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ABSTRACTS

COMPARISON OF TWO WATER AGITATION METHODS IN SEAWEED CULTURE TANKS: INFLUENCE OF THE ROTATING VELOCITY IN THE SEAWEED GROWTH AND ENERGY REQUIREMENT

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Introduction

Integrating seaweed production into land-based marine fish-farms allows removing dissolved nutrients and improves the sustainability of the coastal marine aquaculture. Free-floating seaweed culture in tanks, with suspension provided by tumbling, is the most usual cultivation technique used in this kind of facilities. The two main limiting factors for the integration of seaweeds and fish production is the energy cost and the large area required for the seaweed production process.

Tank-cultured seaweeds must be tumbled by vigorous bottom aeration to improve the exposure of fronds to light and to minimize the thickness of the diffusive boundary layer (DBL), increasing the flow of nutrients to the fronds and the flow of excess oxygen from them. The benefit of aeration in tanks under nutrient limitation, due to the thinning of the DBL has been demonstrated. Nevertheless, the potential growth benefit due to a major exposure of fronds to light, which could be achieved by an optimal hydrodynamic management of the tank, requires further attention.

In this work, the seaweed *Ulva ohnoi* is used to analyze the hydrodynamic behavior of two tank geometries and the influence of the hydrodynamic tank management in the growth of the seaweed is assessed.

Material and Methods

Two tank geometries were characterized: A vertical cylindrical (CV) tank (64 cm diameter, 90 L capacity) and a horizontal semi-cylindrical horizontal tank (SH) (80x80 cm, 180 L capacity). In the horizontal semi-cylindrical tank we compared two configurations: The first, using bottom aeration to tumble the seaweeds (SH2) and the second, using a water current produced by a pump attached to the tank (SH1). The hydrodynamic behavior of seaweed included: (1) the factors determining the rotating velocity of the seaweed fronds and (2) the energy consumption associated to seaweed movement.

In aerated tanks (CV and SH2), the rotating velocity of the seaweed is determined by the air flow rate, while in the no aerated tanks the impulse force (Fi) of the entering water determines the rotating velocity of the seaweed, which can be calculated as $Fi=Q\, v\, \rho$, where Q is the water inlet flow rate, v the water inlet velocity and ρ the density of water.

The effective power per unit surface (EPs) required for seaweed tumbling was calculated as $EPs = Q_{air}\, H_{water}\, \rho\, g/A$ for aerated tanks, and as $EPs=Q\, v^2 \rho/2A$ for no aerated tanks; being A the horizontal area.

Air flow rates analyzed in aerated tanks CV and SH2 ranged, respectively, from 150 to 600 L/h and from 540 to 1200 L/h. These values correspond to EPs values ranging, respectively, from 0.35 to 1.57W/m^2 and from 0.86 to 1.92W/m^2. In the no aerated tank SH1, using 10 water inlet orifices with diameter 2.78 mm, the Fi applied ranged from 0.318 to 0.715N, which correspond to EPs values from 0.57 to 1.92W/m^2

Results and discussion

The relationship between the rotating velocities obtained in each tank and the effective power required per unit surface (EPs) is shown in Figure 2. The higher rotating velocities observed in tanks CV and SH2 are due to the smaller rotation radius. In these tanks, the frequency at which seaweed was irradiated is higher, but the time of irradiation is smaller.

Rotating velocity values in tank CV were more disperse and the pattern of seaweed movement was less homogeneous.

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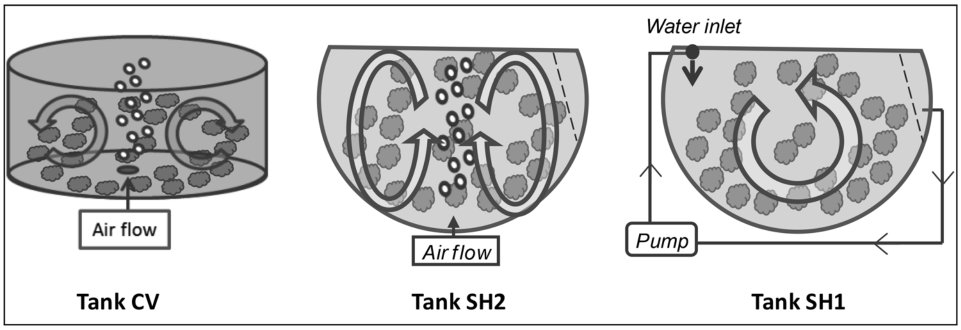

Figure 1: Tank configurations: CV(circular vertical aerated), SH2 and SH1(semicircular horizontal aerated and no aerated)

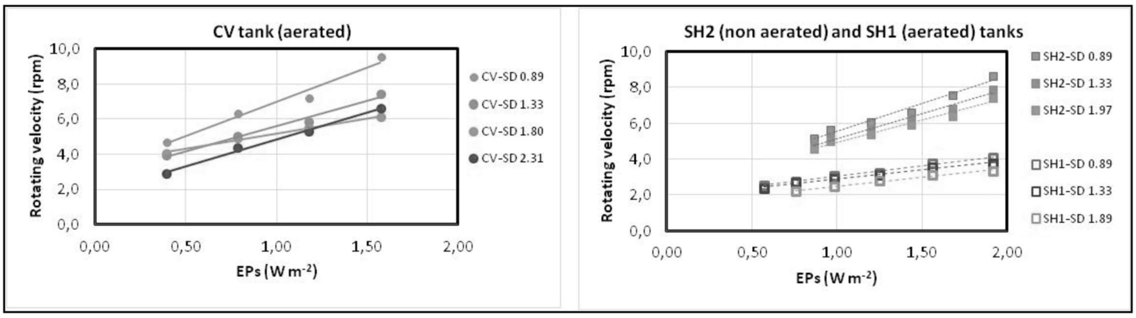

Figure 2: Rotational velocities obtained at different EPs in aerated tanks (CV and SH2) and no aerated tank (SH1).

Tanks SH1 and SH2 showed a more uniform pattern of seaweed movement. Differences in rotating velocities between stocking densities were scarce, especially SH1, but a slight decrease in the rotating velocities were observed when the stocking density increased. Rotating velocity in the aerated tank SH2 was more sensible to the increases of EPs than the no aerated tank SH1.

Water agitation to tumble seaweeds is one of the major energy sinks in land-based seaweed culture systems and their cost is a large fraction of the total production cost. Their efficiency plays an essential role in the feasibility of tank-cultured seaweed systems. In this work, the use of bottom aeration to achieve water tumbling was compared with the use of water inlet jets. The differences observed in terms of effective power required per unit surface were not relevant, but the rotation of seaweeds in the no aerated tank seemed to be more uniform. When two tank geometries were compared, the cylindrical vertical tank showed a more irregular flow pattern than a semi-cylindrical horizontal tank, aerated or not.

The tumbling pattern of seaweed into the tank, their uniformity and angular velocity can be a crucial factor to the radiation interception by seaweeds and could have a noteworthy influence in the yield. The effect of the hydrodynamic management of tanks in the growth of *Ulva Ohnoi* is being analyzed by comparing the growth in tanks at different air flow rates. These experiments are conducted with high nutrient flow coming from the effluent of recirculating tanks of *Solea senegalensis* and similar lighting, temperature, stocking density and CO_2 availability. Growths of seaweed in the two horizontal semi-cylindrical tank configurations (aerated and no aerated) are being compared and the influence of aeration in the availability of inorganic Carbon will be assessed.

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