LITHUANIAN RESEARCH CENTRE FOR AGRICULTURE AND FORESTRY

The response of tomato growth and photosynthetic performance during different growth stages to variable LED lighting intensity

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The objective:

To evaluate the effect of variable LEDs light intensity on the growth and photosynthetic performance of tomato (*Solanum lycopersicum* L. cv. Micro Tom) at seedling and development stages.

Materials and methods:

Experiment was performed in controlled environment growth chamber: day/night temperature 23/18°C, photoperiod 16-h, relative humidity 50-60%. In seedling stage, tomato grew under red (R; 660 nm) and blue (B; 445 nm) LED lighting with different photosynthetic photon flux density (PPFD; 150 and 250 µmol m^{-2} s^{-1}). After seedling stage, the lighting intensity was shifted as follows: 150, 150 to 250, 250, 250 to 150 µmol m^{-2} s^{-1}.

Table 1. Experimental design

	Input	PPFD, µmol $m^{-2}s^{-1}$	PPFD, µmol $m^{-2}s^{-1}$
Total	100%	**250**	**150**
M 445 nm	20%	50	30
R 660 nm	80%	200	120
Seedling stage		**Vegetative growth**	
150		**150**	
250		**150 to 250**	
		250	
		250 to 150	

Summary and conclusions:

Results showed that light intensity leads to different growth response of tomato seedlings. The irradiation with 250 µmol m^{-2} s^{-1} led to significant increase of tomato leaf area, fresh and dry biomass. Plants subjected to lower light intensity resulted in longer hypocotyls, internodes and smaller leaves. Continuous irradiation with 150 µmol m^{-2} s^{-1} or reduction to 150 µmol m^{-2} s^{-1} during vegetative growth resulted in stem elongation. The increase till 250 µmol m^{-2} s^{-1} PPFD at seedling or development stage led to higher number of inflorescences with fruits.

Table 2. Response of growth rates to light flux at different growth stages

PPFD, µmol $m^{-2}s^{-1}$	Leaf area, cm^2	Fresh biomass, g	Dry biomass, g	Height, cm	Leaf area, cm^2	Fresh biomass, g	Dry biomass, g	Height, c m	Inflorescense with fruits, pcs.
	Seedlings				Vegetative growth				
150	145.64a	5.05a	0.47a	9.13b	475.98a	17.56a	2.12ab	18.67c	2.67ab
250	157.49b	6.05b	0.66b	6.00a	450.45a	22.45c	2.47b	11.23a	3.00ab
150 to 250					449.69a	20.00ab	2.22ab	15.00b	3.33b
250 to 150					498.61b	20.87ab	2.26ab	17.43c	3.33b

The photosynthetic response of tomato varied depending on applied irradiance intensity. The higher photosynthetic rate (P_r) was for tomato seedlings subjected to 250 µmol m^{-2} s^{-1} PPFD; these plants had reduced stomatal conductance (g_s), transpiration rate (T_r) and increased water use efficiency (*WUE*). In vegetative growth stage, the continuous irradiation with 150 µmol m^{-2} s^{-1} resulted in significant P_r stimulation, due to decreased g_s, T_r and increased *WUE* and light usage efficiency (*LUE*). The changes of PPFD from "150 to 250" or "250 to 150" µmol m^{-2} s^{-1} PPFD during development stage led to inhibition of photosynthetic performance.

Table 3. Response of the photosynthetic system to light flux at different growth stage

PPFD, µmol $m^{-2}s^{-1}$	Pr, µmol CO_2 m^{-2} s^{-1}	Tr, mmol H_2O m^{-2} s^{-1}	gs, mol H_2O m^{-2} s^{-1}	WUE, µmol CO_2 $mmol^{-1}$ H_2O	LUE, mol CO_2 mol^{-1} photons	Pr, µmol CO_2 m^{-2} s^{-1}	Tr, mmol H_2O m^{-2} s^{-1}	gs, mol H_2O m^{-2} s^{-1}	WUE, µmol CO_2 $mmol^{-1}$ H_2O	LUE, mol CO_2 mol^{-1} ph otons
	Seedlings					Vegetative growth				
150	16.36a	3.68b	0.51b	4.46a	0.11b	19.2d	0.77a	0.03a	24.81c	0.13d
250	19.37b	3.30a	0.39a	6.08b	0.08a	17.0bcd	2.02c	0.19c	8.55a	0.07b
150 to 250						10.8a	1.25b	0.10b	8.84a	0.04a
250 to 150						15.0b	1.10ab	0.09b	14.32b	0.10c

Acknowledgement:

This research was funded by a grant (No. S-MIP-17-23) from the Research Council of Lithuania.

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Seedling stage

Vegetative stage