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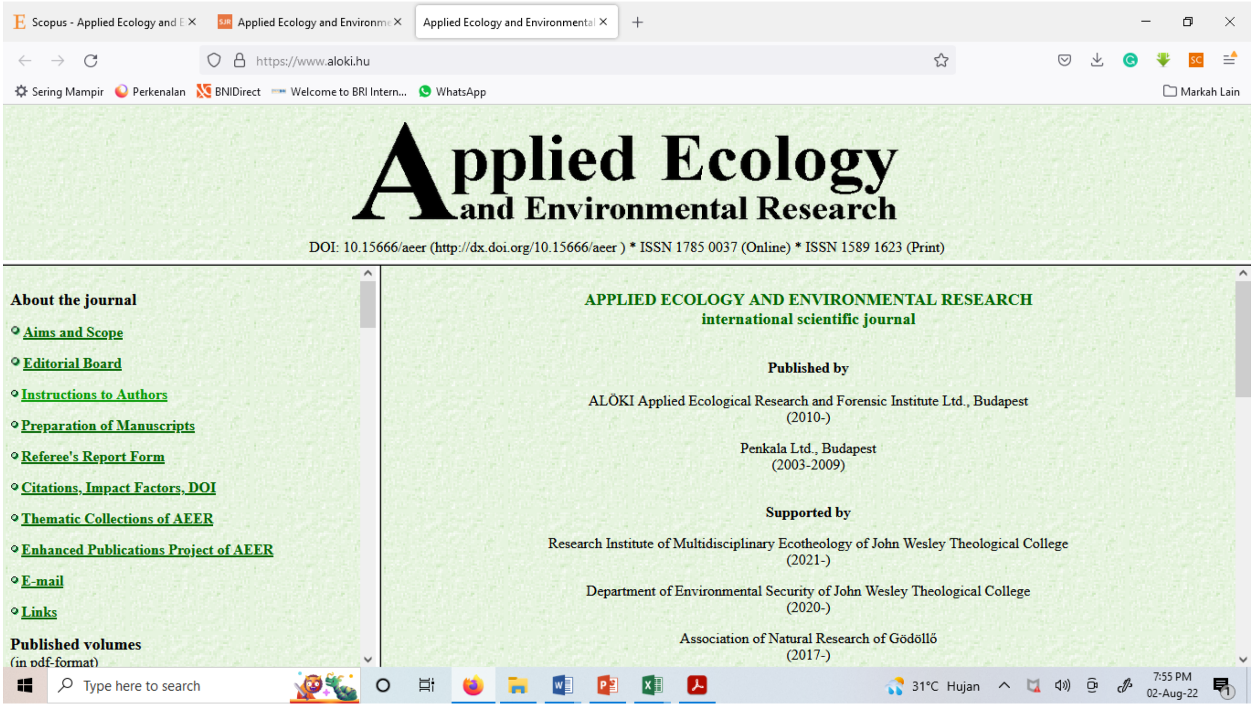

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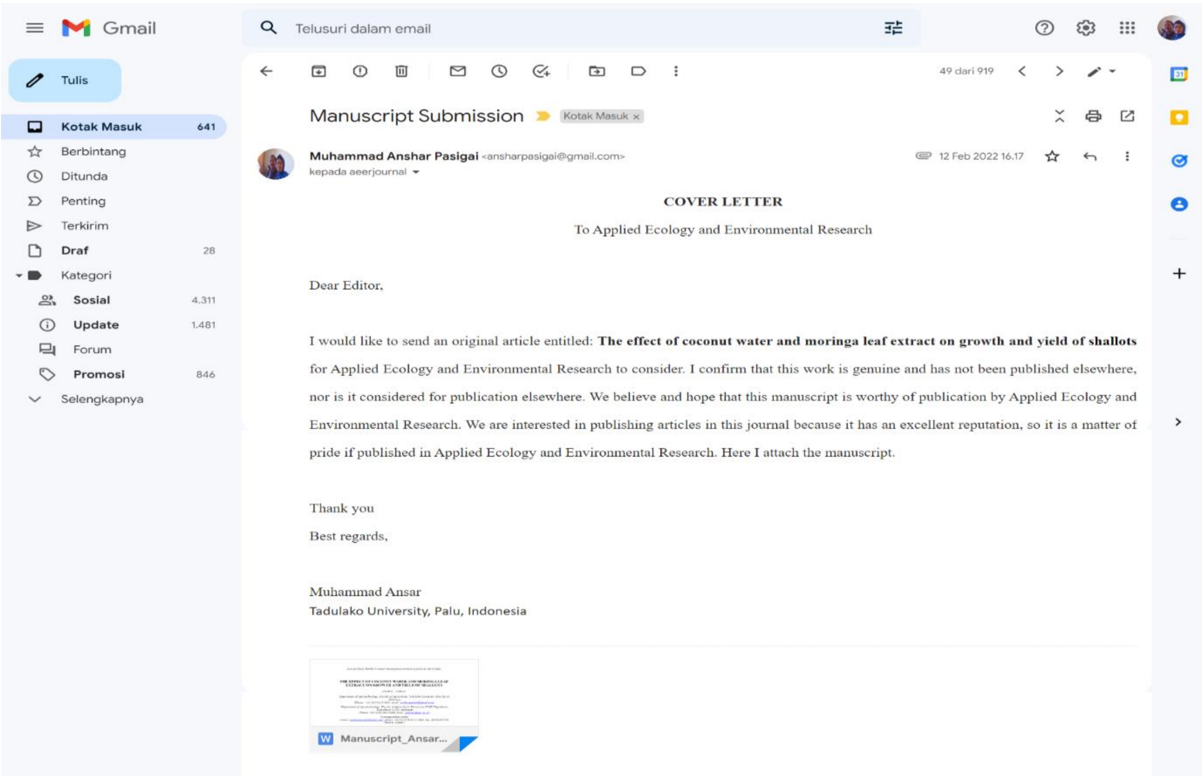

COVER LETTER

To Applied Ecology and Environmental Research

Dear Editor,

I would like to send an original article entitled: **The effect of coconut water and moringa leaf extract on growth and yield of shallots** for Applied Ecology and Environmental Research to consider. I confirm that this work is genuine and has not been published elsewhere, nor is it considered for publication elsewhere. We believe and hope that this manuscript is worthy of publication by Applied Ecology and Environmental Research. We are interested in publishing articles in this journal because it has an excellent reputation, so it is a matter of pride if published in Applied Ecology and Environmental Research. Here I attach the manuscript.

Thank you

Best regards,

Muhammad Ansar
Tadulako University, Palu, Indonesia

Manuscript_Ansar...

Manuscript yang di submit

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

ANSAR M.[1*] – PAIMAN[2]

[1]*Department of Agrotechnology, Faculty of Agriculture, Tadulako University, Palu 94118, Indonesia (Phone: +62-813-9212-2864, email: ansharpasigai@gmail.com)*

,[2]*Department of Agrotechnology, Faculty of Agriculture, Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia*
(Phone: +62-813-2862-9000, email: paiman@upy.ac.id)

[*]*Corresponding author*
e-mail: ansharpasigai@gmail.com; phone: +62-62-813-9212-2864; fax: (0451)429738
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Abstract. In Central Sulawesi Province, 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), as a result of the use of small bulbs (seeds) with low PGR content to support their growth. It is necessary to provide effective plant growth regulators (PGR) in increasing the growth and yield of shallots, especially Lembah Palu shallot variety (LPSV). One of the PGR is natural PGR, including coconut water (CW) and moringa leaf extract (MLE). This study aims to know the effect of CW and MLE at various concentrations on the growth and yield of shallots. This research was arranged out in randomized completely block design (RCBD) and three replications. The first factor was the natural PGR types consisted of two kinds, i.e., coconut water and moringa leaf extract. The second factor was the natural PGR concentration consisted of five levels, i.e., 20, 40, 60, 80, and 100%. The results showed that 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 hectare^{-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 to increase. The research findings show that PGR type of CW at a concentration of 40% provides the highest growth and yield of shallots. Besides, it is necessary to carry out further research with various sources of other types of natural PGR.

Keywords: *plant growth regulator, shallots, Lembah Palu, coconut water, moringa leaf extract*

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 LPVS, which is one of the local types which is the result of a natural cross between local onions and is widely cultivated in the Lembah Palu area. This shallot has a high adaptation, suitable for planting in lowlands (<400 m ASL.) with dry climates with low rainfall. The tubers are slightly white, oval, and relatively small (Rabinowitch and Currah, 2002).

In general, the LPSV productivity was lower than other types of shallots, where the Bima, Brebes, Philippine varieties can reach 20 tons ha^{-1}. In comparison, the LPVS only had a productivity potential of 9.7 tons ha^{-1}, and at this farmer's level, only range 4-5 tons ha^{-1}. The low productivity of LPVS caused the need for raw materials for the fried onion industry in Palu city and its surroundings not to be fulfilled continuously. The low shallots productivity of LPSV was due to the application of cultivation techniques that are not according to the recommended technical standards (Pasigai et al., 2016).

The application of 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, both in composition and concentration can lead to better plant growth and development. Some PGR is synthetic, but some are natural. The PGR 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. CW contains indole-3-acetic acid (IAA) and is the main auxin in plants (Yong et al., 2009).

Higher concentrations contained the highest amount of inorganic elements and growth hormones than low concentrations. MLE is effective to improve the growth and productivity of cereal forages under stress 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 on 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 leaf phenolic content (78%) in moringa seedlings (Batool et al., 2019).

Application of MLE 10% at two weeks after emergence and every two weeks thereafter 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). Application of 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). 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 as 71.9 mg quercetin equivalent g^{-1}, and alkaloids total as 3 mg quinine equivalent g-1, tannin as 24.7 mg tannic acid equivalent g^{-1}, and saponin as 44.4 mg g^{-1}. The minimum inhibition concentration (MIC) of drumstick leaf extract is 3.125%, while the minimum bactericidal concentration (MBC) was 6.25%. 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. Coconut water is traditionally used as a growth supplement in plant tissue culture/micropropagation. The wide applications of CW can be justified by its unique chemical composition of sugars, vitamins, minerals, amino acids, and phytohormones (Yong et al., 2009). Morphogenesis of watermelon cotyledon segments can be obtained from explants collected from the proximal region of three-day-old cotyledons of in vitro germinated seedlings on a culture media supplemented with CW (Krug et al., 2005).

Multiple beneficial biochemicals such as vitamins, minerals, proteins, sugars, and enzymes have been identified in CW. Phytohormones, particularly cytokinins were one of the most interesting components reported present in CW. Different maturation levels of CW were found to affect the cytokinin concentration, and higher at the immature and mature stages of coconut (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) present 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 either 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. Application of PGR with optimal concentration is very important to accelerate plant growth, especially in LPVS. By testing types and concentrations of natural PGR in the study, it is hoped to know the effect of CW and MLE at various concentrations on the growth and yield of shallots.

Materials and methods

Study area

This research was conducted in Oloboju Village, Sigi Biromaru District, Sigi Regency, Central Sulawesi Province. 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"; place altitude 120 m above sea level (m ASL), with a daily average temperature of 30.8°C and daily average air humidity of 62.3%.

Experimental design

This research is experimental design research arranged in an RCBD factorial with three replications. The first factor was the natural PGR types, which consisted of two kinds, i.e., CW and MLE. The second factor is the concentration of natural PGR, which consisted of five levels, i.e., 20, 40, 60, 80, and 100%. Experiments obtained 10 (ten) treatment combinations.

Research procedures

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 are made according to the experimental plot with a length of 255 cm, a width of 105 cm, and a height of 25 cm. Seedlings that came from tubers that were free from 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 was used green color with the characteristics of smooth skin color, free from pests and diseases, and had a soft and thin endosperm. Meanwhile, MLE was made by refining the material and giving it water in a ratio according to the treatment. Moringa leaves used are young moringa leaves with a 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 blend 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 that were ready for planting are soaked according to the treatment that has been set for 90 minutes. After that, the seeds were dried.

The plant spacing in the bed used 15 × 15 cm. The seeds were immersed in the planting hole and planted in an upright position like turning a screw until the tuber's end appears 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 and was done according to conditions in the field. Weeding activities were carried out in conjunction with soil tilling. Tilling aimed to weaken the soil which will support early plant growth and made it easier for tubers to develop optimally. Fertilizers were used, namely bokashi goat manure and NPK (15:15:15) fertilizers. Bokashi was given before planting by mixing the fertilizer with the soil. Meanwhile, NPK was given when the plants are two weeks after planting at a dose of 2 g.plant^{-1}. Pest and disease control are adapted to field conditions. 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 and fungicides.

Harvesting was done when the plants are ≥ 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 data 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 levels by using IBM SPSS Statistics 23 software. Differences between treatments were compared using Duncan′s new multiple range test (DMRT) at 5% significant levels.

Results

The results of analysis of variance on tiller number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1} showed a significant interaction between CW and MLE. The results of DMRT at 5% on tiller number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1} can be seen in Table 1.

Table 1. *tiller number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1}*

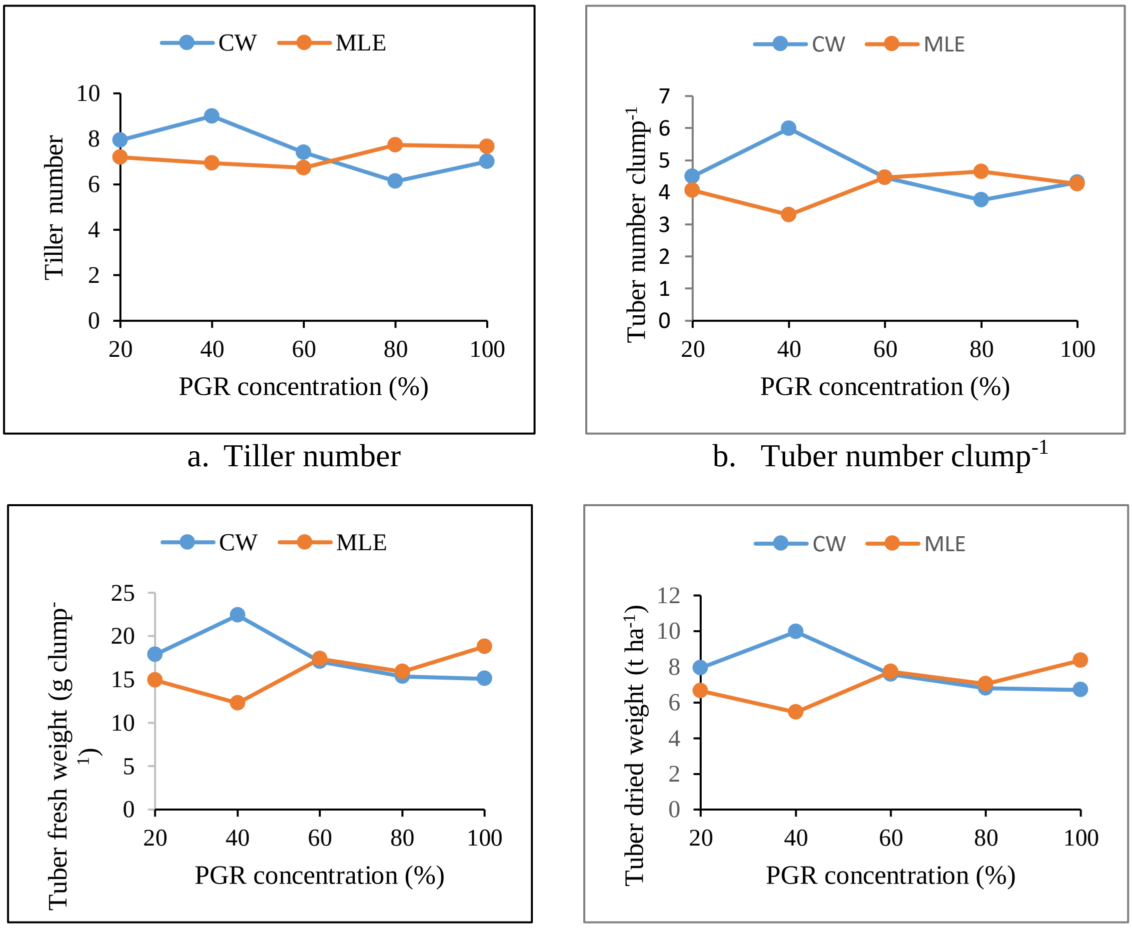
PGR types	PGR concentration (%)	Tiller number clump^{-1}	Tubers number clump^{-1}	Tubers fresh weight (g clump^{-1})	Tuber dried weight (t ha^{-1})
CW	20	7.93 bc	4.49 ab	17.87 a	7.94 a
	40	9.00 c	5.99 b	22.40 b	9.96 b
	60	7.40 ab	4.47 ab	17.07 a	7.59 a
	80	6.13 a	3.76 a	15.33 a	6.81 a
	100	7.00 ab	4.32 ab	15.07 a	6.70 a

MLE	20	7.20 a	4.06 a	14.93 a	6.64 a
	40	6.93 a	3.30 a	12.27 a	5.45 a
	60	6.73 a	4.47 a	17.40 a	7.73 a
	80	7.73 a	4.65 a	15.87 a	7.05 a
	100	7.67 a	4.27 a	18.80 a	8.36 a
Interaction of CW and MLE		(+)	(+)	(+)	(+)

Remarks: the average number of treatment combinations in the column followed by the same letter is not significantly different based on DMRT at the 5% significance levels. (+) = significance interaction between PGR types and concentration.

Table 1 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 hectare^{-1}.

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



a. Tiller number

b. Tuber number clump^{-1}

c. Tuber fresh weight clump^{-1}

d. Tuber dried weight ha^{-1}

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

Figure 1 shows that there was a difference in the trend of the two PGR types. The CW shows an increase of the tiller number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1} from concentrations of 20% to 40%, but after a concentration of 40% continues to decrease to 100% concentration. This was different in MLE, there was a decrease in tiller number from a concentration of 20% to 60%, but after concentration 60% continues to increase and is constant at 100% concentration. Therefore, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1} decrease from a concentration of 20% to 40%, but after a concentration of 40% increased to 100%. For CW, at low concentrations (20-40%) increased the growth and yield, in contrast, MLE was better at higher concentrations (60-100%).

Discussion

From this experiment, it was found that CW at a concentration of 40% resulted in the highest tillers number. CW is a natural ingredient that contains various types of hormones such as auxins and cytokinins, which can stimulate plant growth, thus increasing the growth parameters of the shallots. The CW was 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 will stimulate cell division and influence the differentiation pathway (Widiastoety, 2014). Supported by Sukamta (2015), which showed that CW concentration had a significant effect on 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 et al., 2013). Auxins can stimulate the work of cytokinins in the process of 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 and following the general nature of the hormone that was relatively low concentrations it can stimulate cell division and elongation, thereby affecting plant growth and development. Young et al. (Yong et al., 2009) stated that CW contained auxins, various cytokinins such as trans-zeatin and kinetin, gibberellin, and ABA. The CW also contained 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 fresh weight clump^{-1} and tubers dried weight ha^{-1} can be influenced by the leaf area number as the source of the photosynthesis process which produced 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. 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 ingredient that contains various types of hormones such as auxins, cytokinins, and gibberellins which function to stimulate plant growth. The CW was a natural hormone that can provide the most optimal results for the yield of shallots because it contained many types of hormones needed for plant growth. Natural PGR types contained different growth hormones and minerals, so they will have different effects on the growth and yield of LPSV plants. For this reason, to obtain maximum results, natural PGR was needed 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 stated by Indriani et al.(2014), the complexity of hormone and mineral content in CW resulted in a significant multiplication effect when compared to the addition of BA synthetic hormone.

Conclusion

Based on the results and discussion can conclude that 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 hectare^{-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 to increase. The research findings show that PGR type of CW at a concentration of 40% provides the highest growth and yield of shallots. We suggest that it is necessary to carry out further research with various sources of other types of natural PGR.

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According to this, the reviewing process of your manuscript has been suspended until you declare whether you would like to pay the open access publication fee related to its category, which is 850 EUR. The payment should only be made if your manuscript gets accepted.

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In case of a positive answer please send us the email address of each author of the manuscript. It is inevitable for starting the full reviewing process.

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Best regards,

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Applied Ecology and Environmental Research
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Approval to pay publication fee: 22 Pebruari 2022

Muhammad Anshar Pasigai <ansharpasigai@gmail.com>
kepada Applied
22 Feb 2022 09.15

APPROVAL TO PAY PUBLICATION FEES

Dear
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Applied Ecology and Environmental Research

Our manuscript is entitled: The effect of coconut water and moringa leaf extract on growth and yield of shallots was categorized as medium priority.

We state that agree to pay the open access publication fee related to its category, which is 850 EUR after being declared accepted.

We send the email address of each author of the manuscript.
1. Muhammad Ansar, email: ansharpasigai@gmail.com
2. Paiman, email: paiman@upy.ac.id

This is the statement of agreement that we made.

Best regards,

Muhammad Ansar
Tadulako University, Palu, Indonesia

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Tulis

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Submitted manuscript: Applied Ecology and Environmental Research (ref. 13417)

Kotak Masuk

Applied Ecology <aeerjournal@gmail.com>
kepada saya, M.P.
Kam, 10 Mar 01.19

Inggris > Indonesia Terjemahkan pesan | Nonaktifkan untuk: Inggris

Dear Authors,

We would like to inform you that the full reviewing process of MS ref. 13417 titled:
THE EFFECT OF COCONUT WATER AND MORINGA LEAF EXTRACT ON GROWTH AND YIELD OF SHALLOTS; by authors:

Ansar M. – Paiman

is in progress.

If you did not co-author this submission or disagree with the process for any reason, please contact us by e-mail as soon as possible!
Thank you in advance!

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Thanks a lot. | Received, thank you. | Thank you for the information.

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Extract of referee opinions for MS 13417 Kotak Masuk ×

Applied Ecology <aeerjournal@gmail.com>
kepada saya

Sab, 30 Apr 01.03

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Dear Author,

We are sending you enclosed an extract of referee opinions for your manuscript ref. 13417.

Please consider the suggestions and resubmit the final ready-to-publish version within approximately 2 weeks if possible.

Thank you in advance!

Best regards,

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Extract from Refe…

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Comments reviewer:

Extract of referee opinions and editorial suggestions for manuscript ref. 13417

The authors conducted a simple field experiment in one growing season in which the plant growth promoting effects of coconut water and moringa leaf extract was aimed to confirm. The moringa extract treatment did not influence the plant growth and productivity and only the 40% coconut water increased the measured parameter. The authors mentioned that the interactions of the factors had been evaluated but the experimental design was not suitable for that. It is another issue whether the coconut water is available for such kind of purpose or could be applied more efficiently.

Comments to the Authors:

1. The concentration of the applied solutions should be added because the % is not interpretable in itself.
2. The authors mentioned that the cultivation technology would be the limitation of the shallots production in the study region but plant growth regulators are usually applied to improve the productivity by appropriate or good agricultural practice. But it is highly questionable that the usage of PGR could have high benefits if only half of the potential yielding capacity could be realized.
3. Many times the authors mentioned evidence such as "Higher concentrations contained the highest amount of inorganic elements and growth hormones than low concentrations".
4. Indication the weather conditions during the study would be relevant besides the general climatological description of the study area.
5. It must be explained why not the two PGRs were tested in combinations. Without these treatments, their interactions cannot be determined.
6. Indicating the forecrop would be needed.
7. Introduction the applied insecticides and fungicides would be necessary. Please add the dosage and the ingredients.
8. The authors should specify which type of ANOVA had been applied. Displaying the base ANOVA tables would be required.
9. The MLE did not influence the measured parameters and the CW increased the productivity in the 40% treatment, but other treatments did not differ from each other. Repeating the experiment would be necessary to confirm whether this extraordinary trend is valid or not (many factors could have an impact on the results of a field experiment, therefore repeatability would be a key criterion).
10. The statistical expressions should be applied correctly (e.g. "significance difference").
11. The information content of Table 1 and Figure 1 are overlapping.
12. The authors could improve the significance of the manuscript if the effects of PGRs on the quality of the products would be analysed.
13. It should be confirmed whether the chemical composition of the CW is stable and no significant variability can be observed.
14. The authors explained the modification of the parameters by the hormone content of the CW.

- Keywords should not be the repetitions of the title words, please find such words which are not in the title, this way search engines of the web will find your manuscript with a higher probability.
- At the end of the Introduction please also mention the objective of this study.
- In the abstract please also mention the country of study.
- When first using an abbreviation, please write the whole name and abbreviation in brackets the first time.
- The English throughout needs revision and careful proofreading.

AEER_13417

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

The article is mostly well written, yet it contains numerous language errors that negatively affect clarity and comprehensibility. These include adjective/adverb confusion, missing conjunctions, and confusion of comparative/superlative of adjectives, but the main problem is that some sentences have an unclear structure (something is missing or is on the wrong place).

For example:

Line number	Errors	Problem/correction
8	with low PGR content	Abbreviations should be spelled out at first use
12	This research was arranged out in randomized completely block design (RCBD)	This research was arranged in randomized complete block design (RCBD)
13	The first factor was the natural PGR types consisted	The first factor was that the natural PGR types consisted
14	The second factor was the natural PGR concentration consisted	The second factor was that the natural PGR concentration consisted
15	there was a significant interaction between PGR types and concentration on the growth and yield	there was a significant interaction between PGR types and concentration affecting the growth and yield
26	potential to be developed is the LPVS	Abbreviations should be spelled out at first use (abstract and article text should be treated separately)—valid for all abbreviations
27	which is one of the local types which is the result of a natural cross between local onions and is widely cultivated in the Lembah Palu area.	which is one of the local types and is the result of a natural cross between local onions; it is widely cultivated in the Lembah Palu area.
29	with dry climates with low rainfall	with dry climates and low rainfall
31	In general, the LPSV productivity was lower than other types of shallots, where the Bima, Brebes, Philippine varieties can reach 20 tons ha^{-1}. In comparison, the LPVS only had a productivity potential of 9.7 tons ha^{-1},	In general, the productivity of LPSV was lower than that of other types of shallots. While the Bima, Brebes, and Philippine varieties can reach 20 tons ha^{-1}, the LPVS only had a productivity potential of 9.7 tons ha^{-1},
33	and at this farmer's level, only range 4-5 tons ha^{-1}.	Meaning unclear
34	The low productivity of LPVS caused the need for raw materials for the fried onion industry in Palu city and its surroundings not to be fulfilled continuously	The low productivity of LPVS caused that the need for raw materials in the fried onion industry in Palu city and its surroundings could not be fulfilled continuously
46	Higher concentrations contained the highest amount of inorganic elements and growth hormones than low concentrations.	Higher concentrations contained higher amount of inorganic elements and growth hormones than low concentrations.

……….: 23 Mei 2022

Muhammad Ansharr Pasigai <ansharpasigai@gmail.com>
kepada Applied

23 Mei 2022 07.55

Dear Editor

Thank you for submitting a real extract of the referee's opinion for my manuscript ref. 13417. I will correct it according to the referee's suggestion and will send it back as soon as possible.

Best regards

……..: 27 Mei 2022

Muhammad Ansharr Pasigai <ansharpasigai@gmail.com>
kepada Applied

27 Mei 2022 23.31

MANUSCRIPT REVICED (AEER_13417)

To Applied Ecology And Environmental Research

Dear Editors,

Thanks for the correction. I have improved the content of manuscript and quality of English through the help of colleagues who work as proofread and the article has been carefully checked for language, grammar, and style. Herewith I attach the required files:

1) A revised paper with the highlights as addressed all issues and required corrections/changes.
2) A revised paper without highlights.

Thank you

Best regards,

Muhammad Ansar
University of Tadulako

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

AEER_13417

(Received ; accepted)

Abstract. In Central Sulawesi Province, 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), as a result of the use of small bulbs (seeds) with low PGR content to support their growth. It is necessary to provide effective plant growth regulators (PGR) in increasing the growth and yield of shallots, especially Lembah Palu shallot variety (LPSV). One of the PGR is natural PGR, including coconut water (CW) and moringa leaf extract (MLE). This study aims to know the effect of CW and MLE at various concentrations on the growth and yield of shallots. This research was arranged out in randomized completely block design (RCBD) and three replications. The first factor was the natural PGR types consisted of two kinds, i.e., coconut water and moringa leaf extract. The second factor was the natural PGR concentration consisted of five levels, i.e., 20, 40, 60, 80, and 100%. The results showed that 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 hectare^{-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 to increase. The research findings show that PGR type of CW at a concentration of 40% provides the highest growth and yield of shallots. Besides, it is necessary to carry out further research with various sources of other types of natural PGR.

Keywords: *plant growth regulator, shallots, Lembah Palu, coconut water, moringa leaf extract*

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 LPVS, which is one of the local types which is the result of a natural cross between local onions and is widely cultivated in the Lembah Palu area. This shallot has a high adaptation, suitable for planting in lowlands (<400 m ASL.) with dry climates with low rainfall. The tubers are slightly white, oval, and relatively small (Rabinowitch and Currah, 2002).

In general, the LPSV productivity was lower than other types of shallots, where the Bima, Brebes, Philippine varieties can reach 20 tons ha^{-1}. In comparison, the LPVS only had a productivity potential of 9.7 tons ha^{-1}, and at this farmer's level, only range 4-5 tons ha^{-1}. The low productivity of LPVS caused the need for raw materials for the fried onion industry in Palu city and its surroundings not to be fulfilled continuously. The low shallots productivity of LPSV was due to the application of cultivation techniques that are not according to the recommended technical standards (Pasigai et al., 2016).

The application of 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, both in composition and concentration can lead to better plant growth and development. Some PGR is synthetic, but some are natural. The PGR 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. CW contains indole-3-acetic acid (IAA) and is the main auxin in plants (Yong et al., 2009).

Higher concentrations contained the highest amount of inorganic elements and growth hormones than low concentrations. MLE is effective to improve the growth and productivity of cereal forages under stress 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 on 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 leaf phenolic content (78%) in moringa seedlings (Batool et al., 2019).

Application of MLE 10% at two weeks after emergence and every two weeks thereafter 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). Application of 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). 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 as 71.9 mg quercetin equivalent g^{-1}, and alkaloids total as 3 mg quinine equivalent g-1, tannin as 24.7 mg tannic acid equivalent g^{-1}, and saponin as 44.4 mg g^{-1}. The minimum inhibition concentration (MIC) of drumstick leaf extract is 3.125%, while the minimum bactericidal concentration (MBC) was 6.25%. 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. Coconut water is traditionally used as a growth supplement in plant tissue culture/micropropagation. The wide applications of CW can be justified by its unique chemical composition of sugars, vitamins, minerals, amino acids, and phytohormones (Yong et al., 2009). Morphogenesis of watermelon cotyledon segments can be obtained from explants collected from the proximal region of three-day-old cotyledons of in vitro germinated seedlings on a culture media supplemented with CW (Krug et al., 2005).

Multiple beneficial biochemicals such as vitamins, minerals, proteins, sugars, and enzymes have been identified in CW. Phytohormones, particularly cytokinins were one of the most interesting components reported present in CW. Different maturation levels of CW were found to affect the cytokinin concentration, and higher at the immature and mature stages of coconut (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) present 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 either 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. Application of PGR with optimal concentration is very important to accelerate plant growth, especially in LPVS. By testing types and concentrations of natural PGR in the study, it is hoped to know the effect of CW and MLE at various concentrations on the growth and yield of shallots.

Materials and methods

Study area

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

Experimental design

This research is experimental design research arranged in an RCBD factorial with three replications. The first factor was the natural PGR types, which consisted of two kinds, i.e., CW and MLE. The second factor is the concentration of natural PGR, which consisted of five levels, i.e., 20, 40, 60, 80, and 100%. Experiments obtained 10 (ten) treatment combinations.

Research procedures

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 are made according to the experimental plot with a length of 255 cm, a width of 105 cm, and a height of 25 cm. Seedlings that came from tubers that were free from 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 was used green color with the characteristics of smooth skin color, free from pests and diseases, and had a soft and thin endosperm. Meanwhile, MLE was made by refining the material and giving it water in a ratio according to the treatment. Moringa leaves used are young moringa leaves with a 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 blend 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 that were ready for planting are soaked according to the treatment that has been set for 90 minutes. After that, the seeds were dried.

The plant spacing in the bed used 15 × 15 cm. The seeds were immersed in the planting hole and planted in an upright position like turning a screw until the tuber's end appears 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 and was done according to conditions in the field. Weeding activities were carried out in conjunction with soil tilling. Tilling aimed to weaken the soil which will support early plant growth and made it easier for tubers to develop optimally. Fertilizers were used, namely bokashi goat manure and NPK (15:15:15) fertilizers. Bokashi was given before planting by mixing the fertilizer with the soil. Meanwhile, NPK was given when the plants are two weeks after planting at a dose of 2 $g.plant^{-1}$. Pest and disease control are adapted to field conditions. 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 and fungicides.

Harvesting was done when the plants are ≥ 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 data 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 levels by using IBM SPSS Statistics 23 software. Differences between treatments were compared using Duncan′s new multiple range test (DMRT) at 5% significant levels.

Results

The results of analysis of variance on tiller number, tubers number $clump^{-1}$, tubers fresh weight $clump^{-1}$, and the tuber dried weight $hectare^{-1}$ showed a significant interaction between CW and MLE. The results of DMRT at 5% on tiller number, tubers number $clump^{-1}$, tubers fresh weight $clump^{-1}$, and the tuber dried weight $hectare^{-1}$ can be seen in Table 1.

Table 1*. tiller number, tubers number $clump^{-1}$, tubers fresh weight $clump^{-1}$, and the tuber dried weight $hectare^{-1}$*

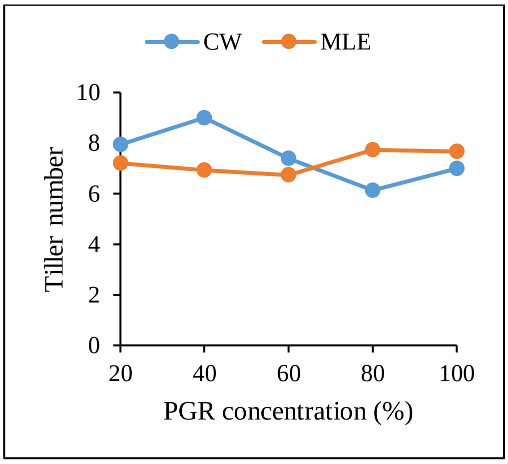
PGR types	PGR concentration (%)	Tiller number $clump^{-1}$	Tubers number $clump^{-1}$	Tubers fresh weight (g $clump^{-1}$)	Tuber dried weight (t ha^{-1})
CW	20	7.93 bc	4.49 ab	17.87 a	7.94 a
	40	9.00 c	5.99 b	22.40 b	9.96 b
	60	7.40 ab	4.47 ab	17.07 a	7.59 a
	80	6.13 a	3.76 a	15.33 a	6.81 a
	100	7.00 ab	4.32 ab	15.07 a	6.70 a
MLE	20	7.20 a	4.06 a	14.93 a	6.64 a
	40	6.93 a	3.30 a	12.27 a	5.45 a
	60	6.73 a	4.47 a	17.40 a	7.73 a
	80	7.73 a	4.65 a	15.87 a	7.05 a

	100	7.67 a	4.27 a	18.80 a	8.36 a
Interaction of CW and MLE		(+)	(+)	(+)	(+)

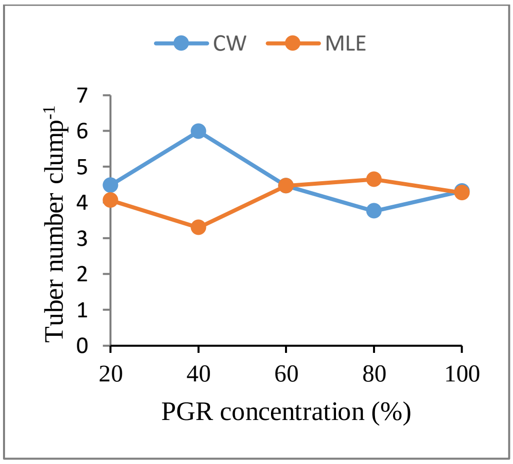
Remarks: the average number of treatment combinations in the column followed by the same letter is not significantly different based on DMRT at the 5% significance levels. (+) = significance interaction between PGR types and concentration.

Table 1 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 hectare^{-1}.

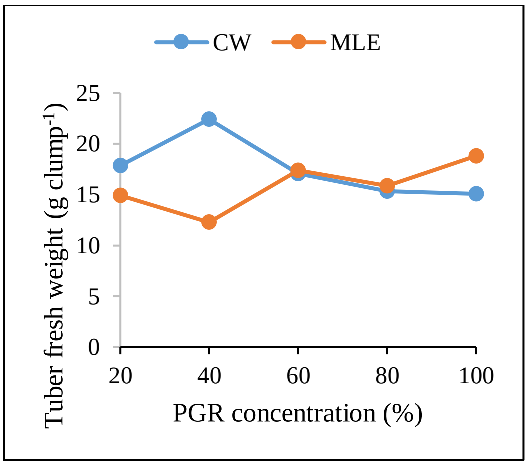
The effect of PGR type and concentration on tiller number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1} are presented in Figure 1.



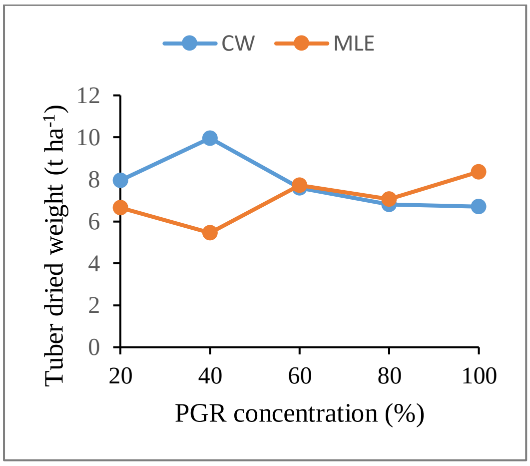
e. Tiller number



f. Tuber number clump^{-1}



g. Tuber fresh weight clump^{-1}



h. Tuber dried weight ha^{-1}

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

Figure 1 shows that there was a difference in the trend of the two PGR types. The CW shows an increase of the tiller number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1} from concentrations of 20% to 40%, but after a concentration of 40% continues to decrease to 100% concentration. This was different in MLE, there was a decrease in tiller number from a concentration of 20% to 60%, but after concentration 60% continues to increase and is constant at 100% concentration. Therefore, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1} decrease from a concentration of 20% to 40%, but after a concentration of 40% increased to 100%. For CW, at low concentrations (20-40%) increased the growth and yield, in contrast, MLE was better at higher concentrations (60-100%).

Discussion

From this experiment, it was found that CW at a concentration of 40% resulted in the highest tillers number. CW is a natural ingredient that contains various types of hormones such as auxins and cytokinins, which can stimulate plant growth, thus increasing the growth parameters of the shallots. The CW was 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 will stimulate cell division and influence the differentiation pathway (Widiastoety, 2014). Supported by Sukamta (2015), which showed that CW concentration had a significant effect on 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 et al., 2013). Auxins can stimulate the work of cytokinins in the process of 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 and following the general nature of the hormone that was relatively low concentrations it can stimulate cell division and elongation, thereby affecting plant growth and development. Young et al. (Yong et al., 2009) stated that CW contained auxins, various cytokinins such as trans-zeatin and kinetin, gibberellin, and ABA. The CW also contained 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 fresh weight clump^{-1} and tubers dried weight ha^{-1} can be influenced by the leaf area number as the source of the photosynthesis process which produced 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. 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 ingredient that contains various types of hormones such as auxins, cytokinins, and gibberellins which function to stimulate plant growth. The CW was a natural hormone that can provide the most optimal results for the yield of shallots because it contained many types of hormones needed for plant growth. Natural PGR types contained different growth hormones and minerals, so they will have different effects on the growth and yield of LPSV plants. For this reason, to obtain maximum results, natural PGR was needed 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 stated by Indriani et al.(2014), the complexity of hormone and mineral content in CW resulted in a significant multiplication effect when compared to the addition of BA synthetic hormone.

Conclusion

Based on the results and discussion can conclude that 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 hectare^{-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 to increase. The research findings show that PGR type of CW at a concentration of 40% provides the highest growth and yield of shallots. We suggest that it is necessary to carry out further research with various sources of other types of natural PGR.

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Manuscript: With highlight

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 country, 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), as a result of the use of small bulbs (seeds) with low plant growth regulator (PGR) content to support their growth. 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 aims to know the effect of CW and MLE at various concentrations on the growth and yield of LPSV. This research was experimental design 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 that there was 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 hectare^{-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 to increase. 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 carry out further research with various sources of other types of 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, which is one of the local types and is the result of a natural cross between local onions; it is 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).

In general, the productivity of LPSV was 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, only ranges from 4-5 tons ha^{-1}, so 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 was due to the application of cultivation techniques that are not according to the recommended technical standards (Pasigai et al., 2016).

The application of 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, both 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. CW contains indole-3-acetic acid (IAA) and is the main auxin in plants (Yong et al., 2009).

Higher concentrations contained a higher amount of inorganic elements and growth hormones than low concentrations. MLE is effective to improve the growth and productivity of cereal forages 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 leaf phenolic content (78%) in moringa seedlings (Batool et al., 2019).

Application of MLE 10% at two weeks after emergence and every two weeks thereafter 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). Application of 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). 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 of 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}. The minimum inhibition concentration (MIC) of drumstick leaf extract is 3.125%, while the minimum bactericidal concentration (MBC) was 6.25%. 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. Coconut water is traditionally used as a growth supplement in plant tissue culture/micropropagation. The wide applications of CW can be justified by its unique chemical composition of sugars, vitamins, minerals, amino acids, and phytohormones (Yong et al., 2009). Morphogenesis of watermelon cotyledon segments can be obtained from explants collected from the proximal region of three-day-old cotyledons of in vitro germinated seedlings on a culture media supplemented with CW (Krug et al., 2005).

Multiple beneficial biochemicals such as vitamins, minerals, proteins, sugars, and enzymes have been identified in CW. Phytohormones, particularly cytokinins were one of the most interesting components reported present in CW. Different maturation levels of CW were found to affect the cytokinin concentration, higher at the immature, and mature stages of coconut (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) present 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 either 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. Application of PGR with optimal concentration is very important to accelerate plant growth, especially in LPSV. By testing types and concentrations of natural PGR in the study, it can contribute to an increase in the growth and yield of LPSV.

Based on the literature review above, so this study aims 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 Province. 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"; place altitude of 120 m ASL., with a daily average temperature of 30.8°C and daily average air humidity of 62.3%.

Experimental design

This research was experimental design and 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%. This study need 30 experimental plots.

Research procedures

Procedure to make the natural PGR solution from CW. The CW was used from young green coconuts, the skin of the fruit is smooth and slippery, free from pests and diseases, and has an endosperm that is still soft and thin. Furthermore, the water from this coconut is used as a stock solution with a concentration of 100%. Futhermore, making MLE is done by taking young moringa leaves that were a maximum of 35 days old since they appear as leaf buds. Cleaned moringa leaves are added to water in a ratio of 1:1 (100 g of moringa leaves are added to 100 ml of water), then blended until smooth. Furthermore, MLE is filtered into a container so that a stock solution of MLE is obtained with a concentration of 100%. To get each concentration of young CW and MLE according to each treatment, dilution is carried out.

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 are made according to the experimental plot with a length of 255 cm, a width of 105 cm, and a height of 25 cm. Seedlings that came from tubers that were free from 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 was used green color with the characteristics of smooth skin color, free from pests and diseases, and had a soft and thin endosperm. Meanwhile, MLE was made by refining the material and giving it water in a ratio according to the treatment. Moringa leaves used are young moringa leaves with a 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 blend 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 that were ready for planting are soaked according to the treatment that has been set for 90 minutes. After that, the seeds were dried.

The bed experiment was covered with silver black plastic mulch.The plant spacing in the bed used 15 × 15 cm. The seeds were immersed in the planting hole and planted in an upright position like turning a screw until the tuber's end appears 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 and was done according to conditions in the field. Weeding activities were carried out in conjunction with soil tilling. Tilling is aimed to weaken the soil which will support early plant growth and make 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 are two weeks after planting at a dose of 2 g.plant^{-1}. Pest and disease control are adapted to field conditions. 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 karbosulfan 200, with consentration of 10 g L^{-1} of water, and fungicides with ingredient propineb 70%, with concentration of 5 g L^{-1} of water).

Harvesting was done when the plants are ≥ 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 the 5% significant levels by using IBM SPSS Statistics 23 software. Differences between treatments were compared using Duncan′s new multiple range test (DMRT) at the 5% significant levels.

Results

The results of ANOVA on tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1} showed no significant between the PGR types of CW and MLE. The CW concentration was a significant effect on 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 hectare^{-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 hectare^{-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: * = Significantly effect at the 5% significant levels, and ns = Significantly effect at the 5% significant levels.

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

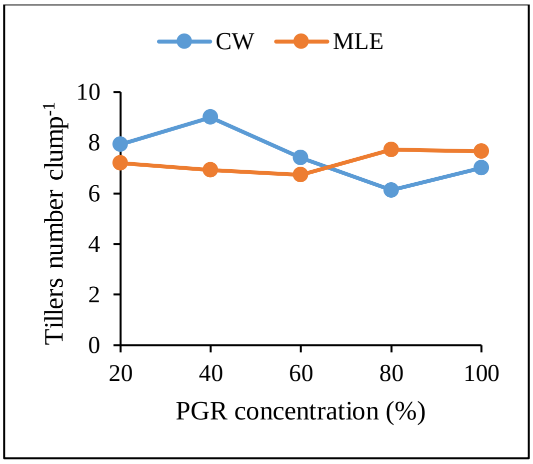
***Table 2**. tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1}*

PGR types	PGR concentration (%)	Tillers number clump^{-1}	Tubers number clump^{-1}	Tubers fresh weight (g clump^{-1})	Tubers dried weight (t 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

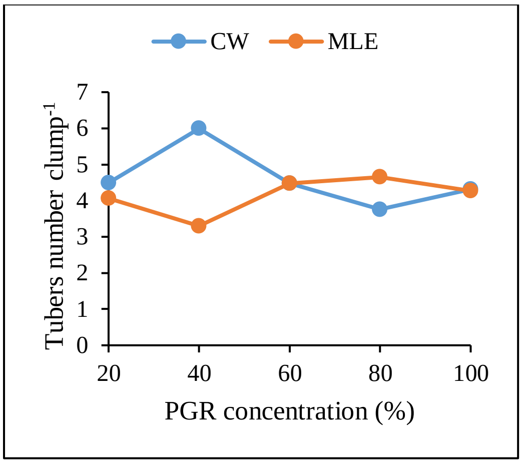
Remarks: the average number of treatment combinations in the column followed by the same letter is not significantly different based on DMRT at the 5% significance levels.

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 hectare^{-1}.

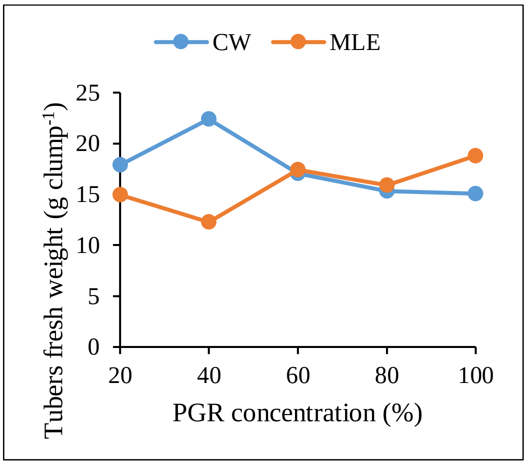
To clarify, the effect of PGR type and concentration on tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tubers dried weight hectare^{-1} are presented in Figure 1.



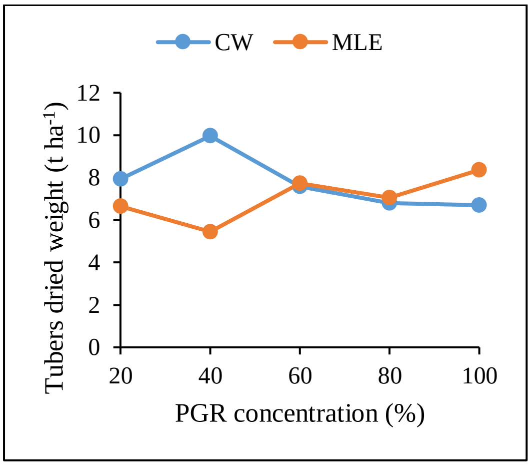
i. Tillers number clump^{-1}



j. Tubers number clump^{-1}



k. Tubers fresh weight clump^{-1}



l. 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 hectare^{-1}*

Figure 1 shows that there was 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 hectare^{-1} from concentrations of 20% to 40%, but after a concentration of 40% continues to decrease to 100% concentration. This was different in MLE, there was a decrease in tillers number from a concentration of 20% to 60%, but after a concentration of 60% continue to increase and was constant at 100% concentration. Therefore, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and tubers dried weight hectare^{-1} decreased from a concentration of 20% to 40%, but after a concentration of 40% increased to 100%. For CW, low concentrations of 20-40% increased the growth and yield, in contrast, MLE was better at higher concentrations of 60-100%.

Discussion

From this experiment, it was found that CW at a concentration of 40% resulted in the highest tillers number. CW is a natural ingredient that contains various types of hormones such as auxins and cytokinins, which can stimulate plant growth, thus increasing the growth parameters of the shallots. The CW was 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 will stimulate cell division and influence the differentiation pathway (Widiastoety, 2014). Supported by Sukamta (2015), which showed that CW concentration had a significant effect on 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 et al., 2013). Auxins can stimulate the work of cytokinins in the process of 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 and following the general nature of the hormone that was relatively low concentrations it can stimulate cell division and elongation, thereby affecting plant growth and development. Young et al. (Yong et al., 2009) stated that CW contained auxins, various cytokinins such as trans-zeatin and kinetin, gibberellin, and ABA. The CW also contained 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 fresh weight clump^{-1} and tubers dried weight ha^{-1} can be influenced by the leaf area number as the source of the photosynthesis process which produced 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. 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 ingredient that contains various types of hormones such as auxins, cytokinins, and gibberellins which function to stimulate plant growth. The CW was a natural hormone that can provide the most optimal results for the yield of shallots because it contained many types of hormones needed for plant growth. Natural PGR types contained different growth hormones and minerals, so they will have different effects on the growth and yield of LPSV plants. For this reason, to obtain maximum results, natural PGR was needed 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 stated by Indriani et al.(2014), the complexity of hormone and mineral content in CW resulted in a significant multiplication effect when compared to the addition of BA synthetic hormone.

Conclusion

Based on the results and discussion can conclude that 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 hectare^{-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 to increase. 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 carry out further research with various sources of other types of natural PGR.

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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 country, 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), as a result of the use of small bulbs (seeds) with low plant growth regulator (PGR) content to support their growth. 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 aims to know the effect of CW and MLE at various concentrations on the growth and yield of LPSV. This research was experimental design 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 that there was 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 hectare^{-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 to increase. 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 carry out further research with various sources of other types of 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, which is one of the local types and is the result of a natural cross between local onions; it is 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).

In general, the productivity of LPSV was 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, only ranges from 4-5 tons ha^{-1}, so 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 was due to the application of cultivation techniques that are not according to the recommended technical standards (Pasigai et al., 2016).

The application of 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, both 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. CW contains indole-3-acetic acid (IAA) and is the main auxin in plants (Yong et al., 2009).

Higher concentrations contained a higher amount of inorganic elements and growth hormones than low concentrations. MLE is effective to improve the growth and productivity of cereal forages 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 leaf phenolic content (78%) in moringa seedlings (Batool et al., 2019).

Application of MLE 10% at two weeks after emergence and every two weeks thereafter 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). Application of 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). 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 of 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}. The minimum inhibition concentration (MIC) of drumstick leaf extract is 3.125%, while the minimum bactericidal concentration (MBC) was 6.25%. 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. Coconut water is traditionally used as a growth supplement in plant tissue culture/micropropagation. The wide applications of CW can be justified by its unique chemical composition of sugars, vitamins, minerals, amino acids, and phytohormones (Yong et al., 2009). Morphogenesis of watermelon cotyledon segments can be obtained from explants collected from the proximal region of three-day-old cotyledons of in vitro germinated seedlings on a culture media supplemented with CW (Krug et al., 2005).

Multiple beneficial biochemicals such as vitamins, minerals, proteins, sugars, and enzymes have been identified in CW. Phytohormones, particularly cytokinins were one of the most interesting components reported present in CW. Different maturation levels of CW were found to affect the cytokinin concentration, higher at the immature, and mature stages of coconut (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) present 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 either 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. Application of PGR with optimal concentration is very important to accelerate plant growth, especially in LPSV. By testing types and concentrations of natural PGR in the study, it can contribute to an increase in the growth and yield of LPSV.

Based on the literature review above, so this study aims 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 Province. The research was carried out from May to August 2019. The location of the study is at coordinates S 1^{o}01'14.6532" and E 119^{o}59'29.0256"; place altitude of 120 m ASL., with a daily average temperature of 30.8^{o}C and daily average air humidity of 62.3%.

Experimental design

This research was experimental design and 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%. This study need 30 experimental plots.

Research procedures

Procedure to make the natural PGR solution from CW. The CW was used from young green coconuts, the skin of the fruit is smooth and slippery, free from pests and diseases, and has an endosperm that is still soft and thin. Furthermore, the water from this coconut is used as a stock solution with a concentration of 100%. Futhermore, making MLE is done by taking young moringa leaves that were a maximum of 35 days old since they appear as leaf buds. Cleaned moringa leaves are added to water in a ratio of 1:1 (100 g of moringa leaves are added to 100 ml of water), then blended until smooth. Furthermore, MLE is filtered into a container so that a stock solution of MLE is obtained with a concentration of 100%. To get each concentration of young CW and MLE according to each treatment, dilution is carried out.

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 are made according to the experimental plot with a length of 255 cm, a width of 105 cm, and a height of 25 cm. Seedlings that came from tubers that were free from 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 was used green color with the characteristics of smooth skin color, free from pests and diseases, and had a soft and thin endosperm. Meanwhile, MLE was made by refining the material and giving it water in a ratio according to the treatment. Moringa leaves used are young moringa leaves with a 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 blend 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 that were ready for planting are soaked according to the treatment that has been set for 90 minutes. After that, the seeds were dried.

The bed experiment was covered with silver black plastic mulch.The plant spacing in the bed used 15 × 15 cm. The seeds were immersed in the planting hole and planted in an upright position like turning a screw until the tuber's end appears 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 and was done according to conditions in the field. Weeding activities were carried out in conjunction with soil tilling. Tilling is aimed to weaken the soil which will support early plant growth and make 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 are two weeks after planting at a dose of 2 g.plant^{-1}. Pest and disease control are adapted to field conditions. 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 karbosulfan 200, with consentration of 10 g L^{-1} of water, and fungicides with ingredient propineb 70%, with concentration of 5 g L^{-1} of water).

Harvesting was done when the plants are ≥ 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 the 5% significant levels by using IBM SPSS Statistics 23 software. Differences between treatments were compared using Duncan′s new multiple range test (DMRT) at the 5% significant levels.

Results

The results of ANOVA on tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1} showed no significant between the PGR types of CW and MLE. The CW concentration was a significant effect on 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 hectare^{-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 hectare^{-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: * = Significantly effect at the 5% significant levels, and ns = Significantly effect at the 5% significant levels.

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

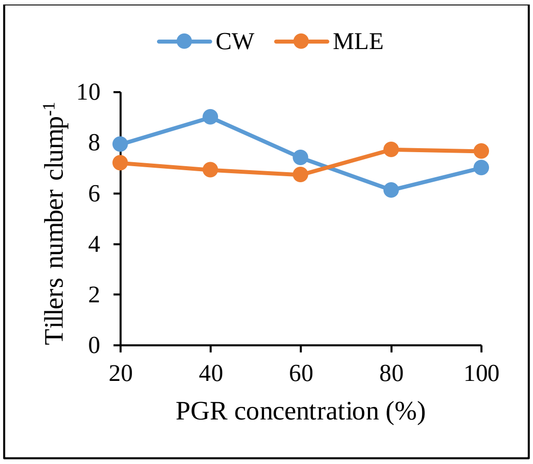
Table 2. *tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight hectare^{-1}*

PGR types	PGR concentration (%)	Tillers number clump^{-1}	Tubers number clump^{-1}	Tubers fresh weight (g clump^{-1})	Tubers dried weight (t 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

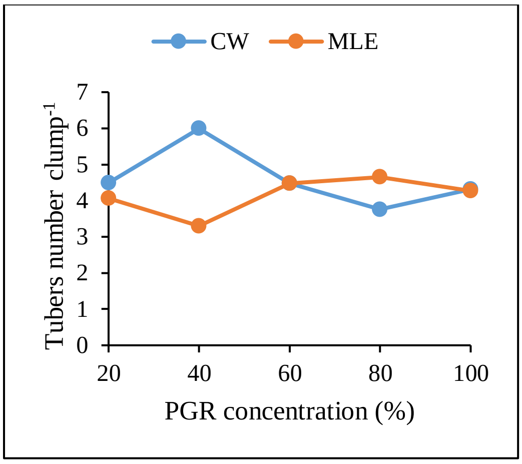
Remarks: the average number of treatment combinations in the column followed by the same letter is not significantly different based on DMRT at the 5% significance levels.

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 hectare^{-1}.

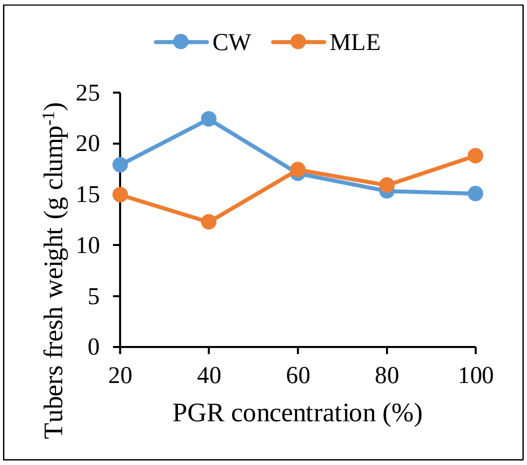
To clarify, the effect of PGR type and concentration on tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tubers dried weight hectare^{-1} are presented in Figure 1.



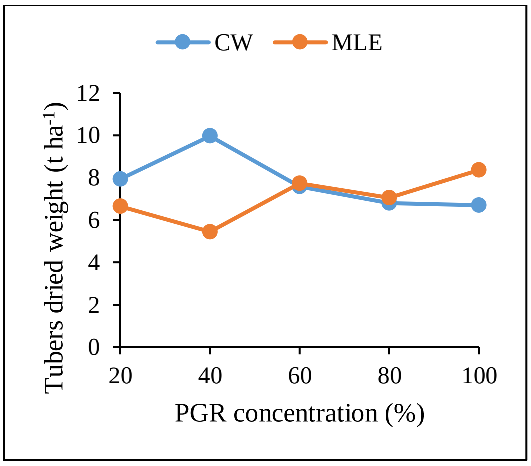
m. Tillers number clump^{-1}



n. Tubers number clump^{-1}



o. Tubers fresh weight clump^{-1}



p. 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 hectare^{-1}*

Figure 1 shows that there was 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 hectare^{-1} from concentrations of 20% to 40%, but after a concentration of 40% continues to decrease to 100% concentration. This was different in MLE, there was a decrease in tillers number from a concentration of 20% to 60%, but after a concentration of 60% continue to increase and was constant at 100% concentration. Therefore, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and tubers dried weight hectare^{-1} decreased from a concentration of 20% to 40%, but after a concentration of 40% increased to 100%. For CW, low concentrations of 20-40% increased the growth and yield, in contrast, MLE was better at higher concentrations of 60-100%.

Discussion

From this experiment, it was found that CW at a concentration of 40% resulted in the highest tillers number. CW is a natural ingredient that contains various types of hormones such as auxins and cytokinins, which can stimulate plant growth, thus increasing the growth parameters of the shallots. The CW was 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 will stimulate cell division and influence the differentiation pathway (Widiastoety, 2014). Supported by Sukamta (2015), which showed that CW concentration had a significant effect on 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 et al., 2013). Auxins can stimulate the work of cytokinins in the process of 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 and following the general nature of the hormone that was relatively low concentrations it can stimulate cell division and elongation, thereby affecting plant growth and development. Young et al. (Yong et al., 2009) stated that CW contained auxins, various cytokinins such as trans-zeatin and kinetin, gibberellin, and ABA. The CW also contained 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 fresh weight clump^{-1} and tubers dried weight ha^{-1} can be influenced by the leaf area number as the source of the photosynthesis process which produced 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. 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 ingredient that contains various types of hormones such as auxins, cytokinins, and gibberellins which function to stimulate plant growth. The CW was a natural hormone that can provide the most optimal results for the yield of shallots because it contained many types of hormones needed for plant growth. Natural PGR types contained different growth hormones and minerals, so they will have different effects on the growth and yield of LPSV plants. For this reason, to obtain maximum results, natural PGR was needed 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 stated by Indriani et al.(2014), the complexity of hormone and mineral content in CW resulted in a significant multiplication effect when compared to the addition of BA synthetic hormone.

Conclusion

Based on the results and discussion can conclude that 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 hectare^{-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 to increase. 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 carry out further research with various sources of other types of natural PGR.

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

ANSAR, M.[1*] – PAIMAN[2]

[1]*Department of Agrotechnology, Faculty of Agriculture, Tadulako University, Palu 94118, Indonesia (e-mail: ansharpasigai@gmail.com; phone: +62-813-9212-2864)*

[2]*Department of Agrotechnology, Faculty of Agriculture, Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia*
(e-mail: paiman@upy.ac.id; phone: +62-813-2862-9000)

[*]*Corresponding author*
e-mail: ansharpasigai@gmail.com; phone: +62-813-9212-2864; fax: +62-451-429-738

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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 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 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^{o}01'14.6532" and E 119^{o}59'29.0256"; a place altitude of 120 m above sea level (ASL), with a daily average temperature of 30.8^{o}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, 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 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}.

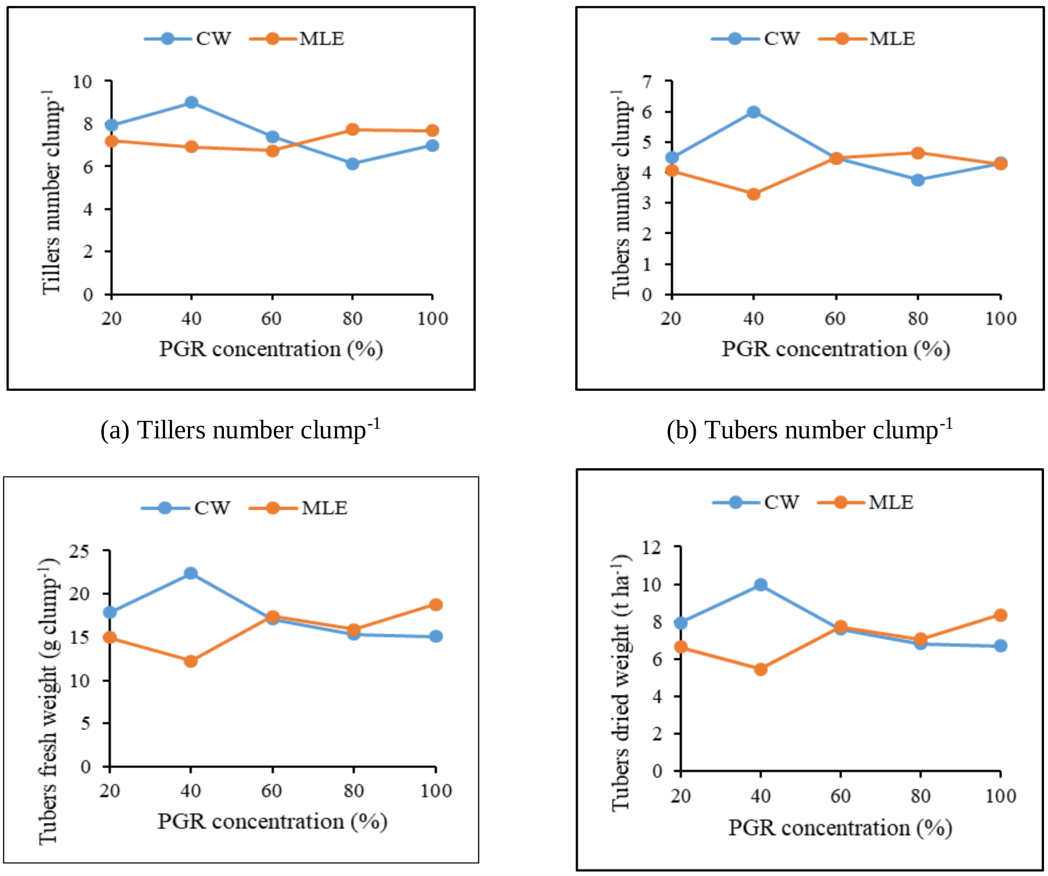
Table 2. *Tillers number, tubers number clump^{-1}, tubers fresh weight clump^{-1}, and the tuber dried weight ha^{-1}*

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}*

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 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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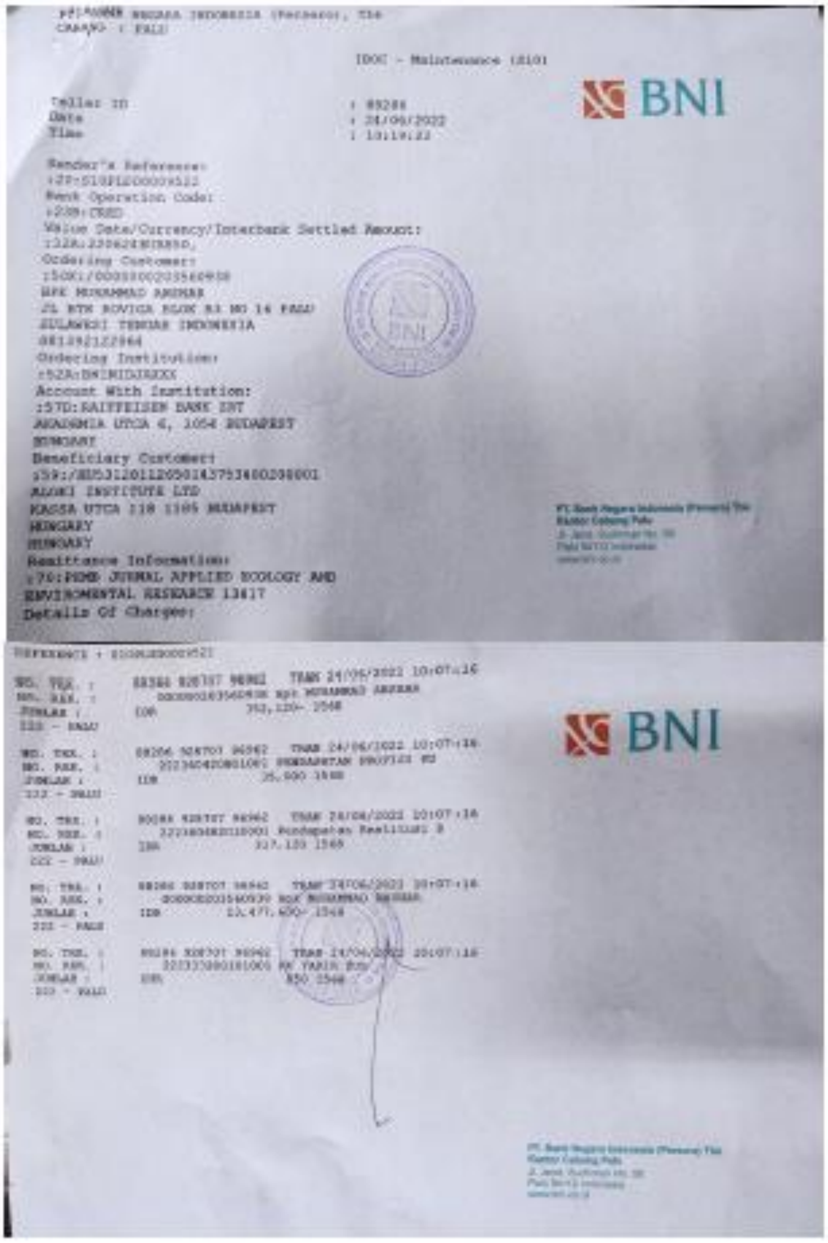

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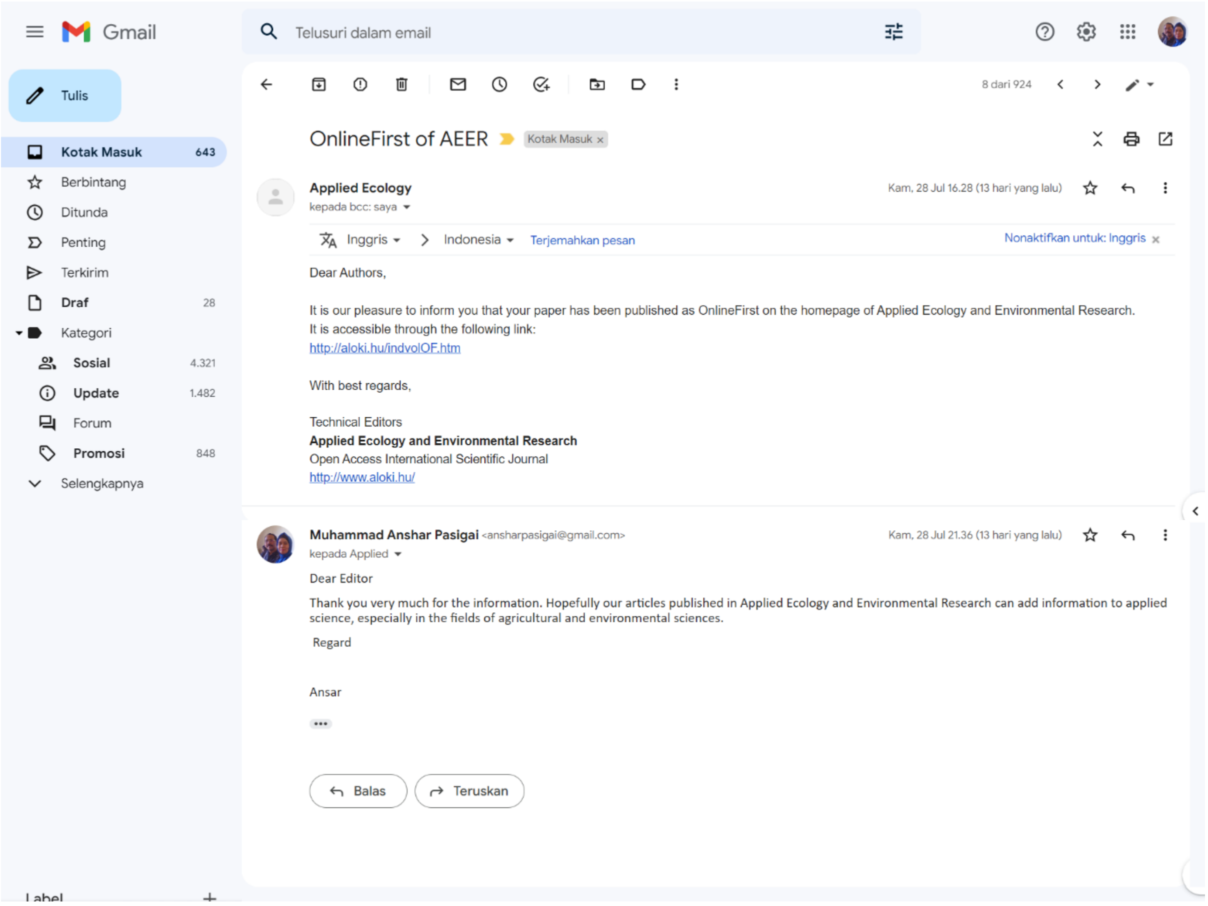

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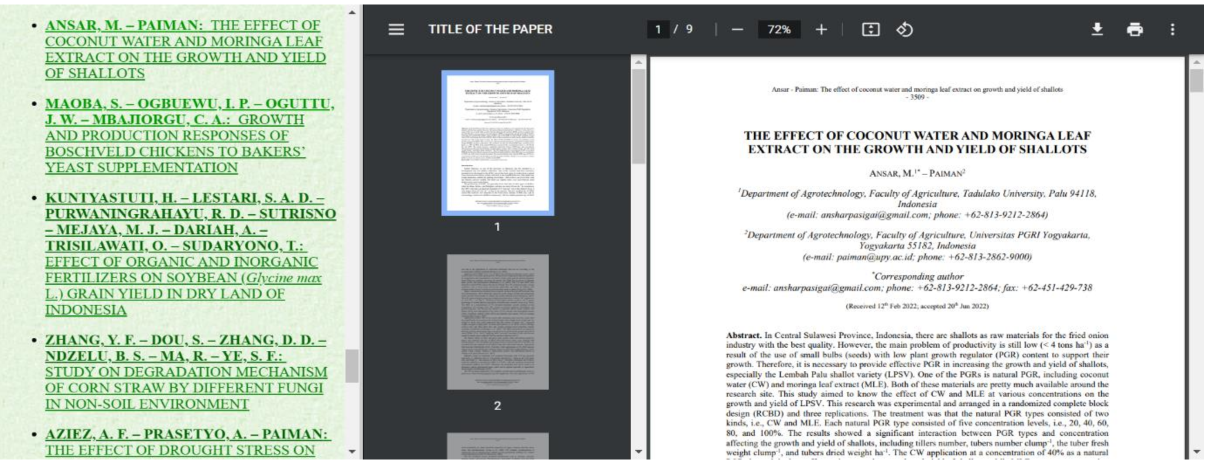

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THE EFFECT OF COCONUT WATER AND MORINGA LEAF EXTRACT ON THE GROWTH AND YIELD OF SHALLOTS

ANSAR, M.[1*] – PAIMAN[2]

[1]*Department of Agrotechnology, Faculty of Agriculture, Tadulako University, Palu 94118, Indonesia*
(e-mail: ansharpasigai@gmail.com; phone: +62-813-9212-2864)

[2]*Department of Agrotechnology, Faculty of Agriculture, Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia*
(e-mail: paiman@upy.ac.id; phone: +62-813-2862-9000)

[*]*Corresponding author*
e-mail: ansharpasigai@gmail.com; phone: +62-813-9212-2864; fax: +62-451-429-738

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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