INTERACTIVE EFFECTS OF SOLAR UV RADIATION AND AMMONIUM ON THE BIOMASS AND NUTRITIONAL COMPOUND PRODUCTION IN TANK CULTIVATED HYDROPUNTA CORNEA (RHODOPHYTA)

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Introduction

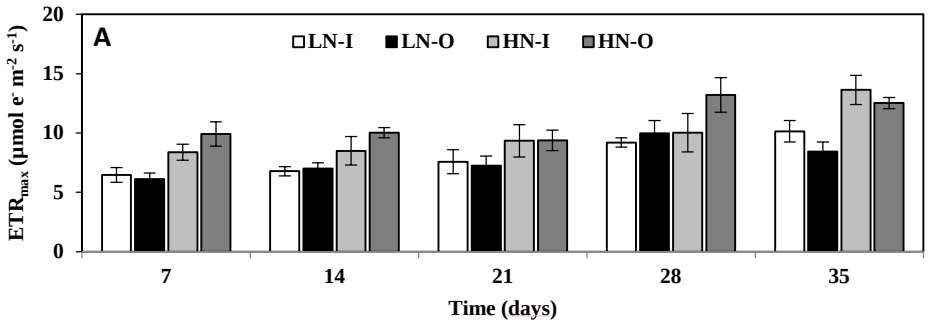
Hydropuntia cornea is a red alga species cultivated in tanks under nitrogen enrichment with high biomass production and content of high value bioactive compounds (Figueroa et al., 2012; Robledo et al, 2014). In this study, the combined effects (2 × 2 factorial design) of solar radiation (in door (I), green house cutting off the UV radiation and out-door (O) with UV radiation) and nitrogen (ammonium) under high (HN) and low (LN) levels on biomass production (g DW m^{-2} d^{-1}), biofiltration as Nitrogen uptake efficiency (NUE, %) and Nitrogen uptake rate (NUR, mmol N m^{-2} h^{-1}), photosynthetic activity as maximal electron transport rate (ETR_{max}), starch content and antioxidant activity were analyzed in *H.cornea* grown in tanks for 35 days in the above mentioned conditions.

Material and methods

The red seaweed *Hydropuntia cornea* was cultivated in cylindrical tanks of 90 L (0.17 m^2 superficial area) with open flow-through N and P-enrichment (5 NH_4Cl: 1 $KHPO_4$, in a concentration ranges between 50 - 250 µM). Seaweed density assayed in tanks was 9 g FW L^{-1}. Turnover rates were 64 and 6.4 vol d^{-1} in high and low flow rate, respectively. Photosynthetic activity was measured by using *in vivo* chlorophyll *a* fluorescence associated to photosystem II i.e. Electron transport rate (ETR) expressed as µmol electrons m^{-2} s^{-1}. Starch (%) was determined according to anthrone method (Brooks et al. 1986) and antioxidant activity was evaluated following ABTS method (Ree et al., 1999) and expressed as Trolox equivalent (µM TEAC g^{-1} DW).

Results

Maximal photosynthetic production (ETR_{max}) increased throughout the culture time. (Fig. 1.A). After 35 d culture, ETRmax was higher under HN than that under LN both under in door and out door conditions (Fig.1A). However, biomass production expressed as g DW m^{-2} d^{-1} decreased throughout the experimental time (Fig 1.B). After 35d culture the highest biomass production was reached under HN-O and the lowest under LN-O although the differences were not so high (Fig.1B). The maximal efficiency of N assimilation (NUE %) was greater under LN (98%) than that under HN treatment (72%). NUE decreased throughout the time although after 35 d a clear increase was observed (Table 1). In contrast, the maximal nitrogen uptake rate (NUR) was higher under HN (45.5 mmol N m^{-2} h^{-1}) than that under LN (25.8 mmol N m^{-2} h^{-1}). The highest values of both NUE and NUR were obtained under solar radiation (outdoor treatments). Starch ranged from 25.1% (LN-I, 21 d) to 49.6 % (LN-O, 28 d) whereas the highest antioxidant activity was reached under LN-O after 21 d culture (68.5 µM TEAC g^{-1} DW). After 35d the highest level was again under LN-O (65.2 µM TEAC g^{-1} DW) followed by HN-O treatment (57.3 µM TEAC g^{-1} DW).



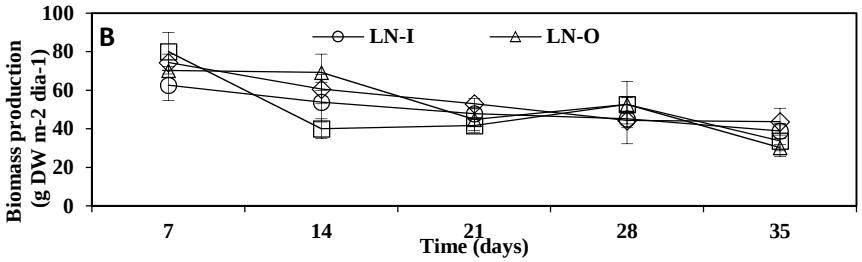


Fig. 1. Electron transport rate (ETR) expressed as µmol electrons m^{-2} s^{-1} vs. time (day) (**A**) and biomass production as g DW m^{-2} d^{-1} (**B**) in the different treatments.

Table. 1. NUE, NUR, starch and antioxidants activity throughout experiments**.**

		Days				
	Treatments	**7**	**14**	**21**	**28**	**35**
NUE %	**LN-I**	98.6 ± 0.3	89.3 ± 2.8	90.6 ± 1.3	34.5 ± 1.1	86.1 ± 4.3
	LN-O	98.6 ± 0.3	98 ± 0.6	94.4 ± 0.7	52.8 ± 1.2	76.9 ± 4.2
	HN-I	48.5 ± 3	14.1 ± 1.2	9.7 ± 1.8	12.1 ± 2	16.4 ± 1.3
	HN-O	72.3 ± 2.6	14.6 ± 2.1	18.5 ± 2.5	10.4 ± 1.3	23.3 ± 1.5
NUR (mmol N m^{-2} h^{-1})	**LN-I**	3.9 ± 0	23.5 ± 0.7	14.1 ± 0.2	7.4 ± 0.2	18.8 ± 0.9
	LN-O	3.8 ± 0	25.8 ± 0.1	14.7 ± 0.1	11.3 ± 0.3	16.8 ± 0.9
	HN-I	18.9 ± 1.2	37.2 ± 3.1	15.1 ± 2.8	25.7 ± 4.3	35.9 ± 2.9
	HN-O	26.5 ± 1.8	38.4 ± 5.7	28.8 ± 3.9	23.7 ± 2.6	45.5 ± 6
Starch (%)	**LN-I**	30.6 ± 0.6	38.3 ± 2.7	25.1 ± 2	44.3 ± 2.9	41 ± 1.9
	LN-O	37.9 ± 3.2	38.3 ± 6.2	38.6 ± 3.1	49.6 ± 9.4	32.3 ± 3.6
	HN-I	26.7 ± 2.4	36.3 ± 2.8	30.7 ± 3.2	35.9 ± 2	34.1 ± 1.2
	HN-O	28 ± 2.8	45.2 ± 9.6	31 ± 0.6	43.5 ± 4.5	40.7 ± 4.8
ABTS (µM TEAC g^{-1} DW)	**LN-I**	60.6 ± 4.8	53.4 ± 13.5	46.4 ± 1.8	65.7 ± 1.6	53.4 ± 6.1
	LN-O	53.6 ± 2.4	55.9 ± 3.8	68.5 ± 4.8	64 ± 2.9	65.2 ± 4.1
	HN-I	49.1 ± 4.5	44 ± 2.3	56.3 ± 6.1	66.8 ± 3.6	54.1 ± 2.4
	HN-O	42.4 ± 5.3	58.6 ± 1.9	59.5 ± 4.4	60.1 ± 2.1	57.3 ± 1.8

Discussion and conclusions

Ammonium supply, simulating fishpond effluents, and full solar irradiation (presence of UV radiation) have a positive effect on photosynthetic rate as ETR_{max}. The decrease in biomass production in spite of the increase of photosynthetic activity and nitrogen uptake rate is explained because the algae through the time could inverse more energy for the accumulation of metabolites (starch and antioxidant compounds) that that for growth. In any case the highest accumulation of starch and antioxidant activity were observed in the treatments associated to the greatest stress conditions i.e LN and outdoor culture due to UVR can negatively affect biological processes related to growth. As expected, under HN supply NUE was lower than that under LN but NUR was the reverse. *H. cornea* grown in simulated fishpond effluents displays a high biofiltration rate of inorganic N and accumulates commercially N compounds, as the photoprotector-antioxidant substances, mycosporine-like aminoacids (Figueroa et al., 2012) and C-compounds for nutritional uses or bioethanol production. In this study, the antioxidant activity was much higher than that reported in other seaweeds (Matanjun et al., 2008). *H. cornea* can be cultured and used to remove nutrient-rich fishpond effluents from aquaculture industries and besides, this biomass provides compounds of high added value for the biotechnology industry.

References

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