Effect of Photosynthetically Active Radiation and Ultraviolet B on the Filamentous Structure of the Cyanobacterium, *Spirulina platensis*

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**Abstract:** Stratospheric ozone depletion results in the leakage of the ultraviolet radiation reaches to the earth’s surface. Cyanobacteria are natural phytoplankton present on the natural ecosystems become the primary targets as they purely depend on photosynthesis. The toxic and energetic UV radiation ultimately targets the lipid protein interactions in the cyanobacterium, *Spirulina platensis* resulting in the breakage of the filaments evidenced from the microscopic analysis. This may be due to the alterations at the level of membrane lipids by UV-B radiation. But in the case of combination of photosynthetically active radiation the breakage is less when compare to its alone action of UV-B because of the dilution.

**Key words:** Cyanobacteria • Morphology • PAR • *Spirulina platensis* • Ultraviolet radiation

**INTRODUCTION**

Depletion of ozone layer leads to the leakage of ultraviolet (UV-B) radiation reaching to the earth’s surface which intern inhibits the fundamental and essential process photosynthesis in plants and their productivity [1-3]. Ultimately they become target for the UV-B stress, which are having the capacity to exhibit the morphological, physiological and biochemical changes in the higher plant system as well as lower photosynthetic organisms like cyanobacteria [4]. Cyanobacteria are the photosynthetic prokaryotes which are present in the natural ecosystem become the primary targets for the UV-B radiation. The cyanobacteria comprise a major proportion of the total phytoplankton biomass. It has been reported that UV-B not only impairs the motility and phototorientation of cyanobacteria [5] but also affects a number of physiological and biochemical processes, such as growth, survival, pigmentation, nitrogen metabolism enzymes [6], CO₂ uptake and ribulose 1,5-bisphosphate carboxyylase activity [7]. *Spirulina platensis* is an economically well known filamentous cyanobacterium that is commercially produced as a source of human health food [8], animal feed [9] and cosmetic and considerable efforts have been made to optimize the growth conditions of this organism for massive production [10-12]. The morphological features of *Spirulina* species include characteristic regular helical coiling or spirals. The helicity has been used as a taxonomic criterion [13], as well as a method to select for high-quality strains [14]. Environmental factors, such as light, temperature and salinity, can affect the helical structure [13, 15-18]. Photosynthetic organisms can actively absorb the radiation between 400-700 nm which is said to be photosynthetically active radiation (PAR). In nature UV-B alone can not reach the earth surface, it is going to mix with the PAR. The studies related to morphological alterations of *Spirulina* under UV-B as well as in combination with PAR seem to be scanty. Therefore an attempt has been made to characterize the structural alterations in the above organism.

UV-B radiation shows a differential response when it works alone or in combination with PAR. Studies related to the effect of UV-B radiation alone and in combination with PAR on intact cells of cyanobacterium, *Spirulina platensis* morphology are limited. Therefore, an attempt has been made to study the differential effect of UV-B alone and in combination with PAR on the structural (morphological) alterations of the intact cells of cyanobacterium, *Spirulina platensis*.

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MATERIALS AND METHODS

Organism: The mother cultures of *Spirulina platensis* were obtained from National Facility for Blue Green Algal Collection, New Delhi, India and cultured autotrophically by providing Zarrouk’s medium [19]. Stock cultures were maintained in a culture room continuously illuminated by cool fluorescent light (40 Wm$^{-2}$) at 25±2°C.

Treatment: The log phase cells were harvested in to fresh growth medium in to petriplates and exposed to UV-B radiation at influence rate of 2 Wm$^{-2}$ (obtained from a Philips TL 20 type O5 type in the spectral range of 280-320 nm and with a peak at 312 nm) for different intervals (20-80 min). In another set of experiments cells were exposed to UV-B radiation (fluence rate of 2 Wm$^{-2}$) in the presence of PAR (40 Wm$^{-2}$ in spectral range 400 to 700 nm; called UV-B + PAR). After exposure the cells of control and treated samples were collected and used for further analysis.

Measurements of Light Intensity: Light intensity was measured with Licor radiometer (Model LI-189, Licor, USA). Calibrated neutral density filters (Balzers, USA) were used to attain to light intensity to desired extent. UV-B irradiance was measured with the help of VLX-312 UV meter (Vilber-Lourmat, France). The detector of UV meter was protected with UV-B interference filter with 100% transmittance at 312 nm and a half band width of 5 nm at half the maximum intensity.

Morphological Examinations: For the morphological examinations the control and treated cells were taken and observed under compound microscope (Olympus, USA). Digital images were recorded with the help of Sony digital camera (8 MPX).

RESULTS

In this investigation we have studied the impact of UV-B radiation alone and in combination with PAR, on the morphological changes of the filamentous organism, *Spirulina platensis*. The morphological features of *Spirulina* species include characteristic regular helical coiling or spirals where, helicity has been used as a taxonomic criterion[13]. Treatment with UV-B radiation for different intervals (20-100 min) caused the structural alterations in the filamentous organism. Increase of duration leads to the maximum breakage in the filaments of the cyanobacteria was found. When the control cells observed under compound microscope showed a maximum spirals in the filamentous organism. But starting from initial exposure (20 min) the breakage was started and finally it showed maximum after 100 min (Fig. 1-6). But, when the UV-B treatment was given along with PAR, it shows a differential effect on the morphology of the filamentous organism. In the presence of PAR it showed loss of pigments rather than breakage (Fig. 7-12). It is due to the presence of PAR, which can minimize the effect of UV-B and protect the organism from breakage. In the presence of PAR, UV-B is not able to break the filaments of the organism. By the increase in duration of exposure leads to the drastic breakage and finally leads to the small pieces of the filaments. But under the influence of PAR, UV-B is not able to show the maximum effect and it was reduced to half when compared to individual application of UV-B. Thus, the microscopic studies showed the structural alterations under the influence of UV-B radiation in time dependent manner and they were minimized by the influence of PAR.

DISCUSSION

Due to depletion of ozone layer, plants under natural conditions receive not only UV-B radiation but also PAR along with it. Therefore aquatic and terrestrial organisms respond to UV-B radiation in different way to the presence and absence of PAR. The *Spirulina* cells were exposed to UV-B (2 Wm$^{-2}$) radiation for short durations (20-80 min) exhibited multiple effects on the structural organization. 20 min of UV-B exposure leads to the breakage in the filamentous structure. It was continued with the duration of UV-B exposure in a time dependent manner. Finally after 80 min of exposure results in the formation of small pieces. The similar observations were found in other organisms under UV-B radiation leads to the alterations in the helical structure [16, 18, 20]. But the alterations are minimized under the influence of PAR. In combination with PAR, UV-B also showed the breakage of the filaments but the extent was minimum. After the exposure of UV-B along with PAR showed the loss of pigments in addition to breakage. From the literature it is clear that UV-B radiation primarily targets the membrane organization and lipid protein interaction [21-25]. Thus the filamentous structure was disrupted under the influence of UV-B radiation due to its effect on membrane lipids. PAR combination can minimize the UV-B radiation induced.
Fig. 1-6: Morphological variations of the cyanobacterium, *Spirulina platensis* under the influence of UV-B (2 Wm$^{-2}$) for different intervals observed under compound microscope (40X).
Fig. 7-12: Morphological variations of the cyanobacterium, *Spirulina platensis* under the influence of UV-B (2 Wm\(^{-2}\)) along with PAR (40 Wm\(^{-2}\)) for different intervals observed under compound microscope (40X)
REFERENCES


