Application of local seaweed extracts on growth and yield of mustard greens (*Brassica juncea* L.)

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Abstract. Mustard greens (*Brassica juncea* L.) is one of the horticultural crops of vegeTable species that are utilized in young leaves. Utilization of seaweed as biofertilizer can be an alternative solution to environmental problems caused by mineral fertilizers because they are safe for soil and plant microbes. The research aimed to determine the effect of extract of seaweeds growing Central Sulawesi on growth and yield of mustard greens. This study consisted of six treatments: P_0 = control, P_1 = NPK fertilizer, P_2 = seaweed extract *Caulerpa* sp., P_3 = seaweed extract *Sargassum* sp., P_4 = seaweed extract *Kappaphycus alvarezii*, P_5 = seaweed extract *Ulva* sp., Plant height, number of leaves, leaf area, fresh weight of plant, dry weight of plant, and chlorophyll content were measured during the growing period and at harvest. The results showed that the seaweed extracts significantly affected on growth and yield of mustard greens plants. The most effective seaweed extracts for mustard greens plants was from *Ulva* sp. which produced average leave fresh weight 772.79 g and 10.40 numbers of leaves.

1. Introduction

Mustard greens (*Brassica juncea* L.), locally known by the generic name sawi is the most popular leaf vegeTable in Indonesia. Several cultivars differentiated by their stem colour, leaf size and flowering habits are grown locally. Mustard green is a vegeTable crop of the *Cruciferae* family which has high economic value. As a leaf vegeTable, mustard is rich in sources of vitamins and minerals [1]. Furthermore, Growing vegeTables mustards contributes to ensuring food security, injecting further revenue to farmers, and improving environmental balances [2].

Seaweed has long been used directly as a soil conditioner and fertilizer in various coastal areas in the world [3] [4], and seaweed extracts have also been widely marketed as additives to plant fertilizers whose benefits and benefits of use have been widely reported [5] [6] [7]. Utilization of seaweed as fertilizer is expected to be an alternative solution to environmental problems [8] because it is safe for soil and plant microbes [9]. According to [5] There are several methods of making seaweed liquid fertilizer including physical fresh liquid seaweed extraction or extraction using alkali [10] and using dry seaweed [11] [12].

The purpose of this research is to study the effect of various types of seaweed extracts on the growth and yield of mustard greens plants and also to find out the type of seaweed extract that is better on the growth and yield of mustard greens plants.

2. Material and Method

This research was carried out on Duyu Village, West Palu District, Palu. Plant analysis was carried out at the Horticultural Laboratory of the Faculty of Agriculture, Tadulako University, Palu. The tools used were hand tractors, hoes, shovels, buckets, gauges, analytical scales, ovens, chlorophyll meter, digital camera, mustard greens seed variety tosakan, NPK fertiliser, seaweed *Caulerpa* sp., *Sargassum* sp., *Kappaphycus alvarezii*, and *Ulva* sp.

This study uses a randomized block design (RBD) with treatments consisting of:

P0 = Control (no fertilizer)
P1 = NPK fertilizer
P2 = Extract *Caulerpa* sp
P3 = Extract *Sargassum* sp
P4 = *Kappaphycus alvarezii*
P5 = Extract *Ulva* sp

The treatment was repeated 4 times so that there were 24 plot experimental.

Field Preparation. All soil in field clearing removed weeds and other materials that disrupt the process of plant growth, the beds are made with a size of 210 x 90 cm, the height of the beds is 30 cm, the distance between the beds is 40 cm.

Seeding and Planting. In the seedling process, the nursery beds are made with a size of 100 cm x 100 cm, seeds are sown on the beds and then covered using banana leaves. After the seeds are 6-7 days old, the cover is opened and replaced with shade making using a paranet with a 45 cm high. After 2 - 3 weeks the seedlings are ready to be transferred to the planting field with a spacing of 30 cm x 30 cm.

Seaweed Extract Preparation. Seaweed is blended fine then weighs seaweed that has been blended as much as 100 g, then incubated in the refrigerator at -20^{0}C for 20 minutes. For 100 g seaweed added 2 litres of distilled water, then heated using a hot plate while stirring at a temperature of around 75^{0}C for 2-3 hours. After heated the seaweed is removed and filtered again using a 60 Mesh filter, the filter results are considered to be 100% seaweed extract [11]. The treatment applied seven days after the mustard greens plants are transferred to the planting area. Seaweed extract was given to mustard greens plants as much as 100 ml per plant, and the treatments applied once a week.

Plant height is measured during growth by measuring from the leaf base to the longest leaf tip. Measurements were made on 14, 21, and 28 DAP. The number of leaves is measured during growth by counting the leaves that have developed perfectly at14, 21, and 28 DAP. For weighing the roots, stems and leaves of the plants using an analytical balance. Measurement of fresh weight of roots, stems and leaves is done at the time after harvest. Measurement of the dry weight of roots, stems and leaves was carried out on 5 plant samples in each plot. The samples were being put in an oven at 80^{0}C for 2 x 24 hours. Then weigh the stems, leaves and roots using an analytical balance. Observation of plant chlorophyll content was carried out on 5 plant samples in each plot using chlorophyll counters by counting 3 points on one leaf for each plant sample.

The Data were analyzed using the analysis of variance (ANOVA) to determine the effect of treatment on observational variables. If the results of the analysis showed a significant effect, further tests were carried out using the Honestly Significant Difference (HSD) test at 5% level [13].

3. Result and Discussion

The results of the analysis showed that the application of seaweed extract at 14 DAP, 21 DAP and 28 DAP significantly affected the average plant height. The average value of plant height can be seen in Table 1.

Table 1. Average plant height (cm) at 14 DAP, 21 DAP, and 28 DAP.

Treatment	Plant Hight		
	14 DAP	21 DAP	28 DAP
P_0	23.25[a]	33.81[a]	36.31 [a]
P_1	28.29[b]	35.78[ab]	37.60 [ab]
P_2	28.51 [b]	34.96[ab]	36.47 [ab]
P_3	27.51[ab]	35.35 [ab]	38.31[ab]
P_4	27.75[ab]	37.80 [b]	41.36 [b]
P_5	27.62[ab]	36.02[ab]	39.32 [ab]
HSD 5%	5.03	3.50	5.00

Note: Numbers followed by the same letter are not significantly different at the HSD test level of 5%

Based on the results of the 5% HSD test in Table 1 shows that the average value of 14 DAP plant height for the treatment *of Caulerpa* sp extract (P2) and NPK (P1) obtained the highest values of 28.51 and 28.29 cm but it showed no different from the extract of *Sargassum* sp. (P3), *Kappaphycus alvarezii* (P4), and *Ulva* sp (P5) but different from the control treatment (P0). The average value of plant height of 21 DAP for the treatment of *Kappaphycus alvarezii* (P4) extract was 37.80 cm, and it was no different from the effect of other treatments but different from the control treatment (P0). The average value of plant height of 28 DAP for the treatment of *Kappaphycus alvarezii* (P4) extract was 41.36 cm, and the lowest value was the control treatment (P0) of 36.31 cm. The results showed that using seaweed extract at 28 DAP observations significantly affected the average number of leaves, but 14 DAP and 21 DAP observations had no significant effect. The average value of the number of leaves can be seen in Table 2.

Table 2. Average number of leaves age 28 DAP

Treatment	Number of Leaves
	28 DAP
P_0	9.70 [a]
P_1	10.15[ab]
P_2	9.75[a]
P_3	9.85[a]
P_4	11.05[b]
P_5	10.40[ab]
HSD 5%	0.99

Note: Numbers followed by the same letter are not significantly different at the HSD test level of 5%

Table 2 shows that the average number of leaf leaves aged 28 DAP in the *Kappaphycus alvarezii* (P4) extract treatment obtained the highest number of leaf which is 11.05 cm and it was no different from the NPK (P1) and *Ulva* sp. (P5) but different from the control treatment (P0), *Caulerpa* sp. (P2), and *Sargassum* sp. (P3). The results showed that the application of seaweed extract at 28 DAP observations significantly affected the average fresh weight of roots, stems and leaves of plants (g). The average weight value of fresh roots, stems and leaves of plants (g) can be seen in Table 3.

Table 3. Average weight of fresh plant age 28 DAP

Treatment	Roots	Stems	Leaves
	28 DAP	28 DAP	28 DAP
P_0	23.14 [a]	15.91 [a]	640.25 [a]
P_1	22.55 [a]	17.74 [ab]	692.54 [ab]
P_2	21.80 [a]	16.11 [a]	665.85 [ab]
P_3	23.17 [a]	17.03 [ab]	697.78 [ab]
P_4	25.27 [ab]	18.04 [ab]	765.14 [b]
P_5	27.83 [b]	18.91 [b]	772.79 [b]
HSD 5%	3.75	2.77	111.89

Note: Numbers followed by the same letter are not significantly different at the HSD test level of 5%

Based on the results of 5% HSD test in Table 4 shows that the heaviest average fresh weight of plant roots at 28 DAP is in the treatment of *Ulva* sp. (P5) ie 27.83 g but it was not different from the treatment of *Kappaphycus alvarezii* (P4), but different from other treatments. The average value of fresh weight of stems of plants is in the treatment of *Ulva* sp. (P5) with a value of 18.91 g but it was no different from the NPK (P1) treatment, *Sargassum* sp. (P3), and *Kappaphycus alvarezii* (P4), but different from the control treatment (P0), and *Caulerpa* sp. (P2) .The heaviest fresh weight of the leaves of the plant is in the treatment of *Ulva* sp. (P5) with a value of 772.79 g but it was no different from the NPK (P1) treatment, *Caulerpa* sp. (P2), *Sargassum* sp. (P3), and *Kappaphycus alvarezii* (P4), but different from the control treatment (P0). The results showed that the application of seaweed extract at 28 DAP observations significantly affected the average dry weight of roots, stems and leaves of plants (g). The average dry weight of roots, stems and leaves of plants (g) can be seen in Table 4.

Table 4. Average dry plant weight (g) age 28 DAP

Treatment	Roots	Stem	Leaves
	28 DAP	28 DAP	28 DAP
P_0	3.09[a]	2.10 [a]	42.80 [a]
P_1	3.41[ab]	2.44 [ab]	47.18 [ab]
P_2	3.21[a]	2.26 [ab]	43.64 [ab]
P_3	3.74[ab]	2.34 [ab]	43.43 [ab]
P_4	4.13[b]	2.63 [ab]	49.74 [ab]
P_5	4.08[b]	2.80 [b]	53.90 [b]
HSD 5%	0.98	0.59	10.63

Note: Numbers followed by the same letter are not significantly different at the HSD test level of 5%.

Table 5 shows that the heaviest average dry root weight of plants aged 28 DAP is in the treatment of *Kappaphycus alvarezii* (P4) and *Ulv*a sp. (P5) with a value of 4.13 g and 4.08 so that it was significantly different from the treatments P0, P1, P2 and P3. The heaviest dry weight of plant stems at 28 DAP was in the treatment of *Ulva* sp (P5) with a value of 2.80 g significantly different from the other treatments. The heaviest weight of dry leaves of plants aged 28 DAP was in the treatment of *Ulva* sp (P5) with a value of 53.90 g and significantly different from other treatments. Chlorophyll Levels showed that the application of seaweed extract at 28 DAP observations significantly affected the average chlorophyll content. The average value of chlorophyll levels can be seen in Table 5.

Table 5. Average chlorophyll levels of 28 DAP

Treatment	Chlorophyll Levels
	28 DAP
P_0	34.19 [a]
P_1	39.10 [ab]
P_2	38.69 [ab]
P_3	36.68 [ab]
P_4	38.85 [ab]
P_5	40.98 [b]
HSD 5%	5.58

Note: Numbers followed by the same letter are not significantly different at the HSD test level of 5%

Based on the 5% HSD test results in Table 6 shows that the highest average age of 28 DAP chlorophyll is in the treatment of *Ulva* sp extract (P5) with a value of 40.98 but it was no different from the NPK (P1) treatment, *Caulerpa* sp (P2), *Sargassum* sp. (P3), and *Kappaphycus alvarezii* (P4), but different from the control treatment (P0). Results of mustard greens yield showed that the application of seaweed extract at 28 DAP observations significantly affected the average yield of mustard greens plants (tons/ha). The average value of mustard greens plants (tons/ha). can be seen in Table 6.

Table 6. Average mustard greens yield (tons/ha)

Treatment	Mustard greens Yield
	(ton/ha)
P_0	11.38 [a]
P_1	12.31 [ab]
P_2	11.84 [ab]
P_3	12.40 [ab]
P_4	13.60 [b]
P_5	13.74 [b]
HSD 5%	1.99

Note: Numbers followed by the same letter are not significantly different at the HSD test level of 5%

Table 7 shows that the highest yield of mustard greens plants was *Kappaphycus alvarezii* (P4) and *Ulva* sp. (P5) but it was no different from NPK (P1) treatment, *Caulerpa* sp. (P2), *Sargassum* sp. (P3) but different from the control treatment (P0) [7]**.** Seaweed extract at 28 DAP observations significantly affected the average number of leaves This is consistent with the results of research by [14] reported that spraying plants using seaweed extract at high concentrations could increase the number of leaves per plant. Plant growth regulators from seaweed can also stimulate plant growth and play a role in increasing nutrient uptake [15]. *Caulerpa* sp extract (P2) and NPK (P1) treatment obtained the highest values of plant high. This shows that the treatment of *Kappaphycus alvarezii* (P4) extract is able to supply the needs of nutrients in the process of growth and development of mustard greens plants. Absorption of nutrients from seaweed extract can be quickly absorbed by plants, where plants need nutrients to carry out metabolic processes, especially during the vegetative period used to encourage cell division and the formation of new cells [16] to form plant organs such as leaves, stems and roots.

The heaviest average fresh weight of plant roots at 28 DAP was *Ulva* sp. This indicated that the application of *Ulva* sp may meet the nutrients requirement for plants which in turn increased roots

biomass [17]. Many products made from seaweed, have been used as additional nutrients and as biostimulants or organic fertilizers (biofertilizer) to increase plant growth and yield [18] [5] [19]. Most of the parameter showed that using *Ulva* sp produced better result compared to other Control treatment. This may indicate that *Ulva* sp extract provide sufficient nutrient requirements for mustard greens plants therefore mustard greens can grow well. In general seaweed have been shown to improve the growth of several plants [20], this potentially as a result of the various organic and inorganic components in seaweed [21][22].

4. Conclusions

Based on the description above, it can be concluded that the various types of seaweed extract significantly affect the growth and yield of mustard greens plants. The seaweed extract *Ulva* sp. better effect compared to other seaweed extracts, NPK, and Control. This has confirmed that seaweed extract can improve plant growth better than NPK and control. A range of plant growth regulators, biostimulants and soil conditioning compounds may be responsible to the growth and the yield of observed plant responses. Further research is required to clarify the role of these compounds in seaweed extracts in stimulating plant growth.

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