The Effect of Seaweed Extract (Sargassum sp.) on Growth and Yield Enhancement of Mustard Greens (Brassica juncea L.)

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Abstract: This research aims to study the effect of applying various seaweed extract concentrations on mustard greens growth and yield (Brassica juncea L.). The study was conducted at the Faculty of Agriculture Screen House, University Tadulako Palu, and arranged using a randomized block design (RBD) with six treatments. These were, without seaweed extract (E0), as well as 20% (E1), 40% (E2), 60% (E3), 80% (E4), and 100% (E5) seaweed extract concentration. The experiment was repeated four times, thus, there were 24 experimental units. Subsequently, the data obtained were analyzed using analysis of variance, followed by Honest Real Difference at level 5%. The results showed seaweed extract with different concentrations significantly influenced plant height, leaf number, leaf area, fresh weight, and dry weight.

1. Introduction

Mustard greens (Brassica juncea L.) are a type of leafy vegetable favored by all groups of people (1) due to the high vitamin A and C content, with an excellent potential as a provider of essential mineral elements for the body, due to the high nutritional value (2). Fertilizer is the primary source of nutrition provided to plants, and must therefore be applied to increase the plant’s yield. Plants require water and mineral nutrients for growth, development, and daily reproduction (3). These nutrients are vital to increasing agricultural productivity, absorbed through roots, stems, as well as leaves, and have several functions supporting each other (4).

The use of chemical fertilizers is proven to have caused severe problems, including soil and water pollution, decreased soil fertility (5), in addition to a dangerous impact on human health, thus, there is a need to switch to organic fertilizers. These are not only affordable, but also environmentally friendly, for instance, seaweed, often regarded as waste, is actually a suitable organic fertilizer.

Seaweed is not only a functional food ingredient but also has potential as an organic fertilizer due to the wide variety of trace metals (Fe, B, Ca, Cu, Cl, K, Mg, and Mn) contained, as well as the
presence of growth regulators (PGR), including auxins, cytokinins, and gibberellins, with the ability to stimulate growth and increase plant production (6) (7) (8).

Therefore, the use of seaweed as fertilizer or additional fertilizer is a presumed alternative solution to environmental problems. This application is safe for soil and plant microbes and increases seaweed's economic value in Indonesia. In this study, the addition of seaweed extract is expected to increase yield and quality in mustard plant (9) (10) (11). Therefore, the study aims to know the effect of various seaweed concentrations on mustard green growth and yield.

2. Materials and method
The research was conducted from August to September, 2017, at the Faculty of Agriculture Screen House, Tadulako University, and at the Horticulture and Agro-Industry Laboratory, Tadulako University, Palu, Central Sulawesi. Meanwhile, the equipment used include hoe, analytical balance, oven, spectrophotometer, Erlenmeyer, research board, blender, knife, hotplate, filter, filter paper, sprayer, bucket, as well as leaf area meter (LAM), while the materials used include Shinta variety mustard seeds, soil as planting medium, sand, Sargassum sp. seaweed extract, Aquades, ethanol, and polybags.

This study utilized a randomized block design (RBD) arrangement with six treatments, E0 = without seaweed extract (control), E1 = seaweed extract with 20% concentration, E2 = seaweed extract with 40% concentration, E3 = Seaweed extract with 60% concentration, E4 = seaweed extract with 80% concentration, and E5 = seaweed extract 100% concentration. Each treatment was repeated four times, thus there were 24 experimental units.

The research implementation includes the seaweed extract preparation stage, planting media preparation, mustard green seeding, planting, seaweed extract application, maintenance, and harvesting (2), while the research observations include plant height (cm), number of leaves (strands), leaf area, fresh plant weight (ton ha⁻¹), plant dry weight (g), and chlorophyll content (nm).

An analysis of variance was conducted to determine the effect of treatments and the experimental parameters. Subsequently, a 5% Honestly Significance Difference (HSD) test performed in cases where a statistical significance was obtained, to separate the significantly different means.

3. Results and discussion

3.1. Plant height
According to the 5% HSD test results, the seaweed extract affected plant height at 7, 14, 21, and 28 DAP (Days After Planting). Table 1 shows the average plant height at 7, 14, 21, 28 DAP.

Table 1: The effect of seaweed extract application on mustard plant height from 7 to 28 DAP.

| Treatment | 7 DAP | 14 DAP | 21 DAP | 28 DAP |
|-----------|-------|--------|--------|--------|
| 0%        | 11.56 b | 17.19 ab | 22.56 ab | 24.44 a |
| 20%       | 10.94 ab | 17.19 ab | 20.75 a | 26.19 b |
| 40%       | 10.75 a | 16.56 a | 22.63 ab | 27.38 b |
| 60%       | 11.81 b | 19.00 b | 24.44 bc | 30.69 c |
| 80%       | 11.25 ab | 18.19 ab | 23.13 b | 31.00 c |
| 100%      | 11.00 ab | 18.81 b | 25.75 c | 32.50 d |
| HSD 5%    | 0.73   | 1.68   | 2.13   | 1.61   |

Note: Mean values followed by the same letter in the same column are not significantly different at the 0.05 HSD level.
The 5% HSD test (Table 1) shows the treatment of *Sargassum* sp. with a 60% concentration produced the highest plant heights of 11.81 and 19.00 cm, at 7 and 14 DAP, respectively. This is similar to the other concentration, except 40%. Meanwhile, the 100% seaweed concentration produced the highest plant heights at 21 and 28 DAP, however the concentration at 21 DAP differed from others, except at 60%. Conversely, at 28 DAP, the concentration was 100% different from the others.

### 3.2. Number of leaves

The 5% HSD test results showed *Sargassum* sp. extract application influences the number of leaves in mustard plants at 14, 21, and 28 DAP. Table 2 shows the average leaf number at 14, 21, and 28 DAP.

**Table 2**: The effect of seaweed extract application on the number of mustard plant leaves

| Treatment | Number of leaves | 14 DAP | 21 DAP | 28 DAP |
|-----------|-----------------|--------|--------|--------|
| 0%        | b               | 5.38   | 6.38   | 7.38   |
| 20%       | b               | 5.75   | 7.75   | 9.75   |
| 40%       | a               | 4.00   | 7.38   | 9.38   |
| 60%       | b               | 4.63   | 7.63   | 9.63   |
| 80%       | a               | 5.38   | 7.38   | 9.38   |
| 100%      | a               | 5.25   | 7.13   | 9.00   |

HSD 5% | 0.84 | 0.87 | 0.89 |

Note: Mean values followed by the same letter in the same column are not significantly different at the 0.05 HSD level.

The 5% HSD test (Table 2) shows the 20% concentration treatment produced the highest mustard leaf number of 5.75 pieces, at 14 DAP. This is similar to the other concentrations (without seaweed extract, and at 60%, 80%, as well as 100% concentrations), except for 40%. Furthermore, at 21 and 28 DAP, the highest leaf numbers of 8.00 and 9.88 respectively, were obtained using 100% concentration. This was not statistically different from other treatments (20%, 40%, 60%, and 80% concentrations), except the control (without seaweed extract).

### 3.3. Leaf fresh weight

The 5% HSD test results showed the application of *Sargassum* sp. seaweed extract in different concentrations influences mustard plant fresh weight. Table 3 shows the average fresh weight after harvest.

**Table 3**: The effect of seaweed extract application on mustard plant fresh leaf weight.

| Treatment | Average (g) | HSD 5% |
|-----------|-------------|--------|
| 0%        | 37.98 a     |        |
| 20%       | 37.71 a     |        |
| 40%       | 51.45 a     | 61.06  |
| 60%       | 76.30 ab    |        |
| 80%       | 74.61 ab    |        |
| 100%      | 118.00 b    |        |

Note: Mean values followed by the same letter in the same column are not significantly different at the 0.05 HSD level.
The 5% HSD test (Table 3) shows the treatment using 100% *Sargassum* sp. Extract produced the highest leaf fresh weight. This was significantly different from the control (without seaweed extract), and the treatments with 20% and 40% concentrations, but not from the 60% and 80% concentrations.

### 3.4. Fresh root weight

According to the 5% HSD test results, the application of *Sargassum* sp. seaweed extract at different concentrations influenced the fresh weight of mustard roots. Table 4 shows the average root fresh weight after harvest.

**Table 4:** The effect of seaweed extract application on the fresh root weight of mustard plants.

| Treatment | Average (g) | HSD 5% |
|-----------|-------------|--------|
| 0%        | 3.59 a      |        |
| 20%       | 3.14 a      |        |
| 40%       | 4.49 ab     |        |
| 60%       | 4.48 ab     | 3.39   |
| 80%       | 3.60 ab     |        |
| 100%      | 6.95 b      |        |

Note: Mean values followed by the same letter in the same column are not significantly different at the 0.05 HSD level.

The 5% HSD test (Table 5) shows the 100% treatment produced the highest root fresh weight of 6.95. This concentration does not differ from 40%, 60%, and 80%, but differs from the control (without seaweed extract) and 20% concentration.

### 3.5. Leaf dry weight

Based on the 5% HSD test results, the application of *Sargassum* sp. seaweed extract in different concentrations influences the plant dry weight. Table 5 shows the mustard plant average leaf dry weight.

**Table 5:** The effect of seaweed extract application on the leaf dry weight of mustard plant.

| Treatment | Average (g) | HSD 5% |
|-----------|-------------|--------|
| 0%        | 2.74 a      |        |
| 20%       | 2.17 a      |        |
| 40%       | 2.76 a      | 3.22   |
| 60%       | 4.24 ab     |        |
| 80%       | 3.41 ab     |        |
| 100%      | 6.24 b      |        |

Note: Mean values followed by the same letter in the same column are not significantly different at the 0.05 HSD level.

The 5% HSD test (Table 6) shows the 100% concentration treatment, the highest leaf dry weight was 6.24 g. This was different from the control (without seaweed extract), as well as 20% and 40% concentrations, but not from the 60% and 80% treatments.
3.6. Root dry weight

Based on the 5% HSD test results, the application of Sargassum sp. seaweed extract from different concentrations influenced the dry weight of mustard roots. Table 6 shows the average root dry weight after oven drying.

| Treatment | Average (g) | HSD 5% |
|-----------|-------------|--------|
| 0%        | 0.24 ab     |        |
| 20%       | 0.12 a      |        |
| 40%       | 0.25 ab     | 0.38   |
| 60%       | 0.22 ab     |        |
| 80%       | 0.18 a      |        |
| 100%      | 0.60 b      |        |

Note: Mean values followed by the same letter in the same column are not significantly different at the 0.05 HSD level.

The 5% HSD test (Table 6) shows the 100% concentration treatment produced the highest root dry weight of 0.60 g. This differs from the 20% and 80% concentrations, but not from the control (without seaweed extract), as well as 40% and 60% treatments.

Sargassum sp. seaweed extract significantly influences plant height, number of leaves, leaf area, fresh weight, and dry weight. This is due to sufficient exposure to sun as well as the presence of plant growth-stimulating hormones, gibberellins, cytokinins, and auxins (7). Brown seaweeds, including Sargassum, Laminaria, and Ascophyllum not only contain macro, micro, and alginate nutrients, vitamins, and antibiotics but also contain growth hormones (auxin, gibberellin, cytokinin-kinetin, cytokinin-zeatin) (12), and these are active plant growth-promoting compounds. Thus, increasing production, protein synthesis, cell division and differentiation, fruit cell development and regulating plant growth (13) (14).

Auxins play a role in plant physiological processes, including growth, cell division and differentiation, as well as protein synthesis, while gibberellin influences peak dormancy, cambium growth, geotropism, abscission, and parthenocarpy, effectively increases fruit cells, and stimulates growth to avoid stunting (15). Meanwhile, cytokinins play a role in cell division, causing growth responses to plant and fruit growth, as well as germination (16).

The degradation of these compounds tends to cause low gibberellin content in commercial organic fertilizer products during processing or production, as well as differences in gibberellin content, depending on the commercial production process (17) (18). Differences in cytokinin content of seaweed extracts is influenced by several factors, including season, seaweed development phase, seaweed type, as well as the detection method (12)(18)(19)(20)

Furthermore, the application of seaweed extract is able to increase the nutrients within leaves, and consequently, plant weight. This is possibly due to the involvement of growth hormone in nutrient absorption and transportation within plants. Also, the seaweed extract contains growth hormones, namely IAA and cytokinins. These organic compounds are able stimulate growth due to protein synthesis and cell division, as well as nutrient metabolism, thus, promoting plant growth.

4. Conclusion

The application of Sargassum sp. seaweed extract to mustard greens plant showed enhancement effects on plant height at 7, 14, 21, and 28 DAP. In addition, the extract increased the number of leaves, leaf area, shoot and root fresh weight, shoot and root dry weight. However, the 100% concentration is most promising, compared to the other treatments.
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