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Effect of application of algae *sargassum* sp. extract to corn plants (*Zea mays* L.) and microbial response

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Abstract. This study aims to determine the effect of the application of algae *Sargassum* sp. extract on the growth of corn plants (*Zea mays* L.) and the response of soil microbes through the use of the Randomized Group Design (RGD) consisting of 3 repeats. The algae *Sargassum* sp. extract had 3 concentrations namely algae 30%, algae 60% and algae 90%. Then the algae *Sargassum* sp. extract was applied to the corn plants (*Zea mays*. L.) by being poured on the soil. Observation parameters stalk circumference (cm), leaf nitrogen content (%), stalk and leaf biomass (grams), cob weight (grams), husked cob weight (grams), cob length (cm), cob diameter (cm), soil bacteria colonies and soil fungi. The use of algae extracts improved the quality and quantity of corn growth using analysis of variances (F-test/ANOVA) with a confidence level of $\alpha = 0,05\%$. This was followed by analysis with the Duncan test using SPSS Statistics program version 22. The research results showed the application of algae *Sargassum* sp. extract on corn plants had a significant effect on stalk and leaf vegetative biomass, cob weight, husked cob weight, cob length and cob diameter, but did not have a significant effect on corn plant height, stalk circumference, leaf nitrogen content, soil bacteria colonies and soil fungi colonies. Even though there was not a significant effect, but quantitatively the corn plant growth with alga 30%, alga 60% and alga 90% treatments tended to be better than control.

1. Introduction

Corn is a plant which requires a large amount of nutrients to grow and produce a good yield. One cause of low productivity is inappropriate fertilization. The productivity of corn (*Zea mays* L.) needs to be improved because it is one of the world's most important food crops [1]. Increasing the production of corn plants requires optimal fertilization because corn is a plant which is responsive to fertilizer. The use of organic fertilizers needs to be optimized as one approach to improve corn productivity.

The use of seaweed extract as a fertilizer can help improve soil fertility, improving its capacity to absorb water and providing nutrients as well as improving soil structure [4], protecting plants from disease and environmental stresses such as salinity, dryness and low temperature [2]. In the field of agriculture, seaweed is used as livestock feed, soil fertilizer and compost in the form of a liquid extract, as a growth-enhancing substance and to protect plants against pests and disease [19].

Another benefit of the use of seaweed as an organic ingredient of fertilizer is its protein and fat content, macro and micronutrients as well as growth hormones such auxin, cytokinin and gibberellin which can stimulate plant growth [13]. In addition, growth hormones from seaweed have a role in the absorption of nutrients by plants [3]. Addition of seaweeds for soil conditioner will provide more nitrogen. Therefore the ratio of C/N will be much lower. Besides containing important minerals from the sea which are needed by plants, seaweed also contains growth hormones which have been proved to have the capacity to improve plant growth and harvest yields [6].

The beneficial effects of using seaweed extracts for plants is a combination of the result of several factors which work synergistically and various different concentrations used, although at present the processes involved are not fully understood [6]. The use of seaweed extract is becoming more popular. This is due to its potential for use in organic sustainable agriculture, especially for rain-dependent agriculture, as a solution to avoid the use of excess fertilizer and to improve the absorption of minerals [14]. Unlike chemical fertilizers, seaweed extracts can degrade naturally, are not toxic, are not contaminants, and are safe for humans and animals [4]. This study aims to determine the effect of the application of algae *Sargassum* sp. extract on the growth of corn plants (*Zea mays* L.) and the response of soil microbes.

2. Materials and Methods

This research was conducted from July to December 2018. The production of algae extract and the observation of soil microbial response was conducted at the Biology Laboratory, State University of Makassar. The measurement of the vegetative phase (circumference of stalk and stalk and leaf biomass) and the generative phase (cob weight, husked cob weight, cob length and cob diameter) was conducted at the Cereal Plant Research Centre (Balitserelia) in Maros. Algae *Sargassum* sp. is extracted using sulphuric acid (H_2SO_4). NPK fertilizer is a fertilizer consisting of 3 components, namely, nitrogen (urea), phosphate and potassium with a ratio of 4:1:1. Corn was planted in a field design according to the randomized group design (RGD) consisting of 3 repeats, each repeat consisting of 5 treatments, namely control, NPK, algae extract 30% concentration, algae extract 60% concentration, and algae extract 90% concentration. Fertilization was conducted 2 times, namely in the first week or 7 days after planting (DAP) and in the fourth week or 28 DAP. At the first fertilization, 100 ml of algae extract was applied for each of algae 30%, 60% and 90% and NPK 4.21 grams. At the second fertilization, 200 ml of algae extract was applied for each of algae 30%, 60% and 90% and NPK 4.21 grams.The effect of fertilizer on the growth of corn plants was observed by measuring the observation parameters, namely stalk circumference, stalk and leaf biomass, cob weight,husked cob weight, cob length, and cob diameter, as well as observation of microbial response (population of bacteria and population of fungi).The research results were analysed using analysis of variances (F-test) or ANOVA with a confidence level of α = 0,05%. Results which showed a significant difference were further tested with the Duncan test using SPSS Statistics program version 22.

3. Results and Discussion

3.1. Vegetative Phase

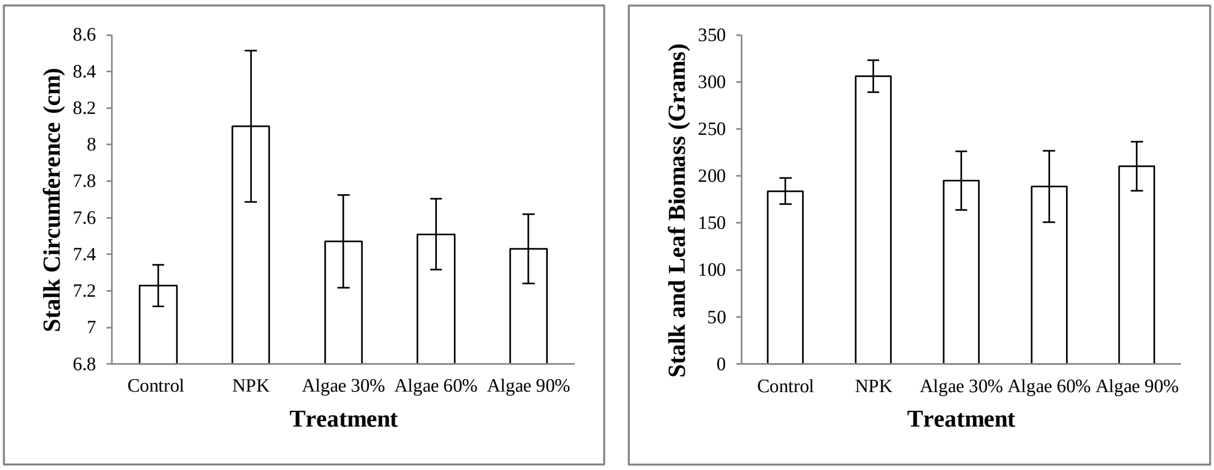
The vegetative phase is the phase from when the first leaves appear until silking (before the female flowers appear). Based on the results obtained, the average measurement of stalk circumference taken at 49 DAPS and the average weight of stalk and leaf biomass can be seen in Table 1 and Figure 1.

Table 1. Average Stalk Circumference (cm) and Stalk and Leaf Biomass (grams)

Treatment	Stalk Circumference (cm)	Stalk and Leaf Biomass (Grams)
Control	7.23[a]	183.80[a]
NPK	8.10[b]	305.93[b]
Algae 30%	7.47[a]	194.93[a]
Algae 60%	7.51[a]	188.86[a]
Algae 90%	7.43[a]	210.26[a]

Note: figures followed by the same letter in the column indicate that there is no significant difference based on the results of the Duncan test with a confidence level of α = 0,05.

Application of algae extract to plants which have entered the vegetative phase will improve growth, increase the number of cells, improve nutrient absorption including nitrogen which is a cell component, and improve the formation of macromolecules [16], with the result that the quality of the stalk is improved to become stronger so as to reduce its vulnerability to collapse [7]. This theory is in accord with the results obtained as shown in Table 1. The results of the statistical analysis show a significant difference, meaning that the application of algae *Sargassum* sp. extract has an effect on the stalk circumference and stalk and leaf biomass. This indicates that algae *Sargassum* sp. is able to increase growth in the vegetative phase.



(a) (b)

Figure 1. (a). Average Stalk Circumference(cm) and (b). Average Stalk and Leaf Biomass (grams)

Application of seaweed extract can increase the levels of potassium in plants [17]. Potassium is a primary osmolyte and an ion involved in the dynamics of plant cell membranes, including being a stomata regulator and maintaining turgor and osmotic balance [21]. The presence of potassium causes a more optimal opening of stomata. The optimal opening of stomata will have an effect on the photosynthesis process by increasing the absorption of CO_2. The increased in CO_2 absorbed by plants will result in an increase in the rate of photosynthesis [16]. The production of biomass in the vegetative organs such as the roots receives the next largest allocation after leaves and stalk until the flower initiation phase when the allocation of biomass to roots decreases [16].

Spraying seaweed extract containing micronutrients (Co, B, Mo, Zn, Cu) and macronutrients, as well as growth hormones (auxin, cytokinin and gibberellin) can increase the capacity of plant roots to grown and absorb nutrients, as well as increasing the thickness of the stalk and strengthening vegetative growth and plant roots. The strength of the response of increased plant growth through the use of seaweed fertilizer can be caused by 1) the additive effect of increasing the absorption of nutrients, and 2) the effect of growth hormones contained in seaweed [8].

3.2. Generative Phase

The generative phase is the growth phase after silking until the plant is physiologically ripe, based on the results obtained for observations of the average cob weight, husked cob weight, cob length and cob diameter. These can be seen in Table 2 and Figure 2.

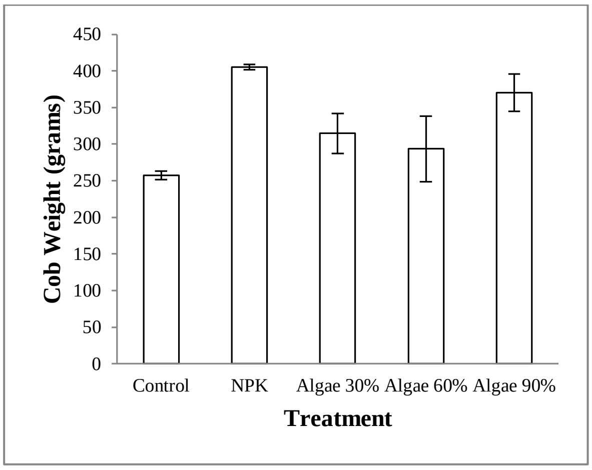
Table 2. Average Cob Weight, Husked Cob Weight, Cob Length and Cob Diameter

Treatment	Cob Weight (grams)	Husked Cob Weight (grams)	Cob Length (cm)	Cob Diameter(cm)
Control	257.46[a]	183.00[a]	15.93[a]	4.64[a]
NPK	405.20[c]	303.86[b]	19.44[b]	5.05[b]
Algae 30%	314.50[b]	227.26[a]	16.70[a]	4.70[a]
Algae 60%	293.40[ab]	211.40[a]	16.80[a]	4.66[a]
Algae 90%	370.13[c]	276.26[b]	18.53[b]	4.88[ab]

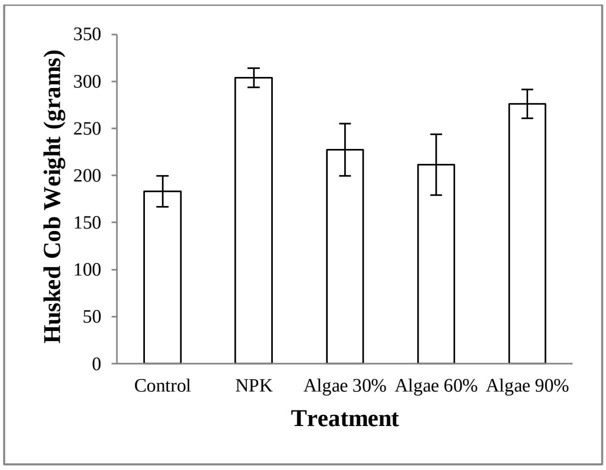
Note: figures followed by the same letter in the column indicate that there is no significant difference based on the results of the Duncan test with a confidence level of α = 0,05.

The results of statistical analysis showed that the cob weight, husked cob weight, cob length and cob diameter showed a significant difference from the control, meaning that algae Sargassum sp. extract had an effect on the generative phase of corn plants This result is in accordance with the theory [18] that states that the application of liquid seaweed extract *Sargassum* sp. as fertilizer can increase the yield of several important commercial plants by 12-36%. Besides that, the growth hormones found in algae such as cytokinin have an important role in cell division causing an increase in the growth of corn [22].

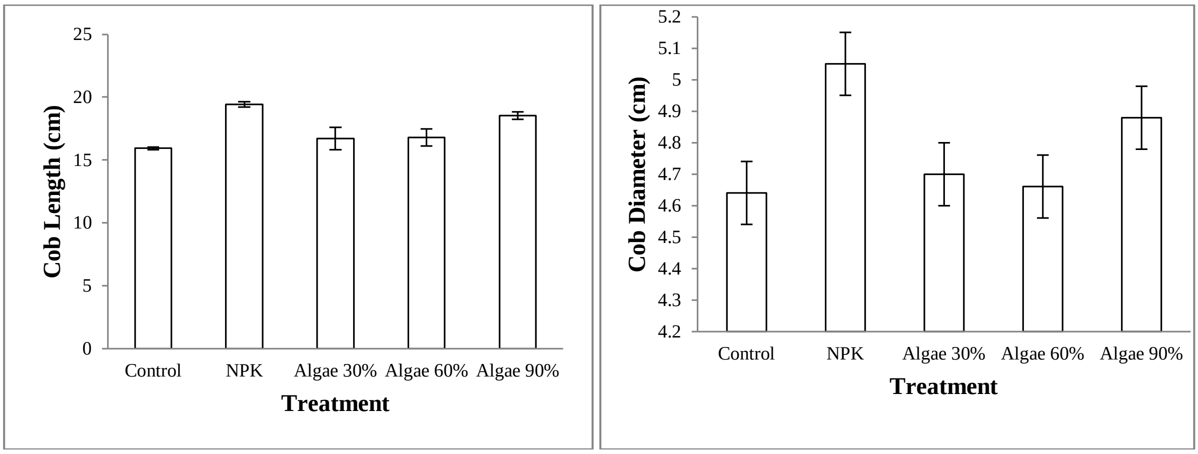
The nutrients which play a role in generative growth of plants are N and P [12] states that the nutrient component N has a role in flowering, but the role of N is not as large as the role of nutrient component P in the formation of flowers. The role of nutrient component P in the formation of flowers affects the formation and size of the cob because the cob develops from the female flower. This is because of the availability of nutrient components most of which are transferred during the generative phase and which can stimulate the formation of the corn cob (kernels). Growth hormones from algae extract also play a role in the absorption of nutrients by plants [3].



(a)



(b)



(c) (d)

Figure 2. (a). Average corn cobweight (grams), (b). The average weight of corn cob with husk (grams), (c). Average corn cob length (cm)and (d). Average corn cob diameter (cm)

According to theory [5] algae extract contains plant growth hormones, regulators, promoters, carbohydrates, amino acids, antibiotics, auxin, gibberellin and vitamins so that it can improve the quantity and quality of plant yields, [20;15] report that cytokinin plays an important role in regulating reproduction, differentiation of plant cells and controlling several processes in plant growth and development such as delaying plant aging, controlling root balance, giving signals for shifting nutrition and improving plant productivity.

The compound auxin plays a role in physiological processes in plants, such as growth, cell division and differentiation, and protein synthesis. Cytokinin plays an important role in cell division which causes a plant response with respect to plant growth, fruit formation and sprout germination [22]. Physio-Chemical properties analysis of Algae *Sargassum* results revealed that brown colour, sour taste, aromatic smell and soft in nature and methanol extract of *Sargassum* showed a number of metabolites presence, of steroids, phenolic groups, saponins, tannin, flavonoids, terpenoids carbohydrates, reducing sugars, and xanthoproteins, seaweed proteins are closely related to the cell wall polysaccharides, they may also play a role in the physicochemical properties, such as water holding.

3.3. Microbial Response

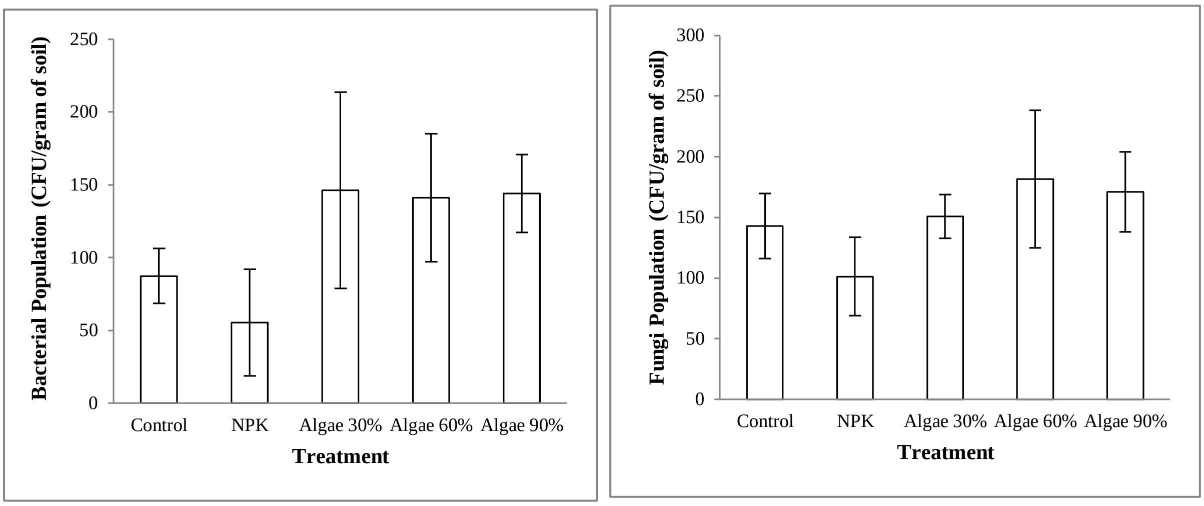
Soil bacteria and soil fungi population were counted using the SPC (*Standard Plate Count*) method. Soil samples were taken at the time the corn entered the generative phase from the rhizosphere. The average soil bacteria population and soil fungi population can be seen in Table 3 and Figure 3.

Table 3. Average bacteria population and average fungi population

Treatment	Bacterial Population (CFU/gram ofsoil)	Fungi Population (CFU/gram ofsoil)
Control	8.73×10^{3ab}	14.30×10^{3ab}
NPK	5.53×10^{3a}	10.13×10^{3a}
Algae 30%	14.63×10^{3b}	$15\times06\times10^{3ab}$
Algae 60%	14.10×10^{3b}	18.16×10^{3b}
Algae 90%	14.46×10^{3b}	17.10×10^{3ab}

Note: figures followed by the same letter in the column indicate that there is no significant difference based on the results of the Duncan test with a confidence level of α = 0,05.

Table 3 shows that the results for microbial response in the soil bacteria population and the soil fungi population do not show significant differences. But quantitatively the responses of the soil bacteria population and the soil fungi population were better with the algae to extract treatment. This was due to the fact that using algae extract as fertilizer can help improve the fertility of the soil, provide nutrients, as well as improving soil structure [4]. The addition of organic fertilizer facilitates decomposition and increases microbial activity [9]. Besides that, marine algae contain polysaccharides and alginate which can activate the growth of symbiotic fungi and bacteria in the rhizosphere [2]. The appropriate use of the plant growth regulator can increase plant growth, increase the population of soil microbes and reduce the effect of salinity and toxic ions [11].



(a) (b)

Figure 3. (a). Average Bacteria Population (b). Average Fungi Population

In agriculture, organic fertilizers have a purpose in the nutrition cycle, in that the plant residue from organic fertilizers will return to the planting area. If they are used, neither synthetic fertilizer nor synthetic pesticide needs to be used. This approach is very dependent on the microbe community being active to break down organic material to become nutrients for plants. The system managed in this conventional way also benefits from a high abundance of microorganisms because of their involvement in processing nutrients and improving soil structure [10].

4. Conclusion

Based on the research carried out it can be concluded that:

1. The effect of the application of algae *Sargassum* sp. extract on corn plants resulted in corn plants producing better yields compared to control after carrying out an analysis of significant differences. Seaweed extract containing micronutrients and macronutrients, as well as growth hormones can increase the capacity of plant roots to grown and absorb nutrients,
2. The effect of the application of algae S*argassum* sp. extract on microbial response resulted in a better microbial population response compared to the data from control and NPK treatments. The highest bacterial population data values were for algae concentration 30%, namely 14.63×10^{3b} and the highest fungi population data values were for algae concentration 60%, namely 18.16×10^{3}.

Acknowledgement
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