The effects of LED light on growth and morphogenesis of vegetable seedlings cultivated in growth chambers

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Cucumber seedlings

ABSTRACT

Tomato and cucumber are ones of the main crops grown in greenhouses. The lack of natural light during winter (short photoperiod, low level of illumination) resulted in slow growth and development, excessive stem elongation, weak leaf greenness and delayed the phase of generative growth. Most often the high pressure sodium lamps (HPS) are used for lighting vegetables during winter months, however the aplication of modern and energy-efficient LEDs gives the opportunity to adjust the spectral composition of the light spectrum, which can significantly improve plant shape and quality. The quality and shape of tomato and cucumber seedling used for winter production are the the key factors for ensuring fast growth and early crop.

THE AIM OF EXPERIMENT

The objective of this study was to evaluate growth and development of tomato and cucumber transplants grown in controlled compartments witch artificial lighting using HPS and two LED different light spectra fixtures, with different ratio of B:R.

MATERIALS AND METHODS

Plant material:The experiment was performed in a climate controlled compartments of the Research Institute of Pomology and Floriculture in Skierniewice, Poland in 2015. Seeds of tomato ‘Debut’ and cucumber ‘Kafkas’ were sown on 26.10.2015 and 27 XI 2015 respectively, into multicell trays with rockwool plugs (Grodan).

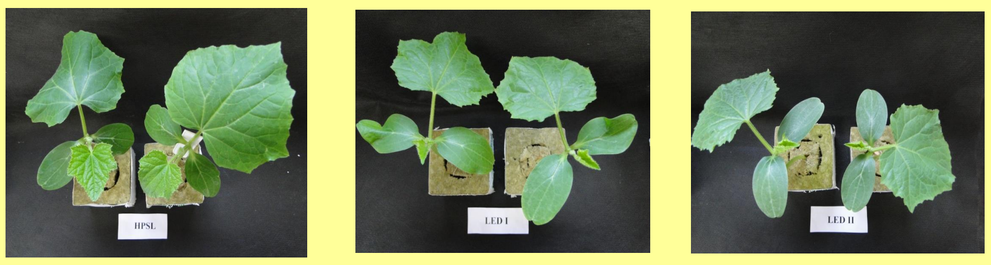
Light treatments: After germination seedling were kept in controlled climate compartment with artificial lighting using HPS (400W Philips lamps) and two types of LEDs fixture, with a power of 110 W: LED I: R (640-660 nm) 54,64%; B (433-450 nm) 43,67%, FR (735 nm) 1,52% and LED II R (640-660 nm) 68,5%, B (433-450 nm) 28,4% and FR (735 nm) 3,1%. Total PPFD were 122 and 118,7 µmol m^{-2} s^{-1} for LED I and LED II, respectively. The photosynthetically active radiation (PAR) at the plant level was 100- ±20 µmol m^{-2} s^{-1}, photoperiod during first week after germination 14/10 h and later on 16/8 h day/night

Growing conditions: seeds were germinated in the rockwool plugs in growth chambers with controlled temperature 22 to 24/18°C day/night and relative air humidity (RH) at 80% at the beginning and then 60-70%. After germination seedlings were transplanted into rockwool cubes 7,7 x 7,5 cm.Plants were fertilized regularly using complete nutrient solution (EC 1,6, pH 5,9), contained (mg dm^{-1}) NPK at 200: 31,5 and 240, respectively. Nutrient solution was prepared using complete fertilizer Kristalon (3:11:38), calcium nitrate and nitric acid.

Plant evaluation: Morphological measurements (height, fresh weight) measurements of the green color of leaves, relative chlorophyll content, expressed as index SPAD (Konica Minolta) were made on 4 weeks old transplants. Measurement of leaf stomatal conductance was done using porometer LICOR (USA). For measuring leaf surface the, the leaf area meter (Delta-T Devices, UK) was used.

Cucumber in climate chambers with LED

Leaf greenness evaluation using SPAD (Konica Minolta Japan)



Cucumber ‘Kafkas’ seedlings after 4 weeks of cultivation

Tomato ‘Debut’ seedlings’ after 4 weeks of cultivation

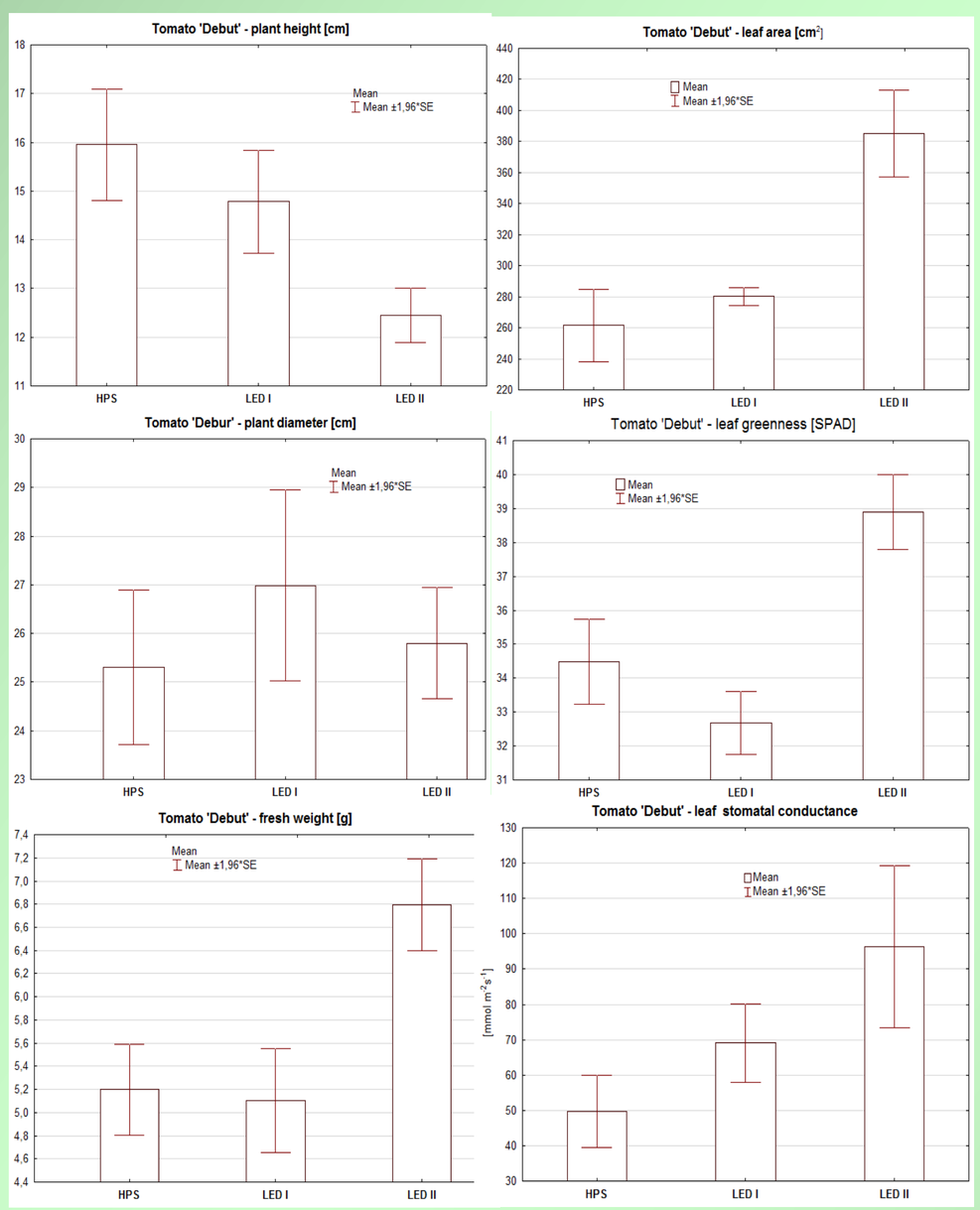


Fig. 1. Tomato ‘Debut’ after 4 weeks of cultivation

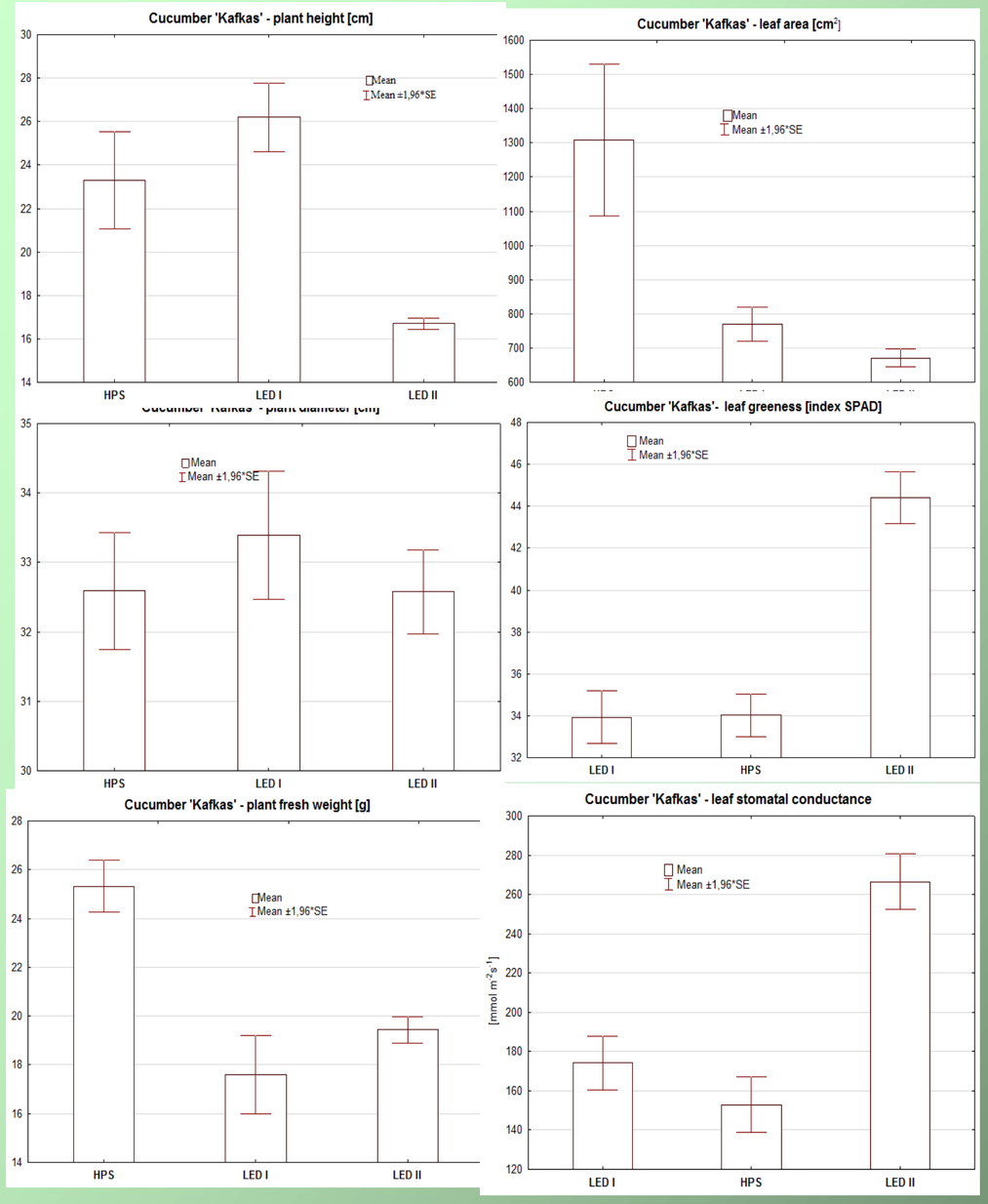


Fig. 2. Cucumber ‘Kafkas’ after 4 weeks of cultivation

SUMMARY OF THE RESULTS:

- The results indicate that varying lighting systems during vegetable seedlings production affected plant growth and quality. More compact plants were obtained using LEDs for seedlings cultivation

- The use of LEDs allowed to obtain very good plant habit, especially in the first stage of cultivation of tomato seedlings. Tomato seedlings grown with HPS were the highest, however that grown with LED II (with lower ratio of B:R than LED I) had the highest fresh weight, highest leaf area and the best leaf coloration. Vegetable growers of tomato and cucumber prefer compact and strong seedlings for winter planting,

- Cucumber seedling reacted differently than tomato to the different light spectra. Cucumber grown with HPS lamps were characterized by higher plant weight and larger surface of the leaves than that grown with LED’s. Seedlings lighted with LED I type lamps were taller and had a larger diameter. In turn, using the lamps LED II resulted in the best leaf coloration and plants were characterized by a high stomatal conductance. Higher fresh weight gain cucumber seedling grown under HPS lamps than that grown under the LED’s, probably due to the effect of higher temperatures of the leaves, as HPS lamps emit more heat and cucumber has higher thermal requirements than tomato.

- Producing vegetable seedlings during winter using LED’s ensuring good plant quality, especially in the case of tomato. Due to the high electrical efficiency of LED fixture and possibility to modification of ligh spectrum it seems that the future for LED’s in horticulture is very promising.

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