Effect of Level and Duration of High Temperatures on Rest in the Peach

Gary A. Couvillon
Department of Horticulture, University of Georgia, Athens, GA 30602

A. Erez
Agricultural Research Organization, The Volcani Center, Institute of Horticulture, Bet Dagan, Israel

Additional index words. Prunus persica, dormancy, chilling negation, cyclic temperatures

Abstract. Rooted ‘Redhaven’ peach [Prunus persica (L.) Batsch] cuttings were exposed to diurnal temperature cycles. A severe reduction in lateral vegetative bud break was found in plants refrigerated at 4°C and given 8 hr daily exposure to 19°C (±0.1°C). Nearly complete chilling negation occurred in plants exposed to diurnal cycles including 8 hr of 20° or 21°. Also, effect decreased with increased time (0 to 8 hr per day) of exposure to 24°C. Buds on plants exposed to cycles including 20° for 2 and 4 hr showed no chilling negation, but gradual increases in chilling negation occurred with longer exposures to 20°. ‘Harvester’ peach plants were exposed to 2, 7, or 12 days of 23° following the accumulation of one-fourth, one-half, or three-fourths of the chilling requirement. Chilling negation occurred only with the 12-day exposure to 23° when high temperatures were applied following the accumulation of one-fourth and one-half of the chilling requirement. No chilling negation was found after 12 days’ exposure to 23° if three-fourths of the chilling requirement had accumulated before exposure.

Materials and Methods

‘Redhaven’ and ‘Harvester’ shoots of current season’s growth were removed on 1 Aug. 1982 from trees grown on the Horticultural Farm in Athens, Ga., and rooted as described previously (1). Leaf drop occurred by the end of October, and in December the cuttings were transported to the Duke Univ. Phytophotron in Durham, N.C. Three chambers with a temperature variation of ±0.1°C were used for 3 cyclic temperature treatments. The cycles were diurnal, with the low temperature (4°C) maintained for 16 hr. The high temperatures of the diurnal cycles were 19°, 20°, or 21°, and the cycles were continued until each treatment group received 1200 hr at 4°C. Additional complete replicates were placed in growth chambers in Athens, and exposed to a diurnal cycle of 15°/4°C (±1°) (8 hr high/16 hr low) or 4°C continuously until 1200 hr at 4°C were accumulated. A 3rd group of plants was held continuously at 22° (±1°C) in the laboratory.

Following 1200 hr exposure to the 4°C portion of the diurnal cycle, all plants were placed in the laboratory at 22° for forcing in light (50 μmol s⁻¹m⁻²). Bud break (greentip stage) counts were taken weekly for 8 weeks.

Similar plants were placed in chambers of the Duke Univ. Phytophotron, in which the diurnal cycles consisted of either 20° or 24°C for 0, 2, 4, 6, or 8 hr with the remainder of the diurnal cycle at 4°C. The plants were removed from the chamber following exposure of each treatment to 1200 hr of 4°C, and then moved to the laboratory as described previously for forcing.

A 3rd group of ‘Harvester’ plants (chilling requirement = 800 hr) was placed in growth chambers in Athens. Following the completion of one-fourth (200 hr), one-half (400 hr) or three-fourths (600 hr) of their chilling requirement at 4°C (±1°), they were exposed to 2, 7, or 12 days of 23° and then returned to the chambers for completion of chilling. Following the completion of the chilling requirement, the plants were removed to the laboratory for forcing at 23°.

The chambers used for all studies (Duke Univ. and Athens, Ga.) provided 50 μmol s⁻¹m⁻² of fluorescent light. Previous data (unpublished) had shown that 50 μmol s⁻¹m⁻² of fluorescent light did not result in increases in bud temperature over that of the ambient air.

To define the degree of promotion or inhibition induced by each temperature treatment, a modulation factor was calculated using the equation:

\[ M = \frac{e - x}{c} \frac{y}{y - 24} \]

where:

- \( M \) = modulation factor per hour of high temperature;
- \( c \) = level of bud break at continuous low temperature;
- \( x \) = level of bud break induced by the temperature cycle;
- \( y \) = number of hours of chilling per day.

A randomized complete block design with 4 replications of 16 plants each was used for each study. The data were analyzed.
by analysis of variance, and the means were separated by Duncan's multiple range test, or by regression analysis.

**Results and Discussion**

Peach plants exposed to a diurnal cycle in which 15°C (8 hr) was alternated with 4°C (16 hr) had higher leaf but not flower bud break levels than plants exposed to 4°C continuously (Fig. 1). Diurnal temperature cycles in which the high temperature was 19°C, 20°C, or 21°C caused significant reductions in both leaf and flower bud break when compared with the continuous 4°C treatment, even though the exposure period to 4°C was equal for all treatments (Fig. 1). Plants exposed to diurnal cycles in which the high was 20°C or 21°C for 8 hr did not differ, but both had poorer bud break levels than plants exposed to a diurnal cycle in which 19°C was the high (Fig. 1).

These data are supported by data relating to the effect of the duration of various high temperature levels on chilling negation of leaf buds where equal amounts of chilling were applied (Fig. 2). In diurnal cycles in which 8 hr of either 20°C or 24°C were cycled with 16 hr of 4°C, the high temperature had the most adverse effect on bud break (Fig. 2). The duration of exposure to the high temperature in a diurnal cycle also had an effect on chilling enhancement or negation. Bud break on plants exposed either to 2 or 4 hr of 20°C cycled with 22 or 20 hr of 4°C, respectively, enhanced bud break when compared with the 4°C treatment (Fig. 2). Increases in the high temperature exposure period to 6 or 8 hr resulted in chilling negation. The duration of exposure to 24°C was correlated negatively with bud break (Fig. 2).

Exposure of 'Harvester' peach plants to a single period of 2, 7, or 12 days of 23°C following the accumulation of one-fourth (300 hr), one-half (600 hr) or three-fourths (900 hr) of their chilling, resulted in chilling negation only at the 12-day exposure following the accumulation of one-fourth or one-half of the chilling requirement (Fig. 3). Exposure of the plants to 23°C for 2 or 7 days had no influence on chilling, regardless of when it was applied in the chilling period (Fig. 3). Twelve day's exposure to 23°C following the accumulation of three-fourths of the chilling requirement also had no influence on bud break.

Chilling negation can change with the level and duration of chilling conditions (°C) in a diurnal cycle following the completion of one-fourth, one-half, or three-fourths of the chilling requirement, (800 hr) on chilling negation in 'Harvester' peach (floral buds). Mean Separation by Duncan's multiple range test, 0.05 level.

![Fig. 2](image)

**CHILLING CONDITIONS (°C) IN A DIURNAL CYCLE**

- 1/4 CHILLING REQ.
- 1/2 CHILLING REQ.
- 3/4 CHILLING REQ.

![Fig. 3](image)

**DAYS AT 23°C**

- 1/4 CHILLING REG.
- 1/2 CHILLING REG.
- 3/4 CHILLING REG.

![Fig. 1](image)

**Results and Discussion**

Peach plants exposed to a diurnal cycle in which 15°C (8 hr) was alternated with 4°C (16 hr) had higher leaf but not flower bud break levels than plants exposed to 4°C continuously (Fig. 1). Diurnal temperature cycles in which the high temperature was 19°C, 20°C, or 21°C caused significant reductions in both leaf and flower bud break when compared with the continuous 4°C treatment, even though the exposure period to 4°C was equal for all treatments (Fig. 1). Plants exposed to diurnal cycles in which the high was 20°C or 21°C for 8 hr did not differ, but both had poorer bud break levels than plants exposed to a diurnal cycle in which 19°C was the high (Fig. 1).

These data are supported by data relating to the effect of the duration of various high temperature levels on chilling negation of leaf buds where equal amounts of chilling were applied (Fig. 2). In diurnal cycles in which 8 hr of either 20°C or 24°C were cycled with 16 hr of 4°C, the high temperature had the most adverse effect on bud break (Fig. 2). The duration of exposure to the high temperature in a diurnal cycle also had an effect on chilling enhancement or negation. Bud break on plants exposed either to 2 or 4 hr of 20°C cycled with 22 or 20 hr of 4°C, respectively, enhanced bud break when compared with the 4°C treatment (Fig. 2). Increases in the high temperature exposure period to 6 or 8 hr resulted in chilling negation. The duration of exposure to 24°C was correlated negatively with bud break (Fig. 2).

Exposure of 'Harvester' peach plants to a single period of 2, 7, or 12 days of 23°C following the accumulation of one-fourth (300 hr), one-half (600 hr) or three-fourths (900 hr) of their chilling, resulted in chilling negation only at the 12-day exposure following the accumulation of one-fourth or one-half of the chilling requirement (Fig. 3). Exposure of the plants to 23°C for 2 or 7 days had no influence on chilling, regardless of when it was applied in the chilling period (Fig. 3). Twelve day's exposure to 23°C following the accumulation of three-fourths of the chilling requirement also had no influence on bud break.

Chilling negation can change with the level and duration of chilling conditions (°C) in a diurnal cycle following the completion of one-fourth, one-half, or three-fourths of the chilling requirement, (800 hr) on chilling negation in 'Harvester' peach (floral buds). Mean Separation by Duncan's multiple range test, 0.05 level.
the high temperature exposure. Highs of 15° to 18°C in a cycle with chilling temperatures resulted in no chilling negation or enhancement, depending upon the level of the high temperature (3). The chilling enhancement of moderate temperatures in a diurnal cycle with chilling can be complicated by light level (6, 7). Temperatures of 19° or greater (for periods longer than 6 hr) in a similar diurnal cycle with chilling were found in this study to negate chilling.

To characterize the degree of chilling negation for each high temperature, a modulation factor was calculated for each treatment (Fig. 4). Plants chilled at 4°C had a zero modulation factor. The 15°/4° cyclic treatment had a modulation factor of +1.8, which means that peach buds exposed for 1 hr to 15° in this cycle responded as though they had 1.8 times the chilling of buds exposed continuously for 1 hr to 4° (Fig. 4). Buds on plants exposed to cycles in which the high was 19°, 20°, or 21°C for 8 hr, and 16 hr at 4°, had modulation factors of −0.8, −1.6 and −1.9, respectively. These data point out the rather drastic effect of temperatures of 19° or higher in diurnal cycles on chilling negation in peaches. On the other hand, 2 or 4 hr exposure to 20° in a diurnal cycle with 4°C resulted in modulation factors of +1.2 and +0.5, respectively (Fig. 2 and 4).

Six or 8 hr exposure to 20°C gave modulation factors of −1.1 and −1.3, respectively. When 24° was the high temperature in similar cycles, modulation factors of −1.5, −2.5 and −2.5 were obtained for 2, 4, or 6 hr, respectively, of exposure to 24°. An effect of this type, where both chilling enhancement and negation can be obtained by exposure of buds to the same high temperature in a diurnal cycle, can be explained only when 2 antagonizing reactions are promoted by the same temperature at the same time. This point has been discussed in detail elsewhere (Erez and Couvillon, personal observation). The promotion effect on chilling of 2–4 hr of 20° in a diurnal chilling cycle has not been reported. It has been shown (5) that 12 days of exposure of peach buds to 20° following the accumulation of about 75% of the chilling requirement, resulted in a promotive effect on bud break.

Long periods of exposure to 23°C will negate chilling only if applied during the early stages of chilling accumulation. These periods of high temperature exposure must be longer than 7 days. The degree of chilling negation induced by these exposure periods does not seem to be as severe as that of similar temperatures given in short cycles (3, 4).

These data clarify the negative relationship between the level and duration of high temperature on bud break and should serve as a guide for the use of evaporative cooling treatments to counteract high temperature during rest (2), and improve performance of the Utah model (8) for predicting bud break in areas where high temperatures occur during rest.

### Literature Cited


