Application of some types of local seaweed extract for the growth and yield of shallot (*Allium wakegi*)

[1]Ramal Yusuf, [1]Abdul Syakur, [2]Yulianti Kalaba, [1]Fatmawati Fatmawati

[1] Program Study Agrotechnology, Faculty of Agriculture, University of Tadulako, Palu, Indonesia; [2] Agribusiness Program Study, Faculty of Agriculture, University of Tadulako, Palu, Indonesia. Corresponding author: R. Yusuf, ryusufus@yahoo.com

Abstract. This study aims to determine the effect of some types of local seaweed extract on the growth and yield of the shallot (*Allium wakegi* A.) variety 'lembah palu' (a name of local shallot variety). The seaweed was collected from Central Sulawesi, Indonesia. This research was conducted in the field in Jone Oge Village, Sigi Biromaru, Palu, Indonesia. The research design was a Randomized Block Design. The following treatments were used: P0 - (control); P1 - NPK fertilizer 1.25 g per plant; P2 - *Caulerpa* sp. extract, 100 mL per plant per week; P3 - *Sargassum* sp. extract, 100 mL per plant per week; P4 - *Kappaphycus alvarezii* extract, 100 mL per plant per week; P5 - *Ulva* sp. extract, 100 mL per plant per week. Therefore, there are 6 treatments, each repeated 4 times. The results indicated that the application of seaweed extract had a significant effect on all observed parameters, including the height of plant (cm), the number of leaves, fresh weight of plant (g), dry weight of plant (g), fresh weight of bulb (g), dried weight of bulb (g), and tuber diameter (cm). The results showed that *Ulva* sp. extract produced better results compared to the control and other seaweed extracts.
Key Words: bulb, dry, fertilizer, *Ulva* sp.

Introduction. The potential of the marine resources of Indonesia is very large. A part of it is represented by seaweeds (Bixler & Porse 2011). However, the use of seaweed in the country is still limited as a food product for humans, as an industrial material, and as ingredient in traditional medicine (Sanger et al 2019). The use of seaweeds in agriculture and horticulture is still not applied on a large scale yet. Seaweeds or algae amount to a large proportion of marine plants (Hong et al 2007), which grow and develop in almost all Indonesian waters and are one of the marines and aquatic commodities that have been used for a long time for export. Seaweeds have important economic value because of extensive use, as food ingredients, as organic fertilizers (Craigie 2011; Vijayakumar et al 2018), in cosmetics, textile, and pharmaceutical industries. The use of seaweed is for various purposes because seaweeds contain a variety of chemicals and other organic compounds and vitamins (Abetz 1980; Yusuf 2012).

Shallot (*Allium wakegi*) is one of the horticulture plants (Hidangmayum & Sharma 2017) used as a spice ingredient because it serves as a distinctive flavor enhancer (Dogra & Mandradia 2012), and is widely used by Indonesians (Maemunah et al 2019). In Central Sulawesi Province, especially in Palu, which has a dry climate, there are varieties of shallots that have better growth and yield. One variety of shallot is known as 'lembah palu' and produces a distinctive aroma when fried. The benefits of shallots include a source of vitamins B and C, protein, fat, and carbohydrates. The production of shallots has a productivity potential above 20 tons ha^{-1}, but practically, the production of shallots is on average lower than the potential yield. Shallot production in 2014 increased by 1.234 million tons, compared to 2013, at 1.011 million tons. Shallot consumption in Indonesia is 4.56 kg per capita per year or 0.38 kg per capita per month so that national consumption needs to reach 1.608 million tons per ha (Maemunah et al 2019). The decline in shallot productivity is due to inadequate cultivation techniques carried out in the field. One alternative to increase the growth and yield of shallots is choosing seaweed liquid organic fertilizer (Szczepanek et al 2017). Also, seaweed extract containing organic ingredients can help plant growth (Sivasankari et al 2006).

Based on the description above, a study of applying some types of seaweed extracts for improving the growth and yield of shallots was conducted as one of the efforts to increase the growth of shallots and utilization of seaweeds in plant cultivation.

Material and Method. This study was conducted from April to June 2017 in Jono Oge Village, Sigi Biromaru District, Sigi Regency and at the Laboratory Horticulture, Faculty of Agriculture, Tadulako University, Palu, Indonesia. Raw seaweeds were collected from beaches at the Salakan area (1.310°S, 123.296°E) and beaches at the Donggala area (0.689°S, 119.739°E). The collected raw seaweeds were cleaned from debris, washed with freshwater, sun-dried for 3 days, and ground in a blender. The ground seaweed was weighed and frozen to -20°C for 24 hours. The freezing causes cellular rupture and a better release of content during subsequent extraction. The extraction was conducted using the method of Win & Saing (2008), where 100 g of dry weight were added to 2 L of distilled water, and the mixture was heated to 75°C with continuous stirring for 2 hours to reach a slurry state. Solids in the slurry were separated from the liquid extract through a fine filter screen.

The tools used in this research were blenders, digital scales, scissors, sieves, funnels, 1500 mL water containers, stirrers, sieves, 50 mL measuring cups, 25 mL measuring cups, hand tractors, shovels, hoes, buckets, meters, cutters, analytical scales, ovens, analytic balance, calipers, digital cameras, and writing instruments. The material used in this study is shallot variety 'lembah palu', water, NPK fertilizer, *Caulerpa* sp., *Sargassum* sp., *Kappaphycus alvarezii*, and *Ulva* sp.

This study used a Randomized Block Design (RBD) consisting of 6 treatments. The treatments were designed as follows: no extract - control; 1.25 g NPK fertilizer per plant; *Caulerpa* sp. 100 mL extract per plant; *Sargassum* sp. extract, 100 mL per plant; *Kappaphycus alvarezii* extract, 100 mL per plant; *Ulva* sp. extract, 100 mL per plant. Thus, there were 6 treatments, each treatment was repeated 4 times, so there were 24 experimental units.

This study (Win and Saing 2008)used the variance analysis (ANOVA), α=0.05. If the variance analysis showed a significant effect of the treatment, the 5% Honestly Significance Difference (HSD) was conducted to determine the differences between treatments.

Results and Discussion

Plant height (cm). Variance analysis showed that shallot treated with *Ulva* sp. extract significantly differ from untreated shallots in the age of 28 days after planting (DAP), 35 DAP, 42 DAP, 49 DAP, and 56 DAP. The average values of plant height can be seen in Table 1. Based on the results of the 5% HSD test, shallots treated with the extract of *Ulva* sp. were not different from shallots treated with other local seaweed and NPK.

Table 1
Average shallot (*Allium wakegi*) height (cm) when treated with various species of seaweed

Treatment	Plant age				
	28 DAP	*35 DAP*	*42 DAP*	*49 DAP*	*56 DAP*
Control	11.36[a]	12.77[a]	14.05[a]	15.5[a]	15.42[a]
NPK	12.15[ab]	14.61[ab]	15.65[ab]	14.95[ab]	16.78[ab]
Caulerpa sp.	11.76[ab]	14.66[ab]	15.83[ab]	16.35[ab]	17.26[ab]
Sargassum sp.	13.33[ab]	14.65[ab]	15.41[ab]	16.73[ab]	18.31[ab]
Kappaphycus alvarezii	12.23[ab]	13.69[ab]	14.7[ab]	16.89[ab]	18.64[b]
Ulva sp.	15.31[b]	16.76[b]	17.7[b]	19.16[b]	22.20[b]
HSD 5%	3.53	2.67	2.19	2.57	3.14

Note: different superscripts indicate significant differences ($p<0.05$).

The number of leaves. Based on the 5% HSD test, the application of seaweed extract made from *Ulva sp*. produced the highest number of leaves, which was different from control, but not different from shallots treated with NPK, *Caulerpa* sp., *Sargassum* sp., *K. alvarezii* at the age of 42, 49, and 56 DAP (Table 2).

Table 2
Average of number of leaves of shallot (*Allium wakegi*) treated with various seaweeds

Treatment	Plant age		
	42 DAP	*49 DAP*	*56 DAP*
Control	9.91[a]	10.97[a]	12.54[a]
NPK	10.34[ab]	11.46[ab]	13.46[ab]
Caulerpa sp.	11.88[ab]	13.56[ab]	15.25[ab]
Sargassum sp.	10.69[ab]	13.43[ab]	14.71[ab]
Kappaphycus alvarezii	11.33[ab]	13.21[ab]	14.67[ab]
Ulva sp.	14[b]	14.96[b]	16.75[b]
HSD 5%	3.24	3.84	3.37

Note: different superscripts indicate significant differences ($p<0.05$).

Fresh weight of plants (g). Based on the 5% HSD test, the application of seaweed extract made from *Ulva* sp. produced the highest shallot fresh weight, which was different from control, but not different from shallot treated with NPK, *Caulerpa* sp., *Sargassum* sp., and *K. alvarezii* (Table 3).

Table 3
Average fresh weight (g) of shallot (*Allium wakegi*) treated with various seaweeds extract

Treatment	*Fresh weight (g)*
Control	2.82[a]
NPK	4.97[ab]
Caulerpa sp.	5.24[ab]
Sargassum sp.	5.47[ab]
Kappaphycus alvarezii	5.25[ab]
Ulva sp.	6.91[b]
HSD 5%	3.02

Note: different superscripts indicate significant differences ($p<0.05$).

Plant dry weight (g). Based on the HSD test showed that shallots treated with seaweed extract and NPK were different from untreated shallots. However, shallot treated with *Ulva* sp. extract produced the highest shallot dry weight (Table 4).

Table 4
Average dry weight (g) of shallots (*Allium wakegi*) treated with various seaweeds

Treatment	Dry weight (g)
Control	0.69^{a}
NPK	1.20^{b}
Caulerpa sp.	1.19^{b}
Sargassum sp.	1.26^{b}
Kappaphycus alvarezii	1.08^{b}
Ulva sp.	1.59^{b}
HSD 5%	0.71

Note: different superscripts indicate significant differences (p<0.05).

Bulbs fresh weight (g). Shallots treated with seaweed extract and NPK were different from untreated shallots, from a bulb fresh weight perspective. However, shallot treated with *Ulva* sp. extract produced the highest shallot bulbs fresh weight (Table 5).

Table 5
Average weight of shallot (*Allium wakegi*) fresh bulbs (g) treated with different seaweed extracts

Treatment	Bulb fresh weight (g)
Control	2.25^{a}
NPK	4.54^{b}
Sargassum sp.	4.61^{b}
Kappaphycus alvarezii	4.51^{b}
Ulva sp.	4.95^{b}
HSD 5%	1.97

Note: different superscripts indicate significant differences (p<0.05).

Bulb dry weight (g). Based on the HSD test, shallot treated with NPK, *Sargassum* sp., *K. alvarezii*, and *Ulva* sp. extract were different from untreated shallots. However, bulbs dry weight of shallots treated with *Caulerpa* sp. extract are not different from those of untreated shallots (Table 6).

Table 6
Average shallot (*Allium wakegi*) bulb dry weight (g) treated with various seaweeds

Treatment	Bulb dry weight (g)
Control	0.49^{a}
NPK	1.01^{b}
Caulerpa sp.	0.97^{ab}
Sargassum sp.	1.06^{b}
Kappaphycus alvarezii	1.15^{b}
Ulva sp.	1.37^{b}
HSD 5 %	0.51

Note: different superscripts indicate significant differences (p<0.05).

The number of bulbs. Based on the HSD test, shallots treated with NPK and *Caulerpa* sp. extract were not different from untreated shallots regarding the number of bulbs. However, shallot treated with *Sargassum* sp., *K. alvarezii*, and *Ulva* sp. extracts were different from untreated shallot on the number of bulbs (Table 7).

Table 7

The average number of bulbs on shallot (*Allium wakegi*) treated with various seaweed extracts

Treatment	Number of bulbs
Control	3.17[a]
NPK	3.42[ab]
Caulerpa sp.	3.88[ab]
Sargassum sp.	4.42[b]
Kappaphycus alvarezii	4.63[b]
Ulva sp.	4.75[b]
HSD 5%	1.24

Note: different superscripts indicate significant differences (p<0.05).

Bulb diameter (mm). Based on the 5% HSD test, the application of seaweed extract made from *Ulva* sp. produced the highest shallot bulb diameter, which was different from control, but not different from shallot treated with NPK, *Caulerpa* sp., *Sargassum* sp., and *K. alvarezii* (Table 8).

Table 8

Shallot (*Allium wakegi*) bulb average diameter (mm) treated with various seaweed extracts

Treatment	Bulb diameter (mm)
Control	13.39[a]
NPK	24.8[ab]
Caulerpa sp.	25[ab]
Sargassum sp.	26.37[ab]
Kappaphycus alvarezii	25.68[ab]
Ulva sp.	27[b]
HSD 5%	13.35

Note: different letters indicate significant differences (p<0.05).

The treatment with *Ulva* sp. extract produces the best values compared to other treatments, especially compared with the control treatment. This is thought to be influenced by the liquid organic fertilizer (Vijayanand et al 2014), which extends to seaweed extracts application to plants (Yusuf et al 2016). Similar results using seaweed extract on onions showed that seaweed can increase the growth and the yield of the plant (Dogra & Mandradia 2012). Sufficient nutrient content in the soil, as a result of applying liquid organic fertilizer, will cause better vegetative growth in shallots. Plants need N, P, and K for growth (Chouliaras et al 2009). The process of plant metabolism is largely determined by the availability of primary macronutrients, namely N, P, and K, in a balanced amount, both in the vegetative growth phase and the generative growth phase (Wang et al 2017).

Seaweeds have macro and micronutrients including growth regulating substances, such as auxin (Buggeln & Craigie 1971), gibberellin, cytokinin, abscisic acid, and ethylene (Panda et al 2012; Yusuf et al 2015). The growth regulation plays a role in plant physiology processes, such as growth, division, differential cells, and protein synthesis. Gibberellin acid is known to influence cambium growth and geotropism, which effectively increases fruit cell growth so that plants are not dwarfed. Cytokinin plays a role in cell division, which causes plant responses to plant growth, fruit growth, and germination (Wu & Lin 2000).

The number of seaweed-based products that are used as additional nutrients and as organic fertilizers (biofertilizers) or biostimulants to improve plant growth and yield is increasing (Wajahatullah et al 2009). This study demonstrated that *Ulva* sp., *Sargassum* sp., *K. alvarezii,* and *Caulerpa* sp. can be used for plants as a liquid organic fertilizer. Growth regulators contained in this seaweed, like auxin (Tay et al 1985; Hong et al 2007; Khan et al

2009) can regulate the growth and yield of shallots. Auxin, besides being found in plants, can also be synthetically produced and used for various purposes, including stimulating the growth and development of roots (Rathore et al 2009). Auxin will increase the content of organic and inorganic substances in cells. Furthermore, these substances are converted into proteins, nucleic acids, polysaccharides, and other complex molecules, where compounds form organs and tissues so that the wet weight and dry weight of plants increases. The increase in metabolic processes in shallots causes an increase in the formation of carbohydrates, proteins, and fats, meaning that the potential yield can be increased (Nabti et al 2017).

The growth and development of shallots are strongly influenced by the provision of fertilizers and the availability of nutrients in the soil. Nutrient uptake is limited by low levels of nutrients in the growing media. Optimum growth can be achieved if all nutrients are in a balanced state. Application of seaweed extract as an organic fertilizer or liquid fertilizer can be considered in shallot farming because it contains nutrients and growth regulators (Crouch & van Staden 1993) that stimulate growth and increase crop yields. These seaweed extracts could be a promising option for yield enhancement.

Conclusions. From the results of this research, it can be concluded that all applications of various seaweed extracts have significant effects on plant growth and development. NPK has a similar effect on shallot growth and development, however, seaweed extract would be more environmentally friendly and sustainable.

Acknowledgements. This paper was supported by the Overseas Seminar Assistance Program Directorate General of Research and Development Strengthening and also by the Directorate of Research and Community Service Ministry of Research and Technology of the Republic of Indonesia.

References

Abetz P., 1980 Seaweed extracts: have they a place in Australian agriculture or horticulture? Journal of the Australian Institute of Agricultural Science 46:23-29.

Bixler H. J., Porse H., 2011 A decade of change in the seaweed hydrocolloids industry. Journal of Applied Phycology 23:321-335.

Buggeln R. G., Craigie J. S., 1971 Evaluation of evidence for the presence of indole-3-acetic acid in marine algae. Planta 97:173-178.

Chouliaras V., Tasioula M., Chatzissavvidis C., Therios I., Tsabolatidou E., 2009 The effects of a seaweed extract in addition to nitrogen and boron fertilization on productivity, fruit maturation, leaf nutritional status, and oil quality of the olive (*Olea europaea* L.) cultivar Koroneiki. Journal of the Science of Food and Agriculture 89:984-988.

Craigie J., 2011 Seaweed extract stimuli in plant science and agriculture. Journal of Applied Phycology 23:371-393.

Crouch I. J., van Staden J., 1993 Evidence for the presence of plant growth regulators in commercial seaweed products. Plant Growth Regulation 13:21-29.

Dogra B., Mandradia R. K., 2012 Effect of seaweed extract on growth and yield of onion. International Journal of Farm Sciences 2:59-64.

Hidangmayum A., Sharma R., 2017 Effect of different concentration of commercial seaweed liquid extract of *Ascophyllum nodosum* on germination of onion (*Allium cepa* L.). International Journal of Science and Research 6:1488-1491.

Hong D D., Hien H. M., Son P. N., 2007 Seaweeds from Vietnam used for functional food, medicine, and biofertilizer. Journal of Applied Phycology 19(6):817-826.

Khan W., Rayirath U., Subramanian S., Jithesh M., Rayorath P., Hodges D., Critchley A., Craigie J., Norrie J., Prithiviraj B., 2009 Seaweed extracts as biostimulants of plant growth and development. Journal of Plant Growth Regulation 28:386-399.

Maemunah, Yusuf R., Samudin S., Kasim H., Yusran, 2019 Optimization and regeneration of in vitro seedling of shallot variety Lembah Palu in providing good quality seedling. IOP Conference Series: Earth and Environmental Science 235:012051, 6 p.
Nabti E., Jha B., Hartmann A., 2017 Impact of seaweeds on agricultural crop production as biofertilizer. International Journal Environment Science Technology 14:1119-1134.
Panda D., Pramanik K., Nayak B. R., 2012 Use of sea weed extracts as plant growth regulators for sustainable agriculture. International Journal of Bio-resource and Stress Management 3(3):404-411.
Rathore S. S., Chaudhary D. R., Boricha G. N., Ghosh A., Bhatt B. P., Zodape S. T., Patolia J. S., 2009 Effect of seaweed extract on the growth, yield and nutrient uptake of soybean (*Glycine max*) under rainfed conditions. South African Journal of Botany 75:351-355.
Sanger G., Rarung L. K., Kaseger B. E., Assa J. R., Agustin A. T., 2019 Phenolic content and antioxidant activities of five seaweeds from North Sulawesi, Indonesia. AACL Bioflux 12(6):2041-2015.
Sivasankari S., Venkatesalu V., Anantharaj M., Chandrasekaran M., 2006 Effect of seaweed extracts on the growth and biochemical constituents of *Vigna sinensis*. Bioresource Technology 97:1745-1751.
Szczepanek M., Wszelaczyńska E., Pobereżny J., Ochmian I., 2017 Response of onion (*Allium cepa* L.) to the method of seaweed biostimulant application. Acta Scientiarum Polonorum - Hortorum Cultus 16(2):113-122.
Tay S. A. B., Macleod J. K., Palni L. M. S., Letham D. S., 1985 Detection of cytokinins in a seaweed extract. Phytochemistry 24(11):2611-2614.
Vijayakumar S., Durgadevi S., Arulmozhi P., Rajalakshmi S., Gopalakrishnan T., Parameswari N., 2018 Effect of seaweed liquid fertilizer on yield and quality of *Capsicum annum* L. Acta Ecologica Sinica 39(5):406-410.
Vijayanand N., Ramya S. S., Rathinavel S., 2014 Potential of liquid extracts of *Sargassum wightii* on growth, biochemical, and yield parameters of the cluster bean plant. Asian Pacific Journal of Reproduction 3:150-155.
Wajahatullah, Rayirath U. P., Subramanian S., Jithesh M., Rayorath P., Hodges D., Critchley A., Craigie J., Norrie J., Prithiviraj B., 2009 Seaweed extracts as biostimulants of plant growth and development. Journal of Plant Growth Regulation 28:386-399.
Wang Y., Xiang L., Wang S., Wang X., Chen X., Mao Z., 2017 Effects of seaweed fertilizer on the *Malus hupehensis* Rehd. seedlings growth and soil microbial numbers under continue cropping. Acta Ecologica Sinica 37(3):180-186.
Win L., Saing K., 2008 Effectiveness of Myanmar brown seaweed (*Sargassum* spp.) extract as organic fertilizer in pot trial of rice. GMSARN International Conference on Sustainable Development. Issues and Prospects for the GMS 12-14, 4 p.
Wu T. W., Lin C. H., 2000 Analysis of cytokinin activity in commercial aqueous seaweed extract. Gartenbauwissenschaf 65:170-173.
Yusuf R., Kristiansen P., Syakur A., Mas’ud H., Hawalina, 2015 Detecting plant growth regulator in seaweeds using bioassay. 1st International Conference on Applied Marine Science and Fisheries Technology, pp. 107-111.
Yusuf R., Kristiansen P., Warwick N., 2012 Potential effect of plant growth regulators in two seaweed products. Acta Horticulturae 958:133-138.
Yusuf R., Syakur A., Budiatno, Mas'ud H., 2016 Application of some type seaweeds of on the growth and yield of shallot (*Allium ascalonicum* L.). Agroland 3(2):81-86.

Received: 18 November 2019. Accepted: 14 March 2020. Published online: 26 August 2020.
Authors:
Ramal Yusuf, Program Study Agrotechnology, Faculty of Agriculture, University of Tadulako, Palu, Jl. Sukarno Hatta Km. 9, 94148 Palu, Indonesia, e-mail:ryusufus@yahoo.com
Abdul Syakur, Program Study Agrotechnology, Faculty of Agriculture, University of Tadulako, Palu, Jl. Sukarno Hatta Km. 9, 94148 Palu, Indonesia, e-mail: abdsyakur@yahoo.com
Yulianti Kalaba, Program Study Agribusiness, Faculty of Agriculture, University of Tadulako, Palu, Jl. Sukarno Hatta Km. 9, 94148 Palu, Indonesia, e-mail: yuli.anti407@yahoo.com
Fatmawati Fatmawati, Program Study Agrotechnology, Faculty of Agriculture, University of Tadulako, Jl. Sukarno Hatta Km. 9, 94148 Palu, Indonesia, e-mail:fatmafat@yahoo.com

How to cite this article:
Yusuf R., Syakur A., Kalaba Y., Fatmawati F., 2020 Application of some types of local seaweed extract for the growth and yield of shallot (*Allium wakegi*). AACL Bioflux 13(4):2203-2210.