Combinations of seaweed extract and NPK on vegetative growth of chili growing under glasshouse condition

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Abstract. Chili (Capsicum frutescens L.) is one of the horticultural crops having many benefits, namely as a cooking spice and a mixture of the food industry. Chili plants need N, P, and K for growth, provided in the form of NPK fertilizer or Seaweed extract as organic fertilizer. This study aimed to determine the effect of various combinations of seaweed extracts and NPK on the vegetative growth of chili. The experiment was arranged based on a randomized complete block design with seven treatments and three replications, so 21 experimental pot was obtained. The treatment of the combination of seaweed extract and NPK fertilizer application was T1 = seaweed extract of Ulfa sp. 100 ml/pot, T2 = seaweed extract of Caulerpa sp. 100 ml/pot, T3 = seaweed extract of Sargassum sp. 100 ml/pot, T4 = 0.5 g NPK fertilizer/pot, T5 = Ulfa sp. 100 ml/pot and 0.5 NPK, T6 = Caulerpa sp 100 ml/pot and 0.5 NPK, T7 = Sargassum sp. 100 ml/pot and 0.5 NPK. The results showed that the T1 treatment produced better results compared to other treatments.

1. Introduction

Chili (Capsicum frutescens L.) has small fruits with a spicy taste and vegetable horticultural crops. This type of chili is cultivated by farmers because it is widely needed by the community, not only on a household scale but also on an industrial scale, and exported abroad. This plant has many benefits, especially in its fruit, namely, a cooking spice, a mixture of the food industry, and a cosmetic ingredient. Apart from the fruit, other parts of this plant, including leaves, stems, and roots, can also be used as medicine [1]. Chili contains fat, protein, calcium, carbohydrates, iron, vitamins, phosphorus, and contain alkaloids compounds, including flavonoids, essential oil, and capsaicin. Capsaicin is a substance or mixture that controls cancer and causes a spicy taste in chilies.

The production of chili from year to year continued to increase. In 2009, the production was 591,294 tons, while in 2010, the production was 521,704 tons. However, in the last year, the production of chili has decreased by 69,590 tons. Besides, the price of chili on the market is often higher than other types of vegetables. This is because a few farmers have experienced crop failure. The occurrence of crop failure is due to several factors, especially soil fertility and pests, that damage flowers, leaves, and chili plants [2].

Cultivated plants often limit the growth and development of water. Plants' response to water deficiency can be seen in their morphology, growth rate, metabolic activity, or productivity. Cell growth is a plant function that is most sensitive to lack of water. Lack of water will affect cell turgor to reduce cell development, protein synthesis, and cell wall synthesis [3]. Drought is one of the main...
constraints that restricted plant quality and production. The drought stress occurrence is a physical-chemical complex associated with many large and small bio-molecules, for example, proteins, nucleic acids, fatty acids, carbohydrates, nutrients, hormones, and ions.

Low production of chilies is caused by insufficient land development, pest and disease attacks, intense drought, and soil fertility. The low level of soil fertility may be overcome by adding organic matter to the soil. This addition can improve the biological, physical, and chemical properties of the soil. To increase chili yield, farmers are trying to overcome these problems by fertilizing using chemical fertilizers [4]. However, the use of these chemical fertilizers causes soil pollution and lowers soil pH. The rapid absorption of nutrients can make the soil deficient in nutrients, especially micronutrients needed by plants to increase yields and plant resistance to pests and diseases.

Today, several innovative technologies have been proposed to improve agricultural production systems’ sustainability via a significant reduction of chemicals. Plant biostimulants, for example, seaweed extracts, represent interesting tools to illuminate the use of chemicals and increase crop tolerance to abiotic stresses, such as water stress and nutrient deficiency.

Marine macroalgae or seaweeds are plenty of diverse substances such as carbohydrates, proteins, lipids, and many more. Their advantage for agriculture is used a long time ago.

Besides containing many essential minerals from the sea needed by plants, seaweed contains proven growth-stimulating hormones that can increase plant growth and crop yield [5][6]. N, P, and K are essential nutrients and must be available to plants because they have a role in plant cells' metabolic and biochemical processes.

A study on "Combinations of seaweed extracts and NPK on the growth of chili (Capsicum frutescens L) vegetative was conducted based on the description above. This study aims to measure the effect of various combinations of seaweed extracts and NPK on the vegetative growth of chili under water stress conditions.

2. Materials and methods
This research was conducted from August to September 2018 at the greenhouse and the Horticulture Laboratory, Faculty of Agriculture, UNTAD, Palu.

The materials utilized are Ulfa sp. extract, Caulerpa sp. extract, Sargassum sp. extract, NPK fertilizer. This research was conducted using a randomized complete block design (RCBD). The treatment consisted of seven combinations of seaweed extract and NPK fertilizer, namely: T1 = seaweed Extract Ulfa sp. 100 ml/pot, T2 = seaweed extract Caulerpa sp. 100 ml/pot, T3 = seaweed extract Sargassum sp. 100 ml/pot, T4 = NPK fertilizer 0.5 g/pot, T5 = Ulfa sp. 100 ml/pot and 0.5 g NPK, T6 = Caulerpa sp. 100 ml/pot and 0.5 g NPK, T7 = Sargassum sp.100 ml/pot and 0.5 NPK. Each treatment was replicated three times so that there were 21 experimental pots. The polybag size of 5 kg was used. The soil is sieved first and then put into the polybag, then left for a few days.

Preparing seaweed extract: Seaweeds were ground using a fine blender and then filtered with a 60 mesh sieve size. The filtered seaweed was weighted about 0.1 kg and then incubated in a freezer for around 20 minutes at -20°C. For 0.1 kg of seaweed, distilled water is added to about 2 liters, then use a hotplate for heating at a temperature of about 75°C for 120 minutes. After heating, the seaweed is taking out and filtered once more, utilizing a filter a 60 mesh size. The filtrate is concluded to be 100% extract. Then seaweed extract is stored in a freezer at -20°C before being used for plants [7].

The water stress technique begins with determining the field capacity. The soil was put into a polybag as much as 4 kg as the initial weight, then water is given until the soil absorbs it down or reaches a saturation point. The soil was then stored for one day and one night and weighed to determine the weight of the field capacity. Furthermore, the plants were watered once every three days to reach the field capacity.

3. Results and discussion

3.1. Plant height
Observation of chili's height at the age of 2 WAP, 3 WAP, 4 WAP, and 5 WAP. It shows that applying a combination of seaweed extract and NPK has a highly significant effect on plant height. The overall
plant height can be seen in Table 1. The results of the 0.05 HSD test in Table 1 show that at 2 WAP, T1 obtained the highest average plant height of 25.67 cm, and was significantly different from the T2, T3, T5, T6, and T7 treatment, but not significantly different from the T4. At 3 WAP, T1 obtained the highest average of 31.72 cm and was significantly different from the T3 and T5 treatments, but not significantly different from the T2, T4, T6, and T7. At 4 WAP, T1 obtained the highest average plant height of 41.44 cm and was significantly different from the T3, T4, T5, T6, and T7 treatment, but not significantly different from T2. At 5 WAP, the highest average plant height of 48.53 cm obtained by T1 and significantly different from the T3, T4, T5, T6, and T7 treatment, but not significantly different from T2.

Table 1. The effect of various seaweed extract and NPK fertilizer application on the height of chili plants from 2 to 5 WAP

| Treatment | Plant height (cm) |
|-----------|-------------------|
|           | 2 WAP | 3 WAP | 4 WAP | 5 WAP |
| T1        | 25.67<sup>b</sup> | 31.72<sup>b</sup> | 41.44<sup>c</sup> | 48.53<sup>c</sup> |
| T2        | 22.01<sup>ab</sup> | 26.17<sup>a</sup> | 31.69<sup>a</sup> | 41.40<sup>a</sup> |
| T3        | 25.34<sup>b</sup> | 29.76<sup>ab</sup> | 39.44<sup>bc</sup> | 47.30<sup>c</sup> |
| T4        | 20.33<sup>a</sup> | 26.74<sup>a</sup> | 34.87<sup>bc</sup> | 44.69<sup>abc</sup> |
| T5        | 23.88<sup>ab</sup> | 29.24<sup>bc</sup> | 38.63<sup>bc</sup> | 46.22<sup>bc</sup> |
| T6        | 23.04<sup>ab</sup> | 27.57<sup>a</sup> | 35.49<sup>ab</sup> | 42.44<sup>ab</sup> |
| T7        | 22.92<sup>ab</sup> | 26.73<sup>a</sup> | 35.96<sup>abc</sup> | 43.96<sup>abc</sup> |
| HSD 0.05  | 4.31   | 3.97   | 5.91   | 4.70   |

Means followed by the same letter in the same column are not significantly different at the 0.05 HSD level.

3.2. Number of leaves
The total of chili leaves at the age of 3 and 4 WAP is presented in Table 2. It shows that applying a combination of seaweed extract and NPK had a significant effect on the number of leaves. The results of the 0.05 HSD test in Table 2 show that at 3 WAP, T1 obtained the highest value, namely 59.11, and was significantly different from the treatment T2, T3, T5, T6, and T7, but it was not significantly different from T4 treatment. At the age of 4 WAP T1 obtained the highest value, namely 77.25 and significantly different from the treatment of T2, T5, T6, and T7, but not significantly different from T3 treatment.

Table 2. The effect of various seaweed extract and NPK fertilization application on the number of leaves of chili plants at 3 and 4 WAP

| Treatment | Number of leaves |
|-----------|-----------------|
|           | 3 WAP | 4 WAP |
| T1        | 59.11<sup>c</sup> | 77.25<sup>b</sup> |
| T2        | 49.16<sup>ab</sup> | 69.44<sup>ab</sup> |
| T3        | 56.92<sup>bc</sup> | 74.22<sup>b</sup> |
| T4        | 42.29<sup>a</sup> | 61.86<sup>a</sup> |
| T5        | 58.44<sup>c</sup> | 73.61<sup>b</sup> |
| T6        | 53.45<sup>bc</sup> | 72.86<sup>b</sup> |
| T7        | 50.03<sup>ab</sup> | 69.57<sup>ab</sup> |
| HSD 0.05  | 8.15   | 9.31   |

Means followed by the same letter in the same column are not significantly different at the 0.05 HSD level.
3.3. Number of branches
The number of chili branches at the age of 4, and 5 WAP are presented in Table 3. It shows that applying treatment by combining types of seaweed extract and NPK had a significant effect on the number of branches. The results of the 0.05 HSD test in Table 3 show that at 4 WAP, T1 obtained the highest average of 9.86 branches and was significantly different from the T2, T3, T4, T5, and T6 treatments, but was not significantly different from T7.

| Treatment | Number of branches |
|-----------|--------------------|
|           | 4 WAP   | 5 WAP   |
| T1        | 9.86b   | 13.00c  |
| T2        | 6.34ab  | 8.56ab  |
| T3        | 9.33b   | 12.00bc |
| T4        | 6.67ab  | 9.56abc |
| T5        | 9.34b   | 11.11abc|
| T6        | 6.24ab  | 8.89ab  |
| T7        | 5.27a   | 7.78a   |

HSD 5% 3.62 3.94

Means followed by the same letter in the same column are not significantly different at the 0.05 HSD level.

3.4. Time to flowering
Observation of chili plants showed that applying a combination of seaweed extract and NPK significantly affected flowering. The average time to flowering is presented in Table 4. The results of the 0.05 HSD test in Table 4 show that the combination of seaweed extract and NPK for the time to flowering in T1 treatment obtained the longest time, namely 29.33 days and was significantly different from treatment T2, T4, and T6 but was not different from T3, T5, and T7 treatments.

| Treatment | Time to flowering (days) |
|-----------|--------------------------|
| T1        | 29.33c                   |
| T2        | 25.00*                   |
| T3        | 28.33 abc                |
| T4        | 25.59 ab                 |
| T5        | 28.78 bc                 |
| T6        | 25.11 ab                 |
| T7        | 26.11 abc                |

HSD 5% 3.68

Means followed by the same letter in the same column are not significantly different at the 0.05 HSD level.

3.5. Root length
The root length of chili at the time of harvesting is presented in Table 5. It shows that applying a combination of seaweed extract and NPK has a significant effect on the root length of the plants. The
results of the 0.05 HSD test in Table 5 show that the combination of seaweed extract and NPK for root length in T3 treatment obtained the longest root, namely 26.43 cm, and was significantly different from treatment T2, T4, T6, and T7 but not significantly different from T1 and T5 treatments.

| Treatment | Root length (cm) |
|-----------|------------------|
| T1        | 25.88 bc         |
| T2        | 22.04 ab         |
| T3        | 26.43 c          |
| T4        | 21.86 ab         |
| T5        | 24.88 bc         |
| T6        | 22.12 ab         |
| T7        | 20.57 a          |

HSD 5% 4.11

Means followed by the same letter in the same column are not significantly different at the 0.05 HSD level.

The results showed that various seaweed extract treatments significantly affected several leaf parameters, plant height, time to flowering, root length, and several branches. This is thought to be influenced by seaweed extract [8], and NPK fertilizer given to chili is an essential element for the plant should be insufficient quantities [2]. These nutrients cannot be fulfilled; the metabolic process and plant growth will be disrupted and even cause death [9]. Giving the seaweed extract could improve soil properties such as physical, chemical, and biological properties [10][11]. Organic matter in seaweed is a source of plant nutrients and energy for most soil organisms [12][13]. Sufficient nutrient content in the soil will lead to better vegetative growth in chili. Plants need primary nutrients, namely N, P, and K, at the development time [14]. The process of plant metabolism is mostly determined by the availability of primary macronutrients, namely N, P, and K, in a reasonably balanced amount, both the vegetative growth phase and the generative growth phase.

Seaweed contains macro mineral components and includes phytohormones as growth regulators such as auxins, gibberellins, cytokinins, abscisic acid, and ethylene [15][16]. Each of these growth regulators has a different function; auxin compounds play a role in plant physiological processes, such as growth, cell division, and differentiation, and protein synthesis [17][18]; Gibberellins are known to affect peak dormancy, cambium growth, geotropism, abscission, and parthenocarpy, are effective in increasing fruit set, stimulating growth between books so that plants are not stunted. In contrast, cytokinins play a major role in cell division resulting in plant responses to plant growth, fruit growth, and sprouts' germination.

The advantages of using seaweeds in agriculture are diverse and numerous, including shoot and root elongation, stimulation of seed germination, health and growth enhancement of plant, water, and nutrient uptake improvement. The large number of by-products produced from seaweed has been used as supplementary nutrients and a biostimulant or organic fertilizer to improve plant yield and growth because they contain suitable growth regulators [19]. The growth regulators in these seaweeds, such as auxins, play a role in plant physiological processes, such as growth, division, cell differential, and protein synthesis [20][21]. The water content of leaf cells is one of the factors that have an essential role in plant metabolism. The water content of cells must be maintained high to ensure stress, which will reduce metabolic processes and limit plant growth [3][22].

Plants can absorb nutrients, including growth regulators from all plant cell surfaces. The absorption of nutrients on almost all plant surfaces causes the competence of cells or tissues to grow and develop to form more significant new organs so that the formation of shoots and leaves becomes more. Auxins
increase the content of inorganic and organic compounds in cells. Furthermore, these substances are converted into nucleic acids, proteins, polysaccharides, and other complex molecules. This compound will form organs and tissues so that the plant's wet weight and dry weight increase. An increase in plants' metabolic processes causes an increase in the formation of carbohydrates, proteins, and fats, which in turn increase the potential for yields.

The combination of seaweed extract and NPK together affected the vegetative growth of chili plants. The possible mechanism is that seaweed extracts used in this experiment function as biostimulants and affects chili's vegetative growth. Biostimulants referred to substances that can be added to the soil close to a plant and positively impact plant growth and biotic and abiotic stress tolerance. Nutrients are not biostimulants. Unlike nutrients, biostimulants help plants to uptake nutrients [18]. Therefore applying seaweed extract and NPK together showed the chili plant performs better than treatment without the combination between seaweed extract and NPK fertilizer. Table 4 showed that the time to the flowering of the chili plant faster within the treatment combination of seaweed extract and NPK fertilizer. The mineral nutrients N, P, and K are known to affect the growth of the plant. N, for example, N fertilizer applications can increase growth depend on the sufficient availability of required nutrients. Growth increased with an increase in nitrogen level, but excessive N application may also decrease the growth. Simultaneously, the seaweed extract, which was added to the rhizosphere, can facilitate the uptake of nutrients. That is why in Table 1, the chili plant applying with seaweed only without NPK fertilizer produced the highest chili plant.

4. Conclusions
The combination of seaweed extract and NPK affected the vegetative growth of chili plants. Without adding NPK, Ulva sp extract showed a potential to use as liquid organic fertilizer for chili plants.

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References
[1] Vijayakumar S, Durgadevi S, Arulmozhi P P, Rajalakshmi S, Gopalakrishnan T and Parameswari N 2018 Acta Ecologica Sinica 39 406-410
[2] Hapsoh, Leyna Z and Murniati 2019 J. Hortikultura Indonesia. 10 20–26
[3] Osakabe Y, Osakabe K, Shinozaki K and Tran L-SP 2014 Front. Plant Sci. 5 86
[4] Hasan M, Robbani M, Parvin R, Mehedi, M. and Hossain, I. 2019 Int. J. Agric. Res. Innov. Technol. 9 35-41
[5] Yusuf R, Syakur A, Budiatno, Mas’ud H 2016 Agrol. Agric. Sci. J. 3 81 – 86
[6] Yusuf R, Syakur A, Kalaba Y, Fatmawati F 2020 AAACL Bioflux 13 2203–2210
[7] Yusuf R, Bahrudin, Mas’ud H and Syakur A 2020 IOP Conf. Ser. Earth Environ. Sci. 484 12066
[8] Nabi E, Jha B and Hartmann A 2017 Int. J. Environ. Sci. Technol. 14 1119–1134
[9] Larcher W 2003 Physiological Plant Ecology, Ecophysiology and Stress Physiology of Functional Groups (Berlin: Springer)
[10] Ali N, Farrell A, Ramsubhag A and Jayaraman J 2016 J. Appl. Phycol. 28 1353–1362
[11] Vijayanand N, Ramya S S and Rathinavel S 2014 Asian Pacific J. Reprod 3 150–155
[12] Dogra B. and Mandradia R K 2012 Int. J. Farm Sci. 2 59–64
[13] Karthik T, Sarkar G, Babu S, Amalraj L D and Jayasri M A 2020 Biocatal Agric. Biotechnol 28 101712
[14] Dubey A, Singh D, Rajput P, Kumar Y, Verma A and Chandraker S 2017 Int. Curr. Microbiol. Appl. Sci. 6 1085–1091
[15] Tay S, Palni L and MacLeod J 1987 J. Plant Growth Regul. 5 133-138
[16] Manimaran P, Lakshmi J and Rajasekar P 2018 Environmental and Ecology 36 262–264
[17] Sanderson K, Jameson P and Zabkiewicz J 1987 J. Plant Physiol. 129 363-376
[18] Van Oosten MJ, Pepe O and De Pascale S 2017 Chem. Biol. Technol. Agric. 4
[19] Du Jardin P 2015 *Sci Hortic* **196** 3–14
[20] Di Stasio E, Rouphael Y, Colla G, Raimondi G, Giordano M, Pannico A, El-Nakhel C and De Pascale S 2018 *Eur J. Hortic. Sci.* **82** 286–293
[21] Halpern M, Bar-Tal A, Ofek M, Dror M, Muller T 2015 *Adv. Agron.* **130** 141–174.
[22] Boutraa T, Akhkha A, Al-Shoaibi A, and Alhejeli M 2010 *J. Taibah Univ. Sci.* **3** 39–48