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The Effect of Fermentation Duration on Nutrition Composition of Seaweed (*Sargassum* sp.) Liquid Organic Fertilizer

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Abstract

This study aims to determine the effect of fermentation duration on the nutrient composition of seaweed liquid organic fertilizer (*Sargassum* sp.). This research was conducted from May to June 2017 at The University of Muhammadiyah Parepare. Test materials used in the form of seaweed and lactobacillus. The container used in the implementation of this research is 6 bottles of 1000 ml size, before the bottles are used first the bottles are washed clean. Then each bottle is filled with extracts of *Sargassum* sp. as much as 800 ml and 40 ml of probiotics. Two bottles of treatment A (without fermentation), 2 bottles for treatment B (7 days fermentation), and 2 bottles for treatment C (14 days fermentation). The design was a completely randomized design (CRD) with 3 types of each treatment. The results showed that the micronutrient iron (Fe) was obtained highest in treatment C (concentration 162 ppm), Silica (Si) in treatment A (100 ppm), and manganese (Mn) in treatment B (29 ppm). For the highest macronutrients potassium (K) obtained in treatment C (concentration 0.52%), Calcium (Ca) in treatment B (0.33%), Sulfur (S) in treatment C (0.31%), Chlorine (Cl) in treatment C (concentration 0.27%). The research concludes that the length of time of fermentation affects the nutrient content of liquid organic fertilizer seaweed.

INTRODUCTION

Indonesia is one of the biggest seaweed producers in the world, however, the use of domestic seaweed is still limited to meet the needs of food products, semi-finished products, and some cosmetic products, while the use of seaweed in agriculture and horticulture is still not widely practiced. The use of organic fertilizers has recently continued to increase due to the negative impact on agricultural ecosystems caused by the increasing intensity of chemical fertilizer use from time to time. Chemical fertilizers are relatively easy to obtain in the market but are relatively expensive (Dewanto *et al.,* 2013) and their use is not environmentally friendly.

The application of organic fertilizers can improve soil properties such as physical, chemical, and biological properties. Organic matter is a loose-grain adhesive, a source of plant nutrients, and a source of energy for most soil organisms. In addition, the use of organic fertilizers is also considered to be able to reduce the excessive application of inorganic fertilizers. In addition to containing many important minerals from the sea needed by plants, seaweed also contains growth-promoting hormones that have been proven to increase plant growth and crop yields. The various mineral content in *Sargassum* sp. which includes Ca, K, Mg, Na, Fe, Cu, Zn, S, P, and Mn, tannins, and iodine are useful for accelerating plant growth (Basmal, 2010; Latique *et al.*, 2013; Widanarto, 2013). Basmal *et al.* (2015) found that the liquid extract of seaweed thallus contained growth-promoting substances auxin at 127.48 ppm, gibberellins 131.11 ppm, cytokinin-kinetin 68.77 ppm, and cytokinin zeatin 82.41 ppm; macronutrients potassium (K) of 345.29 mg/100 g, nitrogen (N) of 0.78%, phosphorus (P) 55.39 mg/100 m.

Handayani *et al.* (2004) reported that *S. crassifolium* contained 5.19% (w/w) protein consisting of 17 types of amino acids, 36.93% (w/w) minerals, Ca 1540.66 mg/100g, Fe 132.65 mg/100g, P 474.03 mg/100g, vitamin C 49.01 mg/100g, vitamin A: 489.11 mg RE/100 g, fat/lipid 1.63% (w/w), acid fat (lauric acid 1.45%, myristic acid 3.53%, palmitic acid 33.59%, oleic acid 13.78%, linoleic acid 33.58%, and linolenic acid 5.94%). Extracts made from seaweed are naturally biodegradable, non-toxic, non-contaminating, and safe for humans and animals (Dhargalkar and Pereira, 2005).

Several methods of making seaweed liquid fertilizer have been carried out previously, including physical extraction of fresh seaweed liquid, as well as extraction using alkali (Basmal, 2010; Sedayu *et al.,* 2013; Widanarto, 2013). Other research from Basmal *et al*. (2019) showed that the treatment temperature and extraction time had a significant effect on the number of nutrients, viscosity, total plate number (TPN), phosphate, Organic C, and Electro Conductivity (EC) of *Sargassum* sp. extraction fluid, but had no effect on pH, nitrogen content, and potassium content.

This study aims to see the effect of fermentation duration on the nutrient composition of liquid organic fertilizer for seaweed (*Sargassum* sp).

METHODOLOGY

Place and Time

This research was carried out at the Fisheries Green House, University of Muhammadiyah Parepare for approximately three weeks starting from May to June 2017, and Analysis of macro and micro nutrient content at the Laboratory of Chemistry Department, State Polytechnic of Ujung Pandang.

Research Materials

The research media used bottles made of glass with a size of 1 liter which was randomly placed in one place with a size of 1 x 2 m, glass bottle, oven, blender, bowl, measuring glass, and analog scale. The test material used was *Sargassum* sp. taken from Barru waters and *Lactobacillus* (EM4) bacteria. *Lactobacillus* bacteria were mixed manually. Each bottle is filled with extract of *Sargassum* sp. 800 ml and 40 ml of probiotics.

Research Design

The media used in this study were 6 bottles of 1000 ml, before using the bottles, the bottles were washed clean. Then each bottle was filled with 800 ml of *Sargassum* sp. extract and 40 ml of probiotics. Two bottles of treatment A (without fermentation), 2 bottles for treatment B (7 days fermentation), and 2 bottles for treatment C (14 days fermentation). The design used was a completely randomized design (CRD) with 3 types of each treatment and 3 replications (Kusriningrum. 2009). The treatment dose used was in accordance with the research of Olaniyi and Salau (2013).

Work Procedure

The manufacture of liquid fertilizer *Sargassum* sp. is first washed to remove mud, sand, salt, shells, and dirt attached to the thallus. The seaweed is chopped manually with a size of ± 5 cm and ground until smooth then put into a composter drum made of plastic. To speed up the decomposition process, a commercial bacterial (EM4) is used. EM4 containing Lactobacillus fermenting bacteria, Actinomycetes, was diluted to a 2% solution. Then sprayed onto each seaweed while stirring until evenly distributed over the entire surface (± 200 ml of solution for 10 kg of seaweed). The composter was tightly closed, then allowed to stand for 7 days and 14 days to produce liquid organic fertilizer (Malik *et al.*, 2018).

The composting process is carried out under semi-anaerobic conditions by an aeration pipe contained in the composter drum. The results of liquid fertilizer are then discharged through the discharge faucet to be accommodated for analysis and plant trials. Analysis of the liquid fertilizer covering macro and micronutrients was carried out at the chemical laboratory of the State Polytechnic of Ujung Pandang.

Observational parameters in this study were testing the content of Micro Nutrients such as Silica (Si), Iron (Fe), and Manganese (Mn) and Macro Nutrients such as Potassium (K), Chlorine (Cl), Calcium (Ca), Sulfur (S).

Data Analysis

The data obtained in this study are displayed in the form of graphs and tabulations. Furthermore, to see the effect of treatment using analysis variance (ANOVA) and Tukey's further test to determine the difference in effect between treatments. SPSS tool version 21 For Windows was used for analyzing the data (Singgih, 2010) while the presentation of graphs and tabulations using Microsoft Excel 2007 (Madcoms, 2015).

RESULTS AND DISCUSSION

Micro Nutrients

The micro nutrients tested were Silica (Si), Iron (Fe), Manganese (Mn). Results of ANOVA and Tukey advanced test for micro nutrients were presented below.

Table 1. Results of Analysis of Variance (ANOVA) of micronutrient silica (Si).

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Si	Between Groups	1151905,450	2	575952,725	17107,490	,000
	Within Groups	202,000	6	33,667		
	Total	1152107,450	8			

Table 2. Tukey Advanced Test for micronutrient silica (Si).

Multiple Comparisons Tukey HSD						
Dependent Variable	(I) treatment	(J) treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound
Si	Treatment A : Control	Treatment B : 7 Days	-704,00000*	4,73756	,000	-718,5361
		Treatment C : 14 Days	99,93000*	4,73756	,000	85,3939
	Treatment B : 7 Days	Treatment A : Control	704,00000*	4,73756	,000	689,4639
		Treatment C : 14 Days	803,93000*	4,73756	,000	789,3939
	Treatment C : 14 Days	Treatment A : Control	-99,93000*	4,73756	,000	-114,4661
		Treatment B : 7 Days	-803,93000*	4,73756	,000	-818,4661

Silica is a large part of the nutrients contained in the soil. Silica plays a role in increasing the rate of photosynthesis and plant resistance to biotic (pest and disease attacks) and abiotic (drought, salinity, alkalinity, and extreme weather) stresses.

The results of the study (Chairunnisa *et al.*, 2013) found that the best silicate material in increasing P uptake, stem diameter, root dry weight, shoot dry weight, and plant height was silicate material derived from reeds. Rice straw was the best at reducing P-retention and Agrosil was the best at increasing available Si in soil. The application of P fertilizer did not affect the chemical properties of the soil and plant growth, while the interaction of silicate material and P fertilizer only significantly affected plant height. The difference in the fermentation results in the treatment is shown in Figure 1.

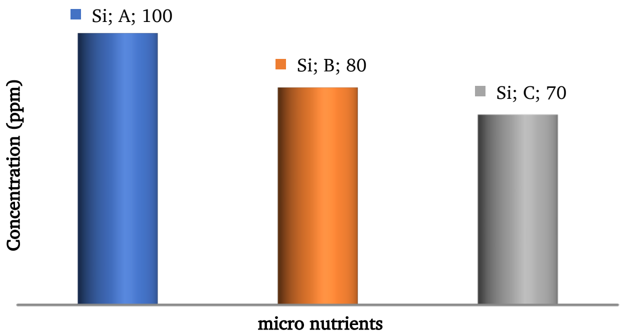

Figure 1. Silica concentration in each treatment. A = 0 (control), B = 7 days, C = 14 days.

Figure 1 shows that treatment A was higher with a concentration of 100 ppm, then in treatment B (80 ppm) with treatment C (70 ppm). This indicates that the Silica content was higher in the control treatment (without fermentation). According to Fitria *et al.* (2008), the occurrence of a decrease in the nutrient content of the fertilizer is due to the activity of microorganisms which in addition to breaking down phosphorus and potassium and also using it for their metabolic activities. Nutrient content can also be caused because the decomposer microbes have reached the static phase (death phase) before the specified variable. If the fermentation process is continued, the results obtained will be less than before (Santi, 2010).

The analysis of variance showed that the results of fermentation with the addition of lactobacillus bacteria had a significant effect ($p<0.05$) on micronutrient silica. while Tukey's further test for each treatment showed that treatment A was significantly different ($p<0.05$) from treatment B and treatment C.

Table 3. Results of Analysis of Variance (ANOVA) of micronutrient iron (Fe).

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Fe	Between Groups	28158,000	2	14079,000	14079,000	,000
	Within Groups	6,000	6	1,000		
	Total	28164,000	8			

Table 4. Tukey Advanced Test for micronutrient iron (Fe).

Multiple Comparisons Tukey HSD						
Dependent Variable	(I) treatment	(J) treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound
Fe	treatment A : control	Treatment B : 7 Days	-7,00000*	,81650	,000	-9,5052
		Treatment C : 14 Days	-122,00000*	,81650	,000	-124,5052
	treatment B : 7 Days	Treatment A : Control	7,00000*	,81650	,000	4,4948
		Treatment C : 14 Days	-115,00000*	,81650	,000	-117,5052
	treatment C : 14 Days	Treatment A : Control	122,00000*	,81650	,000	119,4948
		Treatment B : 7 Days	115,00000*	,81650	,000	112,4948

Iron is one of the most important nutrients for plants because it is needed in the synthesis of chlorophyll. Fe also plays an important role in energy transfer and be a part of several enzymes and proteins. Fe also functions in plant respiration and metabolism as well as involved in nitrogen fixation (Marschner, 1995).

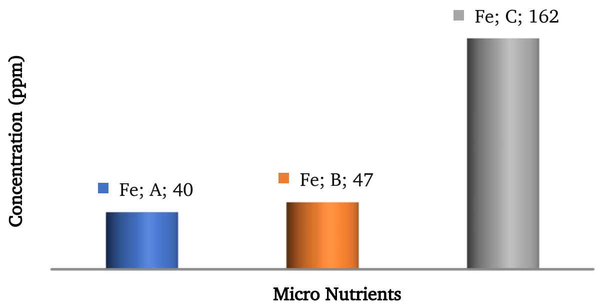

Figure 2. Iron concentration in each treatment. A = 0 (control), B = 7 days, C = 14 days.

Figure 2 can be seen from the fermentation results in treatment A with a concentration of 40 ppm, relatively the same as treatment B with a concentration of 47 ppm, then in treatment C with a concentration of 162 ppm. Fe content in liquid organic fertilizer increased at 14 days when compared to the beginning of fermentation. This happens, due to an imbalance in the population of microorganisms in the fermentation container (Romli, 2010).

The analysis of variance showed that the results of fermentation with the addition of lactobacillus bacteria had a significant effect ($p<0.05$) on iron micronutrients. while Tukey's further test on each treatment showed that treatment C was significantly different ($p<0.05$) from treatment A and treatment B.

Table 5. Results of Analysis of Variance (ANOVA) of micronutrient manganese (Mn).

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Mn	Between Groups	24,000	2	12,000	12,000	,008
	Within Groups	6,000	6	1,000		
	Total	30,000	8			

Table 6. Tukey Advanced Test for micronutrient manganese (Mn).

Multiple Comparisons Tukey HSD						
Dependent Variable	(I) treatment	(J) treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound
Mn	treatment A : control	Treatment B : 7 Days	-4,00000*	,81650	,006	-6,5052
		Treatment C : 14 Days	-2,00000	,81650	,109	-4,5052
	treatment B : 7 Days	Treatment A : Control	4,00000*	,81650	,006	1,4948
		Treatment C : 14 Days	2,00000	,81650	,109	-,5052
	treatment C : 14 Days	Treatment A : Control	2,00000	,81650	,109	-,5052
		Treatment B : 7 Days	-2,00000	,81650	,109	-4,5052

Manganese is a metal that functions as an activator of several enzymes, including oxidases, peroxidases, dehydrogenases, and kinases that play a role in the process of photosynthesis and nitrate reduction (Okajima, 1975).

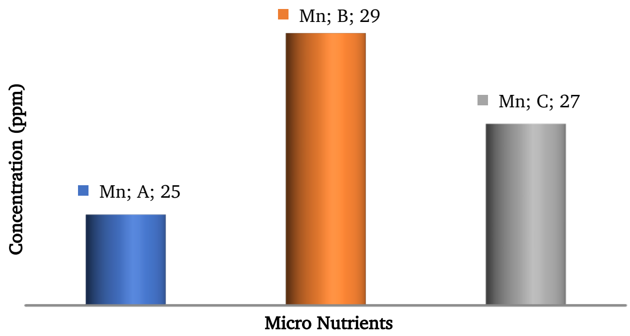

Figure 3. Manganese concentration in each treatment. A = 0 (control), B = 7 days, C = 14 days.

Figure 3 shows that treatment A with a concentration of 25 ppm, while in treatment B with a concentration of 29 ppm it was higher than treatment C with a concentration of 27 ppm. In general, Tisdale *et al*. (1985) stated that an increase in pH increased the availability of Mn and this increase would decrease the availability of microelements. It is suspected that the increase in pH in this range has not resulted in the Mn precipitation reaction.

The analysis of variance showed that the results of fermentation with the addition of Lactobacillus bacteria had a significant effect ($p < 0.05$) on the micronutrient manganese. Meanwhile, Tukey's further test for each treatment showed that treatment B was significantly different ($p < 0.05$) from treatment A but not significantly different ($p > 0.05$) from treatment A and treatment C.

Macro Nutrients

The macronutrients tested were Potassium (K), Chlorine (Cl), Calcium (Ca), and Sulfur (S). Results of ANOVA and Tukey advanced test for macronutrients were presented below.

Table 9. Results of Analysis of Variance (ANOVA) for macronutrient chlorine (Cl).

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Cl	Between Groups	,004	2	,002	21,000	,002
	Within Groups	,001	6	,000		
	Total	,005	8			

Table 10. Tukey Advanced Test for macronutrient Chlorine (Cl).

Multiple Comparisons Tukey HSD						
Dependent Variable	(I) treatment	(J) treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound
Cl	Treatment A : Control	Treatment B : 7 Days	-,04000*	,00816	,006	-,0651
		Treatment C : 14 Days	-,05000*	,00816	,002	-,0751
	Treatment B : 7 Days	Treatment A : Control	,04000*	,00816	,006	,0149
		Treatment C : 14 Days	-,01000	,00816	,483	-,0351
	Treatment C : 14 Days	Treatment A : Control	,05000*	,00816	,002	,0249
		Treatment B : 7 Days	,01000	,00816	,483	-,0151

Chlorine is an element that is absorbed in the form of Cl ions by plant roots and can also be absorbed in the form of gas or solution by the upper part of plants, such as leaves. The chlorine content in plants is about 2000-20,000 ppm by dry plant weight. The best chlorine content in plants is between 340-1200 ppm and is considered to be in the range of micronutrients (Sarief, 1986).

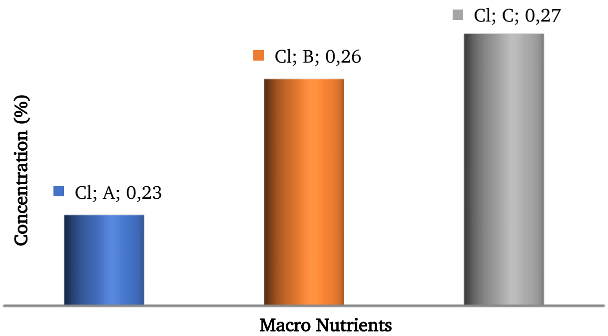

Figure 5. Chlorine concentration in each treatment. A = 0 (control), B = 7 days, C = 14 days.

Figure 5 shows that treatment A (0.23%) is lower than treatment B (0.26%) and treatment C (0.27%). From the fermentation results of *Sargassum* sp. liquid organic fertilizer, it is seen that there is an increase in the concentration of Chlorine from the fermentation of *Sargassum* sp. liquid organic fertilizer. The low content of chlorine can be caused by the element of chlorine being used by microorganisms for their daily needs and the change of elemental chlorine into gaseous form (Marlina, 2016; Lestari *et al.*, 2011).

The analysis of variance showed that the results of fermentation with the addition of lactobacillus bacteria had a significant effect ($p < 0.05$) on the macronutrient chlorine. while Tukey's further test on each treatment showed that treatment A was significantly different ($p < 0.05$) from treatments B and C.

Table 11. Results of Analysis of Variance (ANOVA) macronutrient Calcium (Ca).

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Ca	Between Groups	,077	2	,039	387,000	,000
	Within Groups	,001	6	,000		
	Total	,078	8			

Table 12. Tukey Advanced Test for macronutrient Calcium (Ca).

Multiple Comparisons Tukey HSD						
Dependent Variable	(I) treatment	(J) treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound
Ca	Treatment A : Control	Treatment B : 7 Days	-,21000*	,00816	,000	-,2351
		Treatment C : 14 Days	-,18000*	,00816	,000	-,2051
	Treatment B : 7 Days	Treatment A : Control	,21000*	,00816	,000	,1849
		Treatment C : 14 Days	,03000*	,00816	,024	,0049
	Treatment C : 14 Days	Treatment A : Control	,18000*	,00816	,000	,1549
		Treatment B : 7 Days	-,03000*	,00816	,024	-,0551

Calcium is part of the cell wall and the greatest calcium content is found in the leaves. Calcium is useful for keeping cell membranes functioning; plays a role in plant meristem parts; and encourages root growth (Sutandi, 2004).

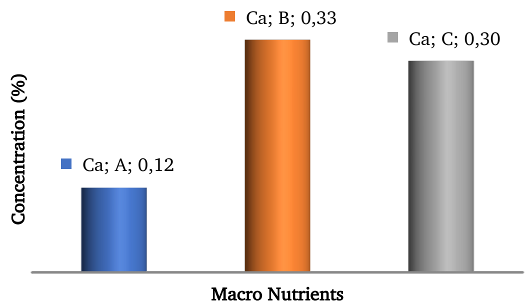

Figure 6. Calcium concentration in each treatment. A = 0 (control), B = 7 days, C = 14 days.

Figure 6 shows that treatment A (0.12%) was lower than treatment C (0.30%), then the highest treatment was found in treatment B (0.33%). This indicates that the fermentation of liquid organic fertilizer *Sargassum* sp. with the addition of the highest Lactobacillus bacteria was obtained in treatment B. According to Putri (2018), this is because microorganisms begin to adapt so that the macronutrient content of calcium on the 7th day increases because the microorganisms experience a long phase and on the 14th day of fermentation the calcium content decreases because the microorganisms reach a balance, namely the number of microorganisms produced is equal to the number of dead microbes.

The results of the analysis of variance showed that the results of fermentation with the addition of lactobacillus bacteria had a significant effect ($p < 0.05$) on the macronutrient calcium. while Tukey's further test on each treatment showed that treatment B was significantly different ($p < 0.05$) from treatments A and C.

Table 13. Results of Analysis of Variance (ANOVA) of macronutrient sulfur (S).

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
S	Between Groups	,106	2	,053	532,000	,000
	Within Groups	,001	6	,000		
	Total	,107	8			

Table 14. Tukey Advanced Test for macronutrient sulfur (S).

Multiple Comparisons Tukey HSD						
Dependent Variable	(I) treatment	(J) treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound
S	Treatment A : Control	Treatment B : 7 Days	-,02000	,00816	,109	-,0451
		Treatment C : 14 Days	-,24000*	,00816	,000	-,2651
	Treatment B : 7 Days	Treatment A : Control	,02000	,00816	,109	-,0051
		Treatment C : 14 Days	-,22000*	,00816	,000	-,2451
	Treatment C : 14 Days	Treatment A : Control	,24000*	,00816	,000	,2149
		Treatment B : 7 Days	,22000*	,00816	,000	,1949

Sulfur is one of the essential elements needed by plants which is absorbed as sulfate ions and is reduced in plants to sulfhydryl groups. Sulfur in soil generally consists of two forms, namely organic sulfur and inorganic sulfur. Sulfur in the topsoil mostly comes from organic matter, the levels vary and are influenced by additional sulfur from irrigation water, air, fertilizers, insecticides, and fungicides (Ismunadji, 1977).

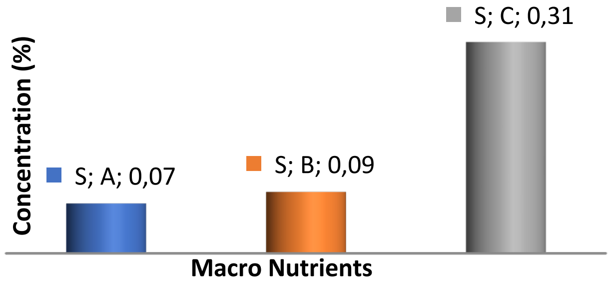

Figure 7. Sulfur concentration in each treatment. A = 0 (control), B = 7 days, C = 14 days.

Figure 7 can be seen from the results in treatment A (0.07%) relatively the same as treatment B (0.09%), then the highest treatment was obtained in treatment C (0.31%). This shows that there is an increase in the concentration of Sulfur. The high sulfur content is also influenced by the high nitrogen content. The higher the nitrogen content, the multiplication of microorganisms that break down sulfur will increase (Hidayati *et al.,* 2011).

The analysis of variance showed that the results of fermentation with the addition of lactobacillus bacteria had a significant effect ($p < 0.05$) on the macronutrient calcium. while Tukey's further test for each treatment showed that treatment C was significantly different ($p < 0.05$) from treatments A and B.

CONCLUSION

Based on the results of the research that has been done, it can be concluded that the length of time of fermentation with the same dose affects the nutrient content of liquid organic seaweed fertilizer (*Sargassum* sp.), the longer the fermented liquid organic fertilizer for seaweed (*Sargassum* sp.), the higher the nutrient content in the liquid organic fertilizer, the treatment which has a significant effect on the nutrient content is fermentation for 14 days.

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