Preliminary Study on the Responses of Three Marine Algae, *Ulva pertusa* (Chlorophyta), *Gelidium amansii* (Rhodophyta) and *Sargassum enerve* (Phaeophyta), to Nitrogen Source and Its Availability

LIU Dongyan¹, Amy Pickering², SUN Jun³,*

¹) College of Marine Life Science, Ocean University of China, Qingdao 266003, P. R. China
²) Department of Biological and Environmental Engineering, Cornell University, Ithaca, NY 14850, USA
³) Key Laboratory of Marine Ecology & Environmental Science, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, P.R. China

(Received February 25, 2003; accepted March 30, 2004)

Abstract An experiment was designed to select economically valuable macroalgae species with high nutrient uptake rates. Such species cultured on a large scale could be a potential solution to eutrophication. Three macroalgae species, *Ulva pertusa* (Chlorophyta), *Gelidium amansii* (Rhodophyta) and *Sargassum enerve* (Phaeophyta), were chosen for the experiment because of their economic values and availability. Control and four nitrogen concentrations were achieved by adding NH₄ and NO₃⁻. The results indicate that the fresh weights of all species increase faster than that of control after 5 d culture. The fresh weight of *Ulva pertusa* increases fastest among the 3 species. However, different species show different responses to nitrogen source and its availability. They also show the advantage of using NH₄ than using NO₃⁻. *U. pertusa* grows best and shows higher capability of removing nitrogen at 200 μmol L⁻¹, but it has lower economical value. *G. amansii* has higher economical value but lower capability of removing nitrogen at 200 μmol L⁻¹. The capability of nitrogen assimilation of *S. enerve* is higher than that of *G. amansii* at 200 μmol L⁻¹, but the former’s increase of fresh weight is lower than those of other two species. Then present preliminary study demonstrates that it is possible to use macroalgae as biofilters and further development of this approach could provide biologically valuable information on the source, fate, and transport of N in marine ecosystems. Caution is needed should we extrapolate these findings to natural environments.

Key words macroalgae; nitrogen source; eutrophication; nutrient uptaking

Number ISSN 1672-5182(2004)01-75-05

1 Introduction

In recent years, eutrophication has become a worldwide environmental problem in the coastal area. Aquaculture becomes a serious pollution source like sewage discharge. Waste products from fish farms consist mainly of nitrogen, phosphorus and carbon dioxide. In pen-based salmon aquaculture, the production of one ton fish results in a discharge of about 56.4 kg total nitrogen and 7.0 kg phosphorus from the feed containing 45% protein and 1% phosphorus with the food conversion rate of 1.2 (Stead and Laird, 2002). And also the red tide frequency and scale have increased mainly due to the eutrophication along the coastal waters in China (Zhou et al., 2003). In order to reduce the nutrient burden of the fish farm effluents, the integration of seaweed cultivation with fish aquaculture has been proposed (Chopin et al., 2001). Various strategies for such integration have been successful (Brzeski and Newkirk, 1997). Several species of *Gracilaria* (Buschmann et al., 1994; Troell et al., 1997; Troell et al., 1999; Xu et al., 2001), *Ulva* (Krom et al., 1995; Neori et al., 2000; Neori et al., 1996), *Laminaria* and other macroalgae⁰ have been considered in the integrated biofilter system and show reasonably high efficiencies in the removal of waste inorganic. Based on these researches, we studied the nutrient uptaking capacities of three typical seaweeds: *U. pertusa* (Chlorophyta), *G. amansii* (Rhodophyta) and *S. enerve* (Phaeophyta). The aim of this study is to pro-

---

* Corresponding author. Tel: 0086-532-2032752
  E-mail:sunjun@ouc.edu.cn

---

vide the background data for the development of a sea-
weed biofilter or production system to reduce eutrophi-
cation.

2 Materials and Methods

*U. pertusa*, *G. amansii* and *S. enerve* were collected
from their natural intertidal habitats near Qingdao and
then cleaned in filtered seawater. After being cultured
overnight in petri dishes, initial weight and length
measurements were taken before the alga samples were
placed in the plastic bottles containing previously pre-
pared culture media. Filtered seawater (0.22 μm filter
to remove unwanted organisms) was used as the con-
trol. The initial ambient concentrations of nitrate (1.4
μmol L⁻¹), phosphate (0.1 μmol L⁻¹), and ammonia
(20.2 μmol L⁻¹) in the seawater from Jiaozhou Bay
were determined. Methods for determining nutrient
concentrations were based on procedures outlined by
Grasshoff *et al.* (1999). These nutrient concentrations
indicated that the initial total dissolved nitrogen to to-
tal phosphorus ratio in the seawater is 216:1. The Red-
field ratio of 16:1 was selected to avoid the unbalanced
N/P effects on uptaking of nitrogen and phosphorus.
Four nitrogen resource grades were achieved by adding
NH₄⁺ and NO₃⁻. Two of them were added with NH₄⁺,
the concentrations being 80 μmol L⁻¹ and 200 μmol L⁻¹
respectively. The other two of them were added with
NO₃⁻, the concentrations were 80 μmol L⁻¹ and 200
μmol L⁻¹. For the ammonia and nitrate solutions,
(NH₄)₂SO₄ and NaNO₃ were added respectively.
NaH₂PO₄·2H₂O was added for the phosphate solut-
ions. A control without adding N and three replicate
containers for each treatment were designed in the ex-
periments. All living algae were moved into 10 L plas-
tic bottles respectively, which were filled with filtered
seawater, maintained at 20–23 °C and exposed to light
on 12:12 h LD cycle and 100 μ Einstein m⁻² s⁻¹ light
intensity. The initial and final fresh weights and
lengths were measured before and after culture. In or-
der to examine nutrient uptake rates of the algae,
200 mL samples were taken every day for the whole
experiment. Nitrate and ammonium were determined
following the procedures of Wood *et al.* (1967)
and Slawyk and MacIsaac (1972) respectively.

The nutrient uptake rate was calculated by the fol-
lowing equation (Gao *et al.*, 1993):

$$
U = \frac{(C_0 - C_t) \cdot V}{B \cdot t}
$$

where *U* is nutrient uptake rate (μmol g⁻¹ h⁻¹), *C₀*
and *Cₜ* are the initial and final nutrient concentrations
(μmol L⁻¹) respectively, *V* is incubation volume (L),
*B* is the biomass of algae (g), and *t* is the time of in-
cubation (h).

3 Results and Discussion

3.1 The Growth of Three Macroalgae in Different N
Source Conditions

The fresh weights of the three species increase in all
bottles after 5 d culture (Fig. 1). The increase of fresh
weight in the case of bottles with added nutrients was
higher than that of control, especially for NH₄⁺-adding
bottles. The fresh weights of algae in NH₄⁺-adding bot-
tles were higher than that of NO₃⁻-adding bottles. The
range of algae fresh weights changed differently in dif-
f erent species. The change of fresh weight for *U. per-
tusa* was larger than that of control (0.71 g) and other
species. It increased by 1.39 g in 80 μmol L⁻¹ NH₄⁺-
adding bottles, 1.4 g in 200 μmol L⁻¹ NH₄⁺-adding bott-
tles, 0.99 g in 80 μmol L⁻¹ NO₃⁻-adding bottles, and
1.05 g in 200 μmol L⁻¹ NO₃⁻-adding bottles. The change
of fresh weight of *G. amansii* was smaller than that
of *U. pertusa*, but larger than those of control and *S.
enerve*. The change of fresh weight of *G. amansii*
increased by 0.79 g in 80 μmol L⁻¹ NH₄⁺-adding bottles,
0.78 g in 200 μmol L⁻¹ NH₄⁺-adding bottles, 0.32 g in
80 μmol L⁻¹ NO₃⁻-adding bottles, and 0.62 g in 200
μmol L⁻¹ NO₃⁻-adding bottles. Unlike *U. pertusa* and
*G. amansii*, the fresh weights of *S. enerve* did not
increase much in 80 μmol L⁻¹ ammonia- and nitrate-
adding bottles. However, its fresh weights increased
obviously in 200 μmol L⁻¹ ammonia and nitrate adding
bottles, being 0.70 and 0.56 g respectively. It seems
that *S. enerve* grew better than those in rich nutrient
condition. *G. amansii* did not show much difference in
NH₄⁺-adding bottles, although it grows better than in
NO₃⁻-adding bottles. Whether the high concentration
of nitrogen can inhabit the growth of *G. amansii* needs
further study.

![Fig. 1](image_url)

Fig.1 The changes of fresh weight of macroalgae at dif-
ferent nutrient grades after 5 d culture

3.2 The Nitrogen Assimilation Capabilities of Three
Macroalgae

During 5 d culture, the nitrogen was depleted quick-