THE EFFECT OF COCONUT WATER AND MORINGA LEAF EXTRACT ON THE GROWTH AND YIELD OF SHALLOTS

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Abstract. In Central Sulawesi Province, Indonesia, there are shallots as raw materials for the fried onion industry with the best quality. However, the main problem of productivity is still low (< 4 tons ha^{-1}) as a result of the use of small bulbs (seeds) with low plant growth regulator (PGR) content to support their growth. Therefore, it is necessary to provide effective PGR in increasing the growth and yield of shallots, especially the Lembah Palu shallot variety (LPSV). One of the PGRs is natural PGR, including coconut water (CW) and moringa leaf extract (MLE). Both of these materials are pretty much available around the research site. This study aimed to know the effect of CW and MLE at various concentrations on the growth and yield of LPSV. This research was experimental and arranged in a randomized complete block design (RCBD) and three replications. The treatment was that the natural PGR types consisted of two kinds, i.e., CW and MLE. Each natural PGR type consisted of five concentration levels, i.e., 20, 40, 60, 80, and 100%. The results showed a significant interaction between PGR types and concentration affecting the growth and yield of shallots, including tillers number, tubers number $clump^{-1}$, the tuber fresh weight $clump^{-1}$, and tubers dried weight ha^{-1}. The CW application at a concentration of 40% as a natural PGR showed the best effect to increase the growth and yield of shallots, while MLE up to a concentration of 100% was still a trend towards increasing. The research findings show that the PGR type of CW at a concentration of 40% provides the highest growth and yield of shallots. Besides, it is necessary to conduct further research on various sources of other natural PGR.
Keywords: *natural PGR, Lembah Palu, concentration, fried onion*

Introduction

Central Sulawesi, as one of the provinces in Indonesia, has the potential as a development area for shallots cultivation. One of the varieties that have enormous potential to be developed is the LPSV, one of the local types. It results from a natural cross between local onions, widely cultivated in the Lembah Palu area. This shallot has a high adaptation, suitable for planting in lowlands < 400 m above sea level (ASL) with dry climates and low rainfall. The tubers are slightly white, oval, and relatively small (Rabinowitch and Currah, 2002).

The productivity of LPSV was generally lower than that of other types of shallots, while the Bima, Brebes, and Philippine varieties can reach 20 tons ha^{-1}. In comparison, the LPSV only had a productivity potential of 9.7 tons ha^{-1}, but at this farmer's level, it only ranges from 4-5 tons ha^{-1} so that it can increase. The low productivity of LPSV caused the need for raw materials in the fried onion industry in Palu city, and its surroundings could not be fulfilled continuously. The low shallots productivity of LPSV

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was due to the application of cultivation techniques that are not according to the recommended technical standards (Pasigai et al., 2016).

Applying natural PGR is one way of improving cultivation techniques to get a good yield because it can affect plant growth. The provision of appropriate growth regulators in composition and concentration can lead to better plant growth and development. Some PGRs are synthetic, but some are natural. The PGRs can be mixed to stimulate plant growth and development (Manurung et al., 2020). The CW and MLE were alternative natural PGR sources that can be utilized. The CW contained auxins, various cytokinins such as trans-zeatin and kinetin, gibberellin, and ABA. In addition, CW contains indole-3-acetic acid (IAA) and is the main auxin in plants (Yong et al., 2009).

Higher concentrations contained more inorganic elements and growth hormones than low concentrations. MLE effectively improves cereal forages' growth and productivity under stressful environments of salinity and aridity (Abusuwar and Abohassan, 2017). The CW produced higher protocorm multiplication than those without CW. Application of 15% CW + 0.5 mg L^{-1} Thidiazuron had higher plantlet numbers and a greater percentage of normal putative polyploidy of *Phalaenopsis amabilis* (Aziz et al., 2019). The MLE at a concentration of 3% provided maximum growth potential at low temperatures for moringa seeds. The content of mineral nutrients, antioxidants, and growth hormones can increase the number of branches (92%), leaves (141%), leaf blades (61%), leaf chlorophyll (51%), and b (71%) and the total chlorophyll content (54%), membrane stability index (60%) and phenolic leaf content (78%) in moringa seedlings (Batool et al., 2019).

Application of MLE 10% at two weeks after emergence and every two weeks after that significantly increased growth of plant height, shoot length, fresh weight and dry weight of shoot, and yield components like the number of grains cob^{-1}, 100-grain weight, and grain weight $plant^{-1}$ in maize plant (Biswas et al., 2016). Leaf of *Moringa oleifera* Lam. and other plant parts may contain potential novel properties, namely secondary metabolites (Carbungco et al., 2017). The MLE performance of sprayed at tillering, jointing, and booting stages was the best as it produced the growth and yield of wheat (Jhilik et al., 2017). Applying MLE increased cumulative yield and nutrient uptake by Sudan grass compared with the untreated (Merwad, 2017).

The highest values of straw and grain yield, quality yield, and nutrient uptake by plants were obtained with 4% of MLE, while the lowest values were obtained with untreated plants. Also, the highest percentage increase in grain yield of 71 and 88% was recorded from the treatment of 4% MLE in the first and second seasons, respectively (Merwad and Abdel-Fattah, 2016). Therefore, foliar applications of 6% MLE aqueous extract can be used effectively to improve fruit set, yield, fruit weight, firmness, color, soluble solids content, vitamin C, anthocyanin content, and antioxidant activity of "Hollywood" plum (Thanaa et al., 2017).

Ethanolic extract of drumstick leaf contained flavonoids total 71.9 mg quercetin equivalent g^{-1}, alkaloids total of 3 mg quinine equivalent g^{-1}, tannin as 24.7 mg tannic acid equivalent g^{-1}, and saponin as 44.4 mg g^{-1}. Therefore, drumstick leaf extract's minimum inhibition concentration (MIC) is 3.125%, while the minimum bactericidal concentration (MBC) was 6.25%. Therefore, the drumstick leaf can be used as an alternative natural antibacterial agent, which can be applied especially in aquaculture (Kenconojati1 and Rukmana, 2019).

The CW has many applications. For example, coconut water is traditionally used as a plant tissue culture/micropropagation growth supplement. The wide applications of CW

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can be justified by its unique chemical composition of sugars, vitamins, minerals, amino acids, and phytohormones (Yong et al., 2009). For example, morphogenesis of watermelon can be obtained from explants in vitro germinated seedlings on a culture media supplemented with CW (Krug et al., 2005).

CW has identified various beneficial biochemicals such as vitamins, minerals, proteins, sugars, and enzymes. Phytohormones, particularly cytokinins, were one of the most interesting components reported in CW. Different maturation levels of CW were found to affect the cytokinin concentration, higher at coconut's immature and mature stages (Lazim et al., 2015). The IAA content decreased while the T-ZR content increased with fruit maturity. Treatments with CW from fully matured dried fruits produced the largest and the most vigorously growing plantlets (Mintah et al., 2018).

The concentration of plant growth hormones (auxin, cytokinin, gibberellins) in CW changes with fruit maturation. It has affected the in-vitro growth of potato plantlets significantly. Therefore, it can be used instead of synthetic PGR in media for potato micropropagation (Muhammad et al., 2015). The CW significantly promoted hypocotyl elongation. Germination of seeds in liquid MS medium supplemented with 0.1 mg L^{-1} kinetin before callus initiation slightly delayed callus induction but did not significantly affect callus size. At two weeks of culture, kinetin significantly decreased the length of hypocotyls (Tantasawat et al., 2010).

Based on previous literature studies, it turns out that no one has applied natural PGR and its concentration on shallots cultivation, especially LPSV. However, applying PGR with an optimal concentration was crucial to accelerate plant growth, especially in LPSV. Therefore, testing types and concentrations of natural PGR in the study can contribute to an increase in the growth and yield of LPSV.

Based on the literature review above, this study aimed to know the effect of CW and MLE at various concentrations on the growth and yield of LPSV.

Materials and methods

Study area

This research was conducted in Oloboju Village, Sigi-Biromaru District, Sigi Regency, Central Sulawesi, Indonesia. The research was carried out from May to August 2019. The location of the study is at coordinates S 1°01'14.6532" and E 119°59'29.0256"; a place altitude of 120 m above sea level (ASL), with a daily average temperature of 30.8°C and air humidity of 62.3%.

Experimental design

This research was arranged in an RCBD with three replications. The treatment was the natural PGRs types, which consisted of two kinds, i.e., CW and MLE. Each natural PGR type consisted of five concentration levels, i.e., 20, 40, 60, 80, and 100%. Therefore, this study needed 30 experimental plots.

Research procedures

Procedure to make the natural PGR solution from CW. The CW was used from young green coconuts. The fruit's skin was smooth and slippery, free from pests and diseases, and had an endosperm that was still soft and thin. Furthermore, the water from this coconut was used as a stock solution with a concentration of 100%. Furthermore,

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making MLE was done by taking young moringa leaves that were a maximum of 35 days old since they appear as leaf buds. Cleaned moringa leaves were added to water in a ratio of 1:1 (100 g of moringa leaves were added to 100 ml of water), then blended until smooth. Furthermore, MLE was filtered into a container as a stock solution with a concentration of 100%. Dilution was carried out for each concentration of young CW and MLE according to each treatment.

The population was all shallot plants in the experimental plot. The sample was part of the number and characteristics possessed by the population observed as a representative of the population of 119 plants in each experimental plot. The sample plants were determined systematically by selecting the observed plants, as many as five clumps of plants per experimental plot.

Soil cultivation was preceded by clearing the land from the remains of previous plants. Apart from that, the first plowing of the land was carried out using a tractor. The second hijack that took place was done one week later. The beds were made according to the experimental plot with a size of 255 cm (length) × 105 cm (width) × 25 cm (height). Shallot seedlings should be free of pests and diseases with relatively the same weight (uniform), then the outermost skin that has dried and the remaining roots are cleaned.

The young coconut that was used is a green color with the characteristics of smooth skin color, free from pests and diseases, and a soft and thin endosperm. Meanwhile, MLE was made by refining the material and giving it water in a ratio according to the treatment. Young moringa leaves were used for the maximum age of 35 days since appearing as leaf buds. The cleaned moringa leaves were added with water in a ratio of 1:1 (100 g of moringa leaves were added with 100 ml of water), then blended until smooth. Furthermore, the MLE was filtered into a container to obtain a stock solution of MLE with a concentration of 100%. To get each concentration of MLE in the treatment was necessary to do dilution. After completing the preparation of the planting media, prepared RGR for the treatment of planting material. Shallot seeds ready for planting were soaked according to the treatment set for 90 minutes. After that, the seeds were dried.

The bed experiment was covered with black silver plastic mulch. The plant spacing in the bed used 15 cm × 15 cm. The seeds were immersed in the planting hole and planted upright, like turning a screw, until the tuber's end appeared flat with the soil surface. Watering was done by sprinkles. The beds were watered until wet evenly every three days or as needed. Embroidering was done at the beginning of growth until the age of 7 days after planting by replacing dead or rotten seeds with spare seeds that have been prepared. Weeding was done with the aim of clearing weeds so that there was no competition with onion plants. Weeding was done manually by removing the growing grass according to conditions in the field. Weeding activities were carried out in conjunction with soil tilling. Tilling aimed to weaken the soil, supporting early plant growth and making it easier for tubers to develop optimally. Fertilizers were used, namely bokashi goat manure and inorganic fertilizers of NPK (15:15:15). Bokashi was given before planting by mixing the fertilizer with the soil.

Meanwhile, NPK was given when the plants were two weeks after planting at a dose of 2 $g.plant^{-1}$. Pest and disease control depends on fielding conditions. Therefore, manual control (picked) and discarded was done when an egg and leeks show signs of attack. Pest control was also carried out by spraying insecticides of the ingredient

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Karbosulfan 200, with a concentration of 10 g L^{-1} of water, and fungicides with ingredient Propineb 70%, with a concentration of 5 g L^{-1} of water.

Harvesting was done when the plant's age of ≥70 DAP. The plants had shown signs of being ready to harvest. The tubers have been lifted above the soil surface. 80–90% of the leaves had turned yellow, and the stems had fallen. Harvesting was done by pulling the shallot plants and their tubers, then cleaning them from the remaining soil that sticks.

Measurement

Observations of plant growth and yield of LPSV included tillers number, tubers number clump^{-1}, tuber fresh weight clump^{-1}, and tubers dried ha^{-1}.

Statistical analysis

The data observations were analyzed with analysis of variance (ANOVA) at 5% significant level using IBM SPSS Statistics 23 software. In addition, differences between treatments were compared using Duncan′s new multiple range test (DMRT) at 5% significant level.

Results

The results of ANOVA on tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight ha^{-1} showed no significant between the PGR types of CW and MLE. The CW concentration significantly affected all of the parameters observed, but the MLE concentration had no significant effect. The results of ANOVA can be represented in *Table 1*.

Table 1. *The results of ANOVA on tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tubers dried weight ha^{-1}*

Source of variation	Degree of freedom	Mean square				F table 5%
		Tillers number	Tubers number clump^{-1}	Tubers fresh weight clump^{-1}	Tubers dried weight ha^{-1}	
Block	2	13.617 *	3.7476 *	113.724 *	22.690 *	3.55
Treatment	9	1.829 ns	1.4555 ns	22.297 ns	4.404 ns	2.46
Type PGRs	1	0.432 ns	1.5687 ns	21.505 ns	4.256 ns	4.41
CW	4	3.424 *	2.0558 *	26.203 *	5.175 *	2.93
MLE	4	0.583 ns	0.8269 ns	18.589 ns	3.670 ns	2.93
Error	18	0.963	0.6469	8.668	1.661	

Remarks: * = Significant at the 5% significance levels, and ns = Not significant at 5% significance level.

The results of DMRT at the 5% on tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight ha^{-1} can be seen in *Table 2*.

Table 2 shows that CW at 40% concentration is the best treatment combination and yielded the maximal tiller number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight ha^{-1}.

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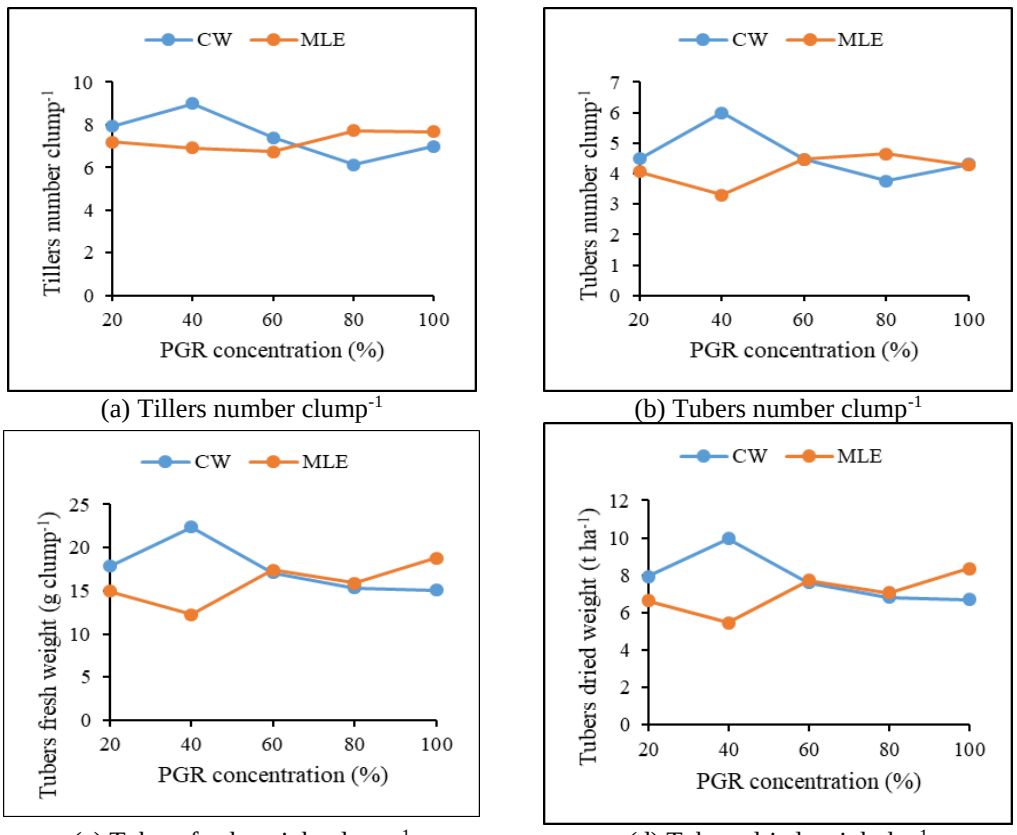
Table 2. *Tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight ha^{-1}*

PGR types	PGR concentration (%)	Tillers number clump^{-1}	Tubers number clump^{-1}	Tubers fresh weight (g clump^{-1})	Tubers dried weight (tons ha^{-1})
CW	20	7.93 ab	4.49 a	17.87 ab	7.94 ab
	40	9.00 b	5.99 b	22.40 b	9.96 b
	60	7.40 a	4.47 a	17.07 ab	7.59 ab
	80	6.13 a	3.76 a	15.33 a	6.81 a
	100	7.00 a	4.32 a	15.07 a	6.70 a
MLE	20	7.20 p	4.06 p	14.93 p	6.64 p
	40	6.93 p	3.30 p	12.27 p	5.45 p
	60	6.73 p	4.47 p	17.40 p	7.73 p
	80	7.73 p	4.65 p	15.87 p	7.05 p
	100	7.67 p	4.27 p	18.80 p	8.36 p
CW		7.49 x	4.62 x	17.55 x	7.79 x
MLE		7.45 x	4.15 x	15.85 x	7.05 x

Remarks: the average number of treatment combinations in the column followed by the same letter is not significantly different based on DMRT at 5% significance level.

The effect of PGR type and concentration on tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tubers dried weight ha^{-1} are presented in *Figure 1*.



(a) Tillers number clump^{-1} (b) Tubers number clump^{-1}

(c) Tubers fresh weight clump^{-1} (d) Tubers dried weight ha^{-1}

Figure 1. *The effect of PGR type and concentration on (a) tillers number, (b) tubers number clump^{-1}, (c) tubers fresh weight clump^{-1}, and (d) tubers dried weight ha^{-1}*

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Figure 1 shows a difference in the trend between the two PGR types. The CW showed an increase of the tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tubers dried weight ha^{-1} from concentrations of 20-40%, but after a 40% continues to decrease to 100% concentration. It was different in MLE. There was a decrease in tillers number from a concentration of 20-60%, but after 60% continued to increase until 100%. Therefore, tubers of number clump^{-1}, fresh weight clump^{-1}, and dried weight ha^{-1} decreased from 20-40%, but after a concentration of 40% increased to 100%. Low concentrations of 20-40% for CW increased the growth and yield. In contrast, MLE was better at 60-100% higher concentrations.

Discussion

This experiment found that CW at a concentration of 40% resulted in the highest tillers number. CW is a natural ingredient that contains various hormones, such as auxins and cytokinins, which can stimulate plant growth, thus increasing the growth parameters of the shallots. The CW is a natural PGR that can provide the most optimal results for the growth of the LPSV. Auxins can promote plant growth and development and work by stimulating the apical meristem cells of the stems and shoots (Tarigan et al., 2017). The combination of auxins and cytokines stimulates cell division and influences the differentiation pathway (Widiastoety, 2014). Supported by Sukamta (2015), CW concentration significantly affected the number of roots, shoot length, number of leaves, and leaf area. The concentration of 40% was the best treatment for pepper cutting compared to 20, 60, 80, and 100%. The CW contains PGR and other compounds that can stimulate and accelerate roots, shoots, and leaves. The content of cytokinins in CW can stimulate cell division in leaf primordia. Cytokinins can accelerate the formation of leaves and promote cell division and enlargement (Wulandari and Mukalina, 2013). Auxins can stimulate the work of cytokinins in cell division and enlargement.

The CW at a concentration of 40% produced the highest number of tubers clump^{-1}. The CW contains several hormones that play an important role in plant growth. Following the general nature of the relatively low concentrations hormone, it can stimulate cell division and elongation, thereby affecting plant growth and development. Young et al. (2009) stated that CW contains auxins, trans-zeatin, kinetin, gibberellin, and ABA. The CW also contains indole-3-acetic acid (IAA), the main auxin in plants. IAA is a weak acid that is synthesized in the meristematic region located in the shoot shoots and then transported to the root tips in the plant. Cytokinins are also found in coconut water cell division and thus promote rapid growth. One of the advantages of CW was that it produced sufficient plant cell proliferation without increasing the number of unwanted mutations.

The tubers of fresh weight clump^{-1} and dried weight ha^{-1} can be influenced by the leaf area number as the source of the photosynthesis process, producing dry plant matter. In addition, it was also affected by the tillers number, which directly forms the tubers number as a sink for stored photosynthetic products. Therefore, increasing the tillers number will increase the tubers number clump^{-1}, and a high rate of photosynthesis will increase the tubers yields plant^{-1} and ha^{-1}. The CW is a natural hormone that contains auxins, cytokinins, and gibberellin. The CW can provide the most optimal results for the shallot's yield because it contains many hormones needed for plant

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growth. Natural PGR types contain different growth hormones and minerals so they will have different effects on the growth and yield of LPSV plants.

For this reason, natural PGR was needed to obtain maximum results, which contained a complete type of hormone with a concentration that needs plant growth and development, including the shallots. The main cause, the highest parameter, was found in the application of young CW because the content of growth regulators in coconut water was more complex. As indicated by Indriani et al. (2014), the complexity of hormone and mineral content in CW resulted in a significant multiplication effect compared to the addition of BA synthetic hormone.

Conclusion

Based on the results and discussion, there was a significant interaction between PGR types and concentration on the growth and yield of shallots, including tillers number, tubers number clump^{-1}, the tuber fresh weight clump^{-1}, and tubers dried weight ha^{-1}. The CW application at a concentration of 40% as a natural PGR showed the best effect to increase the growth and yield of shallots, while MLE up to a concentration of 100% was still a trend towards increasing. The research findings show that the PGR type of CW at a concentration of 40% provides the highest growth and yield of shallots. We suggest that it is necessary to conduct further research with various sources of other types of natural PGR.

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