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GRACILARIA EDULIS AS PHYTOREMEDIATION AGENT TO IMPROVE SHRIMP POND WATER QUALITY

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Abstract: Experimental tank cultivation of *Gracilaria edulis* has been performed without processing for seedlings. Based on logistic growth model, homogeneity and heterogeneity of growth were tested. The analysis was performed through a model selection approach with numerically- partitioned active biomass data. Based on the R^2 coefficient, the active and inactive biomass for vegetative propagation was 0.25% and 99.75%, respectively. The active portion of biomass was employed to logistic model showing R^2 coefficient of 0.9963. The results provide a concrete reason for the needs to activate biomass, and to manage the maximum sustainable yield in a phytoremediation system.

KEYWORDS: Growth rate, Logistic model, Macroalgae, Productivity

Introduction

Intensive shrimp cultivation in tropical countries is one of the potential sources of eutrophication (Graslund & Bengtsson, 2001). To decrease the excess nutrient is a requirement for not only environmental-concern issues, but also to prevent the occurrence of diseases among the cultivating shrimps (Kautsky *et al.,* 2000). Therefore, seaweed cultivation technique has been investigated to increase the production of shrimp and to improve water quality (Troell *et al.,* 1997). For this purpose, mix cultivation of macroalgae in shrimp cultivation pond (Zhou *et al*., 2006), and tank cultivation has been performed, where applicable species and its efficiency has been screened (Troell *et al.,* 1997). The integration of phytoremediation system and aquaculture cultivation is predestined research topic in coastal environmental engineering (Ferrel & Sarisky-Reed, 2010; Neori *et al.,* 2004). Accordingly, this study focused on phytoremediation system by macroalgae propagation to improve excess nutrient of shrimp pond water. *G. edulis* was selected as phytoremediation agent as this macroalgal species naturally grows in canals around the shrimp-cultivation pond in *Johor Bahru,* Malaysia. This species has also been widely cultivated in India for agar production (Kaladharan *et al.,* 1996). Thereby, maximum growth rate is an essential requirement for phytoremediation agent. In this research, a new numerical model approach is employed on *G. edulis* biomass growth in order to improve the growth rate. Thus, the growth rate for vegetative propagation is investigated, as a preliminary research to design a phytoremediation system.

Materials and Methods

The growth of *G.edulis* was examined under controlled conditions in fabricated laboratory tank in Universiti Teknologi Malaysia. Healthy thalli of the seaweed with fresh weight of 1kg were collected at the Brackishwater Culture Research Centre, Gelang Patah, Johor (1°26' 21.5"N and 103°34' 55.2"E) in a canal of natural growth, downstream of shrimp-cultivation pond. The *G. edulis* was transported to the laboratory in a polystyrene box filled with brackish water. Subsequently washed under running tap water and cleaned of the epiphytes. The brackish water used was obtained from the shrimp pond at the research institute. The seaweed was cultivated in three tanks of 36 L volume for six weeks. The macroalgae were maintained in controlled conditions of light intensity (1000 lux), photoperiod (12:12 L: D cycle), temperature (28-30°C) with constant aeration. A total of 240g of

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G. edulis was hung using 1 mm nylon lines and 20 cm submerged. The tanks were weeded twice a week. One fifth of the total volume of water in the tanks was replaced with fresh shrimp pond water once a week. The seaweeds were blotted on paper towel to remove excess water, weighed (fresh weight) and restored back to the tanks (Zhou *et al*., 2006).

Two biomass growth model: the homogeneity and heterogeneity growth models were employed. In former model, homogeneity intrinsic growth rate of biomass is assumed for whole plant. In the latter model, an active growth portion of biomass is assumed, where surplus of the biomass is defined as inactive biomass. Based on this assumption, the discussion on biomass growth rate will be extended from intrinsic growth rate to differentiation of algal cell organisation for vegetative propagation. The homogenous growth pattern is primary assumption in logistic growth model. Heterogeneous growth which encompasses active and inactive portion of biomass is also applicable to logistic model when only active portion of biomass is considered. Average value from triplicates experimental data was used for statistical analysis. Biomass for vegetative propagation was numerically partitioned as follows,

$$W_a = W_t - W_i \qquad (1)$$

Where, W_t was total biomass, W_a was active and W_i was inactive biomass for vegetative propagation.

Numerically-partitioned active biomass as in Equation 1, was applied to logistic model by Curve Expert version 1.4. Then, based on the highest R^2 coefficient of determination, the active biomass and subsequently inactive biomass for propagation were detected, respectively.

Results

Figure 1 shows goodness of fitting against different numerically-partitioned active biomass to logistic model. The R^2 coefficient of determination was low when big portion of active biomass is considered, and gradually increases and made a peak at 0.60g of active biomass with R^2 coefficient of 0.9963 as shown in Figure 1. This result subsequently indicates that initial inactive biomass was 239.4g by logistic model after biomass partitioning as in Equation1. This result encompassed 99.75 % of the total biomass which was inactive for vegetative propagation. The relative growth rate of the species is 3.36g day^{-1} as fresh weight biomass.

Discussion

The results showed strong evidence that almost whole portion of biomass was clearly inactive for vegetative propagation. Lower growth rate of *G. edulis* was a consequence of heterogeneous growth with high portion of inactive biomass. It is suggested that increasing active biomass portion for vegetative propagation is the best strategy to obtain maximum productivity of the phytoremediation agent. Artificial seedlings have been reported to offer better solution for modern macroalgal cultivation technology since 1950s (Lobban & Harrison, 1994). For *Gracilaria* species, the seedlings are produced by cutting and then attached to substrates and transplanted to coastal farms to grow until harvestable size (Jayasankar & Ramamoorthy, 1997). Cell and tissue culture techniques via protoplast (Reddy *et al.,* 2008) and spore control (Lee & Ang 1991) also may be applicable for this purpose.

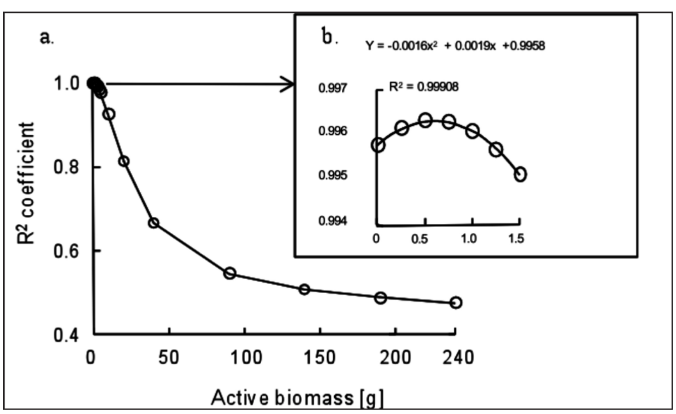

Figure 1: Logistic model fitting against numerically-partitioned active biomass (a), the peak as at 0.60g with the highest R^2 coefficient was 0.9963 (b).

Based on the analysis, the trend of growth curve was completely employed by logistic model (R^2=0.9963). It indicates that the active biomass followed the fundamental assumption of logistic model that is growth rate per unit of biomass linearly decreases as biomass increases. Only two parameters can be the control factors influencing the growth rate i.e. intrinsic growth rate and carrying capacity (Lee & Ang 1991). Based on this fact, when a phytoremediation system is designed for vegetative propagation of *G. edulis*, the architecture needs to be considered on these two parameters. Thereby, planting for more advanced wastewater treatment, such as nutrient removal with high *G. edulis* productivity, does not require maximum biomass stock to achieve the optimum efficiency for the phytoremediation system (Lee & Ang 1991). The optimum efficiency and maximum specific growth rate is represented by the maximum sustainable yield (MSY) as half of carrying capacity.

Conclusion

Experimental tank cultivation of *G. edulis* was conducted to investigate on applicability of logistic model and the concept of MSY to assess the potential ability of phytoremediation agent. In this research, it can be concluded that *G. edulis* can be developed as an agent for phytoremediation system. However, future work needs to be emphasised on how to increase the active portion of biomass for vegetative propagation, and to maximise carrying capacity and intrinsic growth rate to manage MSY.

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