The Content of Agar Seaweed *Gracilaria verrucosa* Fertilized with Vermicompost

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Abstract— *The economic value of seaweed G. verrucosa depends on the content of the agar it has. Cultivation Gracilaria verrucosa generally use inorganic fertilizers that are not environmentally friendly, inorganic fertilizer is not a wise step considering the recent increase in consumers who want a product that is free of pesticide residues. The purpose of this study was to analyze the optimal dose of vermicompost fertilizer to produce high quality of agar rendement, viscosity and gel strength seaweed Gracilaria verrucosa. From the result of the research, it was found that the quality of agar rendement, viscosity and gel strength were normal and homogeneous distribution (p>0,05). Then the ANOVA test showed that the fertilizer treatment gave a significant effect on the quality of agar rendement and viscosity (p <0,05), while the quality of agar gel strength did not give significant effect (p> 0,05). The highest level of viscosity and rendement of Gracilaria verrucosa seaweed was found in treatment A and the lowest in treatment F (control). The highest level quality of agar gel strength Gracilaria verrucosa was found in treatment F compared with other treatment.*

Keywords— ***G. verrucosa, vermicompost fertilizer, rendement, viscosity and gel strength.***

I. INTRODUCTION

Gracilaria verrucosa is a plant widely distributed in tropical waters, can produce agar extracts (a commercial name for natural gelatin polymers containing carbohydrate and sulfate groups). The quantity and quality of agar derived from seaweed cultivation vary, not only by variety but also the age of the plant, rays, nutrients, temperature, and salinity [1], [2], [3].

Vermicompost is a 100% quality organic fertilizer and environmentally friendly derived from worm dung (vermics). Vermicompost contains various nutrients needed by seaweed and plays an important role in the process of photosynthesis. It also plays a role in preparing plasma cells and the formation of carbohydrates and proteins. During the vermicomposting process, essential plant nutrients such as nitrogen and phosphorus required by plants, which are present in the diet are converted through the activity of microorganisms into a form that is more easily absorbed by plants [4]. Improving the quality of crops on farms by extensive testing of vermicompost fertilizers has been done by Ohio State University, Cornell University in America, and SIRO in Australia. The tests show an increase in the size and quality of the plant, by 15-57% [5].

Vermicompost is a source of nutrients for nitrifying bacteria. With the existence of these nutrients microbes decomposing organic materials will continue to grow and decompose organic materials more quickly. Therefore, in addition to improving the quality of seaweed, vermicompost can also help the process of destruction of organic waste [6]. But there is no research data that provides the use of vermicompost to levels for seaweed, especially G. verrucosa. Thus, a study is needed to find out the optimal dose of vermicompost fertilizer to produce the high content of agar rendement, viscosity and gel strength G. verrucosa.

II. MATERIALS AND METHODS

2.1 Study site and sampling design

This research was conducted in open space in the pond area of Maliwowo Village, Angkona District, East Luwu Regency, South Sulawesi Province, April to July 2016 for 42 days. The experimental design used in this study was a complete randomized design (CRD) with 6 treatments and repetition 3 times so that there were 18 units of experiments, while the treatment performed was a dose of vermicompost fertilizer that was different from the treatment A dose of vermicompost fertilizer 300 g/m^2, Treatment B dose of vermicompost fertilizer 250 g/m^2, treatment C dose of vermicompost fertilizer 200 g/m^2, treatment D dose of vermicompost fertilizer 150 g/m^2, treatment E dose of vermicompost fertilizer 100 g/m^2 and F control treatment (without fertilizer).

2.2 The method of collecting data

Seaweed that was analyzed for quality of agar rendement by isopropanol (SNI, 01-26-1998), viscosity using a measuring instrument viscosimeter Brookfield [7] and gel strength using a measuring instrument Curd Meter [8]. Samples were analyzed kelp seaweed is wet, then dried and taken simultaneously for each treatment on the base or its branches. Water quality data collection for temperature, salinity and water pH is done every 7 days in the morning (09.00 am) and afternoon (15.00 pm). Measurements of soil pH, nutrient content of water and soil in the form of nitrate, ammonium, and phosphate were carried out at the beginning and end of the study. The temperature is measured with a thermometer, salinity using a hand-refractometer and pH of the water using Fix pH 0-14, then to the pH soil laboratory test that was extracted using the H_2O ratio of 1:2.5. Analysis of nutrient content of water in the form of nitrate (NO_3) were analyzed with sulfuric acid phenol [9], while phosphate (PO_4) were analyzed by digested sulfuric acid-nitrate and ammonium (NH_4) was measured using a spectrophotometer [10], analysis of nutrient content of the soil in the form of nitrate (NO_3) were analyzed with sulfuric acid phenol with AAS method (Atomic Absorbance Spectrophotometer), the content of soil phosphate (PO_4) were analyzed with HCl solution AAS method, determination of ammonium (NH4) were analyzed using a standard solution of H_2SO_4 and distillation Semi-micro Kjeldahl [11].

2.3 Data analysis

Each parameter of rendement, viscosity, and gel strength was evaluated using two statistical analysis. First, test the normality of Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W), then test homogeneity using Levene test. Second, an Analysis of Variance (ANOVA) test if the data is normally distributed and homogeneous if the real effect is further tested by using the Tukey test. Data that is not normally distributed and homogeneous is transformed $x = \log 10(y)$. While the nutrient content of water and soil is analyzed descriptively based on the life eligibility for *G. verrucosa* seaweed.

III. RESULTS AND DISCUSSION

3.1 Quality of Agar Rendement

From the calculation of variance analysis that the application of vermicompost fertilizer gave a real effect ($p<0,05$) to the quality of agar rendement seaweed *Gracilaria verrucosa*. From Tukey's further test results that the different rendement between treatment F (control) and A (dose 300 g/m^2). But from the results obtained that the treatment of fertilizer provides quality of agar rendement is higher than the treatment without the provision of fertilizer (Table 1). [12] stated that factors affecting the quality of seaweed rendement are nutrients and water quality, both of which have a close relationship to the content of seaweed for 56.2%, while 43.8% is influenced by other factors. Other factors cause the high quality of agar rendement to be influenced by species, cultivation location and climate of their life [13].

3.2 Quality of Agar Viscosity

The variance analysis that vermicompost fertilizer gave a significant effect ($p<0.05$) on the quality of agar viscosity *Gracilaria verrucosa*, meaning that the application of vermicompost fertilizer had an effect on the increase of viscosity. From Tukey's test results, the viscosity of seaweed gave a difference ($p <0.05$) between treatment F (control) and treatment A (dose of 300 g/m^2), B (dose 250 g/ m^2), C (dose 200 g/m^2), D (treatment 150 g/m^2) (Table 2). [14] stated seaweed viscosity ranges from 5 to 800 cps. The highest viscosity content was obtained at treatment A (dose 300 g/m^2) and treatment B (dose 250 g/m^2) high viscosity level followed by the high level of agar rendement in treatment A that is 25,81% and B that is 23,51%. The lowest seaweed viscosity was obtained in F (control/ without fertilizer) treatment with 8.58% of the agar rendement content (Table 2). This is in accordance with the opinion of [15] the higher of rendement followed by increased viscosity. This is due to the high rendement causing the breaking of the agarose and agaropectin structures in *G. verrucosa* which causes molecular chains to tighten and envelop the water-immobilized molecules causing the solution to be viscous, which means the viscosity of the high solution. Other factors causing high viscosity are treatment, temperature, SO_4 content, concentration, dispersion level, the presence of electrolyte and nonelectrolyte [16].

3.3 Quality of Agar Gel strength

The result of verbal analysis with vermicompost fertilizer did not give statistically significant effect on gel strength *Gracilaria verrucosa* ($p>0,05$), so no further Tukey test was done. The highest gel strength was obtained at treatment F (control) of 79.0 g/cm^2 (Table 3). Gravity gel is the maximum load required to solve the polymer matrix in the burdened region [17]. High sulfate levels cause increased viscosity and decreased gel consistency. While on *G. verrucosa*, the higher viscosity will break down agarose and agaropectin structure of seaweed which is a factor to produce high gel strength. This shows that the viscosity value is inversely proportional to the gel strength value, if the viscosity is high then the gel strength tends to be low, and vice versa if the obtained viscosity value is low then the gel strength will be high [18].

3.4 Nutrient Water

Water quality is one of the important factors for seaweed quality. Temperature is an important physical factor, for the growth of seaweed. Temperatures directly affect seaweed in the process of photosynthesis, metabolic processes, and reproductive cycle [19] water temperature in the cultivation container ranges from 28-30ºC which is still in the range that is suitable for seaweed growth (Table 4).

Low water quality range of salinity can cause seaweed growth to be abnormal. Water salinity during the study ranged from 14 to 16 ppt (Table 4). The results suggest that seaweed can still grow at a low salinity range, proving that Gracilaria verrucosa are a type of seaweed that can live on a wide salinity. According to [20] salinity range for seaweed cultivation ranges from 15-30 ppt and optimal for seaweed growth ranges from 20-25 ppt. Pondus Hydrogen (pH) is a measure of the hydrogen ion concentration and shows the acid or base properties of water [21]. Pondus Hydrogen (pH) of water during the study was 7 (Table 4). [22] stated that the optimum pH for seaweed cultivation ranged from 6.8 to 8.2. pH of water in this research was 7 hence container where the research belongs to waters with high productivity [23].

Phosphate (PO_4) water obtained during the study was 0.27 - 0.61 ppm (Table 4). From the concentration of phosphate obtained, belong to a high fertility rate. According to [24] states that the low fertility levels of phosphate levels range from 0 to 0.02 ppm, moderate fertility rates ranging from 0.021 to 0.05 ppm and high fertility above 0.05 ppm. According to [25], good phosphate values for seaweed growth range from 0.09 - 1.80 ppm. Seaweed also requires a nitrogen element, nitrogen is absorbed by seaweed in the form of nitrite, nitrate, and ammonium. Nitrogen serves to help the process of forming chlorophyll, photosynthesis, protein, fat and other organic compounds [26]. The range of ammonium (NH_4) water content was 0.15 – 0.90 ppm and nitrate (NO_3) water was 0.03 - 0.57 ppm (Table 4). The value is feasible for seaweed cultivation. According to [27], the concentration of nitrate and ammonium is good for seaweed ranged from 0.01-3.50 ppm.

3.5 Soil Nutrients

Soil pH range obtained during this study was 4.54 - 5.71 (Table 5), low pH in the soil showed that the soil is acidic. According to [28] states that the nitrification process can still occur at soil pH 3.8. With optimal growth obtained with a soil pH range of 5 - 8.5.

Phosphate (PO_4) of soil obtained during the study ranged from 10.98 to 20.25 ppm (Table 5). Based on soil fertility value of phosphate classified not appropriate with limiting factor of soil fertility. However, the phosphate content in the soil can be increased by providing basic fertilizer with fertilizer application at the time the water has not been filled in the cultivation container, so it will be marginal or suitable enough and even very suitable [29].

The soil NH_4 in this study ranged from 0.59 to 8.99 ppm whereas for NO_3 the soil ranged from 6.45 to 14.61 ppm (Table 5). An increase in soil NH_4 content during the study. NH_4 is an ion of NH_3 or ammonia that is toxic, this is related to low soil pH in this study which has an effect on the increase of NH_4 on the soil. While the soil NO_3 content decreased during the study. The decrease of NO_3 content is caused because soil pH becomes acid so that macro nutrient content decreases in the soil which has the function to stabilize soil pH into the base. If the soil pH acid, then SO_4 in the form of H_2S will increase in the waters so that nutrients such as nitrogen, phosphor and other macro nutrients will be bound and micro nutrients will increase [30].

IV. CONCLUSION

The research conducted the highest level of viscosity and rendement of *Gracilaria verrucosa* seaweed was obtained at treatment A (300 g/m^2) and the lowest in treatment F (Control). The highest level of *G. verrucosa* seaweed gel strength was found in the treatment F (Control). This proved the gel strength inversely proportional to viscosity and rendement. The nutrient content of water is within a reasonable range of seaweed cultivation activities of *G.verrucosa*. Water temperature in the cultivation container ranges from 28-30^{o}C, salinity ranged from 14 to 16 ppt, (pH) was 7, phosphate (PO_4) was 0.27 - 0.61 ppm, ammonium (NH_4) was 0.15 – 0.90 ppm and nitrate (NO_3) was 0.03 - 0.57 ppm. Then the nutrient content of the soil is categorized as less fertile for cultivation activities, but from research conducted, that seaweed *G. verrucosa* can still grow well. Soil pH range obtained during this study was 4.54 - 5.71, phosphate (PO_4) obtained ranged from 10.98 to 20.25 ppm, NH_4 in ranged from 0.59 to 8.99 ppm whereas for NO_3 from 6.45 to 14.61 ppm.

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Table.1: Average Quality of Agar rendement Gracilaria verrucosa was fertilized with different doses of vermicompost.

Dose of Vermicompost Fertilizer (g/m^2)	Rendement (%)	Production Agar (g)
(A) 300	25,81±5,54[a]	5,9
(B) 250	23,51±4,74[ab]	4,9
(C) 200	18,81±2,06[ab]	3,6
(D) 150	16,74±9,34[ab]	3,1
(E) 100	14,56±4,62[ab]	2,6
(F) Control	8,58±5,26[b]	1,2

Description: Different letters in the same column show significant differences between treatments at 5% level ($p<0.05$), ± (distance of minimum and maximum values). (Source: Rahmad, 2016)

Table.2: Average Quality of agar viscosity Gracilaria verrucosa was fertilized with different doses of vermicompost.

Dose of Vermicompost Fertilizer (g/m^2)	Viscosity (cps)
(A) 300	90,00±10,00[a]
(B) 250	90,00±10,00[a]
(C) 200	83,33±5,77[a]
(D) 150	83,33±15,27[a]
(E) 100	76,67±5,77[ab]
(F) Control	46,67±20,82[b]

Description: Different letters in the same column show significant differences between treatments at 5% level ($p<0.05$), ± (distance of minimum and maximum values). (Source: Rahmad, 2016)

Table.3: Average Quality of Agar Gel strength Gracilaria verrucosa was fertilized with different doses of vermicompost.

Dose of Vermicompost Fertilizer (g/m^2)	Gel strength (g/cm^2)
(A) 300	56,6±6,96[a]
(B) 250	46,1±5,60[a]
(C) 200	41,9±8,61[a]
(D) 150	41,7±2,80[a]
(E) 100	40,0±6,61[a]
(F) Control	79,0±34,33[a]

Description: Different letters in the same column show significant differences between treatments at 5% level ($p<0.05$), ± (the distance of minimum and maximum values). (Source: Rahmad, 2016)

Table.4: Water nutrient ranges during the study

Dose of Vermicompost Fertilizer (g/m^2)	Temperature range (^oC)	Salinity range (ppt)	pH range	PO_4 early (ppm)	PO_4 end (ppm)	NH_4 early (ppm)	NH_4 end (ppm)	NO_3 early (ppm)	NO_3 end (ppm)
A (300)	28 - 30	14 - 16	7	0,55	0,27	0,62	0,17	0,57	0,03
B (250)	28 - 30	14 - 16	7	0,46	0,28	0,67	0,15	0,56	0,03
C (200)	28 - 30	14 - 16	7	0,61	0,31	0,90	0,38	0,54	0,04
D (150)	28 - 30	14 - 16	7	0,45	0,28	0,43	0,16	0,06	0,03
E (100)	28 - 30	14 - 16	7	0,47	0,27	0,39	0,24	0,37	0,03
F (Control)	28 - 30	14 - 16	7	0,41	0,27	0,63	0,27	0,05	0,03

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(Source: Rahmad, 2016)

Table.5: The range of soil nutrients during the study

Dose of Vermicompost Fertilizer (g/m^2)	pH of Soil (H_2O) early	pH of Soil (H_2O) end	PO_4 early (ppm)	PO_4 end (ppm)	NH_4 early (ppm)	NH_4 end (ppm)	NO_3 early (ppm)	NO_3 end (ppm)
A (300)	5,71	5,02	12,35	11,98	0,92	8,3	10,28	6,59
B (250)	5,68	5,03	14,65	17,14	1,82	6,69	12,24	7,25
C (200)	5,63	4,92	16,02	19,32	1,96	8,99	13,05	9,95
D (150)	5,35	4,9	16,55	20,25	2,13	6,99	14,15	9
E (100)	5,44	4,54	18,08	17,99	1,94	7,28	14,61	8,58
F (Control)	5,65	4,94	12,22	19,49	0,59	7,3	9,76	6,45

(Source: Rahmad, 2016)