Effect of Cyanobacterial growth on Bryophytes growing in Conservatory

Vinay Sahu, Kiran Toppo, M. R. Suseela and A. K. Asthana

CSIR-National Botanical Research Institute, Lucknow-226001, India

Abstract

Growth of nine species of cyanobacteria was observed on eight species of bryophytes (thalloid liverworts and mosses) growing in the polyhouse, Bryophyte conservatory (Moss House), at National Botanical Research Institute, Lucknow, India. Bryophytes were cultured in the laboratory and transferred to polyhouse for hardening and acclimatization. Cyanobacterial growth was observed on the bryophytes as a contamination due to which there was suppression of bryophyte growth. It was evident that cyanobacteria played a significant role of allelopathy.

Key Words: allelopathy; bryophyte; cyanobacteria.

1. Introduction

Algae and bryophytes prefer to grow at moist and shady places. However, algae need rather aquatic conditions. Algae-moss associations have also been observed on the volcanic island of Surtsey. Schwabe and Behre (1972) found that 6 years after the island's formation all moss locations studied were populated by algae, especially *Anabaena variabilis.* Henriksson and Henriksson (1974) recorded nitrogen fixation by *Nostoc muscorum* and *Anabaena variabilis* in soils inhabited by mosses, including *Funaria.* Further studies have confirmed these reports (Schwabe 1974). Anderson and Rushforth (1977) reported algal association with bryophytes. Saxena (1981) reported that the symbiotic association of Cyanobacteria with *Anthoceros* spp. helps in nitrogen fixation. Campbell and Meeks (1989) reported the association of *Nostoc* spp. with *Anthoceros* spp. and found that it enhances the formation of hormogonia in *Nostoc* spp. Mikter and Shukla (2006) found that bryophyte patches on the bark of tree provides a suitable environment for the growth of some rare species of Cyanobacteria.

21 algal taxa association in the rhizoidal zones of three bryophytes has been observed by Toppo and Suseela (2007). Alam *et al.* (2012) observed that *Ulothrix zonata* (Weber & Mohr) Kutzing, chlorophycean alga grow as an epiphyte on moss *Macromitrium sulcatum* (Hook.) Brid. Sahu *et al* (2013) reported allelopathic effect of green alga on the growth of two bryophytes.

Allelopathy refers to any process involving metabolites/toxins produced by plants, algae, cyanobacteria, bacteria and fungi that suppress the growth of a plant. Algae, especially cyanobacteria (blue green algae) are known to produce toxins and reveal the allelopathic effect on other algae and other living organisms. Lefevre et al. (1952) demonstrated complex inhibitory and stimulatory effects among many species, particularly in the Cyanophycean algae.

The present communication is an interesting observation of allelopathic effect of certain cyanobacteria (Blue green algae) on cultured bryophytes, at Bryophyte Conservatory (Moss House), National Botanical Research Institute, Lucknow, India.

2. Materials and Methods

Bryophytes culture were carried out in laboratory under control temperature (20-23ºC) and provided with continuous illumination of 4000-5500 lux as well as alternate light and dark period of 16 hours and 8 hours respectively with the help of a combination of fluorescent tubes. Hoagland and ½ Knop’s media was used to grow all the plants. Mature plants are transferred to the sterile soil pots for hardening purpose in poly house chamber of moss house. The temperature of the polyhouse was maintained at 25^0C. Blue-green coloured slimy, filamentous growth was observed on the surface of the soil and over and along the thalloid liverworts and mosses growing in polyhouse chamber of Moss House, after one month of bryophyte transplantation. Due to their heavy colonization, there was suppression in growth of bryophytes and some cultured bryophytes could not propagate further.

A total of 8 associated algal samples of bryophytes were collected from polyhouse chamber of moss house and preserved in 4% formaline and deposited at Herbarium of National Botanical Research Institute, Lucknow, India. For detailed study the algal samples were examined using Leica DM 500 microscope and photomicrography was done with the help of attached camera Leica EC3. For the identification of taxa the following references were consulted: Tiffany and Britton (1952), Desikachary (1959).

3. Results

It has been observed that some blue green algae suppressed the growth of the bryophytes. *Lyngbya perelegans* Lemm. filaments were spreading on the thallus surface of *Conocephalum conicum* (L.) Lindenb. (Fig. 1 & 2) and *Oscillatoria vizagapatensis* Rao was growing on the surface of adjacent soil to bryophyte thallus (Figs. 1 & 3). *Microcoleus chthonoplastes* Thur. filaments were growing over the thallus surface of *Lunularia cruciata* (L.) Dum (Figs. 4 & 6). *Oscillatoria tenuis* Ag. ex Gomont, and *Oscillatoria vizagapatensis* Rao filaments were also growing on the surface of the soil near the vicinity of *Lunularia* (Figs. 5 & 7). *Microcoleus chthonoplastes* Thur. filaments were growing on the surface of *Reboulia hemispherica* (L.) Raddi and arrested the growth of the plant (Fig. 8 & 9). *Microcoleus chthonoplastes* Thur. filaments were thickly colonized on the thallus surface of *Targionia hypophylla* L. and destroyed the plant (Figs. 10 & 11). *Tolypothrix byssoides* (Berk.) Kirchner filaments were dominantly growing on the surface of *Cryptomitrim himalayense* Kash. thallus and destroyed the plant (Figs. 12 & 13). *Nostoc punctiforme* (Kuetz.) Hariot was found rarely (Fig. 14). *Scytonema burmanicum* Skuja filaments were growing on the surface of *Plagiochasma appendiculatum* Lehm. *et* Lindenb. *Tolypothrix robusta* Gardner was growing profusely on the surface of *Philonotis thwaitesii* (Figs. 17 & 18). *Scytonema coactile* Montagne ex Born. *et* Flah. was profusely growing on the surface of *Funaria hygrometrica* Hedw. (Figs. 19 & 20).

About 9 taxa of algae were found to be associated with bryophytes which made antagonistic effect on the growth of the plants (Figs. 1-20).

3.1 Enumeration of Cyanobacteria associated with Bryophytes

3.1a *Lyngbya perelegans* Lemm.

Thallus with many entangled, straight, sheath thin, hyaline filaments. Cell 2 µm broad, 5-8 µm long (Fig.2).

3.1b *Microcoleus chthonoplastes* Thur.

Filaments forming an expanded dirty to dark green lamellated thallus. Cells 3-4 µm broad, 4-7 µm long (Figs. 6 & 11).

3.1c *Nostoc punctiforme* (Kuetz.) Hariot

Thallus globose, filament flexuous, densely entangled. Cells 3-4 µm broad, heterocysts 5 µm broad and 6.5 µm long (Fig. 14).

3.1d *Oscillatoria tenuis* Ag. ex Gomont

Thallus thin blue-green, filament straight, fragile. Cells 5-10 µm broad, 3-5 µm long (Fig. 5).

3.1e *Oscillatoria vizagapatensis* Rao

Thallus blue - green, filaments straight, pale blue-green. Cells 8-9 µm broad, 2 µm long (Fig. 3).

3.1f *Scytonema burmanicum* Skuja

Filaments densely aggregated, false branched. Cells 14-16 µm broad, heterocysts 10-15 µm broad, 7-15 µm long (Fig. 20).

3.1g *Scytonema coactile* Montagne ex Born. et Flah.

Thallus radially expanded, wooly, blue-green, false branches long. Cells 12-18 µm broad, 14-20 µm long (Fig. 16).

3.1h *Tolypothrix byssoidea* (Berk.) Kirchner

Thallus woolly, cushion-like, blackish, filaments, irregularly false branched. Cells 9-11 µm broad, 10-15 µm long (Fig.13).

3.1i *Tolypothrix robusta* Gardner

Filament straight, flexuous, brownish and lamellated. Cells 13-17 µm broad, 3-4 µm long (Fig. 18).

4. Discussion

The photoautotrophic micro-organisms collectively termed ‘micro-algae’ (including micro-eukaryotes and cyanobacteria) are known to produce a wide range of secondary metabolites with various biological actions. Allelopathic compounds play a role in the interactions between the emitter organisms and their direct competitors.

The contamination of blue green algae could be probably caused through some insects, air or water. In the case of the thalloid liverworts, algae cover the surface of the thallus and check the photosynthetic activity of the plants that caused death of the plant. In order to check any cellular intervention anatomy, cross section of bryophyte thallus revealed that alga did not penetrate inside the thallus. In the case of mosses, algae check the growth of protonema by formation of algal growth that caused deficiency of oxygen in the soil pots and death of the young protonema.

As far as Bryophytes and algal (endophytic) association is concerned it is a well known phenomenon in ecosystem where algal component exists as endophyte in the gametophytes of thalloid and leafy liverworts. In hornworts such association is very common in the form of nostoc chambers in the thallus of these plants. Paired *Nostoc* chambers are also a characteristic feature of a liverwort *Blasia*. It is a form of symbiotic relationship between the two. Reese (1981) reported green algae *Chlorochytrium* sp. growing endophytically in leaves of the plants. Particularly the growth of algal taxa in the pots of bryophytes resulted due to excessive watering and water retention in the pots.

The antagonistic effect of algal growth over bryophytes created an interest to observe that is there any specificity in the growth of taxa of bryophyte and algae and whether there is any cellular intervention by the algal species. Our observations suggest that all the eight bryophytic taxa were contaminated with different strains of algae and this pattern of growth needs further study to establish the specificity of association between the bryophyte and algal taxa. Allelopathic compounds such as cyclic peptides, alkaloids, lipopolysaccharides are phycotoxins of cyanobacterial origin. Jose Phine Leflaive and Loic Ten-Hage (2007) reviewed the evolutionary, ecological and physiological aspects of the production of allelopathic compounds by micro-algae (including cyanobacteria) in freshwater environments, and compare the characteristics of allelopathic compounds with those of toxins. Allelopathic compounds have various modes of action, from inhibition of photosynthesis to oxidative stress or cellular paralysis.

5. Acknowledgement
Authors are grateful to the Director, CSIR- National Botanical Research Institute, Lucknow for encouragement and providing the facilities.

6. Literature

ALAM, A., SHARMA, V. & SHARMA, S. C. (2012). An association between *Macromitrium sulcatum* (Hook.) Brid. and *Ulothrix zonata* (Weber & Mohr) Kützing. Archive for Bryology 129: 1-4.

ANDERSON, D. C. & RUSHFORTH, S. R. (1977). The Cryptogamic flora of desert soil crust in southern Utah: U.S.A. Nova Hedwigia 28: 691-729.

CAMPBELL, E. L. & MEEKS, J. C. (1989). Characteristics of hormogonia formation by symbiotic *Nostoc* spp. in response to the presence of *Anthoceros punctatus* or its extracellular products. Appl. Environ. Microbiol. 55: 125-131.

DESIKACHARY, T. V. (1959). *Cyanophyta.* Indian Council of Agricultural Research, New Delhi, pp. 686.

HENRIKSSON, L. E. & HENRIKSSON, E. (1974). Studies in the nitrogen cycle of Surtsey in 1972. Surtsey Res. Progr. Rep. *7*: 36-44.

JOSE, P. L. & LOIC, T. H. (2007). Algal and cyanobacterial secondary metabolites in freshwaters: a comparison of allelopathic compounds and toxins. Freshwater Biol. 52: 199–214.

LEFEVRE, M., JAKOB, H. & NISBET M. (1952). Auto- et heteroantagonismes chez les algues d'eau douce. Ann. Stat. Centr. HydrobioL Appl. 4: 5-198.

MIKTER, S. S. & SHUKLA, S. P. (2006). Study on algal flora of algae-moss association on barks of some selected tree species at Rono-hills of Papum pare District in Arunachal Pradesh, India. Bull. Aruna. For. Res. 22 (1&2): 1-8.

REESE, W. D. (1981). *Chlorochytrium* - a green alga endophytic in musci. The Bryologist 84: 75-78.

SAHU, V., TOPPO, K., SUSHEELA, M. R. & ASTHANA, A. K. (2013). Allelopathic effect of *Stichococccus bacillaris* Nageli (Green Alga) on the growth of two bryophytes. Archive for Bryology 162: 1-4.

SAXENA, D. K. (1981). Role of *Anthoceros* as a bio-fertilizer. XIII International Botanical Congress Abstracts: Sydney, 292 pp.

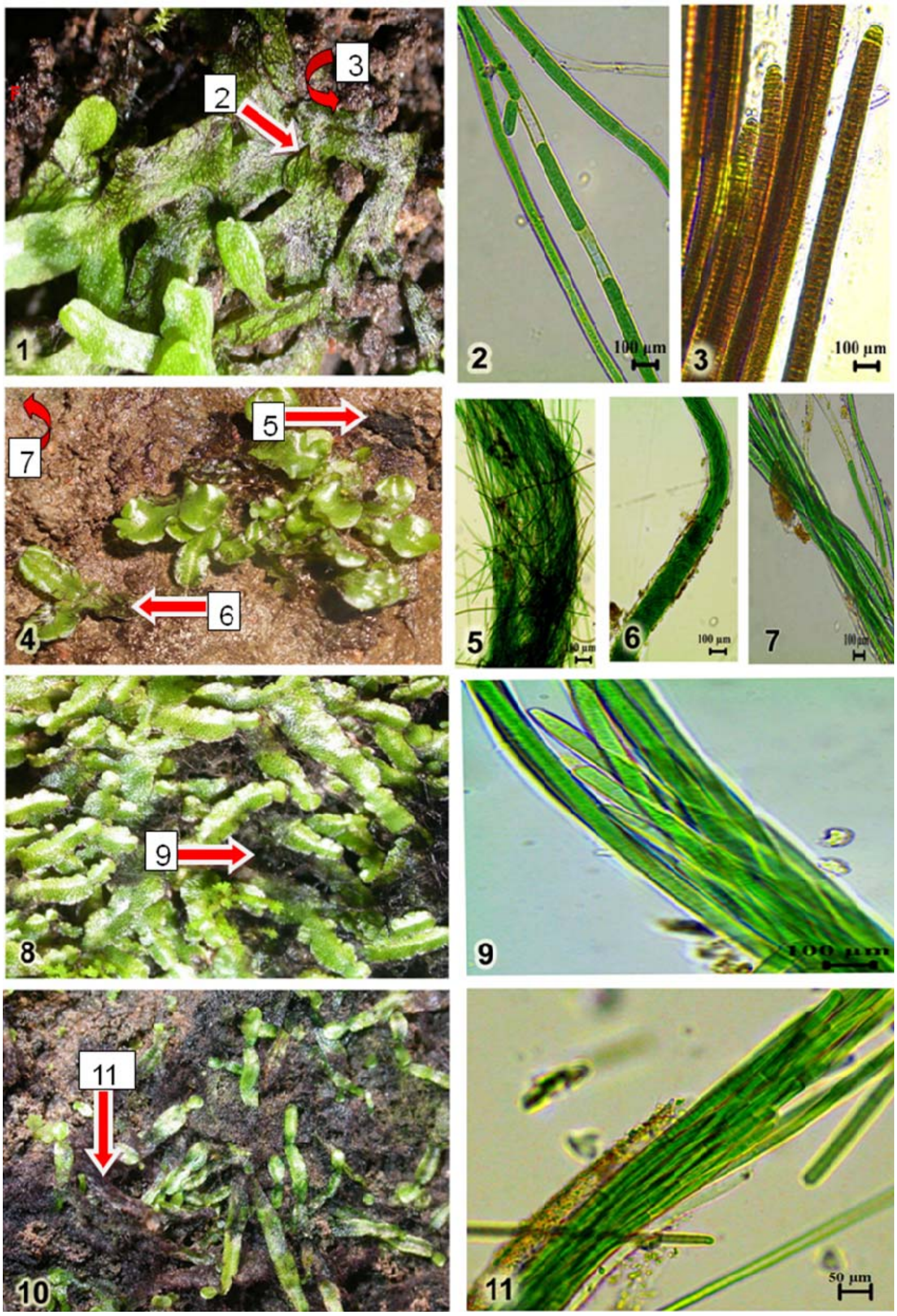
SCHWABE, G. H. & BEHRE, K. 1972. Algae on Surtsey in 1969-1970. Surtsey Res. Progr. Rep. 6: 85-89.

SCHWABE, G. H. (1974). Nitrogen fixing blue-green algae as pioneer plants on Surtsey 1968-1973. Surtsey Res. Progr. Rep. 7: 22-25.

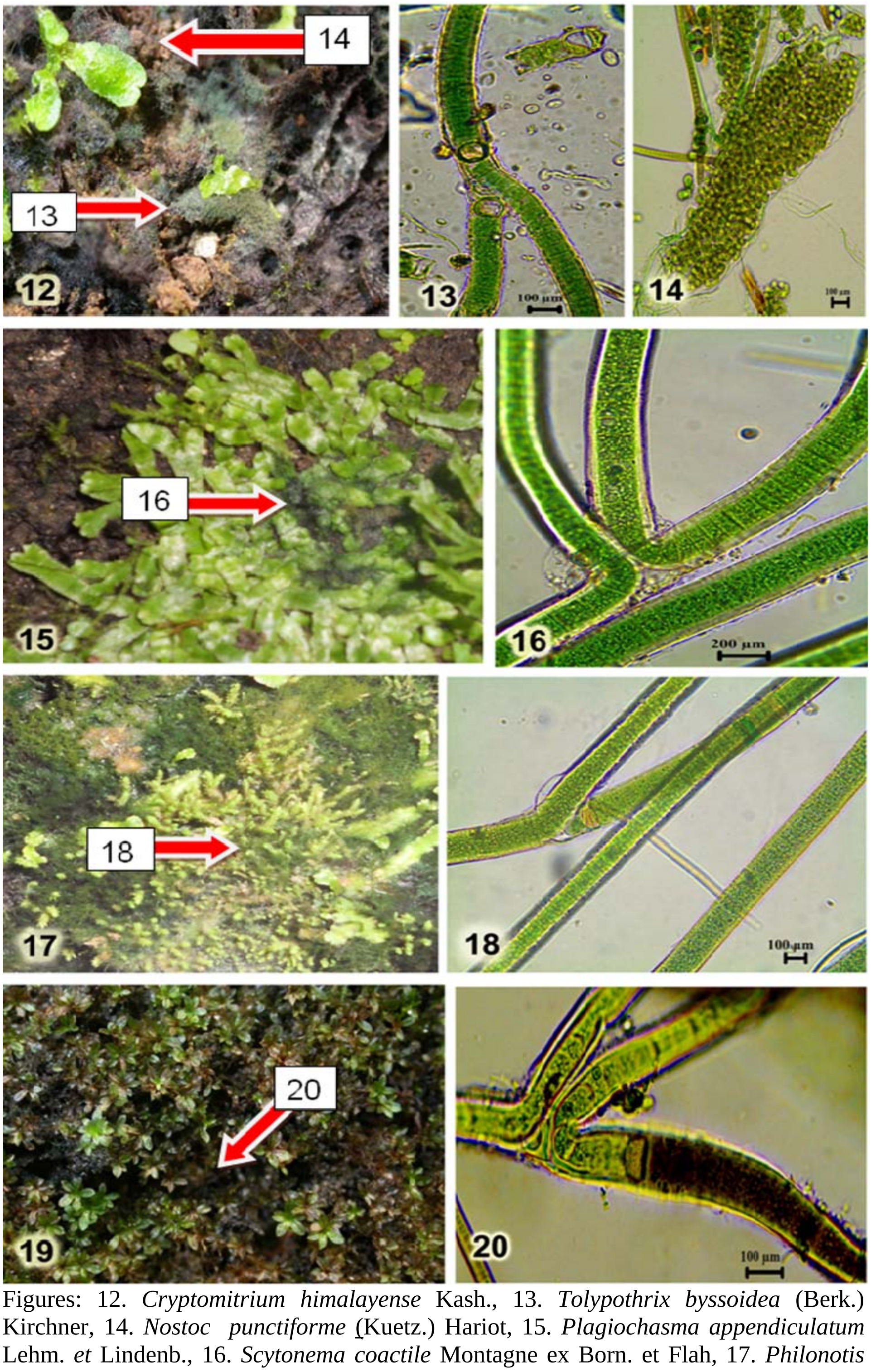
TIFFANY, L.H. & BRITTON, M. E. (1952). Monograph on the algae of Illinois. Hofner Publishing Company, New York, pp. 407.

TOPPO K. & SUSHEELA, M. R. (2007). A preliminary report on Bryophyte and algal associations. In: Nath, V. and Asthana, A. K. (eds), Current trends in Bryology. Bishen Singh and Mahendra Pal Singh, Dehra Dun, India, pp. 279-286 .

Online May 14, 2013



Figures: 1. *Conocephalum conicum* (L.) Lindenb. 2. *Lyngbya perelegans* Lemm. 3. *Oscillatoria vizagapatensis* Rao, 4. *Lunularia cruciata* (L.) Dum. 5. *Oscillatoria tenuis* Ag. ex Gomont, 6. *Microcoleus chthonoplastes* Thur., 7. *Lyngbya perelegans* Lemm., 8. *Reboulia hemispherica* (L.) Raddi, 9. *Microcoleus chthonoplastes* Thur., 10. *Targionia hypophylla* L., 11. *Microcoleus chthonoplastes* Thur.



Figures: 12. *Cryptomitrium himalayense* Kash., 13. *Tolypothrix byssoidea* (Berk.) Kirchner, 14. *Nostoc punctiforme* (Kuetz.) Hariot, 15. *Plagiochasma appendiculatum* Lehm. *et* Lindenb., 16. *Scytonema coactile* Montagne ex Born. et Flah, 17. *Philonotis thwaitesii* Mitt. 18. *Tolypothrix robusta* Gardner, 19. *Funaria hygrometrica* Hedw., 20. *Scytonema burmanicum* Skuja.