Phyton (Austria)	**Vol. 26**	Fasc. 1	59–64	15. 7. 1986

The Effect of Light on the Content of Photosynthetically Active Pigments in Plants. V. *Desmococcus vulgaris* as a Representative of Epiphytes

By

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With 2 Figures

Received April 2, 1985

Key words: *Desmococcus vulgaris*, light, chlorophyll content, carotenoid content, photosynthetically active pigments

Summary

CZECZUGA B. 1986. The effect of light on the content of photosynthetically active pigments in plants. V. *Desmococcus vulgaris* as a representative of epiphytes. – Phyton (Austria) 26 (1): 59–64, 2 figures. – English with German summary.

The photosynthetic active pigments (chlorophyll a + b and carotenoids) of *Desmococcus vulgars* as a representative of epiphytes, grown in white, red, yellow green and blue light were examinated. Yellow light caused major chlorophylls and carotenoids increases in this specimen of the examinated algae.

Yellow light causes the major enhancement of both cell propagation and cell size and increasing of the content of the photosynthetic active pigments in the specimens examinated.

Zusammenfassung

CZECZUGA B. 1986. Der Einfluß des Lichtes auf den Gehalt an photosynthetisch aktiven Farbstoffen in Pflanzen. – V. *Desmococcus vulgaris* als Vertreter der Epiphyten. – Phyton (Austria) 26 (1): 59–64, 2 Abbildungen. – Englisch mit deutscher Zusammenfassung.

Es wurde der Gehalt an photosynthetisch aktiven Pigmenten (Chlorophyll a + b und Carotinoiden) von *Desmococcus vulgaris* als eines Vertreters der Epiphyten nach Kultur in weißem, rotem, gelbem, grünem und blauem Licht untersucht. Gelbes Licht führt zur höchsten Vermehrungsrate und Zellgröße unter den untersuchten Proben und bewirkt die stärkste Erhöhung des Gehaltes an den genannten Pigmenten.

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Introduction

As it was shown in the previous papers (CZECZUGA 1977, CZECZUGA et al. 1980), considerable increase of chlorophylls and carotenoids in fresh water green algae of *Chlorella* and *Scenedesmus* genus was observed in the green-lighted cultures. On the other hand, the same type of investigations carried out with lichen of *Hypogymnia* genus showed a considerable increase of chlorophylls and carotenoids content in blue-lighted cultures (CZECZUGA 1981). As it is known (AHMADJIAN 1967), unicellular algae of protocoidal types are found in the lichen as phycobiontes.

In this context is seemed interesting to investigate whether the conducted cultivation of an epiphytes representative such as *Desmococcus vulgaris* found especially on the bark at the northern side of a tree would show, similarly to *Chlorella,* the increased chlorophylls and carotenoids content in green light, or, like in lichen phycobiont *Hypogymnia* genus, in blue light.

Material and Methods

Pieces of bark (4 × 10 cm) covered with cells of *Desmococcus vulgaris* were collected for the experiment in November from the nothern side of the same clone trunk. Next, the pieces were glued to small cardboards which were then placed in glass beakers at such an angle to the light source as it had been in November when the sunlight hat operated on the bark under investigation. Next, the beakers with the bark pieces were stored in boxes equipped with appropriate glass filters. The glass was manufactured by the FPN – Bytom Works, wavelengths being indicated by the producers. Four basic colours were but to use: the red (λ = 700 nm), the yellow (λ = 590 nm), the green (λ = 500 nm) and the blue (λ = 450 nm). A culture of *D. vulgaris* grows in a box provided with usual, „colourless" (white), glass served for control. The boxes were placed on a table situated 1 metre from the window. In addition, the boxes containing the algae were exposed to light of 2,7 $W \cdot m^{-2}$ from a glow-tube lamp for 12 hours. After passing throught the different filters light intensities were: colourless light – 95.5%, red – 52.6%, yellow – 21.1%, green – 13.2% and blue 7.9% of the 2.7 $W \cdot m^{-2}$ in front of every filter. From time to time the bark was moistened with a sprayer. After 4 weeks of the experiment the alga cells were washed with a brushpencil and distilled water of the same volume for each test. After that, the size of the algal cells was measured and their concentration was counted using a Thoma chamber, whereas the photosynthetic pigments content was determined following the method of JEFFREY & HUMPHREY (1975).

Results

As Fig. 1 shows, the lowest concentration of *Desmococcus vulgaris* cells was noted on the bark when using red filter (11.700.000 cells per ml),

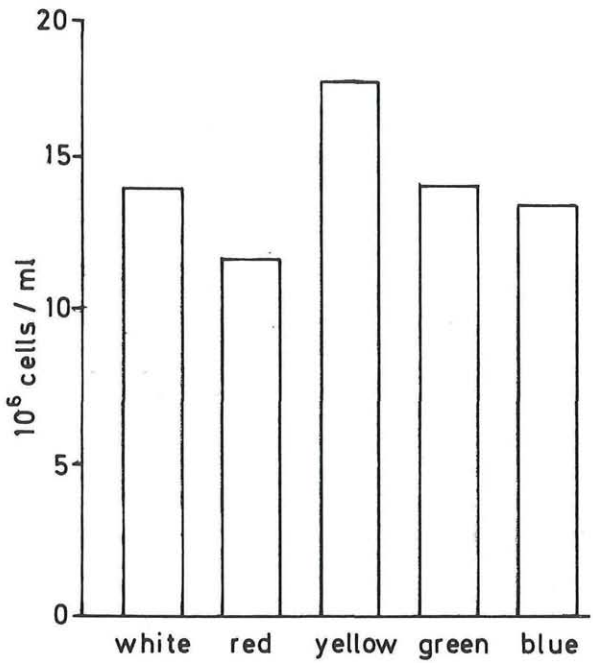

Fig. 1. Cell numbers of *Desmococcus vulgaris* (per ml) cultivated in white, red, yellow, green and blue light.

whereas the highest one – with yellow filter (17.600.000 cells per ml). There were more cells found on the bark with green than with blue filter.

Measurementos of *D. vulgaris* cells of the bark exposed in boxes with different filters showed that the biggest cells (Table 1), after 4 weeks of the experiment, were on the bark behind yellow filter (12.00 µm), whereas the smallest ones (10.98 µm in case of coloured filters) were found behind red filter. The cells got little smaller after illumination through green filter than through the yellow one, and behind the blue filter the average size of the cells was 11.30 µm.

Table 1

Desmococcus vulgaris: Means ($\bar{x}$) and standard deviations (s_x) of cell size after illumination through coloured filters. (In brackets the extreme values)

Light	$\bar{x} \pm s_x$	(Min.-Max.)
White	9.5 ± 1.5	(6.4 – 11.2)
Red	11.0 ± 3.9	(9.0 – 12.8)
Yellow	12.0 ± 1.8	(9.6 – 14.4)
Green	12.0 ± 2.1	(9.4 – 14.4)
Blue	11.3 ± 1.5	(9.0 – 12.8)

Table 2

Pigments content of *Desmococcus vulgaris* grown in white, red, yellow, green and blue light (μg/10^6 cells, n = 5)

Light	Chlorophylls content	Chlorophylls ratio*	Carotenoids content	Carotenoids ratio
White	0.645 ± 0.012		0.462 ± 0.017	
Red	1.022 ± 0.009	1.58***	0.632 ± 0.008	1.37***
Yellow	1.556 ± 0.023	2.41***	0.970 ± 0.025	2.10***
Green	1.425 ± 0.031	2.21***	0.850 ± 0.035	1.84***
Blue	1.027 ± 0.018	1.59***	0.532 ± 0.026	1.15**

* How many times increase in comparison with white light
** ratio significant at 0.01 level
*** ratio significant at 0.001 level

The content of photosynthetically active pigments in *Desmococcus vulgaris* cells with various filters is presented in Table 2. The greatest amount of chlorophylls and carotenoids was found in *D. vulgaris* cells with yellow and green filters, much less with red and blue ones, and the least was recorded in cells with colourless filter. Taking the chlorophylls and carotenoids content in cells with colourless filter as 100% the chlorophylls content in the tekst with yellow filter increased to 241.2%, and the carotenoids content with the same filter to 209.9%. A considerable proportional increase of both chlorophylls and carotenoids was also noted with green filter.

Discussion

The investigation of the content of photosynthetically active pigments in unicellular aquatic algae of *Chlorella* (CZECZUGA 1977) showed the highest concentration of the pigments in cells with green filter. The maximum content of photosynthetically active pigments under blue-green light was also observed in some of sea algae (VESK & JEFFREY 1977). On the other hand, the highest concentration of chlorophylls and carotenoids in unicellular algae as lichen phycobiont was noted by blue light (CZECZUGA 1981). Higher concentration of photosynthetically active pigments observed in cells of aquatic algae illuminated with green or green-blue light should be explained as the phenomenon of certain chromatic adaptation to light conditions.

As it was noted in the previous papers (CZECZUGA 1975, 1978), green-blue light penetrates deepest into water, because red-yellow light is absorbed close to the surface of water basins. Algae cells which are found in the middle zone of a short wavelength light domination increase the con-

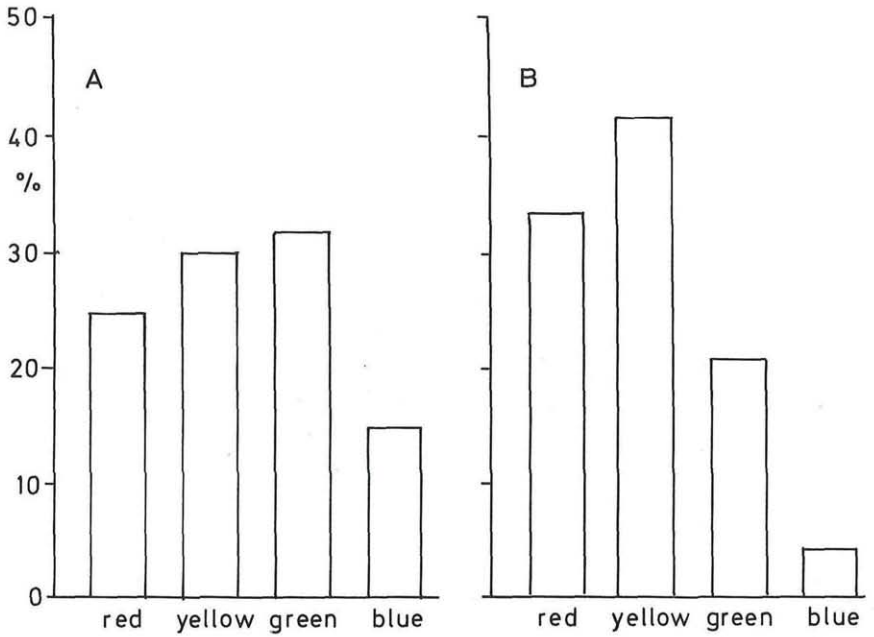

Fig. 2. Relative light intensities within different spectral ranges. A = shadowy conditions, light intensity 11.6 W · m^{-2}; B = when trees become yellow, light intensity 2.1 W · m^{-2}.

centration of photosynthetically active pigments in order to absorb the minimum energy necessary for photosynthesis.

The increase of photosynthetically active pigments in *Desmococcus vulgaris* cells should be also accounted for as the phenomenon of chromatic adaptation to light conditions of algae habitats. As it is known, *Desmococcus vulgars* cells are found in shadowy and moist spots, whereas in case of trees they cover tree bark at the northern side most often. Measurements of individual light concentration made in natural environment seem to prove the thesis. This is so, because in shadow of the trees under investigation the dominating light is green-yellow, while in autumn when tree leaves become yellow (that is when the bark was collected for the experiment) the dominating light is yellow-red (Fig. 2). Even if the proportional ratio of yellow-red to green-blue is compared, the dominating light in this environment is yellow-red in both cases. Taking into account the fact that the highest concentration and the biggest size *Desmococcus vulgaris* cells were noted with yellow filter, it should be assumed that these light conditions were optimal. As LYMAN & KAUFMAN (1980) showed, unicellular mastigophoran cells of *Euglena* genus illuminated with yellow-red light synthesize chlorophylls more intensely than with blue light.

References

AHMADJIAN V. 1967. A guide to the algal occuring as lichen symbionts. – Phycologia 6: 127–160.

CZECZUGA B. 1975. Spheroidenone – a dominating carotenoid in purple bacteria *Thiopedia rosea* WINOGR. *(Thiorhodaceae)*. – Bull. Acad. Pol. Sci., Ser Sci. biolog. 23: 181–184.

— 1977. The effect of light on the content of photosynthetically active pigments in plants. I. Adaptative significance of carotenoids in *Chlorophyta* subjected different light conditions. – Bull. Acad. Polon. Sci., Ser. Sci. biolog. 25: 507–510.

— 1978. Lutein – a carotenoid dominating in *Desmococcus vulgaris (Chaetophoraceae)*. – Bull. Acad. Polon. Sci., Ser. Sci. biolog. 26: 453–455.

— 1981. The effect of light on the content of photosynthetically active pigments in plants. III. The effect of short rays of the visible spectrum on the chlorophylls and carotenoids content of lichens. – Nova Hedwigia 35: 371–376.

—, LENGIEWICZ I. & GOLECKA-RYBACZEK A. 1980. The effect of light on content of photosynthetically active pigments in plants. II. Effect of blue-green light on the total chlorophyll and carotenoid content in *Chlorophyta*. – Bull. Acad. Polon. Sci., Ser. Sci. biolog. 28: 451–457.

JEFFREY S. W. & HUMPHREY G. F. 1975. New spectrophotomeric equations for determining chlorophylls a, b, c_1, and c_2 in higher plants, algae and natural phytoplankton. – Biochem. Physiol. Plant. 167: 191–194.

LYMAN H. & KAUFMAN L. 1980. Synergism between yellow and red light for chlorophyll synthesis in *Euglena*. – 5th Int. Congr. Photosynth., Halkidiki 1: 355.

VESK M. & JEFFREY S. 1977. Effect of blue-green light on photosynthetic pigments and chloroplast structure in unicellular marine algae from six classes. – J. Phycol. 13: 280–288.