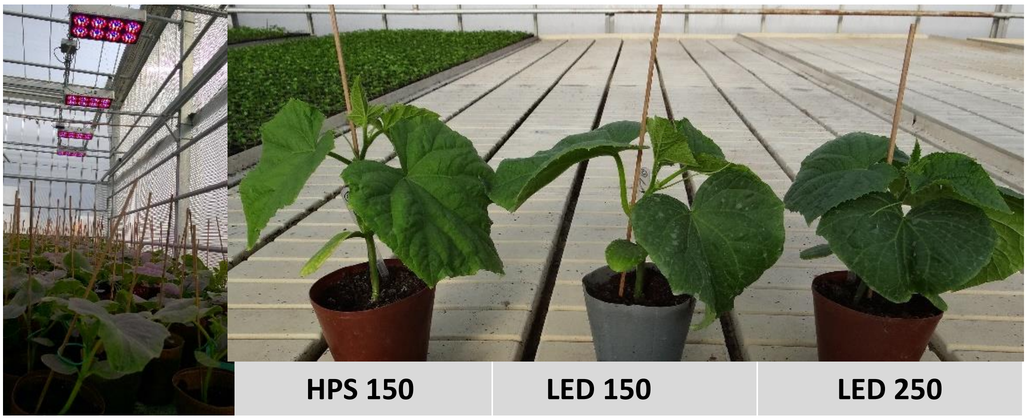
HLFC series lighting for cucumbers

Qualitative cucumber transplants should be short (hypocotyl height up to 5 cm), with strong and thick stem, short internodes and dark green leaves. Seeking to raise such transplants in greenhouse, one of the most important factors is properly selected supplemental lighting.

Experiments, performed in industrial greenhouses of LRCAF Institute of Horticulture show, that raising cucumber transplants, HLFC series LED lighting is superior to high pressure sodium (HPS) lighting both in electricity consumption and light spectral effects on transplant quality (Fig. 1).

Fig 1. Cucumber ’Mandy‘ F1 transplants, raised under HLFC series LED or high pressure sodium (HPS) lamps in the spring of 2014. Photosynthetic photon flux density –150 or 250 µmol m^{-2} s^{-1}



Cucumber ’Mandy‘ F1 transplants, cultivated under HLFC series LED lighting possessed significantly shorter hypocotyls, however this did not affect total plant height. Thicker hypocotyl, as well as higher leaf area, aboveground and root biomass confirm higher transplant quality, as compared to the ones, raised under HPS lamps (table 1). Increasing HLFC series LED light intensity form 150 to 250 µmol $m^{-2}s^{-1}$, positive light effects on cucumber transplant biometric parameters were highlighted even more.

Table 1. Biometric parameters of cucumber ’Mandy‘ F1 transplants, raised under HLFC series LED or high pressure sodium (HPS) lamps in spring of 2014, when photosynthetic photon flux density was 150 or 250 µmol m^{-2} s^{-1}.

Biometric parameters	Lighting in greenhouse		
	HPS 150	**LED 150**	**LED 250**
Hypocotyl height, cm	5,6±0,8	**4,7**±0,5[b]	**4,1**±0,5[b]
Hypocotyl diameter, cm	0,4±0,0	**0,5**±0,0[a]	**0,6**±0,0[a]
Plant height, cm	17,5±2,8	17,0±2,3	17,1±2,5
Leaf number, pcs.	4,4±0,2	4,3±0,1	4,3±0,1
Leaf area, cm^2	656±56	**735**±45	**789**±29
Green weight, g	23,5±2,2	27,3±1,9	**30,4**±0,6[a]
Root green weight, g	8,0±0,8	**8,7**±0,7	**9,4**±1,3

a – significantly higher, b – significantly lower than HPS when; p≤0,05.

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Repeating cultivation experiments with the same cucumber hybrid during different cultivation seasons it was determined, that transplant photosynthesis intensity rate in winter time is 2-4 times lower, than in spring. When overall plant vitality is higher, positive LED light effect is more pronounced: photosynthesis intensity in transplants, raised under LEDs in spring is ~30% higher as compared to transplants, raised under high pressure sodium lamps under the same intensity. Independently from season, HLFC series LED lighting resulted in higher chlorophyll ratio in greenhouse, what also reflects higher photosynthetic potential of these transplants. The ratio between aboveground plant weight and root weight, reflecting biomass allocation between source and sink organs, was dependent not only on the different season of the year, but on specific microclimatic conditions during each run. The trend was observed, that LED results in higher root biomass formation, as compared to leaf biomass, what results in better rooting after transplanting. Together, the slight inhibiting effect (independently from cultivation season) on flower formation and growth under LED light was determined.

Fig. 2. Physiological indices of cucumber 'Mandy' F1 transplants, raised during different seasons under HPS and HLFC series LED lighting. Photosynthetic photon flux density –150 µmol m^{-2} s^{-1}.

HLFC series lighting for cucumber harvesting and fruit quality

After transplanting in industrial greenhouse (with no further artificial illumination, the residual effect of the lighting on transplants was observed. Slower cucumber flower formation under LED illumination in transplant stage resulted in slightly lower early harvest (table 2), but did not affect total harvest or fruit weight.

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Table 2. Cucumber 'Mandy' F1 harvest indices, when transplants rased under HPS or HLFC series LED lighting (HPS Transpalnts and LED Transplants) or when plants are also illuminated with LED during harvesting (LED Harvesting). Photosynthetic photon flux density – 150 µmol m^{-2} s^{-1}.

Harvest indices	**HPS Transplants**	**LED Transplants**	**LED Harvesting**
Early harvest, kg per plant	2,3±0,2	1,9±0,2	1,9±0,2
Total harvest, kg per plant	9,0±0,5	9,0±0,5	**8,0**±0,5
Fruit weight, g	75±2	75±2	76±2

When cucumbers were illuminated with LED during harvesting, the inhibiting effect on their elongations was observed, as well as slightly decreased harvesting. In spring-summer season supplemental lighting in Lithuanian climate zone is not actual, because natural illumination in greenhouse is sufficient.

Evaluating LED lighting effects on fruit quality, the lighting applied in transplant stage, later had no remarkable effect on fruit quality. LED lighting, applied during harvesting resulted in slightly higher contents of antioxidant phenolic compounds and ascorbic acid in fruits (Fig. 3).

Fig. 3. Biochemical parameters of cucumber 'Mandy' F1 fruits, when their transplants were raised under HPS or HLFC series lighting (HPS Transplants and LED Transplants) or when plants were illuminated with LED during harvesting (LED Harvesting). Photosynthetic photon flux density – 150 µmol m^{-2} s^{-1}. Results presented in fresh weight.

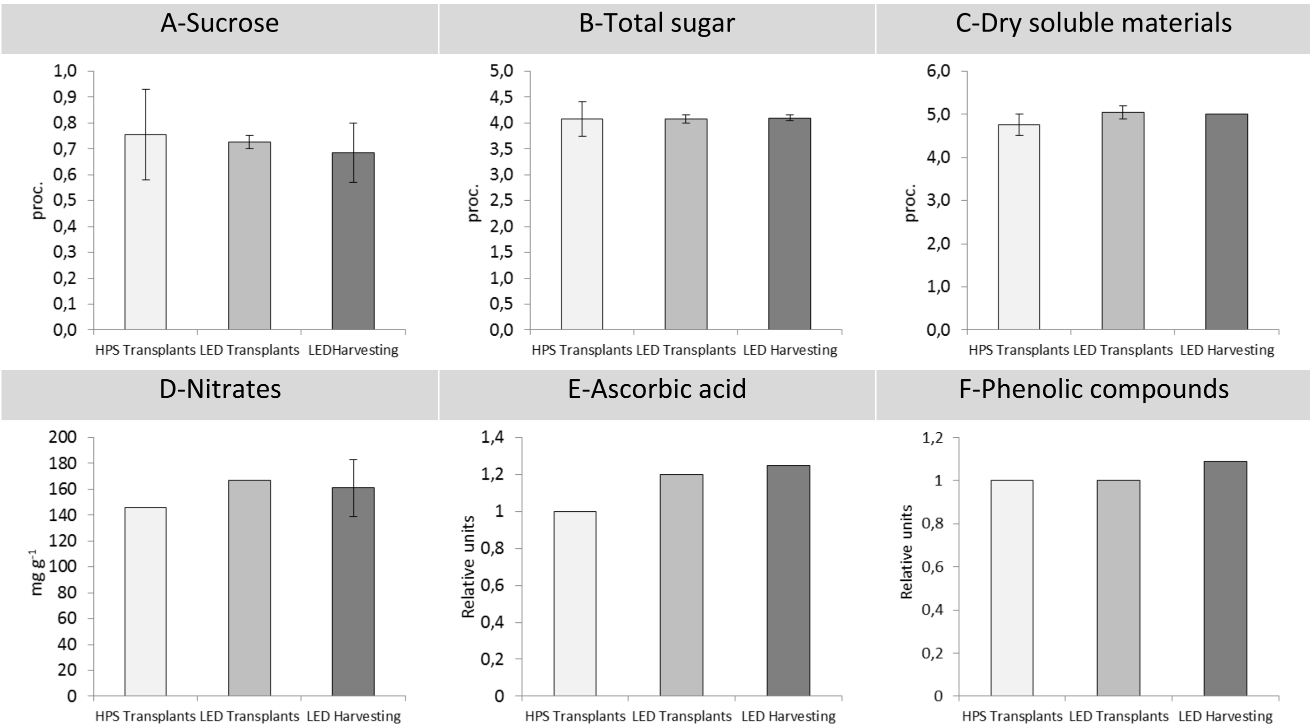

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Table 3. Mineral element contents in cucumber leaves and fruits in harvesting time. Only transplants were illuminated with HPS or HLFC series LED light, or plants were illuminated with LED during harvesting (LED Harvesting). Photosynthetic photon flux density – 150 µmol m^{-2} s^{-1}. Results presented in green weight.

		HPS Transplants	LED Transplants	LED Harvesting	HPS Transplants	LED Transplants	LED Harvesting
Elements			**Leaves**			**Fruits**	
mg g^{-1}	Ca	13,8±0,2	12,9±0,1[b]	**14,3**±0,1[a]	0,2±0,0	**0,3**±0,0[a]	**0,3±0,0**[a]
	K	2,6±0,0	**2,7**±0,0[a]	**2,8**±0,0[a]	1,7±0,0	1,7±0,0	1,7±0,0
	Mg	2,7±0,0	2,7±0,0	**2,8**±0,0[a]	0,2±0,0	0,2±0,0	0,2±0,0
	P	0,5±0,0	0,4±0,0[b]	**0,6**±0,0[a]	0,3±0,0	0,3±0,0	0,3±0,0
	Na	1,4±0,0	**1,5**±0,0[a]	**1,5**±0,0[a]	0,4±0,0	0,4±0,0	0,4±0,0
µg g^{-1}	Fe	27,7±0,3	**33,5**±0,1[a]	24,8±0,1[b]	0,9±0,0	**1,4**±0,1[a]	**1,1±0,0**[a]
	Zn	1,3±0,1	**1,8**±0,1[a]	**2,4**±0,1[a]	0,9±0,0	0,8±0,0[b]	**1,1±0,0**[a]
	Mn	39,4±0,2	29,9±0,4[b]	36,9±0,0[b]	0,6±0,0	0,6±0,0	**0,9±0,0**[a]
	B	8,1±0,2	**11,3**±0,2[a]	**10,2**±0,1[a]	-	-	-

a – significantly higher, b – significantly lower than HPS when; p≤0,05.

HLFC series LED lighting in most cases resulted in better cucumber root formation and higher mineral element uptake to leaves (table 3). Qualitative cucumber transplants, raised under LEDs, even with no supplemental lighting during further growth and harvesting, resulted in higher mineral uptake, especially of zinc and iron. This could be attributed for higher overall vitality of plants. Illuminating cucumbers with LEDs during harvesting time, more of potassium, calcium, magnesium, phosphorus were accumulated as compared to non-illuminated plants. Evaluating mineral element contents in fruits, ir was observed, that in cucumber fruits, whose transplants were raised under HLFC series LEDs, slightly higher contents of calcium and iron were determined. When plants were illuminated during harvesting, better uptake of potassium, iron, and zinc was observed.

Conclusions

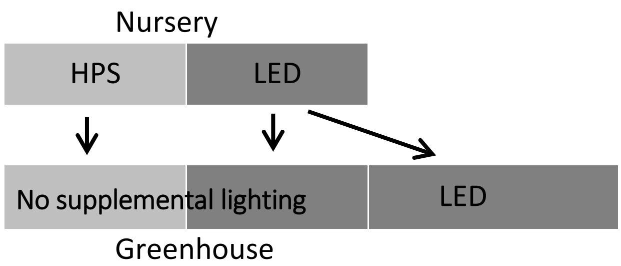
- Evaluating HLFC series LED lighting for cucumbers in industrial greenhouse, pronounced seasonality effects were observed, associated with overall plant vitality. In winter season transplant physiological indices differed more sensitively, depending on applied lighting intensity. Despite these trends, both in winter and spring 150 µmol $m^{-2}s^{-1}$ flux of HLFC LED lighting is sufficient.
- Independently from applied light source, the effects of lighting spectra and intensity are specific for plant species, variety, and developmental stage and preparing recommendations for lighting regimes, it is necessary to proportionate them with plant morphological, physiological features.
- Supplemental LED lighting resulted in higher root biomass formation in cucumber transplants, better rooting after transplanting and higher uptake of mineral elements.
- Though cucumber transplants, illuminated with LEDs in spring, developed slower, as compared to ones, raised under HPS lamps, after two weeks after transplanting no differences in growth parameters were observed. The effects of supplemental LED lighting in greenhouse were superseded by high natural illumination level.

- Slower cucumber transplant development, as compared to HPS lams, resulted in slightly latter and smaller early harvest however, no remarkable effect on total harvest or harvesting duration were observed.
- Supplemental LED lighting in greenhouse had no remarkable or tendentious effect on fruit quality.

Methods

The objective of studies – cucumber hybrid 'Mandy' F1. Experiments were performed in November-December of 2014, April-May of 2014 and 2015. Transplants were cultivated in heated V-type plastic greenhouse in polymer pots, filled with neutralized peat substrate with fertilizers (PG MIX (NPK 14-16-18; 1,3 kg/m^3)). Together with natural lighting transplants were illuminated with HLFC series LED lamps at photosynthetic photon flux density of 150 or 250 µmol m^{-2}s^{-1} and high pressure sodium lamps for reference (HPS, Son-T Agro 400 W, Philips). Photoperiod – 16 h. Day/night temperature 21/17°C.

Cucumbers were transplanted and further cultivated (May-July of 2015) in double plastic covered greenhouse. Cucumbers cultivated in 25L peat bags (2 plants per bag). Plant density –2,5 plants per square meter. Drip irrigation was used for plant nutrition. "Nutrifol" green and brown complex fertilizers, magnesium sulphate, calcium and ammonium nitrate were applied according to the growth stage. EC of nutrition solution – 2,5-2,8, pH 5,5-5,8. The residual LED and HPS lighting effect for transplant harvesting was evaluated, when no further artificial lighting was applied, or when plants were illuminated with HLFC series LED lighting during harvesting time. Photosynthetic photon flux density ~150 µmol m^{-2} s^{-1}.



After lighting experiment, transplant quality was evaluated. The photosynthetic pigment contents were evaluated by spectrophotometric method, biometric measurements were performed. Photosynthesis intensity was measured (Licor LI6400 XT). Micro and macro element contents were determined by ICP-OES method. After transplanting in greenhouse, biometric observations were performed, harvesting recorded. Fruit quality parameters (ascorbic acid, phenolic compound, saccharide contents evaluated. All measurements performed in three repetitions; results presented as average ±standard deviation.

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