DIURNAL CHILLING SENSITIVITY OF SOME VEGETABLE CROPS

Alscher, G.
Institute of Vegetable Crops University of Hannover

Rietze, E.
Institute of Vegetable Crops University of Hannover

Wiebe, H. -J.
Institute of Vegetable Crops University of Hannover

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DIURNAL CHILLING SENSITIVITY OF SOME VEGETABLE CROPS

G. ALSCHER, E. RIETZE and H.-J. WIEBE

Institute of Vegetable Crops, University of Hannover, West Germany

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ALSCHER G., RIETZE E. and WIEBE H.-J. *Diurnal chilling sensitivity of some vegetable crops.* BIOTRONICS **17**, 17–20, 1988. Seedlings of sweet pepper, cucumber, tomato and beans chilled for 24 to 120 h at 2°C in the dark starting at different times during the diurnal light/dark cycle were most sensitive to chilling at the end of the night. During continued dark or light chilling sensitivity occurred again at the corresponding time. Chilling sensitivity of these plants seems to be endogenously controlled.

Key words: sweet pepper; cucumber; tomato; beans; chilling injury; diurnal sensitivity.

INTRODUCTION

Crop species of tropical or subtropical origin are sensitive to low temperature. The occurrence of chilling injuries depends on the level of temperature, duration of exposure to cold conditions, species of the plant and morphological and physiological condition of the plant material at time of exposure.

Diurnal changes in chilling sensitivity of tomato seedlings and other species are known (*3*, *5*). The experiments reported here check these results with four vegetable crops and intend to find out whether the rhythm is endogenously or exogenously controlled.

MATERIAL AND METHODS

In two experiments the following species were used in the seedling stage: Sweet pepper—*Capsicum annuum* L. 'Calypso' (2 leaves), cucumber—*Cucumis sativus* L. 'Corona' (1 leaf), tomato—*Lycopersicon lycopersicum* L. 'Sonatine' (2 leaves) and beans—*Phaseolus vulgaris* L. var. *vulgaris* 'Aschers Hiltrud' (2 leaves).

Prechilling conditions

The seedlings were pregrown in growth chambers at 20°C; light (49 Wm^{-2}, 300–2800 nm, resp. 127 μEm^{-2} s^{-1} PAR) from 8:00–20:00 h with fluorescent lamps 'Cool white' and incandescent lamps; water vapour pressure deficit 7.0 hPa. After emergence they were transplanted in 10 cm plastic pots.

Chilling conditions

Every 4 h throughout a 24 h-period 6 plants of each species were transferred to chilling conditions (2°C in the dark; 0.4 hPa). Depending on the different sensitivity the species were removed from chilling exactly 24, 48, 72 or 120 h after the time of initial chill. During the transport the plants were exposed to low light intensities for not more than half a minute.

Postchilling conditions

On removal from chilling the plants were placed for 48 h under continuous light (49 Wm^{-2}), 20°C and 7.0 hPa. Then they were transferred to a glasshouse with 24/20°C.

Evaluation

In experiment one the damage on the leaves of the different species was described by a rating with the range from 0 (no damage) to 9 (necrotic area more than 80%) two days after chilling. The plants got a chilling treatment according to Fig. 1. In experiment two leaf area of the plants was determined ten days after chilling. Duration time of chilling was reduced (Fig. 2). The significance of the data obtained were tested by variance analysis (7).

RESULTS

Chilling causes curling of leaf margins as well as chlorotic and necrotic leaf areas. Extension of the injury is dependent on the day time (Fig. 1). A stronger damage in all species occurred from 8: 00–12: 00 h than from 16: 00–4: 00 h. Some species had already a decrease of the damage at 12: 00 h, but at the beginning of the

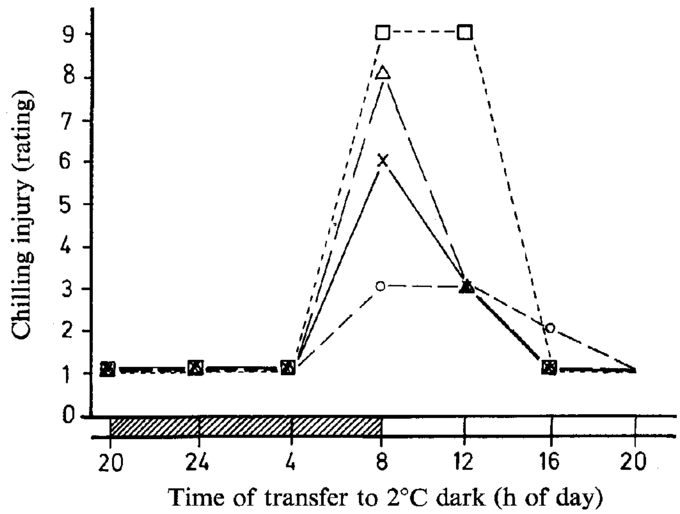

Fig. 1. Occurence of chilling injuries on four plant species transferred from a growth chamber at successive 4 h time periods over 12 h dark and 12 h light period to 2°C dark. Duration of chilling (h): × Cucumber (24 h); ○, Beans (48 h); △, Tomato (72 h); □, Sweet pepper (120 h). Tukey test gave significant differences for all crops.

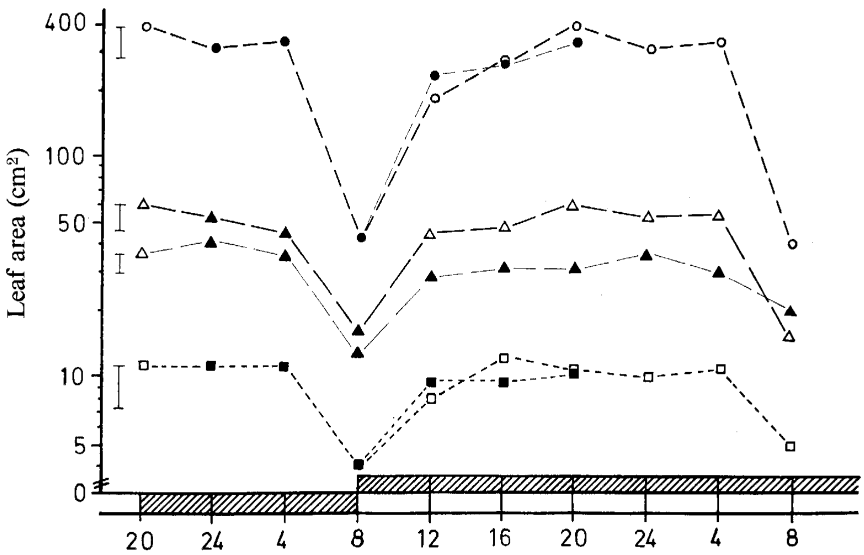

Fig. 2. Effect of chilling on leaf area of seedlings exposed to 2°C at different times of the day/night cycle and following continuous light or dark. ○, Beans (24 h); △, Tomato (48 h); □, Sweet pepper (72 h). Dark symbols indicate darkness before and open symbols light before chilling treatment. I=LSD 0.05

light period (8:00) all species showed the strongest injury. Compared to sweet pepper in Fig. 2, plants in Fig. 1 show more damage at 12 h because chilling duration was extended. Under constant conditions a rhythm was still apparent (Fig. 2), shown in the leaf area ten days after the end of chilling. In continued dark the leaf area was reduced (=strong damage) after 12 h dark. This could be expected from Fig. 1. But after that the leaf area increased in spite of prolonged dark. So it seems that this rhythm is of endogenous character, induced by a dark/light regime. This opinion is supported by an experiment on tomato with an extended period of darkness before chilling treatment (Fig. 2). Here the leaf area decreased after 36 h dark (corresponds to 8:00 h). The same phenomenon can be observed in continued light. After 12 h of prolonged light the leaf area decreased again.

DISCUSSION

The results show that diurnal fluctuations in chilling sensitivity of the tested species exist. This confirms the results of King *et al.* (*3*). They worked with a 9 h day and found the highest sensitivity after 12 h dark. In our experiments with a 12 h day the highest sensitivity is after 12 h dark as well but this coincides with the beginning of day.

King *et al.* (*3*) assumed an exogenous control of the rhythm because they found less damage on seedlings exposed to light before the chilling compared with seedlings given a normal night with dark. This conclusion cannot be sustained by our results. The continuation of the diurnal changes in chilling sensitivity under constant light or dark conditions indicates an endogenous controlled rhythm which is synchronized by the light/dark cycle (*1*).

The daily changing water status of the plant as main cause of the rhythm can be excluded (*4*). It is assumed that the carbohydrate level is responsible for the diurnal variation. A shortage of carbohydrates at the end of the dark period may cause the increased sensitivity to chilling. With *Cucumis sativus* an endogenous rhythm of starch depletion is proposed (*2*) similar to that described for Clamydomonas (*6*).

It may be that the carbohydrate level causes the diurnal chilling sensitivity but the mechanism of chilling injury is not yet clear. Further research is needed to explain the endogenous rhythm of chilling sensitivity.

The work is being continued with experiments on the role of light during and after chilling.

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