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Radiation Use Efficiency by Tomato Transplants Grown Under Extended Photoperiod

ABSTRACT

The study focused on the effect of an extended photoperiod on the radiation use efficiency (*RUE*) by the tomato transplants *(Solanum lycopersicum L.)* in the pre–reproductive period. In two consecutive series of experiments, the photoperiod was 16 and 22 hours. The photon irradiance at the plant tops was maintained at low, medium and high levels: 100, 170 and 240 μmol.m–2s–1, respectively. The plants were grown under two lighting systems with different light quality. The difference was7% higher blue flux share in Spectrum II. The use of an extended photoperiod, especially in combination with high irradiance level, resulted in the plant leaf chlorosis. When varying the radiation dose components, the deviation from the reciprocity law was recorded. By the analysis results, the chlorophyll degradation was a response to the extended photoperiod rather than the radiation dose. Without additional blue flux, under a regular photoperiod, *RUE* reduced by 8% at the high irradiance level. Under extended photoperiod, the shift from the low to high irradiance level reduced *RUE* by 20–37%, with bigger reduction values being observed at higher irradiance levels. Seven percent addition of blue flux made it possible to increase *RUE* by 5–8% at the same and lower irradiance levels and under the regular photoperiod. With the extended photoperiod under these conditions, *RUE* decreased by 8–21%. The study results verify a great influence of an extended photoperiod on *RUE*, while the degree of influence depends on other parameters of light environment – light quality and irradiance level.

METHODS

The study object was tomato transplants (*Solanum lycopersicum* L.) of Blagovest F1 variety. The air temperature was automatically maintained at +21±1.0°C with the humidity of 65–70%. The air velocity in the plant growing zone was 0.2–0.3 m.s–1. Two lighting systems were used in the experiment. The light sources were OSRAM L58W/840 LUMILUX Cool White and OSRAM L58W/77 FLUORA fluorescent lamps. The first lighting system (reference) had only fluorescent lamps with the overall spectral ratio blue:green:red = 32 %:34 %:34 % (Spectrum I). The second lighting system had the same number and type of fluorescent lamps as the first lighting system but the LEDs with 440 nm wavelength were added. They redistributed the energy in PAR range towards the shorter wavelengths. The spectral ratio of the second lighting system was blue:green:red = 39 %:31 %:30 % (Spectrum II). The radiation use efficiency (*RUE*) was calculated by the formula

$$RUE = \frac{SLW}{H}.$$

RESULTS

The application of extended photoperiod could increase the growth and yields of plants. At the same time, it leads to leaf chlorosis and necrosis. In our experiment with the extended photoperiod, the leaf variegation was observed already on the sixth day at all irradiance levels and both spectra.
Fig. 1 shows the typical tomato transplants grown under different irradiation levels. Fig. 2 shows the tomato leaves under different photoperiods at the end of the experiment. In our experiment, the difference in leaf appearance under different spectra was not recorded.

Figure 1. Tomato transplants grown under different photoperiods (16 h - left and 22 h right) and different irradiation levels (100, 170, and 240 μmol m-2 s-1)

The experiment demonstrated that the longer photoperiod resulted in the significant decrease in the chlorophyll content and the development of heavy intervein chlorosis in tomato leaves.

Fig. 2 shows the deviation of Δ*RUE*, %, depending on the irradiance level for different light quality and photoperiods. Δ*RUE* calculation basis was the experimental conditions with the regular photoperiod (*PP*=16h), medium irradiance (E=170 μmol.m–2.s–1, and no additional blue flux (Spectrum I).

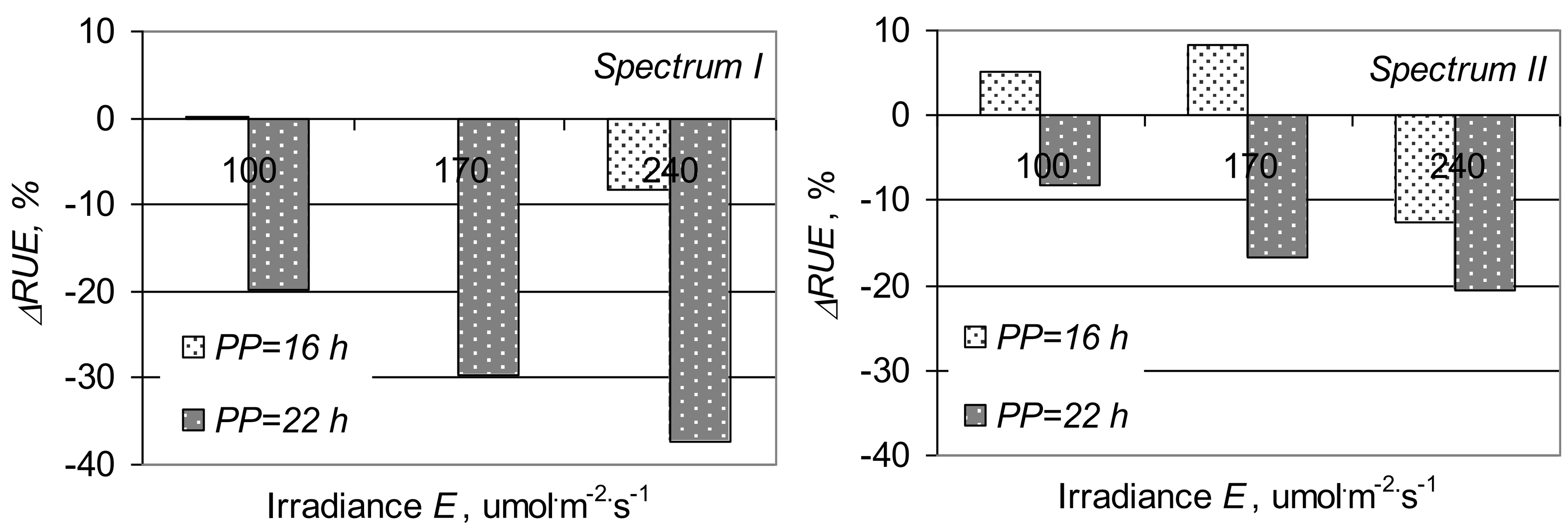

Figure 2. Deviation in *RUE* under varied light environment parameters

Without additional blue flux, under a regular photoperiod, *RUE* reduced by 8% at high irradiance levels. With the extended photoperiod, under these conditions, the change in the irradiance level reduced *RUE* by 20–37%, with bigger reduction values being observed at higher irradiance levels. Seven percent addition of blue flux made it possible to increase *RUE* by 5–8% at the same and lower irradiance levels and under *PP*=16 h. Under *PP*=22 h and these conditions, *RUE* decreased by 8–21%.

CONCLUSIONS

An extended photoperiod was found to result in the development of leaf chlorosis. When varying the radiation dose components, the deviation from the reciprocity law was recorded. The analysis showed that the chlorophyll degradation was a response to the extended photoperiod rather than to the radiation dose. The chlorophyll content at *PP* = 16 h increased with higher irradiance, while its increment rate decreased under radiation with a bigger share of blue flux. The study results verify a great influence of an extended photoperiod on *RUE*, while the degree of influence depends on other parameters of light environment – light quality and irradiance level.

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