Effects of barley straw (Hordeum vulgare) on freshwater and brackish phytoplankton and cyanobacteria

Emily F. Brownlee1, Stella G. Sellner2 & Kevin G. Sellner3,*

1422 Snug Harbor Road, Shady Side, MD, USA 21037
2Estuarine Research Center, The Academy of Natural Sciences, 10545 Mackall Road, St. Leonard, MD, USA 20685
3Chesapeake Research Consortium, 645 Contees Wharf Road, Edgewater, MD, USA 21037

(*Author for correspondence; e-mail: sellnerk@si.edu)

Received 31 March 2003; revised and accepted 12 August 2003

Key words: phytoplankton, cyanobacteria, barley straw

Abstract

A short-term laboratory study was conducted to investigate the effect of barley straw in controlling several common phytoplankton and cyanobacterial species. Following a one-month incubation of barley straw in coarsely filtered fresh Potomac River and brackish Patuxent River waters, the growth of six autotrophic taxa was followed in culture. Barley straw slurry reduced the yield of three taxa (Ankistrodesmus falcatus, Chlorella capsulata, Isochrysis sp.) in comparison with cultures not receiving the slurry. Although no significant changes in growth were detected with three other taxa (Cyclotella sp., Prorocentrum minimum, freshwater Pseudanabaena sp.), some patterns indicated potential impacts of the barley straw. First, a higher addition of straw to Cyclotella sp. resulted in a lower biomass accumulation than in cultures receiving lower levels. Second, the bloom-forming dinoflagellate Prorocentrum minimum was apparently stimulated at low barley straw levels, perhaps suggesting conditions associated with the straw (metals-chelation, bacterial-produced nutrients) might stimulate dinoflagellate growth. Third, species shifts were observed in two of the cultures, with barley straw favoring shifts from Isochrysis to a Cyclotella sp. – Thalassiosira sp. mixture and shifts from Pseudanabaena to a Pseudanabaena – Scenedesmus mixture. These results provide new records for the susceptibility of freshwater and brackish phytoplankton taxa to barley straw exposure, including species-specific responses and shifts in species dominance in mixed assemblages.

Introduction

In an attempt to reduce the growth and accumulation of algae in some aquatic systems, several techniques have been explored over the last half century, including the addition of copper sulfate, aeration, manipulation of top piscivores, and in the last decade, the addition of barley straw to ponds and small reservoirs. The use of the last method is becoming increasingly frequent, particularly in the United Kingdom (Everall & Lees, 1996; Barrett et al., 1999), with firms providing bundled barley straw for algal control in fish ponds, canals, and small commercial systems. Exposures vary, but generally barley straw must age in ambient waters prior to mass algal accumulation to be most effective.

Concentrations of barley straw limiting algal biomass vary across laboratory and small freshwater systems. Barrett et al. (1999) reported effective control of reservoir phytoplankton including diatoms and cyanobacteria, at dosages as low as 6 g m⁻³ (6 mg L⁻¹). Much higher levels, 440 g dry wt barley straw m⁻³, were required in a canal with a turnover time of 5.3 h (Welch et al., 1990). Similarly, barley straw applied to the Press Top Reservoir, UK, reduced the spring diatom bloom and caused a shift in dominance in spring and summer assemblages, severely reducing the summer Aphanizomenon – Anabaena bloom (Everall &
In the laboratory, *Microcystis aeruginosa* was inhibited at 2.57 g dry wt barley straw m\(^{-3}\) in one study (Newman & Barrett, 1993), a concentration much lower than most field applications; Butler (1998) & M.D. Ferrier, B.R. Butler, D.E. Terlizzi & R.V. Lacouture (pers. comm.) have found a similar inhibition in this taxon. Martin & Ridge (1999) reported this taxon to be the most sensitive of 22 species and strains tested, but with 70 g dry mass m\(^{-3}\) required for 50% reduction in yield in 4–8 d assays. Several taxa were insensitive to barley straw, or were even stimulated. A number of examples of stimulation were reported in a study by Butler (1998). Of 12 species examined, 8 species increased over a two-week period on exposure to barley straw extract.

Brackish waters also routinely experience algal ‘blooms’, but the application of barley straw to brackish or tidal waters has not been reported, although there are some unpublished observations suggesting highly variable, species-specific responses. In a laboratory study, barley straw enhanced growth of three estuarine dinoflagellate taxa *Prorocentrum minimum* and *Gyrodinium inistriatum*, inhibited growth in *Karldinia micrum* (*G. galatheanum*), *Akashiwo sanguinea* (*Gymnodinium sanguineum*), *Heterocapsa triqueta*, and *H. pygmaea*, and had no effect on *G. estuariale*, *G. uncatenum*, *Ceratium furca* and *Peridinium sp.* (Terlizzi et al., 2002).

The present study was undertaken to explore and compare the impacts of barley straw on brackish taxa with some freshwater species, using both cultured and field assemblages collected from Chesapeake Bay tributaries. Results could indicate whether populations of unwanted members of the natural assemblages of the region might be controlled by the addition of readily available barley straw to ambient waters as well as expand community knowledge of taxa susceptible to barley straw control.

**Materials and methods**

The study was conducted at the Estuarine Research Center of the Academy of Natural Sciences laboratory in St. Leonard, MD, USA. Five phytoplankton cultures maintained at the laboratory were grown in filtered and autoclaved Patuxent River water approximating 11 psu. Culture conditions were 14:10 L:D cycles with cool-white fluorescent lighting and 19°C. Aliquots from exponential phase stock cultures of *Chlorella capsulata* (Provasoli-Guillard Collection, CCMP245), *Isochrysis* sp. (T-iso, Provasoli-Guillard Collection, CCMP1324) and *Prorocentrum minimum* were transferred to Gelman AE-filtered brackish Patuxent River water enriched with f/2 nutrients (Guillard and Ryther 1962); each taxon was distributed to 9 tubes, with 0.04 L medium in each. Freshwater taxa, i.e., *Ankistrodesmus falcatus* and *Cyclotella sp.*, were transferred to deionized water enriched with HYCO nutrients (Riedel & Sanders, 1996). A freshwater *Pseudanabaena*-dominated assemblage, obtained from field-deployed cubitainers (translucent, flexible containers) of upper Potomac River water enriched with f/2 nutrients, was transferred to filtered Potomac River water enriched with HYCO nutrients. All tubes were returned to the incubator for initial growth.

One month prior to setting up the culture tubes, 0.2 L of AE-filtered Patuxent River (12 psu) and tidal-fresh Potomac River water were decanted into small cubitainers containing 5 g diced barley straw. Foil-covered, loosely capped containers were returned to the incubator and shaken daily.

After an initial growth period of 4–7 d, *in vivo* fluorescence (IVF) of each tube was determined using a Turner Designs 10–005 field fluorometer. The aged barley straw slurry was then added to 6 of the 9 tubes for each taxon, yielding 3 tubes with no barley straw, 3 with low barley straw levels (312.5 mg barley straw L\(^{-1}\)), and 3 with high straw levels (1250 mg barley straw L\(^{-1}\)). IVF was again recorded. The IVF of algae-free filtered medium plus the low and high barley straw additions was also noted, and subtracted from IVF of each tube. All tubes were placed in the incubator and at day to two day intervals, the loosely capped tubes were gently inverted several times to mix tube contents. At 4–8 d intervals, IVF of each gently inverted tube was recorded.

Growth was rapid and consequently, dilution with medium and new additions of barley straw were necessary throughout the experiment. IVF was always determined prior to and after such dilutions, and final IVF recorded following corrections for dilution. Aliquots from tubes were also removed aperiodically, fixed with Lugol’s iodine solution, and cell densities and composition determined by light microscopy at magnifications of 250–400 x.

Differences in cell yield were (with one exception) determined through an analysis of variance of IVF at the end of each taxon’s growth period. IVF differences between the 3 barley straw levels for *Isochrysis* were determined at day 23, at a time just prior to a change