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Toxin production in *Nodularia spumigena*: effects of salinity, phosphorus, nitrate and light

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Introduction

The potential hazards associated with human exposure to cyanobacterial toxins has led to increased investigation into factors controlling toxin production. It is well established that environmental factors, such as salinity, light and nutrient concentrations, affect toxin production in cyanobacteria (Lehtimaki et al. 1994; Blackburn et al. 1996), and that toxin production is strain and not species specific (Sivonen 1996).

The cyanobacterium *Nodularia spumigena* produces a harmful hepatotoxin, called nodularin. Nodularin production in *N. spumigena* has been well documented for strains from Lakes Alexandrina and Albert in South Australia, Peel Harvey estuary in Western Australia, and Orielton Lagoon in Tasmania (Jones et al. 1994; Blackburn et al. 1996). However, very little is known regarding the influence of environmental factors on toxin production by Gippsland Lakes isolates. Although algal blooms are generally considered to occur as a consequence of increased eutrophication, given that salinity and light have been suggested as controlling factors for bloom formation (Jones et al. 1994; Blackburn et al. 1996; Sivonen 1996), the aim of this study was to assess the relative effects of salinity, nitrogen and phosphorus and irradiance on the growth and production of nodularin by *N. spumigena* isolated from the Gippsland Lakes.

Methods

*N. spumigena* was grown at salinities of 0, 5, 15, 25 and 35, phosphorus concentrations 0, 0.01, 0.1, 0.5, 1.5 and 2.5 mg P L⁻¹ or nitrate concentrations of 0, 0.2, 0.02, 0.75, 1.5 and 3 mg N L⁻¹ at one of two irradiances (40 or 100 µmol photons m⁻² s⁻¹).

Growth was determined daily by in vivo chlorophyll fluorescence for 16 d period. Intracellular and extracellular nodularin contents were determined on day 8 and 16 to represent late logarithmic and stationary growth phases. Nodularin concentration was determined using ELISA.

Results

- Increases in salinity cause a decrease in both growth rate and nodularin content (Figs. 1-5).
- Increases in phosphorus concentration significantly increase growth rates (Fig. 1) and intracellular nodularin content (Figs. 2 & 4). Extracellular nodularin concentration is independent of phosphorus concentration (Figs. 3 & 5).
- Growth is independent of nitrate concentration (Fig. 1), whereas intra- and extracellular nodularin increases with increasing nitrate (Figs. 3-5) except at 8d for intracellular nodularin which decreases with increasing nitrate concentration (Fig. 2).
- Nodularin content was generally greater in cells during logarithmic growth and out of cells during stationary growth (Figs. 2-5).

Conclusion

*Nodularia* is the most common toxic cyanobacterium in estuarine and brackish waters (Blackburn et al. 1996). This research demonstrates that, for the Gippsland Lakes strains at least, toxic blooms of *N. spumigena* may be expected when salinity is between 5-15, when there is high phosphorus availability, low nitrate levels and moderate light, i.e. during stratified conditions in summer and autumn, after spring high flows. Mature blooms are more likely to show greater levels of nodularin than developing ones, but once they begin to decline nodularin will be released into the surrounding aquatic environment.

References


