Egyptian Journal of Aquatic Research (2015) **41**, 69–81

HOSTED BY

ELSEVIER

National Institute of Oceanography and Fisheries

Egyptian Journal of Aquatic Research

http://ees.elsevier.com/ejar
www.sciencedirect.com

FULL LENGTH ARTICLE

Bioactivity effect of two macrophyte extracts on growth performance of two bloom-forming cyanophytes

M.G. Ghobrial *, H.S. Nassr, A.W. Kamil

National Institute of Oceanography and Fisheries, Egypt

Received 20 September 2014; revised 13 January 2015; accepted 13 January 2015
Available online 25 February 2015

KEYWORDS

Allelopathy;
Ceratophyllum;
Potamogeton;
Microcystis;
Oscillatoria

Abstract Allelopathy is a biological phenomenon by which an organism produces one or more biochemicals that influence the growth, survival, and reproduction of other organisms. These biochemicals are known as allelochemicals and can have beneficial (positive allelopathy) or detrimental (negative allelopathy) effects on the target organisms. The current research aims at using selected brackish water adapted submerged aquatic macrophytes allelopathy to combat bloom-forming cyanophytes, in laboratory bioassay experiments. Dry matters of macrophytes were extracted in solvents and the initial cyanophytes inoculum, derived from unialgal culture media, was used. Therefore, aqueous extracts with 50% and 100% acetone and ethanol solvents of two freshwater macrophytes; *Potamogeton pectinatus* and *Ceratophyllum demersum* were used to test their growth performance exhibited on two bloom-forming cyanophytes, *Microcystis aeruginosa* and *Oscillatoria tenuis*. The results revealed insignificant difference between the overall total average growth performance at treatment with 50% and 100% *Ceratophyllum* acetone extracts expressed by optical density (OD) as well as chlorophyll *a* (chl *a*). Results showed, also, stimulation of *M. aeruginosa* growth. The highest growth increase in 100 μl/100 ml treatment with 50% acetone extract had a percentage rate (*R*) of 94.66. On the contrary, treatment with ethanol extract recorded the highest inhibitory effect, thus in 1.5 μl/100 ml treatment with 50% *Ceratophyllum* ethanol extract *R* recorded −87.54, sustaining LC_{50} value of 1.12 μl/100 ml. The highest stimulating effect in 10^5 μl/100 ml treatment with 50% *Ceratophyllum* acetone extracts against *O. tenuis* was; *R*, 169.4. The highest inhibition in 1500 μl/100 ml treatment with 50% *Ceratophyllum* ethanol extracts against *O. tenuis* was; *R* −74.32, with LC_{50} 0.830 μl/100 ml. While, the highest inhibition by 50% and 100% *Potamogeton* acetone or ethanol extracts against *M. aeruginosa* was in 80 and 70 μl/100 ml treatments with *R*, −99.80 for both. There are significant differences between the overall averages for each solvent, both of 50% and 100% *Potamogeton* extracts against *Oscillatoria*. The highest inhibitory effect for *Potamogeton* against *Oscillatoria* was in 10^3, 800, 200 and 180 μl/100 ml using 50%, 100%, either acetone or ethanol extracts treatments, having LC_{50} 932, 590, 129.50 and 101.428 μl/100 ml, respectively. The potential way for utilizing allelochemicals of aquatic macrophytes could be performed through extracting allelochemicals from

* Corresponding author.
E-mail address: mary_ghobrial@hotmail.com (M.G. Ghobrial).

Peer review under responsibility of National Institute of Oceanography and Fisheries.

http://dx.doi.org/10.1016/j.ejar.2015.01.001
1687-4285

dried plants and synthesizing allelochemicals with natural structures, as these macrophytes are available excessively in our lakes.

Introduction

Allelopathy was defined as the inhibitory or stimulative effects of one plant (including microorganism) on another plant (including microorganism) via releasing chemical compounds into the environment (Rice, 1984). The role of allelopathy in aquatic systems has received increasing attention as a potential means of controlling algal blooms. Macrophytes with allelopathic potential may play an important role in the restoration of eutrophic lakes. Considerable attention has been paid on the allelopathic potential of aquatic macrophytes against blue-green algae. Fariba et al. (2013) results suggest that allelopathic macrophytes have the potential to mitigate phytoplankton blooms in systems dominated by cyanobacteria. Meng et al. (2008) mentioned that, the inhibition of algae growth by hydrophytes has advantages of ecological safety, quick speed and high efficiency, which is of great importance in controlling lake eutrophication.

Eutrophication is a major management issue in shallow lakes worldwide, as it is the main cause of cyanobacterial mass occurrences in the form of water blooms in lakes and reservoirs around the world. Three potentially toxigenic and bloom forming cyanobacterial genera: *Microcystis*, *Anabaena* and *Oscillatoria*, are hazardous due to the production of secondary metabolites and endotoxins. Cyanobacterial toxins are released into the surrounding medium by senescence and lyses of blooms. Microcystins are toxins produced by cyanobacteria that entail serious health and environmental problems (Sevilla et al., 2008). The released toxins could come into contact with a wide range of aquatic organisms. *Microcystis aeruginosa* is a cyanobacterium species that can form harmful blooms in freshwater bodies worldwide (Straub et al., 2011). *M. aeruginosa* are not true algae, but rather photosynthetic bacteria known as cyanobacteria, named after the color of their blue-green algal blooms. *Microcystis* blooms pose a threat to aquatic ecosystems at every level via direct or indirect impacts, including heterotrophic bacteria, phytoplankton, zooplankton, invertebrates, and fish (Kirsten, 1996; Vinagre et al., 2002; Miquel, 2003; Rattapoom et al., 2006; José et al., 2011). Direct impacts are a result of toxicity from exposure or ingestion and reduced food intake. Indirect impacts arise from *Microcystis* affecting the overall food quality for zooplankton, species interactions, and bio-accumulation. Zooplanktons are either killed by microcystins, or show reduced feeding, growth, and reproduction, combined with different physiological sensitivities to the toxin (Kirk and Gilbert, 1992; El-Sheekh and El-Shendy, 2010).

Today, relatively scarce good-quality algal food resources often limit zooplankton growth (Mueller-Solger et al., 2002). If available high quality food at the base of the food chain (phytoplankton) is declining, and *Microcystis* blooms are increasing apparently, this could be a profound threat for the food web (Lehman et al., 2010). The latter authors mentioned that, it is hypothesized that *Microcystis* contributed to a recent decline in pelagic organisms. Bioaccumulation of microcystins extends the toxin to higher trophic levels such as fish. Changes in community structure result from *Microcystis* altering the dominant herbivores. This can be a shift in zooplankton species, from large cladocerans to smaller zooplankton, or a shift from planktonic secondary production to benthic production. Overall, it has the ability to reduce the efficiency of pelagic food webs (Vanderploeg et al., 2001). *Oscillatoria* is common in lagoons, where sewage is treated; it forms dense, slimy, benthic mats on mud or rocks and is the most tolerant of organic pollutants. *Oscillatoria* species are known to produce both neurotoxins (anatoxins and hepatotoxins) called microcystins (Hawazin, 2012). The effects of *Oscillatoria* sp. bloom are not related to toxin production only but rather are related to deplete dissolved oxygen concentrations in water caused by algal proliferation or night respiration and physical damage to the gills of fish caused by the structure of some algal organisms. All of these effects can lead to mortality of aquatic invertebrates, zooplankton, aquatic plants, phytoplankton, coral reef or fish and may produce an environment conducive to botulism (Tellez et al., 2001; Laurence, 2003; Sanna and Shanab, 2007 and Stanic, 2010). Various other studies have demonstrated a similar effect on zooplankton, where the size and shape of cyanobacteria filaments strongly interfere with water filtration, reducing the zooplankton's ability to capture prey. In addition to the mechanical interference, the presence of filaments in the digestive tract could cause damage that would increase the risk of bacterial infections (Laurence, 2003).

Several studies investigated allelopathic inhibitory activities against *M. aeruginosa*. Zuo et al. (2014a,b) in their field investigations, discovered that in areas of high diversity of aquatic macrophytes species, there was low density of harmful phytoplankton *M. aeruginosa* and so it was feasible for macrophyte biodiversity to eliminate the cyanobacteria in some shallow lakes.

Jianzhong et al. (2012) investigated the influence of eight species of aquatic macrophytes on the growth of *M. aeruginosa*. Yang-Lei et al. (2012) studied fractions of 40 traditional medicinal plants for antialgal activity against the bloom-forming cyanobacterium *M. aeruginosa*. Qiming et al. (2006) examined the allelopathic activity of volatile substances from submerged macrophytes on *M. aeruginosa*. Jun-ying et al. (2011) estimated culture filtrate effects of three submerged macrophytes on *M. aeruginosa*.

In the present study two submerged macrophytes were chosen, *Ceratophyllum demersum* and *Potamogeton pectinatus*, as they are brackish water adapted and most abundant in Egyptian Delta Lakes. Wium-Andersen et al. (1983) mentioned that, *C. demersum* could produce instable sulfides to inhibit the growth of phytoplankton. Their studies showed the instable sulfides were oxidized to produce the element sulfur and also inhibited a variety of diatoms, green algae and cyanobacteria. They also noticed that, the modes of action