Stem Extension Rate in Light-Grown Plants

EFFECTS OF PHOTO- AND THERMOPERIODIC TREATMENTS ON THE ENDOGENOUS CIRCADIAN RHYTHM IN CHENOPODIUM RUBRUM

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the transducer cores via a beam-balance system and a short...

...the experiments, during which 32°C induced just 100% germination. In the experiments this transition from 32°C to 10°C gave no response. Only at constant temperatures did a 10-fold amplification of the SER recorded at 20°C give a good response.

The kinetics of the SER were investigated during the transition from 32°C to 10°C or vice versa (32°C to 10°C). The kinetics of the SER was much slower during the transition from 32°C to 10°C. Even after 20 h at 32°C, the SER did not return to the base-line value.

The kinetics of the SER were measured using a double loop. The transducer cores were attached to the stem by means of a thread tied to cotton and the transducer cores were used to detect the extension of the stem. The extension of the stem was detected by a beam-balance system and a short thread tied to the transducer cores. The extension of the stem was then amplified and recorded.

FIG. 1. Changes in the SER recorded during the transition from 32°C to 10°C. The SER was measured using a double loop. The transducer cores were attached to the stem and the transducer cores were detected by a beam-balance system and a short thread tied to the transducer cores. The extension of the stem was amplified and recorded.

The SER was measured using a double loop. The transducer cores were attached to the stem and the transducer cores were detected by a beam-balance system and a short thread tied to the transducer cores. The extension of the stem was amplified and recorded.
SER was high during darkness and low during light. The transitions between these two conditions were very rapid. After a dark-light transition, SER showed a rapid stimulation for about 20 min followed by a rapid decline to almost 0 SER at about 3 h after the change of conditions. Thereafter, SER increased again to reach a maximum at the 6th h of light.

With thermoperiodic cycles in constant light, 12L (32°C)-12L (10°C) (Fig. 2B), SER was high at the high temperature and practically 0 during the low temperature treatment.

In normal photo-thermoperiodic cycles, 12L (32°C)-12D (10°C) (Fig. 2C), SER was high during light at high temperature and low during darkness at low temperature. However, SER was not 0 in D10°C and after a minimum at the 2nd to 3rd h of darkness, SER increased to reach a maximum at the 7th h of darkness.

In inverse photo-thermoperiodic conditions, 12L (10°C)-12D (32°C) (Fig. 2D), SER was high during darkness at 32°C and almost 0 during the whole light span at 10°C in contrast to the SER at 10°C in darkness (Fig. 2C).

B. Constant Conditions, LL (32°C) Figure 2. Phase of Rhythm in SER. Irrespective of the preceding periodic conditions, SER always displayed a circadian rhythm in LL (32°C) with the same phasing and a first maximum around the 10th h of light, a second maximum at the 31st h, and a third at the 54th h. The phasing of the rhythm after the dark-to-light transition at 32°C was essentially the same as the one already observed at 24°C (15) (dotted line, Fig. 2A).

Amplitude of Rhythm in SER. The amplitude of the first peak (about 10 h) in SER after the transition to light at 32°C depended very much on the preceding periodic conditions. Clearly, the amplitude in SER depended only on the temperature preceding the transition, either in the light or in the dark. After a pretreatment at 32°C in darkness, the first peak in SER at the 10th h had only about half the value of the subsequent ones (Fig. 2, A and D). However, after a pretreatment at 10°C either in darkness (Fig. 2C) or in light (Fig. 2B), the first peak in SER was of much higher amplitude than the subsequent ones.

C. Effects of Different Temperature Treatments of Roots and Shoots. In Figure 1 it is shown that a transition from 32°C to 10°C is much slower in the soil than in the air surrounding the plants. The difference is considerable during the first 4 to 5 h and could be of importance in relation to the water status of the shoot and could possibly influence the SER of the first peak after a transition from 10 to 32°C. This problem was analyzed by monitoring SER in photo-thermoperiodic cycles of 12D (10°C)-12L (32°C) and subsequent transitions to LL (32°C) (Fig. 2C), with and without additional temperature control of the soil water to obtain the same rate of change in temperature in the air and the soil.

As shown in Figure 3, after the first low temperature pulse without additional temperature control of the soil, there is the same kinetic in SER as in Figure 2C with a maximum at the 5th h of light. The second low temperature pulse during which the temperature of the soil received additional control by a thermostat, results again in a strong stimulation of SER as compared to a pure photoperiodic treatment 12D (32°C)-12L (32°C) (dotted line, Fig. 3). However, thermostating the soil obviously had no influence on phase of the rhythm in SER.
These results show that it is the difference in temperature which is resetting the rhythm and not a specific temperature level. The minimum difference in temperature for resetting the phase in SER in *C. rubrum* has not yet been determined. The equivalence of low-high temperature and dark-light treatments for the rephasing of circadian rhythmic phenomena has been shown in other plants in continuous light (12, 18) and continuous darkness (4, 7, 27).

**Low Temperature and Amplitude Modulation of SER.** The first maximum in growth after resetting the rhythm by 12 h at low temperature is strongly increased in comparison to that of plants kept at constant temperature. This stimulation cannot be explained by a combined effect of the extension rate reduction of SER and the increase in growth. It is
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