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Effects of Different Light Treatments on the Stomata Movements of Tomato (*Lycopersicon esculentum* Mill. cv. Joker) Seedlings

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Abstract: In this study, the effects of different light treatments (blue, green, orange, purple, red, transparent and yellow) on the stomata movements in the leaves of tomato seedlings were studied. In the control seedlings, the epidermis cell number, stomata number and index were higher in the lower surfaces of leaves in comparison with their upper surfaces. In addition, the stomata width and length in the leaves of control plants were fewer in the lower than in the upper surface. As for the applyings, they generally decreased the stomata number and index in varying degrees in both surfaces, while they partly increased the stomata width and length especially, in the lower surface according to control. Moreover, most of the treatments slightly increased the epidermis cell number in the upper surface, but did not show a meaningful effect, statistically, on this parameter in the lower one.

Key words: Light, stomata index, stomata number, stomata size, tomato

INTRODUCTION

Plants are able to modify their growth, development and physiology according to a variable environment. This ability of plants plays a key role in determining their tolerance to stresses and maintains efficient growth (Murchie and Horton, 1997; Walters *et al*., 2003). One of the most important environmental factors is light. Light is not only an energy source for photosynthesis but also, a stimulus that regulates numerous developmental processes, from seed germination to the onset of flowering (Christie, 2007).

It is well known that light plays an important role in many physiological processes such as seed germination (Faravani and Bakar, 2007), seedling growth (Kitaya *et al*., 1995), morphogenesis (Goins *et al*., 1997), chloroplast development (Akoyunoglou and Anni, 1984), chlorophyll and carotenoid contents (Lee *et al*., 2007), photosynthesis (Saebo *et al*., 1995), transpiration (Brogardh, 1975), respiration (Ribas-Carbo *et al*., 2001), flowering (Mor and Halevy, 2006), osmoregulation (Talbott and Zeiger, 1996), phototropism (Kubo and Mihara, 1996) and enzyme activity (Montagnoli, 2008).

Light mostly causes also alterations in the stomata movements of plants. Unfortunately, there are few studies about the effects of light on this subject especially, the parameters examined in this study. Plant leaf stomatal opening or closure is modulated by various environmental and endogenous factors. One of the components of major importance is light. Sharkey and Raschke (1981), Eckert and Kaldenhoff (2000) and Talbott *et al*. (2006) observed that blue and red light stimulated the stomatal opening, whereas green light inhibited the opening. The specific responce of guard cell protoplasts to blue and red light induces a change of guard cell osmotic potential caused by proton pumping and hyperpolarization of the plasma membrane (Assmann *et al*., 1985) followed by influx of ions (Hedrich and Schroeder, 1989) as well as starch degration and malate biosynthesis (Talbott and Zeiger, 1993). As a concequence, water enters the cell resulting in stomatal opening. Fernandez and Mujica (1973) determined that an increase in light intensity decreased the epidermis cell number and increased the stomata number, index and size. Schoch *et al*. (1984) reported that blue and far-red light reduced the stomata index while red light increased this index. Kim *et al*. (2004) showed that blue and red light increased the stomata size and decreased the stomata number. Lee *et al*. (2007) found that white light increased the stomata number and size, while blue light reduced the mentioned parameters. In addition, the same researchers pointed out that red light decreased the stomata number, but increased the stomata size.

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The aim of this study is to examine the influences of different light treatments on the stomata movements in the leaves of tomata seedlings.

MATERIALS AND METHODS

Plant materials and light treatments: In this study, tomato (*Lycopersicon esculentum* Mill. cv. Joker) seedlings were used. The colors of light used in the experiments were blue, green, orange, purple, red, transparent and yellow. In addition, day light was used for control seedlings. Light intensity was 27826 lux for blue, 35143 lux for green, 24372 lux for orange, 33355 lux for purple, 29301 lux for yellow and 86065 lux for day light.

Growth conditions of the seedlings: The experiments were carried out in Agricultural Research Central of Suleyman Demirel University. Ten seedlings were implanted into each parcel with 30 cm distances on June 4. The seedlings were covered with plastic tunnels (PE) with different colors and were grown for 60 days. The control seedlings were not covered with PE and were grown in day light conditions. The height of tunnels was 80 mm and their thickness was 0.3 mm. Irrigation and fertilization procedures were made by using trickle irrigation system.

Anatomical observations: Superficial sections were taken from the second leave of 60 days old seedlings by a microtome, in 6-7 μm thickness. Stomata and epidermis cells in a 1 mm^2 unit area were counted to determine the stomata index. The counts were made both in the lower and upper surfaces of each leaf 10 times as 3 replicates and the averages were calculated. After the determination of the number of stomata and epidermis cells in the leaf unit area, the stomata index was estimated according to the method of Meidner and Mansfield (1968).

Stomata width and length were also determined in μm by using ocular micrometer. Statistical evaluation concerning all parameters was realized by using SPSS program according to Duncan's multiple range test.

RESULTS

The findings related with effects of different light treatments on the stomata movements in the leaves of tomato seedlings are shown in Table 1.

The epidermis cell number in the leaves of control seedlings grown in day light conditions was lower in the upper than in the lower surface. The applyings mostly increased it the upper surface, while they were generally ineffective on this parameter in the lower one. Green, orange, purple and transparent lights caused a slight increase in the epidermis cell number in the upper, whereas green light in the lower surface.

The stomata number in control group was higher in the lower than in the upper surface. The treatments mostly decreased this parameter, in both surfaces; the biggest reduction in their number in the lower and upper surfaces was caused by blue and purple lights, respectively. Moreover, transparent light partly increased the stomata number in the lower, while red light caused a slight increase in the upper surface.

The stomata of control was wider in the upper than in the lower surface. Most of the applyings decreased the stomata width in the upper surface; the biggest reduction in their width in the upper was caused by transparent light. As for the lower surface, many treatments increased this parameter. Green, red and yellow lights leaded to maximum increase in the stomata width in the lower surface.

The stomata of control was longer in the upper than in the lower surface. The applyins generally increased the stomata length, especially in the lower surface. Yellow light caused maximum increase of this parameter in the lower one. Blue, green and red lights followed this. As for the upper surface, transparent and yellow lights partly increased the stomata length while the others except for purple showed the same values as the control.

The stomata index of control was higher in the lower than in the upper surface. The treatments mostly decreased this index, in both surfaces. Green light leaded

Table 1: Stomata movements in the leaves of tomato seedlings grown under different light conditions

	Epidermis cell number		Stomata number		Stomata width (μm)		Stomata length (μm)		Stomata index	
Treatments	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Control	*22.1±0.8^{a}	21.8±1.3^{b}	7.1±0.7^{d}	3.8±1.1^{de}	19.6±1.1^{ab}	21.3±1.5^{bcd}	32.1±3.7^{bc}	33.8±3.1^{ab}	24.4	14.8
Blue	22.1±2.1^{a}	18.4±1.1^{a}	4.8±1.1^{a}	1.5±0.6^{ab}	22.6±2.9^{de}	21.8±1.8^{d}	32.8±3.5^{c}	32.7±2.3^{ab}	17.8	7.7
Green	25.6±3.6^{b}	23.3±3.3^{c}	5.4±1.2^{b}	2.9±0.8^{c}	23.4±2.6^{e}	21.7±2.1^{cd}	33.4±2.8^{cd}	33.2±2.4^{ab}	17.5	11.2
Orange	22.1±0.8^{a}	22.7±0.8^{bc}	5.7±1.1^{b}	3.4±0.6^{cd}	20.5±1.3^{bc}	20.9±1.1^{abc}	29.7±2.7^{a}	32.8±2.6^{ab}	20.6	13.1
Purple	21.7±1.2^{a}	23.6±1.6^{c}	5.6±0.6^{b}	1.3±0.4^{a}	21.2±2.5^{cd}	20.4±1.2^{ab}	28.9±1.8^{a}	32.1±1.4^{a}	20.4	5.2
Red	21.2±1.1^{a}	22.1±1.2^{b}	6.3±0.5^{c}	4.3±1.2^{e}	23.7±2.1^{e}	20.9±1.7^{abc}	33.1±3.9^{cd}	32.7±2.9^{ab}	22.8	16.2
Transparent	22.2±0.7^{a}	22.6±0.8^{bc}	7.9±0.7^{e}	2.1±1.2^{b}	18.6±1.5^{a}	19.7±2.4^{a}	29.9±1.8^{ab}	34.6±4.8^{b}	26.2	8.4
Yellow	21.7±0.8^{a}	22.2±0.7^{b}	6.4±0.8^{c}	3.1±0.6^{c}	23.2±3.3^{e}	20.5±0.9^{abc}	35.1±5.2^{d}	34.3±2.7^{b}	22.7	12.4

*The difference between values with the same letter in each column is not significant at the level 0.05 (±SD)

to maximum reduction in the stomata index in the lower, whereas purple light in the upper surface. On the other hand, transparent and red lights caused a slight increase in the lower and upper surfaces, respectively.

DISCUSSION

Plant stomata, the vital gate between plant and atmosphere may play a central role in plant responses to environmental conditions, which have been and are being investigated from molecular and whole plant perspectives, as well as at ecosystem and global levels (Nilson and Assmann, 2007). Many researchers have reported the stomata movements response to various environmental factors, such as CO_2 concentration (Sharkey and Raschke, 1981), high temperature (Beerling and Chaloner, 1993), salinity (Cavusoglu *et al*., 2007a), drought (Xu and Zhou, 2008), precipitation change (Yang *et al*., 2007) and plant density (Zhang *et al*., 2003). Besides, the changes in environmental conditions, internal factors such as photohormones were found to play a significant role in regulating of the stomata movements (Cavusoglu *et al*., 2007b, 2008).

Among the environmental factors affecting plant activity, light quality is one of the most important factors regulating the stomata movements (Willmer and Fricker, 1996). Most research has concentrated on light quantity. High light intensity is believed to promote the stomata movements (Fernandez and Mujica, 1973), although this correlation is not always observed (Kubinova, 1991). The effects of light quality have not been extensively studied. Kleiber and Mohr (1963) and Schoch *et al*. (1984) suggested that phytochrome controlled stomata development. Blue or far-red light appeared to decrease stomata index when provided as a night-treatment at low fluence and compared with darkness or red light in *Vigna sinensis* (Schoch *et al*., 1984). Alternatively, Rajapakse and Kelly (1993) reported a 10% decrease in stomata density in *Chrysanthemum* when the blue/red ratio increased. Unfortunately, none of the studies, in which blue light was varied maintained constant phytochrome phototationary states between treatments; therefore, possible effects of blue light due to phytochrome were not eliminated.

In the present study, different light treatments generally increased the stomata width and length, especially in the lower surface, compared to the control, but decreased the stomata number and index in both surfaces. Moreover, they increased the epidermis cell number, particularly in the upper surface (Table 1).

Reducing effects of different light applyings on the stomata number (Kim *et al*., 2004) and stomata index (Schoch *et al*., 1984) were reported. On the other hand, there are reports indicating that different light treatments increase the stomata width and length (Lu *et al*., 1993; Lee *et al*., 2007).

These results indicate that tomato leaves acquire succulent (for example, the decrease in stomata number and the increase in stomata size) properties (Strogonov, 1964) under different light conditions. Moreover, the tomato seedlings can provide adaptation to different light conditions by reducing their stomata numbers in both surfaces and so decrease transpiration and water loss. In addition, a greater stomata size can facilitate CO_2 diffusion into the leaf (Parkhurst, 1994) and thus, increase photosynthesis rate. Furthermore, an increase of leaf area as a result of increasing the epidermis cell number of the upper surface can serve to the same aim.

CONCLUSION

There are few study yet on the effects of different light treatments on the stomata movements. There is a need for more comprehensive and detailed researches for this subject to be made clear.

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