Assessing the effects of organic fertilizer vermicompost on the growth and chlorophyll of sea lettuce *Ulva lactuca* under laboratory conditions

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Abstract. Nutrient availability in aquatic environments is a critical factor influencing the growth and productivity of seaweeds, particularly *Ulva lactuca*, commonly known as sea lettuce. Due to its nutritional and economic significance, this green macroalga has gained prominence in aquaculture, human consumption, and bioproduct development. The increasing demand for seaweed across various industries, especially in food and pharmaceuticals, necessitates innovative approaches to enhance biomass production, such as applying organic fertilizers. This study investigates using vermicompost as a nutrient enrichment strategy to promote the growth and pigment composition (chlorophyll-a and total carotenoid) of *U. lactuca* cultured in a controlled laboratory setting. The experimental design comprised five treatment groups with varying concentrations of vermicompost in sterilized seawater (SS): Group I (0 mg L^{-1}), Group II (5 mg L^{-1}), Group III (10 mg L^{-1}), Group IV (15 mg L^{-1}), and Group V (20 mg L^{-1}), with each group replicated three times. The vermicompost was sourced from Sulu, Philippines, and was homogenized in SS to create the culture media according to the specified concentrations. Samples of *U. lactuca* were collected from Brgy. Kasanyangan, Bongao, Tawi-Tawi, Philippines, with an initial weight of 3 grams per replicate, were cultured in glass jars containing 300 mL of the prepared culture media. A total of fifteen culture jars were utilized, arranged randomly using a completely randomized design. The culture set-up was illuminated with fluorescent lamps, and mild aeration was provided in each jar. Environmental conditions, including salinity (35 ppt), pH (7.4-8.17), and temperature (25°C), were consistently maintained throughout the experiment. Statistical analysis using one-way ANOVA revealed that after 42 days of culture, the group with the highest concentration of organic fertilizer (20 mg L^{-1} of vermicompost) exhibited significantly enhanced growth performance, evidenced by biomass (11.33±0.88 g), specific growth rate (SGR) (3.15±0.18 % d^{-1}), and weight gain (WG) (8.33±0.88 g) compared to other groups. Conversely, the control group, which received no vermicompost, demonstrated the lowest growth metrics. Notably, Group II (5 mg $L^{-1}$of vermicompost) achieved the highest chlorophyll-a (20.11±0.38 µg mL^{-1}) and total carotenoid content (6.88±0.05 µg mL^{-1}). However, these values were statistically different from the control group. The findings of this study provide substantial evidence that organic fertilizer, vermicompost, can effectively enhance the production of *U. lactuca* and its chlorophyll content while potentially reducing reliance on synthetic or inorganic fertilizers.

Key Words: *Ulva lactuca*, growth, chlorophyll, vermicompost, organic fertilizer.

Introduction. The rising demand for high-value seaweed products spans food, pharmaceuticals, biofuels, and aquaculture (Jung et al 2016; Tanaka et al 2020), with *Ulva lactuca*, a green seaweed from the Chlorophyta division, standing out for its rich nutritional profile, including proteins, carbohydrates, essential fatty acids, vitamins and antioxidants making it valuable for human consumption and industrial applications (Harsha Mohan et al 2023; Putra et al 2024). This species is commonly incorporated into salads, soups, fermented food, bread, jelly desert and snacks (Harsha Mohan et al 2023), utilized in cosmetics (Janssens-Böcker et al 2023) for its moisturizing and anti-aging properties (Kalasariya et al 2020; Resende et al 2021); valued in pharmaceuticals (Zaatout et al 2019); and increasingly adopted in aquaculture as a sustainable feed and biofertilizer (Hamouda et al 2022; Yusuf et al 2022).

Despite this wide-ranging utility, a notable research gap exists in the limited studies that have explored the effect of organic fertilizers, particularly in laboratory-controlled cultures of *U. lactuca*, where optimal growth conditions are crucial for seed stock production. Most of the current research on seaweed has focused on the effects of inorganic fertilizers, as demonstrated in studies involving *Kappaphycus* (Illud 2020; Robles 2020), *Caulerpa racemosa* (Robles & Tahiluddin 2022; Lideman et al 2024), and *Gracilaria* spp. (Rahim et al 2023; Ya'la et al 2023). While synthetic fertilizers can improve growth, their high cost and long-term environmental impacts, continual extensive usage of inorganic fertilizers may not result in high crop yields over time (Ogundare et al 2015; Kugbe et al 2019).

Organic fertilizer, particularly vermicompost, offers a promising alternative as a nutrient-rich fertilizer that promotes growth (Walia & Kaur 2024). Rich in nitrogen (N), phosphorus (P), potassium (K), and essential micronutrients like magnesium, calcium, and iron, vermicompost supports key metabolic and physiological processes in seaweeds (Mistry et al 2015). Unlike synthetic fertilizers, it releases nutrients gradually, minimizing environmental risks and sustaining nutrient availability in culture systems (Tahiluddin et al 2022a, 2022b). Studies have shown that vermicompost significantly enhances the growth of seaweed *Gracilaria verrucosa* and *Caulerpa racemosa* (Rahim 2017; Susilowati et al 2019); however, its application on *Ulva lactuca* under controlled laboratory conditions remains underexplored.

This study aims to evaluate the effectiveness of vermicompost as an organic fertilizer on the growth and chlorophyll contents of *Ulva lactuca* in a laboratory setting. By addressing the lack of data on organic nutrient supplementation in controlled culture systems, this research contributes to more eco-friendly, cost-effective, and sustainable seaweed farming practices, particularly in support of the increasing demand for seaweed in the food, feed, energy, and pharmaceutical sectors.

Material and Method

Experimental site and duration. This study was conducted at the Ministry of Fisheries and Agrarian Reform - Regional Fisheries Research Center (MAFAR-RFRC) located in Pagasinan, Bongao, Tawi-Tawi (7500), at coordinates 5°2.0930'N, 119°44.9560'E. The culture duration is 6 weeks, from November to December 2024, cultured in the laboratory with controlled environment.

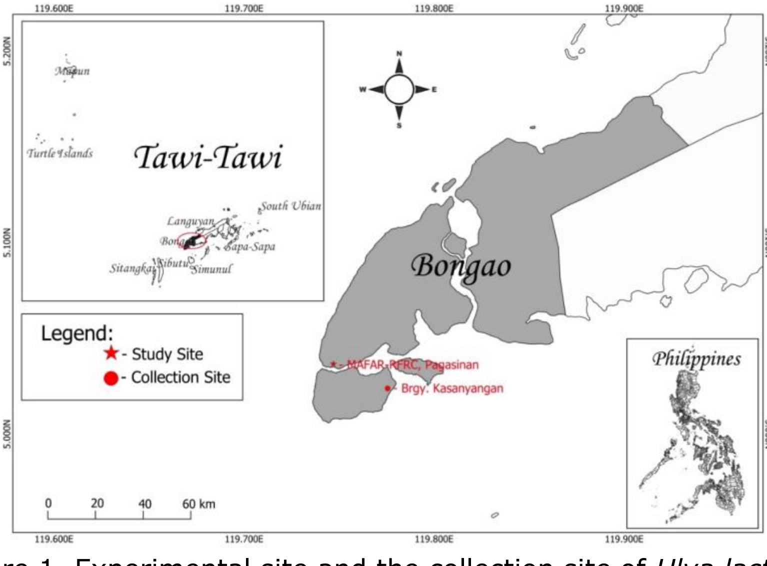

Figure 1. Experimental site and the collection site of *Ulva lactuca*.

Collection of Ulva lactuca. The *U. lactuca* was verified based on its morphological structure (Ismail & Mohamed 2017). The thallus of *U. lactuca* is shown in Figure 2. The naturally growing *U. lactuca* were collected attached to the rocks and sand on the coastal shoreline of Barangay Kasanyangan, Bongao, Tawi-Tawi, Philippines (Figure 1). Water parameters were measured for acclimatization purposes, and the water parameters are under the ideal range for seaweed; the salinity is 30 ppt, the temperature is 30°C, and the pH is 7.52. The devices used are multifunctional parameters for pH and temperature, and a refractometer (Atago, ATC) for salinity. The seaweeds were placed in a 24-liter plastic container and transported to the laboratory. Upon arrival, the seaweeds were acclimatized in sterilized seawater (SS) with mild aeration provided to maintain water agitation.

Figure 2. Sea lettuce *Ulva lactuca* collected from Barangay Kasanyangan, Bongao, Tawi-Tawi, Philippines.

Preparation of the Ulva lactuca. The green seaweed was cut to approximately three centimeters in length and weighed three grams to have a uniform size for all replicates. After cutting, the seedlings were gently blotted on dry tissue for 30 seconds to remove excess water, then weighed using a weighing scale (0.1 g) to record their initial weight. Before stocking, the seaweed samples were submerged in 0.5% Povidone-iodine for five minutes to facilitate the healing of the trimmed edge. The seaweed was rinsed twice with SS to remove any remaining solution thoroughly.

Layout of the experiment. Five treatment groups were used in the experiment, presented in Table 1; each group was replicated three times. A total of fifteen replicates. The culture jars were placed in a wooden divider (Figure 3a) with an attached fluorescent lamp (20W) and an air hose for aeration. To minimize bias, replicates were assigned using a completely randomized design. This involved a drawing lots method, where folded, numbered papers were shuffled and randomly selected to determine the treatment order. The selected treatments were then arranged sequentially from left to right across the area until all had been assigned.

Table 1
Concentrations of vermicompost in a liter of sterilized seawater

Groups	*Concentrations (mg L^{-1})*
Group I (G-I)	0
Group II (G-II)	5
Group III (G-III)	10
Group IV (G-IV)	15
Group V (G-V)	20

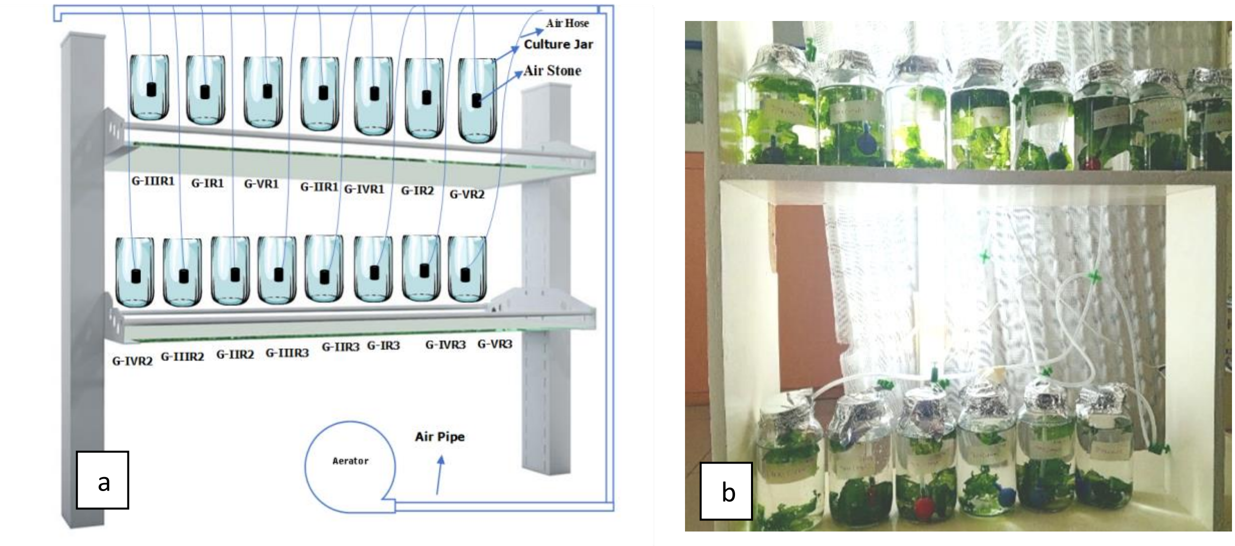

Figure 3. The experimental setup (a) a schematic diagram, and (b) an image of the actual setup of the study.

Preparation of culture media. The vermicompost was used as the organic fertilizer in the experiment. It was purchased from Jolo, Sulu, Philippines, and made by the locals in the province. The composition of the nutrients can be seen in Table 2. The weighed fertilizer was placed in a plastic container with a liter of SS. The mixture was thoroughly mixed and left for 1 hour. Then, a 45-micron filter cloth was used to filter the vermicompost pulp before pouring the solution into the culture jars.

Table 2
Vermicompost nutrient composition provided by Aditha's Farm Supply, certified organic by the Organic Certification Center of the Philippines

Nutrients	*Composition*
OM	36%
C:N ratio	15:1
MC	30%
pH	7.20
N	1.89%
P205	2.49%
K20	1.40%
Ca	5.09%
Cu	95.46ppm
Mg	1.71%
Mn	1.233ppm
Zn	329ppm
Fe	26.340ppm

Monitoring and growth measurement. The seaweed was tapped and placed on a tissue paper for 30 seconds to remove excess water. The seaweeds' initial and final weights were recorded to assess their growth performance. A superior mini digital platform scale (0.1 g) weighed the samples. Biomass is the final weight of the seaweed, and weight gain (WG) is the difference between the final weight and the initial weight of the *U. lactuca.* The specific growth rate (SGR) was computed using the following formula (Yang et al 2005):

$$SGR = ((Ln\ (Wf) - Ln\ (Wi))/t) \times 100$$

Where:
Ln = the natural log;
Wi = the initial weight (g);
Wf = the final weight (g);
t = period of culture.

Chlorophyll extraction. The chlorophyll-a and total carotenoid extraction from *U. lactuca* was performed using the method of Sasadara et al (2021) and modified based on the available equipment in the laboratory. After 42 days of culture, the seaweed was brought to the Marine Integrated Laboratory, College of Fisheries, MSU-TCTO, for the extraction and analysis of the chlorophyll. Each sample in a jar was pounded separately using a mortar and pestle. 25 mg of mashed *U. lactuca* was placed into a 15 mL Falcon tube, then 10 mL of 99.9% methanol was added as the solvent. The sample was vortexed ($DLAB_{MX-S}$) for 1 minute and centrifuged (800D) at 2500 rpm for 10 minutes. Subsequently, it was re-vortexed for one more minute and also centrifuged at 4000 rpm for 5 minutes to degreen the *U. lactuca* samples.

Chlorophyll-a and total carotenoid analysis. In analyzing the chlorophyll-a and total carotenoid of the sample. The samples were first cooled. Then, 3 mL supernatant was transferred to a cuvette vial and measured using a pre-calibrated spectrophotometer (Dynamica). The values were read at a wavelength of 666 nm for chlorophyll-a and 475 nm for total carotenoids. The formula used to compute the chlorophyll-a and total carotenoid is based on the study of Sarri et al (2024).

$$Chlorophyll\text{-}a\ (\mu g\ mL^{-1}) = 13.9\ (A666)$$

Where: A_{666} - the absorbance of chlorophyll-a

$$Total\ carotenoids\ (\mu g\ mL^{-1}) = 4.5\ (A475)$$

Where: A_{475} - the absorbance of carotenoids

Statistical analysis. The data on final weight, WG, SGR, chlorophyll-a, and total carotenoid were analyzed using IBM SPSS version 20. One-way Analysis of Variance (ANOVA) was conducted to determine significant differences among treatments, and homogeneity of variance was assessed using Duncan's test. A post-hoc test was performed to identify significant differences at a $p < 0.05$.

Results. The growth indices and chlorophyll-a results after the 42 days of laboratory culture of *U. lactuca* in response to different concentrations of vermicompost fertilizers, including final weight, SGR, WG, and chlorophyll-a and total carotenoid, are presented in Table 3.

Table 3

Response indices of *U. lactuca* in different concentrations of vermicompost fertilizers after 42 days of culture

Treatments	*Final weight (g)*	*Specific growth rate (% day^{-1})*	*Weight gain (g)*	*Chlorophyll-a (µg mL^{-1})*	*Total carotenoid (µg mL^{-1})*
G-I (0 mg L^{-1})	3.10±0.28^{c}	0.05±0.22^{c}	0.10±0.28^{c}	15.06±1.00^{b}	5.36±0.22^{b}
G-II (5 mg L^{-1})	5.26±0.88^{bc}	1.27±0.38^{b}	2.26±0.88^{bc}	20.11±0.38^{a}	6.88±0.05^{a}
G-III (10 mg L^{-1})	4.93±0.64^{bc}	1.14±0.29^{b}	1.93±0.64^{bc}	17.02±0.47^{ab}	6.32±0.08^{ab}
G-IV (15 mg L^{-1})	6.16±0.89^{b}	1.65±0.37^{b}	3.16±0.89^{b}	17.44±1.77^{ab}	6.17±0.60^{ab}
G-V (20 mg L^{-1})	11.33±0.88^{a}	3.15±0.18^{a}	8.33±0.88^{a}	15.11±0.15^{b}	5.39±0.09^{b}

Values are measures of triplicates. G-I (0 mg L^{-1} vermicompost); G-II (5 mg L^{-1} vermicompost); G-III (10 mg L^{-1} vermicompost); G-IV (15 mg L^{-1} vermicompost); G-V (20 mg L^{-1} vermicompost). Values are in triplicate. Means with the same letters within a row do not differ significantly ($p > 0.05$), n=15.

The results are summarized in Table 3, which outlines the final weight, specific growth rate, WG, chlorophyll-a, and total carotenoid content for each treatment group. The final weight of *U. lactuca* increased with the concentration of the treatment, with G-V (20 mg L^{-1}) achieving the highest weight at 11.33±0.88 g, significantly ($p < 0.05$) differing from the other groups ($p < 0.05$). Conversely, G-I (0 mg L^{-1}) recorded a notably lowest final weight of 3.10±0.28 g. The SGR of *U. lactuca* exhibited a positive correlation with treatment concentration; G-V had the highest SGR at 3.15±0.18% day^{-1}, while G-I displayed the lowest at 0.05±0.22% day^{-1}. WG in *U. lactuca* mirrored the trend observed in final weight, with G-V showing the highest WG of 8.33±0.88 g, significantly surpassing ($p < 0.05$) the other groups. G-I, on the other hand, had the least WG at 0.10±0.28 g. Moreover, the chlorophyll-a content varied among the treatment groups, with G-II (5 mg L^{-1}) exhibiting the highest concentration at 20.11±0.38 µg mL^{-1}, which was significantly different from both G-I and G-V. The total carotenoid content was also highest in G-II, measuring 6.88±0.05 µg mL^{-1}, while G-I recorded the lowest at 5.36±0.22 µg mL^{-1}.

Final weight. On the first week of *U. lactuca* One-way Anova manifested no significant difference ($p > 0.05$) to different concentrations of vermicompost as media, but after 2 weeks, there is a significant difference, and 20 mg L^{-1}, which is the high concentration of vermicompost (G-V) significantly ($p < 0.05$) higher (5±0.00 g) than to other groups however, the control (G-I) showed lowest final weight with 3±0.00 g. In the 3rd week, the G-III to G-V with final weights of 3.83±0.29 g, 3.67±0.29 g, and 5.17±1.44 g, respectively, show significantly higher final weight ($p < 0.05$) than the G-II (3.5±0.87 g) and G-I (2.5±0.50 g). On the fourth week of culture, G-V and G-II, with final weights of 7.83±2.57 g and 5.17±1.04 g, respectively, were significantly higher ($p < 0.05$) than G-I, G-III, and G-IV (3.33±0.29 g, 4.83±0.22 g, and 4.83±0.22 g, respectively). On the fifth week, the G-V had the highest mean weight (9.16±1.16 g), followed by G-IV (6.00±0.28 g) and G-II (6.00±0.28 g), and was significantly higher ($p < 0.05$) than G-I (3.33±0.16 g), but G-II and G-IV had no significant difference from G-III (4.50±0.00 g) and had the lowest final weight. In the last week of culture (6th), G-V reached a maximum weight of 11.33±0.89 g, which was significantly higher ($p < 0.05$) than that of the other groups. These results demonstrate a clear range in biomass among the groups; G-V regularly shows the highest weight increase.

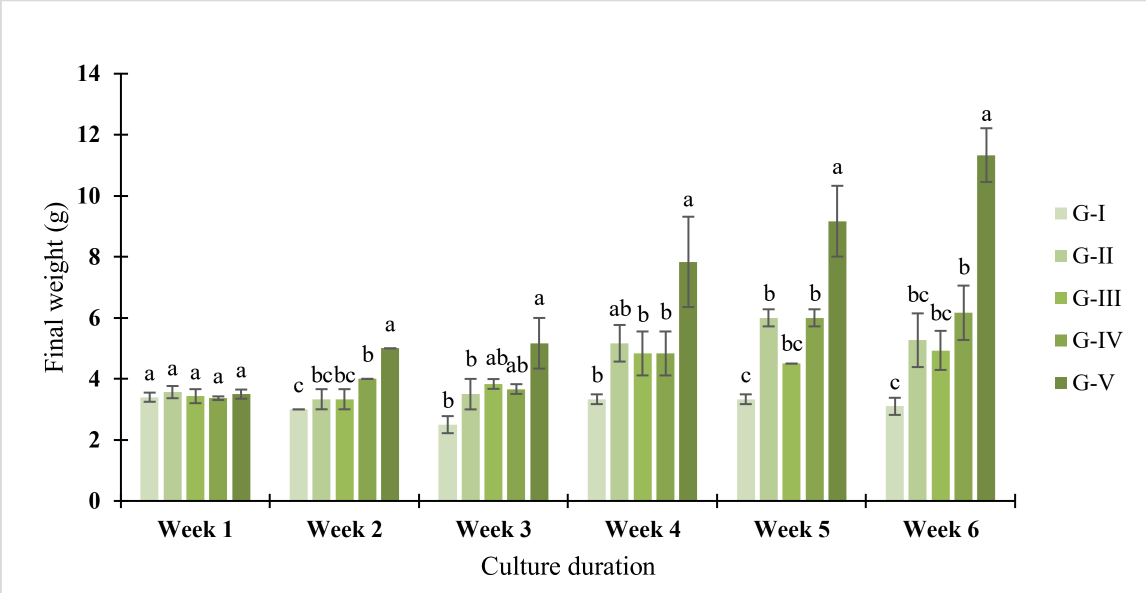

Figure 3. Final weight (g) of the *Ulva lactuca* culture at different concentrations of vermicompost fertilizers: G-I (0 mg L^{-1} vermicompost); G-II (5 mg L^{-1} vermicompost); G-III (10 mg L^{-1} vermicompost); G-IV (15 mg L^{-1} vermicompost); G-V (20 mg L^{-1} vermicompost). Values are in triplicate. Bars with different letters per week are considered statistically different ($p < 0.05$), n = 15.

Weight gain. One-way ANOVA revealed that, after one week of culture of *U. lactuca*, there was no statistically significant difference ($p > 0.05$) in WG between the different concentrations of vermicompost utilized as the growth medium. The second week's WG, at 2.00±0.00 g, was observed when the dosage was highest at G-V with 20 mg L^{-1} and significantly higher ($p < 0.05$) than those in lower concentrations and control. In the control group G-I (0.00±0.00 g), no WG. In the third week, G-V gained the maximum weight, at 2.16±0.83 g, followed by G-III at 0.83±0.16 g and G-IV at 0.66±0.16 g. These were all significantly higher ($p < 0.05$) than those for G-II (-0.50±0.28 g) and G-I (0.73±0.20 g). G-V showed a 4.83±1.48 g increase during the fourth week; G-II showed a 2.16±0.16 g increase, which was statistically significant compared to G-IV (4.83±0.72 g) and G-III (1.83±0.72 g). The highest WG in the fifth week was 6.16±1.16 g, which was significantly higher ($p < 0.05$) than in the lower concentration groups and control, group with no vermicompost (G-1) showed the lowest gain with 0.33±0.16 g. In the last week (6^{th}), culture G-V (8.33±0.88 g), G-IV (3.16±0.89 g), G-II (2.26±0.88 g), G-III (1.93±0.64 g), and G-I (0.10±0.28 g) had declining weight. Among all the treatments, G-V with a value of 20 mg L^{-1} vermicompost constantly showed the most notable WG across the culture period. Over the entire culture period, G-V consistently demonstrated the most significant weight increase across all the treatments.

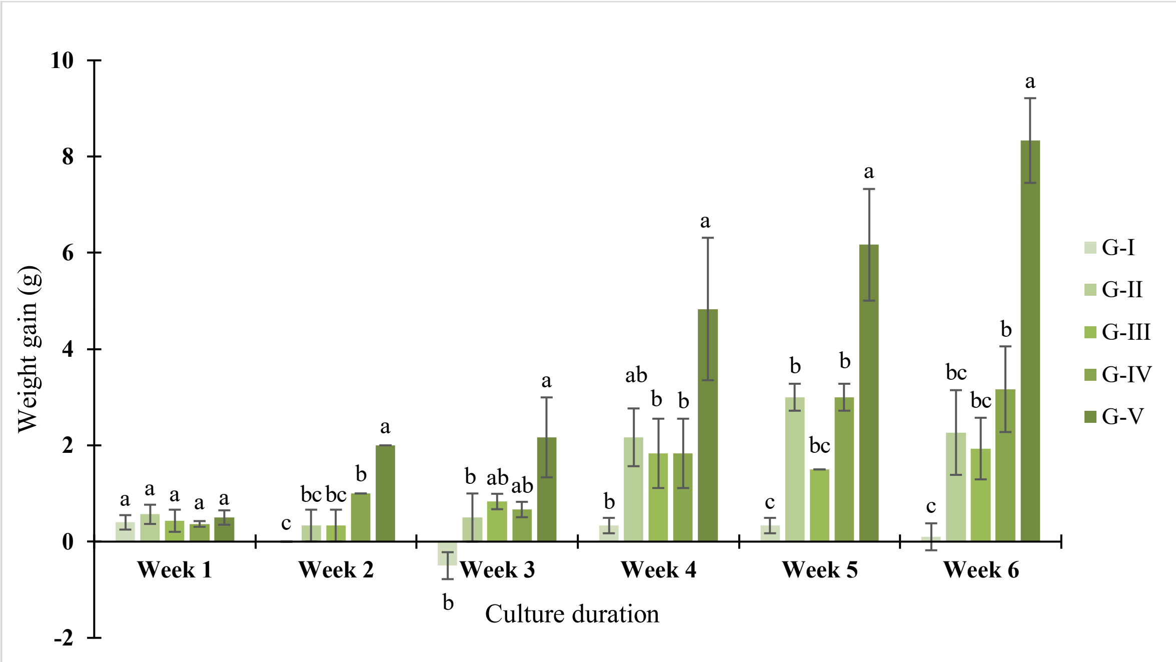

Figure 4. Weight gain (g) of the *Ulva lactuca* culture at different concentrations of vermicompost fertilizers: G-I (0 mg L^{-1} vermicompost); G-II (5 mg L^{-1} vermicompost); G-III (10 mg L^{-1} vermicompost); G-IV (15 mg L^{-1} vermicompost); G-V (20 mg L^{-1} vermicompost). Values are in triplicate. Bars with different letters per week are considered statistically different ($p < 0.05$), n = 15.

Specific growth rate. In the 6-week culture in the laboratory conditions, G-V showed the highest SGR, significantly higher ($p < 0.05$) than the control, from week 2 to week 6. In the first week, experimental groups showed no difference ($p > 0.05$) in SGR. In the 2nd week, the highest SGR was observed in G-V (3.64±0.00% day^{-1}), while the control had the lowest value of 0.00±0.00% day^{-1}, indicating no growth. During the third week, control (G-1) showed significantly ($p < 0.05$) lower SGR among the groups, while the high concentration (G-V) showed the highest SGR. In the fourth week, G-V remains the highest SGR with 3.28±0.74% day^{-1}, higher than that of the other lower concentration groups and control, and reveals a significant difference at $p < 0.05$. G-V continued to exhibit a positive growth rate of 3.14±0.38% day^{-1}, which was higher than G-IV, G-III, and G-II, and statistically higher ($p < 0.05$) compared to the SGR of G-I (2.29 ± 0.14% day^{-1}) in the fifth week. During the sixth week, the SGR of G-V (3.15±0.18% day^{-1}) was maintained at the top and significantly higher ($p < 0.05$) among the other groups. G-IV (1.65±0.37% day^{-1}), G-II (1.27±0.38% day^{-1}), G-III (1.14±0.29% day^{-1}) found no significant differences ($p > 0.05$) but statistically higher ($p < 0.05$) than G-I (0.57±0.22% day^{-1}). These variations in growth highlight the dynamic changes occurring within each group over time. G-V showed a steady increase in weight during the study period compared to the other groups; it exhibited the most significant growth rate performance.

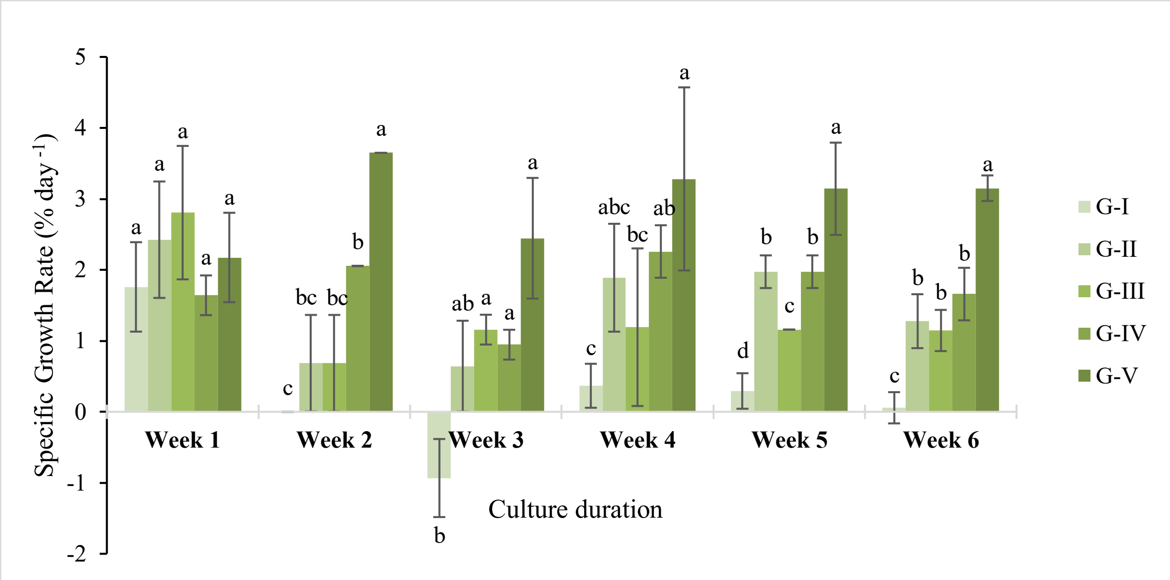

Figure 5. Specific growth rate (day^{-1}) of the *Ulva lactuca* culture at different concentrations of vermicompost fertilizers: G-I (0 mg L^{-1} vermicompost); G-II (5 mg L^{-1} vermicompost); G-III (10 mg L^{-1} vermicompost); G-IV (15 mg L^{-1} vermicompost); G-V (20 mg L^{-1} vermicompost). Values are in triplicate. Bars with different letters per week are considered statistically different ($p < 0.05$), n = 15.

Chlorophyll-a and carotenoid. The One-way ANOVA results revealed that vermicompost levels increased, and there were no significant differences ($p > 0.05$) in chlorophyll-a and total carotenoid content between groups. G-II exhibited the highest concentration of chlorophyll-a (20.11±0.38 µg mL^{-1}), substantially greater ($p < 0.05$) than other treatments ($p < 0.05$). G-V and G-IV showed lower values (15.06±1.00 µg mL^{-1} and 15.11±0.15 µg mL^{-1}, respectively) than G-II. The same tendency was seen with carotenoids. G-II had the highest value of 6.88±0.05 µg mL^{-1}, which was substantially higher ($p < 0.05$) than G-V (5.36±0.22 µg mL^{-1}) and G-IV (5.39±0.09 µg mL^{-1}). Three replications of each treatment were employed. G-III (6.17±0.60 µg mL^{-1}) and G-I (6.32±0.08 µg mL^{-1}) both exhibited high values, although not statistically different ($p > 0.05$) from G-II.

Discussions. This study investigated the effects of different vermicompost concentrations on the growth, biomass, and chlorophyll content of *Ulva lactuca*. The result of this experiment revealed that a high concentration of vermicompost, such as 20 mg L^{-1}, improved the SGR to 3.15% day^{-1} in *U. lactuca* culture. In other studies, Robles & Tahiluddin (2022) reported that the cultivation of *Caulerpa racemosa* enriched with inorganic fertilizers yielded an SGR of 2.34% day^{-1}, which was lower than the current study. In addition, the study of Susilowati et al. (2019) demonstrated that vermicompost can increase the growth rates of *Caulerpa racemosa*, a type of green seaweed. However, the responses did not show statistical significance, as they varied depending on the species and environmental conditions. Other species of seaweed, such as *Kappaphycus alvarezii*, performed better at lower concentrations of organic fertilizers (Borlongan et al 2011). Furthermore, *C. racemosa* achieved the highest growth rate of 2.26±0.52% day^{-1} at a concentration of vermicompost 250 g m^{-2}, followed by 1.71±0.47% day^{-1} at 150 g m^{-2}, while control or no enrichment of the vermicompost had 1.47±0.50% day^{-1}, which is lower compared to the two groups after 28 days of culture (Susilowati et al 2019). In the case of *Gracilaria verrucosa*, using vermicompost as fertilizer at a dose of 450 ppm was found to be optimal for the characteristics of the cells, growth, and quality of the seaweed: the higher the dose, the greater the growth rates and biomass production (Rahim 2017). These findings suggest that organic fertilizers such as vermicompost can be a viable alternative to inorganic fertilizers in seaweed farming. Vermicompost as a culture media for water stress sweet basil (*Ocimum basilicum*) provides a significant result (Celikcan 2021). Notably, the present study indicates that the SGR was highest at 20 mg L^{-1} vermicompost, which exceeded the 2% day^{-1}, similar to the result of Tahiulddin et al (2022a) using organic fertilizers (seaweed extracts) produced significantly higher SGR than in the control group. This enhanced growth may be attributed to better nutrient uptake and utilization, facilitating a higher growth rate in *U. lactuca*.

The result of this study concurs with the findings of Rahim (2017) and Nurfebriani et al (2015), reinforcing that biomass production is fundamentally a function of nutrient availability. Different organic fertilizers exert varied effects on plant growth. For instance, Abd & Abdullah (2024) compared the vermicompost and fish emulsion; findings showed both improve the growth of plant Tarragon (*Artemisia dracunculus*), while in this study, enriched with vermicompost, produced higher biomass and increased pigment production of *Ulva lactuca*. Similarly, Nasmia et al (2020) reported that using seaweed extract-based fertilizer promotes the growth of the red seaweed, *Gracilaria verrucosa*. In the current study, higher concentrations of vermicompost, such as 20 mg L^{-1}, increased the biomass production of *U. lactuca* culture. However, in contrast to other studies, at lower concentrations, the variation in weight increase was less pronounced, possibly due to a sub-optimal food supply that limits maximum growth, as Steffensen (1976) noted regarding the negative impact of nitrogen shortage on seaweed growth. Nutrient imbalances may reduce photosynthetic efficiency at higher concentrations (20 mg L^{-1}). Thus, as Vogelmann & Gorton (2014) noted, finding the optimal nutrient enhancement for seaweed cultivation is essential. Although vermicompost represents an effective organic fertilizer option, its application must be carefully managed to prevent nutrient over-enrichment, which could negatively impact seaweed growth and photosynthetic performance.

Vermicompost also affected seaweed pigments, specifically chlorophyll-a and carotenoids. This study recorded the highest chlorophyll-a content of 20.11 μg mL^{-1} in 5 mg L^{-1} vermicompost. At the same time, the lowest value was observed in the control group with 15.06 μg mL^{-1}, indicating that nutrient availability is an essential factor influencing pigment formation. Although the highest average value of chlorophyll-a was observed at a dose of 100 g m^{-2} (≈ 0.022), it was only slightly higher than that achieved with 300 g m^{-2} of vermicompost (Susilowati et al 2019). In the groups treated with vermicompost, the chlorophyll-a content tends to decrease, with 20 mg L^{-1} vermicompost displaying the lowest content of 15.11 μg mL^{-1}. The lowest content level of chlorophyll-a was observed in the control group, which did not receive vermicompost, at 15.06±1.00 μg mL^{-1} and 5.36±0.22 μg mL^{-1}, respectively. This decline suggests that excessively high nutrient levels can adversely affect photosynthetic efficiency, as observed by Buapet et al (2008). In terms of total carotenoids, similar results were observed in chlorophyll-a. Treatment with 5 mg L^{-1} vermicompost had the highest total carotenoid content, at 6.88 μg mL^{-1}, whereas the control, at 0 mg L^{-1}, showed the lowest value, at 5.36±0.22 μg mL^{-1}. These results are consistent with those of Susilowati et al (2019), who reported that moderate vermicompost concentrations favor pigment production, while excessively high concentrations impede photosynthetic efficiency.

Conclusions. This study demonstrates that vermicompost, a locally available organic fertilizer, significantly enhances the growth performance of *Ulva lactuca*, achieving an SGR of up to 3.15% day^{-1} and a biomass yield of 11.33 g at a concentration of 20 mg L^{-1}. While the highest pigment content, chlorophyll-a, and total carotenoids were observed at lower concentrations (5 to 15 mg L^{-1} vermicompost), indicating a trade-off between maximizing biomass and enhancing pigment quality. These findings suggest that fertilizer concentrations should be tailored to specific production goals, whether focused on biomass yield or pigment extraction. The use of vermicompost presents a promising, sustainable alternative to synthetic fertilizers, offering practical benefits for seaweed farmers by improving productivity without compromising environmental integrity. It also supports local economies by fostering demand for organic fertilizer production. To strengthen the applicability of these results, further research is recommended through long-term studies, field trials in natural cultivation settings, and the exploration of mixed organic-inorganic fertilizer strategies for optimized seaweed farming systems. Integrating such practices can lead to more resilient, productive, and eco-friendly aquaculture operations.

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