that had been exposed to 1-MCP for 6 hours showed the least ethylene production during 0 to 7 weeks, and that of 18 hours showed the least ethylene production during the last couple weeks.

![Figure 3. Ethylene production of shallot during storage after different duration of 1-MCP exposure.](image)

Statistically, difference was only found between treated and non-treated shallot, and no significant difference was found among different durations of 1-MCP exposure (Table 2). As non-climacteric bulbs, the *Allium* sp. produce very low levels of ethylene and therefore reducing exogenous ethylene levels with ethylene inhibition agents was presumed ineffective, hence the lack of studies [20].

| Duration of 1-MCP Exposure (hours) | Ethylene production Average ± SD (ppm) |
|-----------------------------------|----------------------------------------|
| 0                                 | 5.08 ± 8.65                            |
| 6                                 | 2.95 ± 1.45                            |
| 18                                | 2.91 ± 0.71                            |
| 30                                | 4.23 ± 4.59                            |
| 42                                | 3.17 ± 3.96                            |

Note: numbers followed by different letter(s) show significant difference at $\alpha = 0.05$.

While 1-MCP treatment on shallot had not been reported yet, the treatment had been experimented on onions (*Allium cepa* L.). 1-MCP had been found to be effective in suppressing sprout growth in onion. Exposure of onions with 1-MCP for 24 hours reduced sprout growth when subsequently stored at 4 or 12°C for 100 and 50 days, respectively [25]. It was also found that 1-MCP can have differential effects depending on temperature [12, 20].
3.2.3 Weight loss

The longer storage duration of shallot, the more it experiences weight loss. Weight loss increases mostly caused by high transpiration rate [22]. The weight loss of shallot during storage in the study is shown in Table 3.

While 1-MCP gave significantly different result on the weight loss of shallot, the duration of 1-MCP exposure duration did not give significant different. This may be caused by several factors that, regarding weight loss of shallot, were more influential compared to ethylene inhibition.

Getahun et al [26] observed that the time of harvesting and the season in which the shallot was stored had significant influence on the quality of shallot bulb quality and yield after storage. A study on other Allium sp, i.e. onion [27] concluded that lower moisture content of the bulbs had increased the dry matter content of onion gradually, regardless the drying or curing duration. It was also found that slight increase in dry matter was due to loss of moisture from the outer surface whereas the reduction corresponded well to hydrolysis of fructans and termination of the dormancy period where the bulbs began to sprout [20]. Moreover, through storage, fructans were gradually hydrolysed to fructose, increasing dry matter [28].

| Duration of 1-MCP Exposure (hours) | Total Weight Loss Average ± SD (%) |
|-----------------------------------|-----------------------------------|
| 0                                 | 34.71± 11.89                      |
| 6                                 | 26.91± 11.15                      |
| 18                                | 26.82± 10.18                      |
| 30                                | 29.21± 12.45                      |
| 42                                | 25.07± 12.63                      |

Note: numbers followed by different letter(s) show significant difference at α = 0.05.

4. Conclusion

1-MCP treatment was effective in controlling respiration rate, ethylene production rate, and preventing excessive weight loss in shallot during storage. 18 hours of exposure was the most optimum duration for 1-MCP treatment on shallot. It was concluded that 1-MCP (EthylBloc™) showed the potential to prolong the shelf life of shallot.

5. References

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