The Role of Polyethylene Films in Reducing the Harmful Effects of UV Radiation on the Productivity of Euglena Gracilis

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Abstract

The study was achieved during 2017 in the laboratories of the department of Botany at Tishreen University, Lattakia, Syria. The effect of ultraviolet radiation (UV-C, UV-B) on the carbohydrate content and the oxygen evolution of Euglena gracilis was studied for different periods (0, 5, 30 minutes). The results show that the carbohydrate content and the oxygen evolution as indicators of photosynthesis and productivity were more sensitive to UV-C compared to UV-B. The decrease in productivity was correlated with the exposure time, reaching the lowest value after 30 minutes (57.23% for carbohydrate content and 36.25% for oxygen evolution). On the other hand, the usage of polyethylene films alleviates the negative effect of UV radiation. This alleviation percentage was more evident against UV-C (8.07% for carbohydrate content and 20.91% for oxygen evolution after exposing the algae to UV radiation + polyethylene films for 30 minutes).

Keywords

UV-C, UV-B, Polyethylene films, Euglena gracilis, Carbohydrate, Oxygen evolution.

Abbreviations

UVR: Ultraviolet Radiation, UV-C: Ultraviolet Radiation C, UV-B: Ultraviolet Radiation B, LHC: Light Harvesting Complexes, OEC: Oxygen Evolution Complex, ETR: Electron Transport Rate, RubisCO: Ribulose 1,5 Diphosphate Carboxylase Oxygenase.

I. INTRODUCTION

Ultraviolet radiation (UVR) is ubiquitous and has several properties which combined make it a potent environmental stressor to organisms that are exposed to sunlight. UVR is differentiated into 3 bands (UV-C :100–280 nm, UV-B: 280–320 nm and UV-A :320–380 nm) which have different effects on organisms. Both UV-A and UV-B reach the biosphere in different quantities, while UV-C is strongly absorbed by oxygen and stratospheric ozone ([1], [2], [3], [4]).

In recent decades, the release of anthropogenic atmospheric pollutants, such as chlorofluorocarbons, chlorocarbons, organobromides and reactive nitrogen species (RNS), including nitric oxide, nitrous oxide, and peroxynitrite has caused the depletion of the ozone layer. This depletion caused an increase in solar UV radiation reaching the Earth's surface, which became an important issue to investigate ([5], [6], [7], [8]).

Aquatic ecosystems with high transparency of oligotrophic waters (marine and freshwaters) are exposed to the highest levels of ultraviolet radiation. UV irradiation in lakes can affect phytoplankton down to a depth of 10-15 m [9]. The depth of the UV penetration depends, among other factors, on the incidence of solar radiation and transparency of waters [10].

It`s important to realize that phytoplankton is the most widespread and the fastest-growing photosynthetic organisms in nature. Their photo-chemical efficiency is 7 to 31 times greater than the land-based plants. Therefore, phytoplankton is considered the most promising long-term sustainable source of biomass. There is also an indication that these organisms will play an important role in meeting the increasing energy demands and environmental concerns in the near future [11]. One of the most important genera of phytoplankton is *Euglena*.

Euglena gracilis is a motile unicellular alga which belongs to Euglenophyta. It is characterized by an elongated spindle-shaped cell (15 to 500 micrometres) with two flagella and one nucleus. This alga has many disc shaped chloroplasts which include different photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids (β and γ carotene) ([12], [13]).

UV radiation can be regarded as a stress factor which is capable of significantly affecting cell division, growth, development, biomass, photosynthesis, productivity and other physiological processes in phytoplankton and other algae ([8], [10], [14], [15]). UV also induces the destruction of amino acids especially the aromatic ones (such as tyrosine and tryptophane), which leads to the denaturation of

structural protein and the inactivation of enzymes. Lipid peroxidation can also be detected under UV stress ([1], [10], [16]). UV radiation has negative effects on photosynthesis apparatus, pigments, thylakoids integrity, light harvesting complexes (LHC), oxygen evolution complex (OEC), electron transport rate (ETR) and many photosynthetic enzymes, such as protochlorophyllide oxidoreductase, ATPase and ribulose 1,5 diphosphate carboxylase oxygenase (RubisCO), ([1], [4], [9], [10], [11], [17], [18], [19], [20], [21], [22], [23]).

In this study, we investigate the effect of UV-C and UV-B radiation with or without the existence of polyethelene films on the carbohydrate content and the oxygen evolution in *Euglena gracilis*.

II. MATERIAL AND METHODS

A) Cell culture

Euglena gracilis was obtained from Goettingen Algal Culture Collection in Germany and cultured in a growth chamber (23°±1 degrees, 70%±1 humidity, 14 light/10 dark, with continuous aeration). The experiments were achieved during summer 2017 in the laboratories of Botany Department at the Faculty of Science, Tishreen University, Latakia, Syria.

B) UV treatments

The cultures were exposed to artificial UV lamps (USHIO UV-B= 306 nm and New Nec Technology UV-C= 254 nm) for different periods (0, 5, 30 minutes).

C) Carbohydrate content

Carbohydrates were extracted after 6, 24, 48 hours of exposure to UV radiation using Anthrone reagent. The reduced carbohydrate contents were determined using a standard solution of glucose and measured by Spectrophotometer UV/VIS (Model: SECOMAM) at 520 nm.

D) Oxygen evolution

The oxygen evolution rate was evaluated immediately after exposure to UV radiation using Clark electrode (YSI Incorporated, yellow springs Instrument Co., Ohaio, USA).

E) Statistical analysis

data were analyzed using one-way ANOVA.

III. RESULTS AND DISCUSSION

A) The effect of UV/Polyethylene on carbohydrate content

1) The effect of UV-C/Polyethylene

After exposing the algae to UV-C for 5, 30 minutes, reduced carbohydrates decline significantly, reaching their lowest level after the exposure to 30 minutes (27.33, 29.8, 57.23% with maintenance rates 72.67, 70.20, 42.77% after 6, 24, 48 hours respectively) (Fig. 1). These results are consistent with previous study on Satureja hortensis exposed to UV-C radiation [24].

On the other hand, reduced carbohydrate contents decrease constantly with significant differences after exposing the algae covered by polyethylene films to UV-C for 5 and 30 minutes, reaching their lowest level after 30 minutes (19.19, 25.62, 49.15% with maintenance rates 80.81, 74.38, 50.85% after 6, 24, 48 hours respectively).

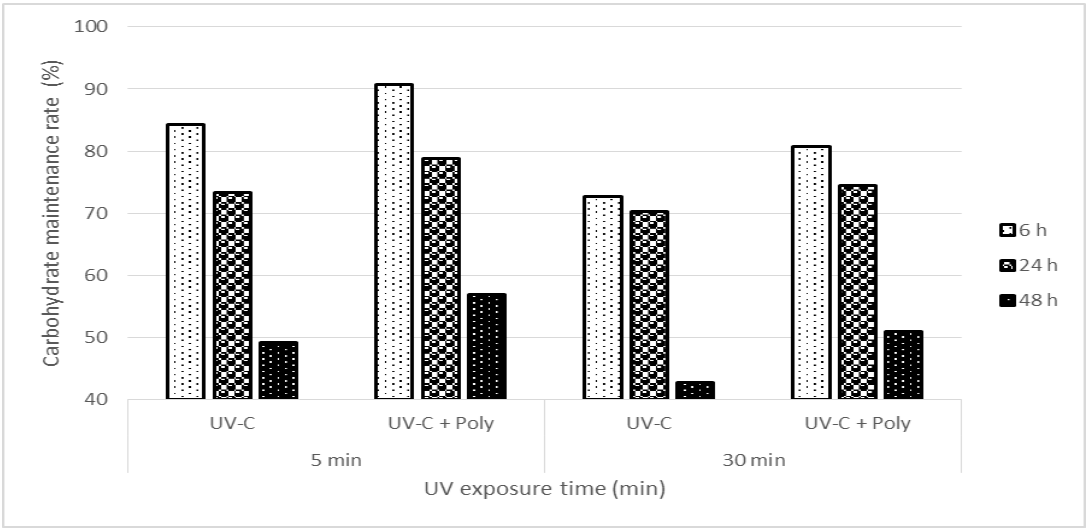

Fig. 1: The effect of UV-C / polyethylene on carbohydrate content

2) The effect of UV-B/Polyethylene

After the exposure of the algae to UV-B for 5, 30 minutes, reduced carbohydrate decline significantly after 6, 24, 48 hours, reaching their lowest level after 30 minutes (17.33, 23.77, 40.53% with maintenance rates 82.67, 76.23,

59.47% respectively) (Fig. 2). These results are similar to the findings on the cells of *Chlorella vulgaris* exposed to UV-B radiation ([25], [26]).

However, reduced carbohydrate contents decrease constantly with significant differences after exposing the algae covered by polyethylene films to UV-B for 5 and 30 minutes, reaching their lowest level after 30 minutes (17.11, 21.61, 35.67% with maintenance rates 82.89, 78.39, 64.33% after 6, 24, 48 hours respectively).

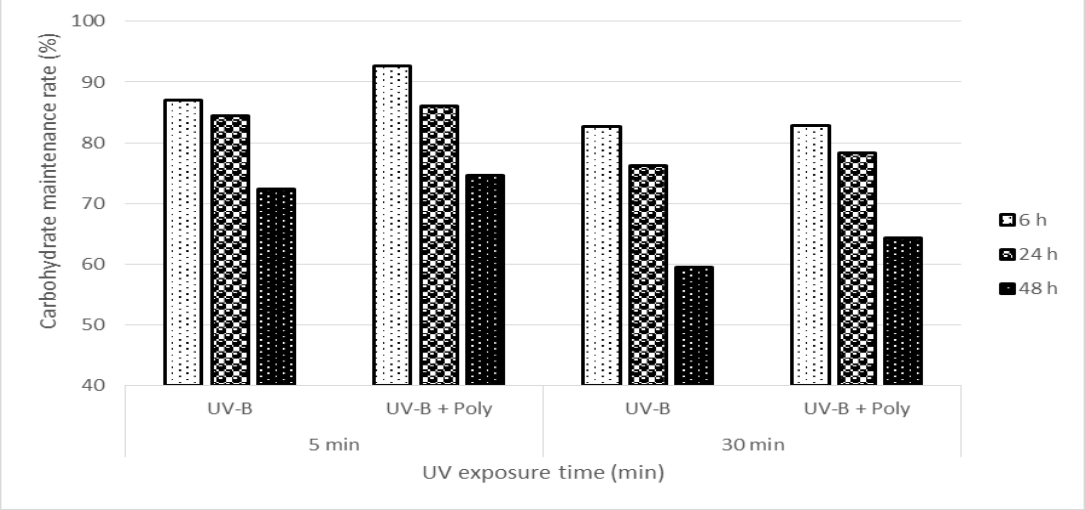

Fig. 2: The effect of UV-B / polyethylene on reduced carbohydrate content

The reduction in carbohydrate content in the samples exposed to UV radiation (both types) can be due to the inactivation of Calvin cycle enzymes, especially Rubisco which considered as the principle CO_2 fixing enzyme in algae and plants [24].

B) The effect of UV/Polyethylene on oxygen evolution

1) The effect of UV-C/Polyethylene

After exposing the algae to UV-C for 5, 30 minutes, a significant decline in the oxygen evolution rate happens immediately after the exposure for 5, 30 minutes (30.87, 36.25% with maintenance rates 69.13, 63.75% respectively) (Fig. 3).

Oxygen evolution rate decreases constantly with significant differences after exposing the algae covered by polyethylene films to UV-C for 5 and 30 minutes (13.69, 15.34% with maintenance rates 86.31, 84.66% respectively).

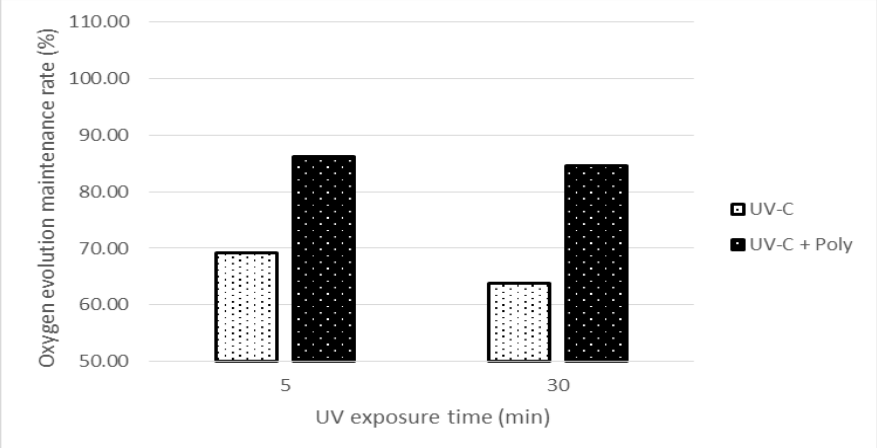

Fig. 3: The effect of UV-C / polyethylene on oxygen evolution rate

***2) The effect of UV-B/Polyethylene*:**

Shortly after exposing the algae to UV-B for 5, 30 minutes, oxygen evolution rate declines significantly (6.03, 10.48% with maintenance rates 93.97, 89.52% respectively) (Fig. 4). These results are similar to the findings on the cells of Cyanobacterium *Arthrospira platensis* exposed to UV-B radiation [27].

On the other hand, oxygen evolution rate decreases slightly after exposing the algae covered by polyethylene films to UV-B for 5 minutes (0.25% with maintenance rate 99.75%). However, the reduction of

oxygen evolution rate was more evident and significant after exposure for 30 minutes (8.31% with maintenance rate 91.69%).

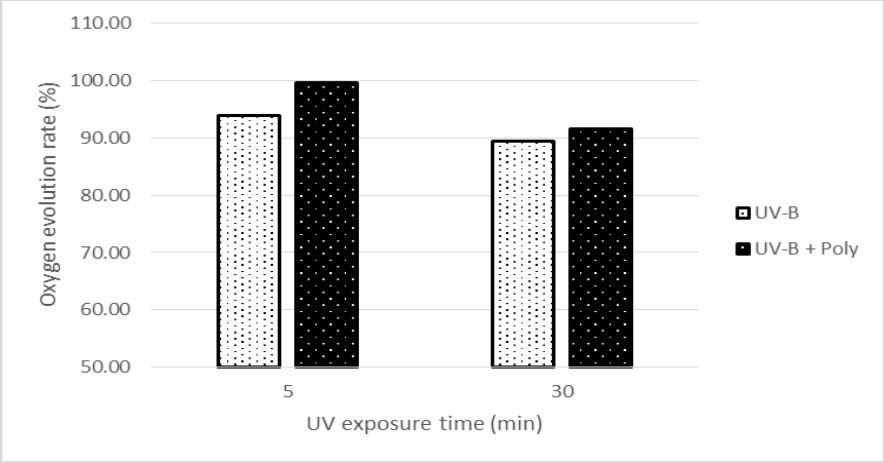

Fig. 4: The effect of UV-B / polyethylene on oxygen evolution rate

Oxygen evolving complex (OEC) is an important target of ultraviolet radiation. Some researchers indicate that UV provokes inhibition of OEC through direct absorption within the manganese cluster or by damaging intermediates of the water oxidation process [28].

IV. CONCLUSION

The study reveals that both UV-C and UV-B reduce the productivity measured in carbohydrate content and oxygen evolution.

As a result, the carbohydrate content decreased slightly after exposure to UV-B compared to UV-C. However, polyethylene films alleviated the effect of UV-C / UV-B on carbohydrate content in the algae exposed for 30 minutes at the end of the experiment (8.07% in the case of UV-C).

Both UV-C and UV-B also caused a noticeable decline in the oxygen evolution rate, which was more prominent in the case of UV-C. However, polyethylene films alleviated the effect of UV-C / UV-B on oxygen evolution rate (20.91, 2.17% at the end of the experiment respectively).

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