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Application of Seaweed (*Eucheuma cottonii*) Extract and Shrimp Waste as Biofertilizer for Mustard (*Brassica juncea* L.)

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Abstract: The extensive use of chemical fertilizers in agriculture poses serious collateral problems such as environmental pollution, pest resistance development and food safety decline. Researches focused on developing organic fertilizers from waste to partially replace chemical fertilizer use is increasing due to the requirement of sustainable agriculture development. Therefore, a pot experiment was carried out to study the effect of organic fertilizer made from seaweed and shrimp waste in improving crop growth and soil pH in green mustards. Three treatments were set up: seaweed and shrimp waste fertilizer (SSF), organic fertilizer (OF) and chemical fertilizer (CF). Although the SSF treatment had the highest number of leaves and plant height, ANOVA showed no significant differences between the three treatments. Soil pH in the SS treatment (pH= 7.43) was also higher than OF (pH= 6.49) and CF (pH= 7.07) though no significant differences were observed. Therefore, the fertilizer produced using seaweed and shrimp waste is comparable to other organic and chemical fertilizer and is suitable for growing leafy vegetables. The production and use of organic fertilizers made from seaweed extract and shrimp head waste can be a new wave of organic fertilizer in promoting plant growth and increasing crop yields.

Keywords: Organic fertilizer, seaweed fertilizer, shrimp waste fertilizer

1. Introduction

Organic fertilizers are natural fertilizers made from living organisms and mineral substances (Shaji et al., 2021). It can be made from municipal or agriculture solid wastes. In agriculture sector, organic fertilisers play an important role as they improve the soil quality without damaging water and plants (Shaji et al., 2021). Improved soil quality enables farmers to achieve better yields and higher quality crops. The organic matters contained in organic fertilizers are decomposed slowly by the soil organisms, compared to the inorganic fertilizers (Kumar et al., 2019). Slow release of the organic matter in organic fertilizers reduces the effect of nutrient leaching and helps maintain the soil fertility. Food wastes can be used to produce useful soil amendments for farming (Chew et al., 2014). Organic fertilizers produced using food wastes can reduce the dependency of farmers on conventional nitrogen-based fertilizers that can cause leaching into natural water resources.

Seaweed extracts contain a wide range of bioactive compounds, and their extraction methods are purpose-dependent. However, due to manufacturing data confidentiality, there is no detailed data on the processes of algal extraction technologies for the use in agriculture (Craigie, 2011). Extraction procedures for agricultural bio-stimulant production from marine macroalgae includes processes using water, alkalis or acids, or physically by disrupting the seaweed by low-temperature milling to give a micronized suspension of fine particles (Roj et al., 2009; Sharma et al., 2014).

Water extraction is the most cost effective and practical method for seaweed utilization as fertilizer as it assists the release of micro and macro elements from the biomass (Michalak et al., 2015). The application of seaweed extract was reported to help with various aspects including seed germination, root development, frost resistance nutrient uptake and control of phytopathogenic fungi (Farid et al., 2009), bacteria (Rhimou et al., 2010), insects or other pests (Nassar et al., 1999), and restoration of plant growth under high salinity stress (Nabti et al., 2010). The use of marine algae provides a suitable solution to overcome pollution problems caused by the extensive use of chemical fertilizers and industrialization.

Shrimp head and shells have a substance known as chitosan/chitin. This chitosan or chitin gives many benefits to the plant. Among the benefits of chitosan to plants, it can be said to be a natural fertilizer because plants absorb nutrients without other chemical fertilizer elements. The substance can restrict fungus growth and activate natural defence

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mechanisms in plants (Abirami et al., 2022). However, shrimp heads and shells are not being fully utilized here, and a significantly large amount of waste has accumulated in seafood processing industries and seafood restaurants.
Vegetables are very important food commodity as they help fulfil vitamins, minerals, fibre and protein requirements as well as provide a steady source of income to farmers (Torrefiel, 2006). The income generated from growing vegetables is comparable to other crops as growers can harvest more crops from a small area in a short period of time. Green mustard (*Brassica juncea* L.) is a foliage type mustard believed to have originated from the Himalayan region of India. It is widely grown in vegetable and home gardens and is popularly used in daily cooking in Malaysia. The fully expanded leaves are often shredded, cooked and served as a vegetable dish with the staple food.

Local plants and crops can gain maximum benefits from seaweed and shrimp shells while reducing biological waste at the same time. Good organisms favour chitosan in the soil, such as worms and bacteria. The plant is considered more stronger against fungal infection and allows the plant to be more fertile. Organic fertilizer made from shrimp heads and shells can reduce soil damage and even repair damaged soil structure. Therefore, this study aims to study the effect of seaweed and shrimp waste fertilizer on the growth of green mustard plant.

2. Research Method

2.1 Preparation of Seaweed Extract

One kilograms of seaweed was gathered and rinsed for 15 minutes to remove salt and dirt. The seaweed was then chopped into small pieces and put into a beaker containing one litre (L) of distilled water. The mixture was boiled for an hour and allowed to cool. The mixture was then filtered using a muslin cloth and transferred into a clean bottle.

2.2 Preparation of Shrimp Shell Powder

One kilogram of collected shrimp waste was dried in the oven at 90◦C for 30 minutes. It was then pulverized into powder by using a grinder.

2.3 Preparation of Seaweed and Shrimp Extract

150 ml of seaweed extract was mixed with 50g of shrimp shell powder in a beaker. Water was added into the beaker until the total volume is 500ml. The seaweed and shrimp fertilizer mixture was then transferred into a glass bottle and left for two weeks before using it on crops.

2.4 Treatments and Experimental Design

The study was conducted under the rain shelter at Polytechnic Sandakan Sabah (5.9187° N, 118.0028° E), involving 3 treatments (Table 1). The mustard seeds were sown in seedling trays filled with peatmoss. The seedlings were transplanted into the polybags sized 16” x 16” 7 days after germination. One seedling was planted per polybag. The media used was garden soil and compost with 1:1 ratio.

Table 1: Treatment types and rates of application

Treatments	Treatment Type	Rate of Application
T1	Seaweed and shrimp extract	100ml
T2	Organic fertilizer (goat dung)	500g
T3	Chemical fertilizer (NPK Green 15:15:15)	50g

Each plant's fertilizer application rate is 100ml of seaweed and shrimp extract for T1, 500g of commercial organic fertilizer for T2, and 50g of NPK Green (15:15:15) fertilizer for T3. Each treatment had 10 plants and was replicated 4 times in a randomized complete block design (RCBD). The fertiliser application was conducted once every week for one month.

2.5 Parameter and Data Analysis

Parameters involved for data collection were the number of new leaves, plant height and soil pH. Data were collected 7, 15, 22 and 30 days after sowing (DAS). All the data were statistically analyzed using SPSS v24 at α 0.05.

3. Results and Discussions

Seaweed and shrimp extract fertilizer (SSF) showed a higher number of new leaves among the three treatments, followed by chemical fertilizer (CF) and organic fertilizer (OF) (Fig. 1). SSF and CF treatment showed a 50% increase in number of leaves on 15 DAS compared to OF at only 43%. At 22 DAS, OF showed a higher increase in number of leaves which was 28% compared to SSF and CF at 26%. Although SSF had the highest number of leaves at 30 DAS, CF had the highest increase in total number of leaves (132%) followed by OF (127%) and SSF (120%). No significant differences between the treatments were observed.

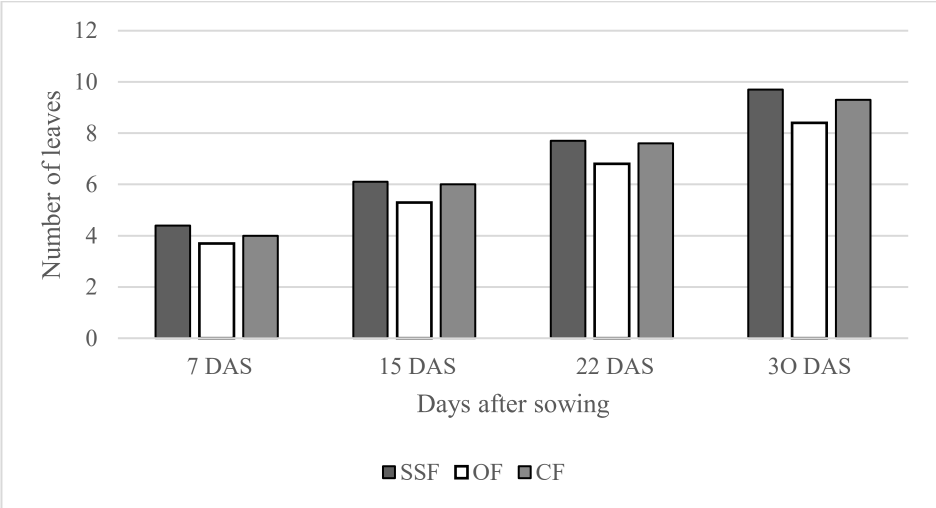

Fig. 1: The number of new leaves in mustard treated with seaweed and shrimp extract fertilizer, organic fertilizer and chemical fertilizer treatment

Fig. 2 shows the plant height of all three treatments from day 7 until day 30. The data shows that the SSF treatment constantly recorded the highest plant height, whereas the OF treatment recorded the lowest height on average. SSF has the highest increase in height (101%) on 30 DAS compared to the CF (99.5%) and OF (57.8%) treatments. No significant differences between the treatments.

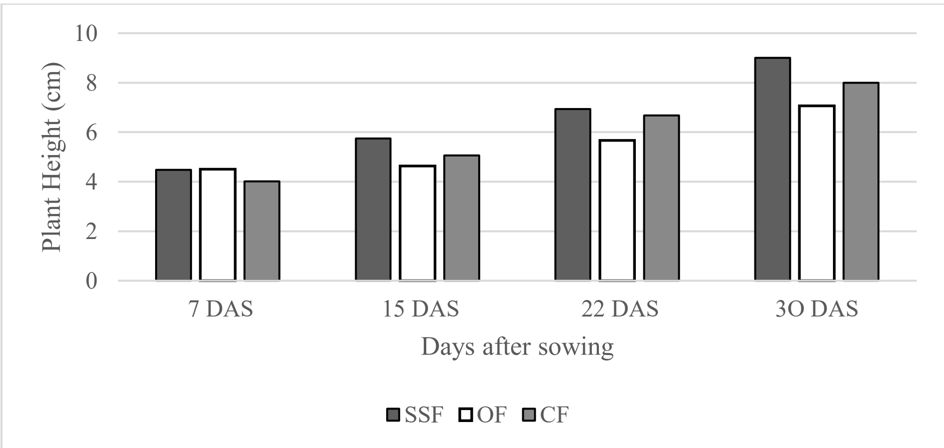

Fig. 2: Plant height of mustard treated with Seaweed and shrimp extract fertilizer, organic fertilizer and chemical fertilizer treatment.

Fig. 3 shows the soil pH value of three different treatments. SSF recorded a higher pH value throughout the experiment compared to the other two treatments. According to Maharana & Singh (2018), minerals such as sodium (53.2 mg/g), potassium (47.5 mg/g), calcium (89.1 mg/g), magnesium (27.1mg/g), iron (39.4 mg/g), phosphorus and manganese have been assessed in shrimp waste powder. All shrimp waste had a neutral to slightly alkaline pH ranging from 7.02-8.3.

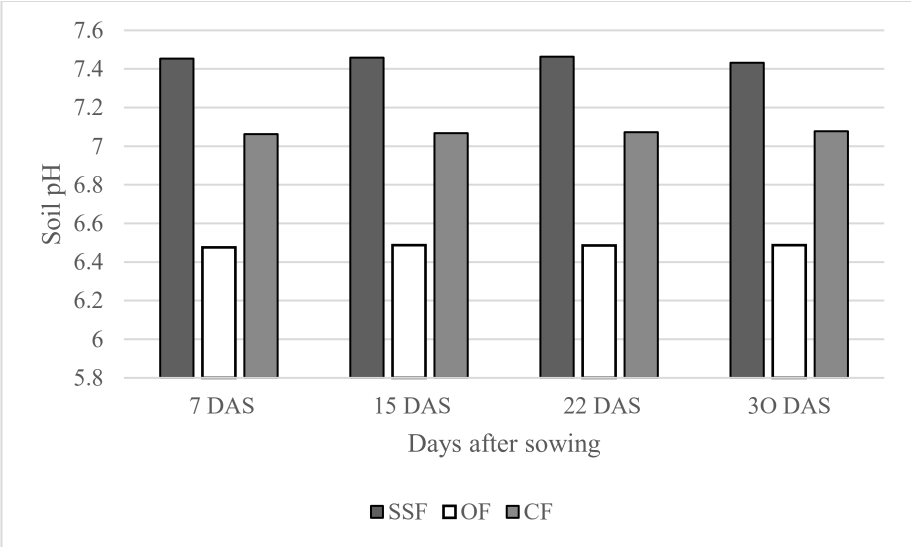

Fig. 3: pH of soil treated with Seaweed and shrimp extract fertilizer, organic fertilizer and chemical fertilizer treatment.

The mechanism as to how seaweed extracts and shrimp wastes improve the growth and vigour of plants has been difficult to elucidate as they contain numerous bioactive compounds which is not fully researched. In a study comparing different concentrations of seaweed extracts, Yusuf et al. (2021) reported that seaweed extract application affects the number of leaves in mustard plants at 14, 21, and 28 days after planting (DAP). The highest number of leaves (5.75 pieces) was produced by the 20% seaweed concentration treatment. The highest number of leaves of 8.00 and 9.88 were obtained at 21 and 28 DAP respectively using 100% concentration of seaweed extract. Seaweed extract significantly affected plant height, leaf number, leaf area, fresh weight, and dry weight of mustard greens. This effect was due to sufficient exposure to the sun as well as the presence of plant growth-stimulating hormones, gibberellins, cytokinins, and auxins. Another study by Dogra & Madradia (2012) using different concentrations of seaweed extract on onion showed an increase in shoot height over untreated control to the extent of 151 to 169 %. Bi et al. (2011) used kappa carrageenan, an extracted red algal polysaccharide to induce secondary metabolites in chickpea and maize plants. A significant change in plant height, stem diameter and number of leaves per plant was observed although the number of cobs per plant and flowering time were not changed by the treatments.

Muymas et al. (2015) reported that the treatment of lettuces with shrimp shell powder markedly promoted growth and yield production in terms of fresh weight, leaf number, leaf width, leaf length and dry weight in all crop seasons. Similarly, use of shrimp shell compost on okra induced the shoot length, root length, internodes length, fresh weight of leaves, dry weight of leaves and chlorophyll content significantly (Abirami et al., 2022). Shrimp waste improved the synthesis of photosynthetic pigments and increased the activity of antioxidant enzymes such as polyphenol oxidase and ascorbate peroxidase and also reduced the toxic metal availability and uptake, mitigated the oxidative stress, and minimized the levels of malondialdehyde and hydrogen peroxide (Mousa et al., 2022). Izzati et al. (2019), in a study to evaluate the use of seaweeds to improve sandy and clay soil fertility, indicated that the addition of seaweeds significantly increased organic material content and was proven to reduce pH to a normal level. However, in a study by Kazemi et al. (2019), application of shrimp waste showed an increase in N concentration in corn shoots, attributed by the reduction in dry matter yield. The study concluded that addition of shrimp waste significantly decreased roots and shoots N uptakes and also decreased the biomass of corn plants. Costa (1977) reported that shrimp waste should be applied at rates necessary to supply the recommended rates of N and is an effective source of N and P for crop plants. The degradation of chitin in Shrimp Shell Powder, including naturally produced chitosan, provides useful nutrient elements and plant growth stimulators.

Although the results in this study favours the use of seaweed and shrimp waste fertilizer, there were no significant results obtained. This may be due to the diluted concentration of seaweed and shrimp waste fertilizer extract used in this study in comparison to Dewi et al. (2019). The nutrient content of the seaweed and shrimp waste also differs according to harvest and handling of wastes.

4. Conclusion

Plant growth and development relies on the availability of a favourable growing conditions, which includes healthy soils, availability of nutrients and also protection from pests and other stresses. Applying seaweed and shrimp shell powder fertilizer to green mustards enhanced the new number of leaves and plant height at 7, 15, 22, and 30 DAS. The results show that seaweed and shrimp shell powder fertilizer is comparable to chemical fertilizer and can be used to enhance soil performance. The use of this fertilizer will help to reduce the waste that is produced by the shrimp processing industries. However, further studies are needed to evaluate these results in open area cultivation on a larger scale with more parameters measured such as chlorophyll content, fresh weight and dry weight taking into consideration the population growth of the beneficial microbes. It is suggested that future studies prepared a highly concentrated fertilizer and study the effect of different ratio of seaweed extract and shrimp waste concentrations on plants. A nutrient analysis of the prepared fertiliser should also be carried out.

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Conflict of Interest

The authors declare no conflicts of interest.

References

Abirami, S., Gnanamuthu, G., & Nagarajan, D. (2022). Bioconversion of shrimp shell waste into compost preparation and its plant growth study. *Indian Journal of Agricultural Research*, *56*(5), 588-593.

Bi, F., Iqbal, S., Arman, M., Ali, A., & Hassan, M. U. (2011). Carrageenan as an elicitor of induced secondary metabolites and its effects on various growth characters of chickpea and maize plants. *Journal of Saudi Chemical Society*, *15*(3), 269-273.

Chew, K. W., Chia, S. R., Yen, H. W., Nomanbhay, S., Ho, Y. C., & Show, P. L. (2019). Transformation of biomass waste into sustainable organic fertilizers. *Sustainability*, *11*(8), 2266.

Costa, R. E. (1977). The fertilizer value of shrimp and crab processing wastes. M.S. thesis, Oregon State University. p. 184.

Craigie, J. S. (2011). Seaweed extract stimuli in plant science and agriculture. *Journal of applied phycology*, *23*(3), 371-393.

Dewi, E. N., Rianingsih, L., & Anggo, A. D. (2019, March). The addition of different starters on characteristics Sargassum sp. liquid fertilizer. In *IOP Conference Series: Earth and Environmental Science* (Vol. 246, No. 1, p. 012045). IOP Publishing.

Dogra, B. S., & Mandradia, R. K. (2012). Effect of seaweed extract on growth and yield of onion. *International Journal of Farm Sciences*, *2*(1), 59-64.

Farid, Y., Etahiri, S., & Assobhei, O. (2009). Activité antimicrobienne des algues marines de la lagune d'Oualidia (Maroc): Criblage et optimisation de la période de la récolte. *Appl. Biosci*, *24*, 1543-1552.

Izzati, M., Haryanti, S., & Setiari, N. (2019, May). The use of macroalga sargassum sp. and Gracilaria verrucosa in improving sandy and clay soil fertility. In *Journal of Physics: Conference Series* (Vol. 1217, No. 1, p. 012179). IOP Publishing.

Kazemi, R., Ronaghi, A., Yasrebi, J., Ghasemi-Fasaei, R., & Zarei, M. (2019). Effect of shrimp waste–derived biochar and arbuscular mycorrhizal fungus on yield, antioxidant enzymes, and chemical composition of corn under salinity stress. *Journal of Soil Science and Plant Nutrition*, *19*(4), 758-770.

Maharana, A. K., & Singh, S. M. (2018). Cold active lipases produced by Cryptococcus sp. Y-32 and Rhodococcus erythropolis N149 isolated from Nella Lake, Antarctica. *International Journal of Current Microbiology and Applied Sciences*, *7*(3), 1910-1926.

Michalak, I., Tuhy, Ł., & Chojnacka, K. (2015). Seaweed extract by microwave assisted extraction as plant growth biostimulant. *Open Chemistry*, *13*(1).

Mousa, M. A., Abo-Elyousr, K. A., Ibrahim, O. H., Alshareef, N. O., & Eissa, M. A. (2022). Shrimp-Waste-Derived Biochar Induces Metal Toxicity Tolerance of Wastewater-Irrigated Quinoa (Chenopodium quinoa). *Agriculture*, *12*(11), 1748.

Muymas, P., Pichyangkura, R., Wiriyakitnateekul, W., Wangsomboondee, T., Chadchawan, S., & Seraypheap, K. (2015). Effects of chitin-rich residues on growth and postharvest quality of lettuce. *Biological Agriculture & Horticulture*, *31*(2), 108-117.

Nabti, E., Sahnoune, M., Ghoul, M., Fischer, D., Hofmann, A., Rothballer, M., ... & Hartmann, A. (2010). Restoration of growth of durum wheat (Triticum durum var. waha) under saline conditions due to inoculation with the rhizosphere bacterium Azospirillum brasilense NH and extracts of the marine alga Ulva lactuca. *Journal of Plant Growth Regulation*, *29*(1), 6-22.

Nassar, M. M., Hafez, S. T., Nagaty, I. M., & Khalaf, S. A. (1999). The insecticidal activity of Cyanobacteria against four insects, two of medical importance and two agricultural pests with reference to the action on albino mice. *Journal of the Egyptian Society of Parasitology*, *29*(3), 939-949.

Rhimou, B., Hassane, R., José, M., & Nathalie, B. (2010). The antibacterial potential of the seaweeds (Rhodophyceae) of the Strait of Gibraltar and the Mediterranean Coast of Morocco. *African Journal of Biotechnology*, *9*(38), 6365-6372.

Roj, E., Dobrzynska-Inger, A., Kostrzewa, D., Kolodziejczyk, K., Sojka, M., Krol, B., ... & Markowski, J. (2009). Extraction of berry seed oils with supercritical CO2. *Przemysl Chemiczny*, *88*(12), 1325-1330.

Shaji, H., Chandran, V., & Mathew, L. (2021). Organic fertilizers as a route to controlled release of nutrients. In *Controlled Release Fertilizers for Sustainable Agriculture* (pp. 231-245). Academic Press.

Sharma, H. S., Fleming, C., Selby, C., Rao, J. R., & Martin, T. (2014). Plant biostimulants: a review on the processing of macroalgae and use of extracts for crop management to reduce abiotic and biotic stresses. *Journal of applied phycology*, *26*(1), 465-490.

Torrefiel Jr, D. B. (2006). Growth and yield performance of pechay (Brassica napus L.) as influenced by biogas digester effluent and rice hull ash application. Undergrad. *Visca, Baybay. Leyte*.

Yusuf, R., Laude, S., Syakur, A., & Kalaba, Y. (2021, July). The Effect of Seaweed Extract (Sargassum sp.) on Growth and Yield Enhancement of Mustard Greens (Brassica juncea L.). In *IOP Conference Series: Earth and Environmental Science* (Vol. 828, No. 1, p. 012011). IOP Publishing.