ICES CM 2013/K:09

Future of farming of *Saccharina latissima* (Laminariales, Ochrophyta) in land-based IMTA systems in Galicia (NW. Iberia)

Pablo Touriñán[a], José R.C. Freitas[a], Miguel Lastres[b], Javier Cremades[a]

[a] Coastal biology research group (BioCost), Facultad de Ciencias and Centro de Investigaciones Cientificas Avanzadas (CICA). Universidad de A Coruña. 15071 A Coruña. Spain; javier.cremades@udc.es
[b] Instituto Galego de Formación en Acuicultura (IGAFA). Consellería do Medio Rural e do Mar. Xunta de Galicia.

Summary

An integrated multi-trophic aquaculture system (IMTA) was developed by placing a "sugar kelp" (*Saccharina latissima*) tank cultivating system using the effluent from an experimental sole (*Solea senegalensis*) land-based culture facility in Galicia (Northwest Iberia). There were two different experiences with the idea of obtaining basic information about the dynamics of nutrient intake and influence of the renewal of water in the seaweed culture development in different environmental conditions. The results show that the use of this species as a winter-spring biofilter in this type of installation is perfectly viable with average growth rates around 5% day. Given the high photosynthetic efficiency of *S. latissima*, its high growth rate at low temperatures and its many high-value applications, we think that this species has a promising future in their use at inland multi-trophic systems in cold-temperate regions (Chopin *et al.*, 2001). On the other hand, the results of this experiment show that the potential stress that crops may suffer because of an excess of light and temperature can be largely offset if the nutrient uptake is sufficient, what is interesting in climate change scenarios, especially in regions such as the Northwest Iberia, where the cultivation of kelps is at its southern distribution limit.

Introduction

The development of co-culture techniques of several organisms placed at different levels in the trophic chains allows greater crop diversification and higher performance rates of nutrients added to the system. The final inorganic residues from higher-level species are ultimately used by seaweeds that regenerate the system. Most of the nutrients added to the system are converted to cultivated matter with an evident economic and ecological improvement (Neori *et al.,* 2007). In this case is cultivated in an inland facilities the edible seaweed "sugar kelp" (*Saccharina latissima*) with the water effluent of a sole (*Solea senegalensis*) culture in a recirculating system.

Material and methods

The experiment was carried out from March to July at the Instituto Galego de Formación en Acuicultura (IGAFA) (Northwest Iberia). In the present experience was used the effluent of experimentals sole flatfish (*Solea senegaliensis*) culture tanks located inside the facilities, automatically pumped out to the facilities where were placed four seaweed cultivation tanks of 250 l. These tanks are cylindrical, with conical bottom and central air inlet to move the seaweeds. The tanks were distributed in series so that the first tank feeds by overflow the second tank and so on to the fourth tank. Moreover, every week was taken a sample of the input and output water of our series of tanks to analyzing the basic chemical parameters: NO3, NO2, NH4, and PO4; and water samples from the four tanks to study the evolution of the alkaline reserve and thus know if this is not a limiting factor for the growth of the seaweeds. Finally was done a constant monitoring of the temperature of the tanks 1 and 4 plus a pH measurement in the first tank.

Weekly the total biomass and biometrics of 30 plants of each tank was done. The measurements obtained are the weight, maximum width and length and total area of the blade of each individual. In addition were taken samples to analyze the C and N percentages.

Results and discussion

The most important data to point out is the graduation of growth observed from the first tank to the fourth, with much higher rates of growth in the tanks near the head of the series, getting to be higher than 5 times in the case of most active growth periods. For small seedlings reached 15% of growth/day and the maximum in the second growing season was close to 7%. The growth rates decrease at the end of the experience mainly because of the higher temperatures reached at this time (Gerard, 1997 a,b). However, this decline of growth was mitigated mainly in the first tanks by the important nutrient supply of the effluent. Recent transcriptomic studies also indicates the ability of these organisms to adapt to the synergistic effect of high temperatures and increasing photoperiod by activation/deactivation of different metabolic pathways (Heinrich *et al.*, 2012).

Related to the growth rate, we have also provided the maximum culture density in these conditions in 12,000 g/m^3 and the optimal weekly production is reached at densities of 6,000 g/m^3 in both plant sizes. This is an important factor in establishing the different cultivation strategies that must be taken into account. Moreover, there have been obtained very good results in terms of removal of dissolved substances in water effluent, especially the almost complete removal of NO_3. This is the element more difficult to remove from the closed-circuit cultures with conventional filter methods that are only efficient in the oxidation of nitrogen in the forms NH_4 and NO_2. The nitrogen removal results in a higher protein content in the seaweed blade.

In conclusion *Saccharina latissima* may be a good candidate to use as a biological filter in indoor IMTA systems in Galicia during the winter months because of its high growth rate and added value of biomass particularly in integrated systems.

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