Advanced Studies in Biology, Vol. 15, 2023, no. 1, 9 – 13
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https://doi.org/10.12988/asb.2023.91606

Influence of Blue and Red Light on Physiological and Biochemical Indicators of Tomato Plants

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Abstract

The effect of blue and red light on the relative humidity of leaves, on the content of photosynthetic pigments, the activity of photosystem 2, the amount of proteins and soluble carbohydrates in tomato leaves was studied. Photosynthetic pigments were determined by homogenizing leaves in 96% ethanol, then centrifuged at 200 g and in a spectrophotometer with wavelengths of 665, 649, and 440.5 nm. The amount of dissolved sugar was determined by the accelerated dichromate method at a wavelength of 630-570 nm. The amount of protein was determined on SP 2000 spectrophotometers at wavelengths of 230 and 260 nm**.** Studies have shown that in all varieties of tomatoes grown in red light, there is a slight decrease in the amount of protein during exposure to red light, an increase in the amount of photosynthetic pigments and soluble carbohydrates. In the leaves of all studied plants, an increase in carbohydrate content was noted under red light, while blue light stimulated protein synthesis in tomato leaves.

Key words: tomatoes; pigments; photosystem 2; proteins; carbohydrates

Introduction

It is well known that one of the important factors necessary for the growth, development and productivity of plants is the intensity and spectral composition of light. In the process of life in conditions of insufficient supply of sunlight, the process of photosynthesis is disrupted in the cells of the plant organism, immunity and resistance are reduced, both to negative environmental influences and to diseases, with subsequent disruption of the processes accompanying the growth and development of the organism. Vegetable crops, in response to a lack of sunlight, are one of those crops whose negative reaction is subsequently accompanied by a decrease in productivity indicators. Among vegetable crops, tomatoes occupy a special place in their reaction to the spectral composition of light. It is known that (Shchegolov and Zhmurko, 2006; Parks, 2003; Schäfer and Bowler, 2002; Smith, 1995), among plant receptors that perceive external light signals, the phytochrome system plays the most important role. Three classes of photoreceptors included in this system are now known: phytochromes, cryptochromes, and phototropins. Phytochromes perceive and transduce a light signal in the red region (660–730 nm). Plants contain at least five phytochromes - A, B , C , D and E , which differ in their physiological role (Halliday and Whitelam, 2003). Growth, development, morphogenesis, activity of a number of enzymes, synthesis of ribulose-1,5-bisphosphate carboxylase, chlorophyll, intensity of photosynthesis, accumulation and distribution of assimilates are subject to phytochrome control in plants. However, it should be noted that most studies have studied the rapid response to red light. There are only a small number of works devoted to the study of the action of blue and red light under field experimental conditions. Therefore, research in this direction seems appropriate.

Material and Method

Tomato varieties (Lycopersicon esculentum Mill.) were used in the work. Plants were grown in the experimental plot on plots with an area of 1 m2. Experimental plants were covered with a transparent film that transmits light at a wavelength of 420-480 nm (blue light) and 640-680 nm (red light). Photosynthetic pigments were determined by leaf homogenization in 96% ethanol using coefficients from Wintermans and De Mots, 1965 (Gavrilenko and Zhigalova, 2002). The content of soluble sugars was determined by the accelerated bichromate method, at a wavelength of 630-570 nm [Big practice 2012]. The content of proteins was determined on a spectrophotometer SP 2000, at wavelengths of 230 and 260 nm, according to the method of Kalb, Bernlohr [1977]. Means were compared using Duncan's multiple range test ($p = 0.05$)

Results and discussion

According to some literature data, the activation of phytochromes leads to an increase in the intensity of carbohydrate metabolism and the activity of carbohydrate metabolism enzymes. In our experiments, an increase in the content of chlorophylls and carotenoids was revealed, which was accompanied by the activation of the photosystem 2, a slight decrease in the content of proteins, and an increase in the content of carbohydrates in plant leaves. The results of the experiments showed that the morphometric and physiological parameters of tomato plants in red light change in one direction (table). The relative humidity of the leaves decreased in the Falcon variety by 12%, in the 22-74 variety - 7%, in the Krasnodar variety - 8%, in the Volgograd variety - 7%, in the Tolstoy variety - 8%, in the Rally variety - 15%. The amount of chlorophyll and carotenoids slightly increased in all varieties. The efficiency of Photosystem 2 was the same for varieties Falcon and 22-74, but slightly increased for varieties Krasnodar, Volgograd, Tolstoy and Rally. There was a slight decrease in the amount of proteins and an increase in the amount of carbohydrates. The greatest increase in the amount of carbohydrates was found in the leaves of the Krasnodar Tolstoy varieties. The results of our research show that the leaves of all studied tomato varieties show an increase in the amount of carbohydrates at red light. Blue light had a stimulating effect on protein synthesis in tomato leaves. Similar results were obtained in the works of other researchers. The study [Shchegolev, Zhmurko, 2008] showed that the amount of carbohydrates changes during the day: there are fewer water-soluble carbohydrates in the morning than in the evening, which, according to the authors, is associated with their intensive use in growth and metabolic processes.

Conclusion

Thus, the results of our studies showed that in the leaves of all the studied plants, an increase in the content of carbohydrates was noted under red light, while blue light stimulated protein synthesis in tomato leaves.

Table. The effect of blue and red light on the physiological and biochemical parameters of wheat and tomatoes*

Variety of tomata Spektrum of light	Relative humidite leaves, in %	Chlorophyll a+b, mg/l	Carotenoids, mg/l	F_v/F_m	Protein content ,in %	Carbohid rate content, in %
Falkon Blue light Red light	66 ±2,3 58 ±3,4	15,5 ±0,4 19,8 ±1,2	5,4 ±0,4 6,5 ±0,3	0,65 0,65	1,9 1,6	3,1 3,9
22-74 Blue light Red light	69 ±1,2 64 ±0,8	15,6 ±1,4 20,2 ±2,1	5,8 ±0,2 6,9 ±0.1	0,65 0,65	1,9 1,7	3,8 4,6
Krasnodar Blue light Red light	77 ±2,4 71 ±1,9	16,6 ±1,4 21,2 ±2,1	6,2 ±0,2 7,6 ±0,5	0,72 0,75	1,9 1,7	4,1 4,7
Volgograd Blue light Red light	72 ±0,8 67 ±1,2	18,7 ±1,1 23,2 ±2,5	7,5 ±0,4 8,4 ±0,6	0,71 0,76	2,0 1,8	3,9 4,8
Tolstoy Blue light Red light	82 ±0,7 75 ±1,3	20,4 ±0,6 26,5 ±1,7	8,2 ±0,3 9,5 ±0,6	0,72 0,76	1,9 1,7	3,9 4,9
Rally Blue light Red light	77 ±2,6 65 ±3,1	19,6 ±1,8 25,5 ±2,1	7,9 ±0,5 8,7 ±0,6	0,61 0,69	1,6 1,5	3,5 4,2

* Each value represents the mean ± SD (standard deviation) for the mean of $n = 3$ independent experiments $p = 0.05$.

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Received: January 5, 2023; Published: February 1, 2023