

The effect of far-red (FR) enriched spectrum and end-of-day FR on tomato seedling in a controlled environment

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Introduction

The red to far-red (FR) ratio has significant effects on plant morphology. FR promotes extension growth of the stem and leaf in various plant species. Intelligent LED technology enables a high level of control over the amount and quality of light provided to plants as supplemental or sole-source lighting and this provides opportunity for commercial growers to control morphology of crop-plants. For example controlling stem height and thickness of tomato seedling provides more uniform stock material and thus allows easier matching rootstock and scions for grafting.

To study growth response on tomato in seedling stage we investigated growth performance of tomato seedling grown in three LED lighting strategies: without FR (noFR), FR-enriched spectrum (FR), and with FR only as a 30-minute end-of-day (EOD) treatment. Our goal was to identify lighting strategies that may be used for manipulating seedling stem morphology.

Conclusion

- Tomato seedlings treated with FR were taller and had larger leaves compared to seedlings grown without far-red which were shorter and also darker in color.
- Tomato seedlings grown under EOD FR were taller and had larger leaves than plants grown under FR-enriched spectrum.
- By adding FR only at the end of the day, growers will also be able to reduce energy use.
- Smart LED lighting systems can be implemented for energy-efficient and non-chemical control of plant morphology.
- This study has demonstrated the potential that Heliospectra's helioCORE™ can provide different light strategies that influence extension growth in tomato seedlings; giving horticultural LEDs another potential advantage over traditional non flexible technologies for lighting applications.

Materials and methods

Seedlings of tomato rootstock, *Solanum lycopersicum* 'Kaiser RZ F1' and 'Emperador RZ F1' were cultivated in a controlled environment growth room. The seedlings were germinated for 5 days under continuous LED light (lightbar V30H-P2A) before moving to experimental light treatment. The plants were cultivated under three different LED lighting strategies: without FR, FR-enriched spectrum, and with FR only as a 30-minute end-of-day (EOD) treatment. The photosynthetic photon flux density (PPFD) was similar (200 $\mu\text{mol photons/m}^2/\text{s}$) across lighting regimes; FR was added to provide the red-to-FR ratio of 8:1. The intensity of FR light in the EOD FR regime was the same as in the FR-enriched regime. The plants received 17.5 h of full spectrum LED light, the EOD had an additional 30 min of FR, from Heliospectra ELIXIA60-C series fixtures, as sole source lighting. The Heliospectra intelligent lighting system with the helioCORE™ scheduling module was used. The electricity consumption was monitored. Temperature was set to be maintained between 22/17 \pm 1°C and humidity to 60% in the growth room. Plants were irrigated according their needs with water with fertilizer (Plant-Prod® 20-20-20). The initial plant height was measured at the start of the light treatments and then recorded throughout the experiment. At the end of the experiment, after 15-18 days of treatment, the stem diameter was measured with a digital caliper. The experiment was repeated three times.

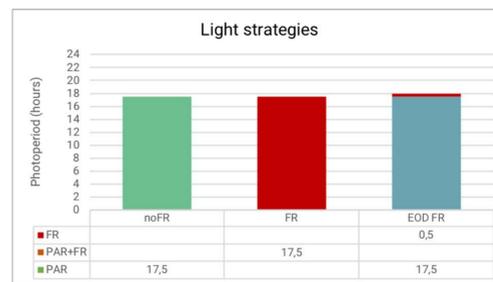


Figure 1. Duration of light exposure during photoperiod for each light regime.

HOURS	Energy Consumption (kWh)		
	NO FR	EOD FR	FR
8:00-1:30	4.7	4.7	5.1
1:30-2:00	-	0.1	-
Total daily	4.7	4.8	5.1
Total 18 days	84.6	86.4	91.8

Table 1. Electrical usage for each light regime.

The electrical usage was measured with wattmeter Christ electronic Professional for each light regime.

Results

There were visual morphological differences between the seedlings grown under the different light regimes.

Tomato seedlings grown without far-red were shorter and had darker green leaves compared to seedlings grown with far-red either as FR-enriched spectrum or EOD FR. The tomato seedlings grown under EOD FR had a taller stem and larger leaves than plants grown under FR-enriched spectrum.



Figure 2. 'Emperador' 17 days of treatment, from left to right noFR, EOD FR and FR.



Figure 3. 'Kaiser' 17 days of treatment, from left to right noFR, EOD FR and FR.

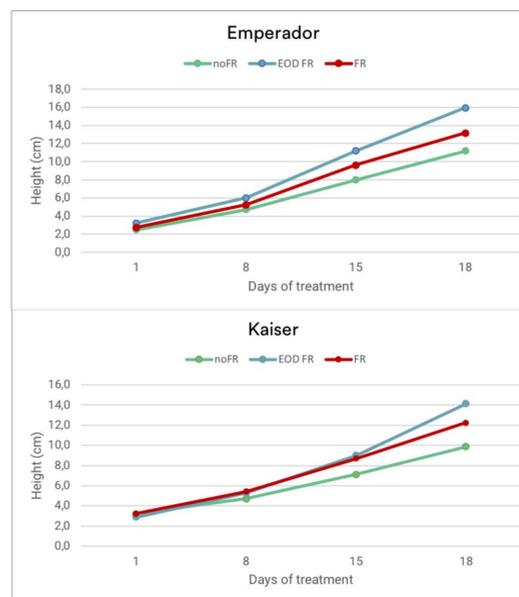


Figure 6. Plant height for each light regime during one repetition.

The light treatments effected both plant height and stem diameter. The far-red grown seedlings were both taller and had thicker stems than seedlings grown without FR. Seedlings treated with EOD FR had thicker and taller stem than those grown with FR-enriched spectrum.

	Plant height (%)		Stem diameter (%)	
	EOD FR	FR	EOD FR	FR
'Kaiser'	+14.7 %	+11.6 %	+3.6 %	+3.3 %
'Emperador'	+14.9 %	+12.4 %	+3.8 %	+3.5 %

Table 2. Plant height and stem diameter compared to seedlings grown without far-red.



Figure 4. The 3rd leaf of 'Emperador' seedlings.

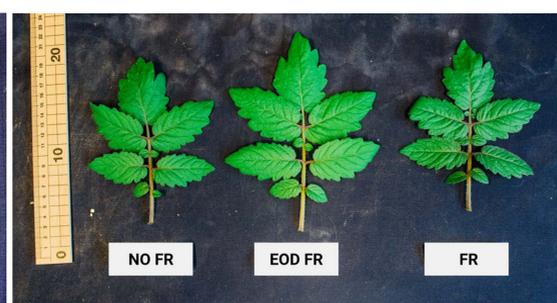


Figure 5. The 3rd leaf of 'Kaiser' seedlings.

The results indicate that differences in growth performance should be expected as an outcome of applying different FR strategies. If an extension growth of a tomato seedling is a wanted result, far-red can be utilized. By adding FR at the end of the day, growers may be able to reduce energy use compared to having a FR-enriched spectrum. If on the other hand a more compact seedlings is the goal, that can be achieved by excluding far-red from the spectrum. Smart LED lighting systems can be implemented for energy-efficient and non-chemical control of plant morphology.

More info

This is a part of a larger investigation on the effect of far-red on plants growth performance. Additional experiments has been conducted on herbs, lettuce, microgreens and other crop.

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