Nitrogen uptake by Porphyra purpurea: its role as a nutrient scrubber

George P. Kraemer
Purchase College, State University of New York

Thierry Chopin
University of New Brunswick

Chris Neefus
University of New Hampshire

Jose Zertuche
Autonomous University of Baja California

Nitrogen Uptake by *Porphyra purpurea*: its Role as a Nutrient Scrubber

[1]R. Carmona, [2]L. Chanes, [3]G. Kraemer, [4]T. Chopin, [5]C. Neefus, [6]J.A. Zertuche, [7]R. Cooper and [1]C. Yarish

[1]Dept. of Ecol. and Evol. Biol., University of Connecticut, One University Place, Stamford, CT 06901-2315, USA; [2]DGETI-CBTis41, Mexico; [3]Division of Natural Sciences, State University of New York, Purchase, NY 10577, USA; [4]CCSA, Dept. of Biol., University of New Brunswick, Saint John, N.B., E2L 4L5, Canada; [5]Department of Plant Biology, University of New Hampshire, Durham, NH 03824, USA; [6]IIO, Universidad Autonoma de Baja California. P.O. Box 453. Ensenada, B.C. 22860 Mexico; [7]Marine Sciences and Technology Center, 1084 Shennecossett Road, Groton, CT 06340-6097, USA

Introduction

Finfish mariculture along the Northeast U.S. coast continues to grow, developing into a vibrant industry. But it can be, at a regional level, a significant contributor to nutrient loading in coastal waters (Kautsky *et al.*, 1997). One solution to the need to comply with local, state and federal legislative standards, is to develop a balanced ecosystem approach, based on integrated aquaculture with other marine organisms, i.e. macroalgae or seaweeds and shellfish (Chopin *et al.*, in press).

The contribution of macroalgae importance in coastal waters have frequently been either ignored or misunderstood, especially in the Western World. Macroalgae are able to concentrate nutrients and grow at high rates. In addition, seaweed mariculture is by itself a multi-billion dollar industry. The red alga *Porphyra* (commonly called nori) is a major source of food throughout the world and has an annual value of over $US 1.8 billion (Yarish *et al.*, 1998). The ecological role (Yarish *et al.*, 1998) and the potential productivity (Kraemer and Yarish, 1999) of native *Porphyra* in Northeast America have been studied. It has also been reported the capability of *Porphyra* to remove N and P and its growth in sites of experimental nori/salmon integrated aquaculture (Chopin *et al.*, 1999).

In conventional aquaculture systems, seaweeds not only can act as renewable biological nutrient scrubbers for coastal water quality enhancement, but also represent marine crops of commercial value (Chopin *et al.*, in press).

Within the general goal of determining the capacity of local species of *Porphyra* in integrated aquaculture, the specific goals were to study the growth and nitrogen accumulation by a common northeast American species of *Porphyra*, *P. purpurea*.

Materials and methods

Two types of experiments were carried out: long-term experiments, to understand the interaction of inorganic nitrogen (NO_3^- *vs.* NH_4^+) and the DIN (dissolved inorganic nitrogen) concentration and its effects on growth; and short-term experiments to study the N uptake kinetics.

The long-term experiments were carried out with blades of *P. purpurea* (Long Island Sound strain, LIS) grown at 15°C, 150 μmols m^{-2} s^{-1} for 30 days at different N concentrations (NO_3^- or NH_4^+): 25, 75, 150, 300 μM .

The short-term experiments were done with strains from LIS and Maine, at 150 μmols m^{-2} s^{-1}, different temperatures (5, 10, 15 °C) and several N concentrations (10, 25, 40, 75, 150 μM). N uptake rates were quantified over of 20 minutes.

All the blades were grown from conchocelis cultures at the Marine Biotechnology Laboratory of the University of Connecticut at Stamford.

Results and Discussion

Growth of *P. purpurea* in NO_3^- was saturated at 75 μM, while growth continued to increase up to 300 μM when plants were supplied with NH_4^+, with a rate of 8 % d^{-1} (Figure 1). The high growth rates under high NH_4^+ concentration were noteworthy, because it has been reported that this form of N can be toxic for some marine species of macrophytes (van Katwijk *et al.,* 1997). This is fortunate since ammonium is the major source of N to which *Porphyra* would be exposed in integrated aquaculture (150 μM is the mean value of this nutrient in the effluent of Great Bay Aquafarms in New Hampshire, G. Nardi,

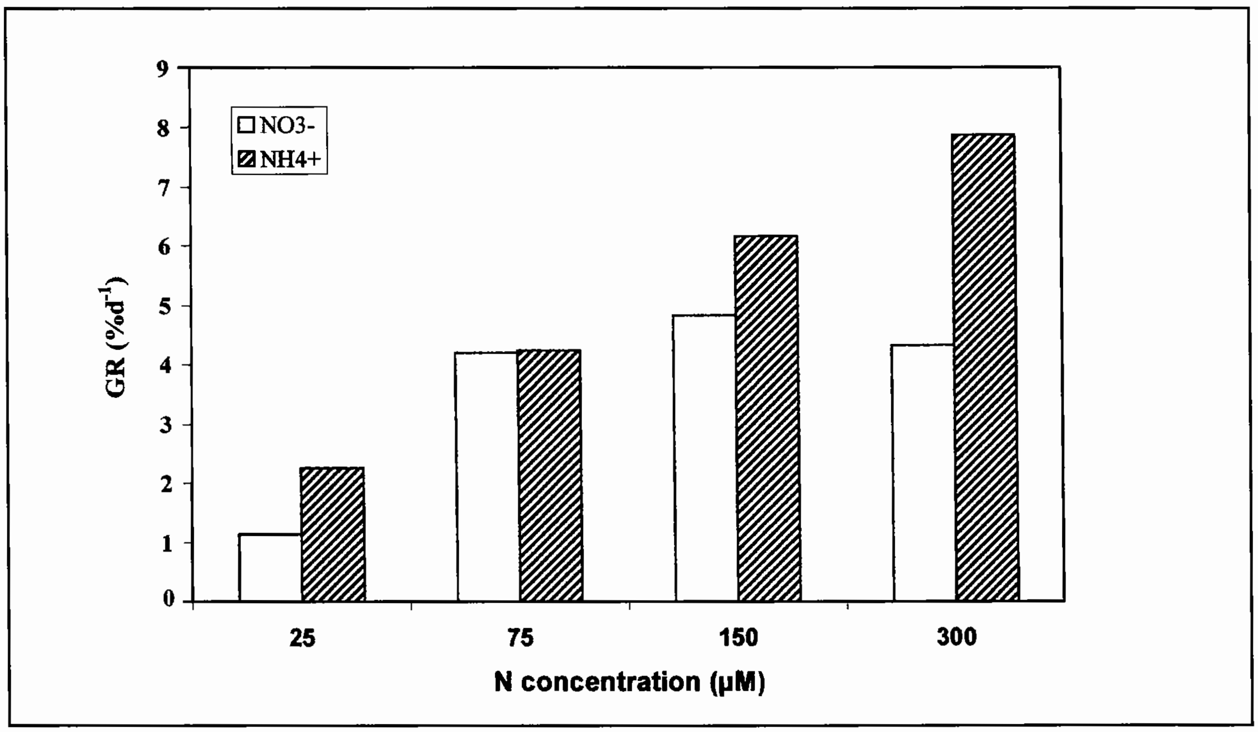

Figure 1. Growth rate of *P. purpurea* (LIS strain) at different concentrations of two N sources. (The standard deviations are not shown in the graph and were quite high due to the fact that blades started to reproduce and that was reflected in the biomass weight variation).

Table 1. N content (% DW) in *P. purpurea* (LIS strain) initially and after 30 days growing at different concentrations of two N sources. Standard deviations are shown in parenthesis (n=3).

N concentration	NO_3^-	NH_4^+
Initial	2.92 (0.02)	2.92 (0.02)
25 μM	2.92 (0.02)	2.53 (.052)
75 μM	1.57 (0.3)	3.56 (0.92)
150 μM	2.78 (0.22)	4.91 (0.63)
300 μM	5.37 (0.18)	6.5 (0.55)

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Porphyra blades presented a significant higher N content after 30 days, in relation to the initial value, under 150 and 300 μM, especially when NH_4^+ was the N source. The obtained value of ca. 7% (DW) indicates that *Porphyra* can take NH_4^+ from the medium and concentrate it in the tissue (Table 1).

In short-term experiments, there was no significant difference between the two N sources (Table 2). These uptake rates were similar to those presented by starved algae (data not shown), indicating that they are capable of removing nutrients from the medium even when they are replenished or at least with a high internal N content.

In the experiments carried out with the strain from Maine at three different temperatures, a higher NH_4^+ uptake rate was observed at the lowest temperature of 5 ^oC, regardless the N concentration,

Table 2. Nitrate and ammonium uptake rate (μmols/DW g min) in *Porphyra purpurea* (LIS strain). Standard deviations are shown in parenthesis (n=6).

N concentration (μM)	NO_3^-	NH_4^+
20	0.11 (0.04)	0.07 (0.03)
40	0.14 (0.04)	0.11 (0.06)
75	0.24 (0.12)	0.34 (0.11)
150	0.77 (0.23)	0.80 (0.05)

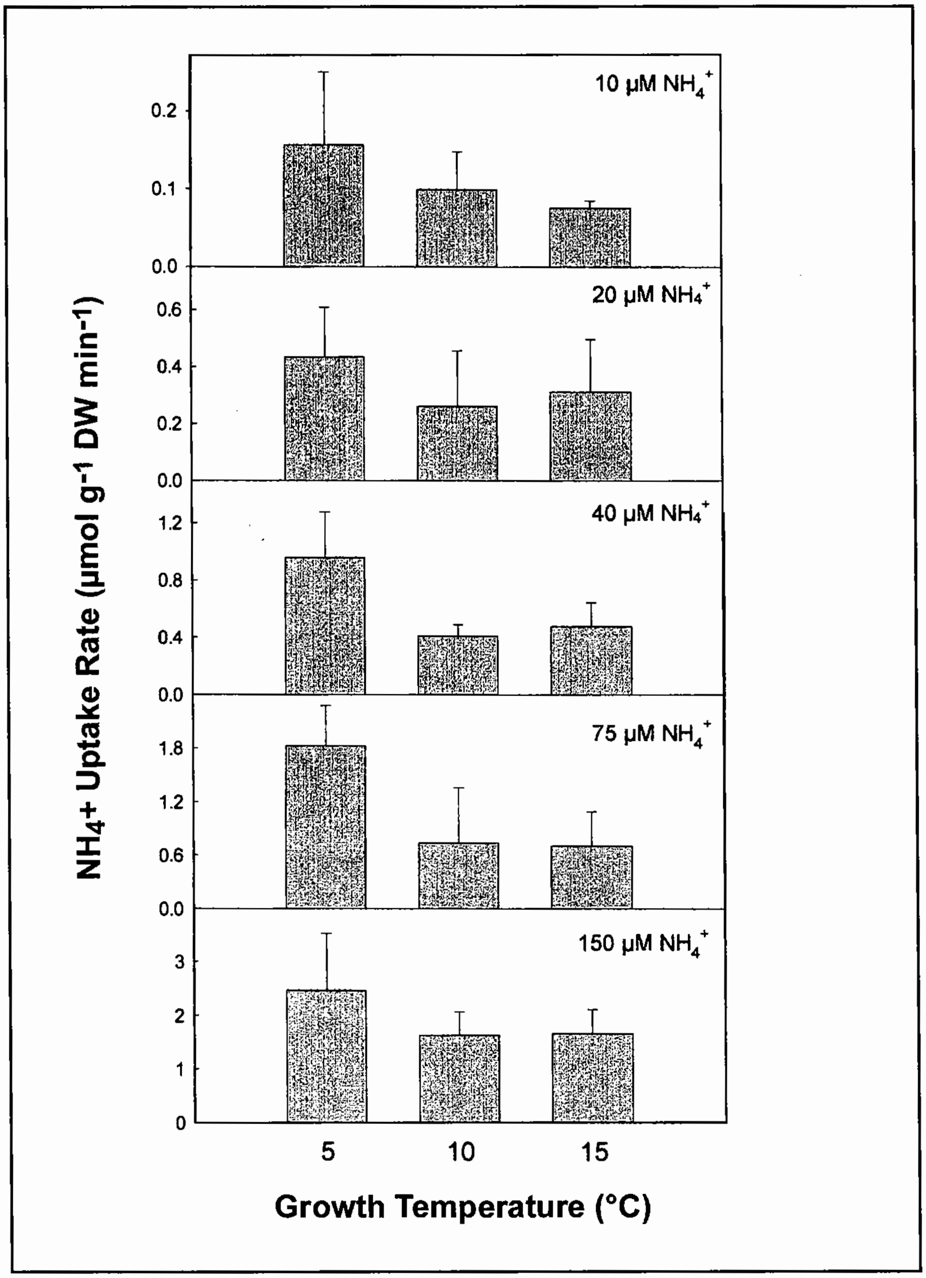

Figure 2. NH_4^+ uptake in *P. purpurea* (Maine strain) at different temperatures.

whereas rates at 10 °C and 15 °C were similar (Figure 2). The kinetics showed no saturation up to 150 µM and the uptake at 15 °C was higher than that recorded for LIS strain.

Conclusions

The results showed that *P. purpurea* is good candidate for bioremediation. This species presents the highest growth rate and tissue N accumulation at 300µM of NH_4^+. There is no difference in NO_3^- and NH_4^+ uptake in short-term experiments, which was not saturated within the range of N concentrations assayed (10-150 μM). On the other hand, the strain from Maine has a higher NH_4^+ uptake rate than the one from Long Island Sound, showing that interstrain differences exist and that the Maine strain could be used in the winter months and be an efficient nutrient remover.

Acknowledgments

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