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The Effect of Cycle Length on Chilling Negation by High Temperatures in Dormant Peach Leaf Buds[1]

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Abstract. **Leaf bud break of 'Redhaven' and 'Redskin' peach (*Prunus persica* (L.) Batsch) following exposure of plants to temperature cycles of 1, 3, 6 and 9 days was examined. During each cycle the plants were exposed to 4°-6°C for 2/3 of the cycle length and 24° for the remaining 1/3 with all cycles repeated until the plants were exposed to a designated number of chilling hours. Thus, all plants within each treatment were exposed equally (in total) to chilling and heat. No lateral bud (LB) break occurred with 'Redskin' in the 1-day cycle, a low level was obtained in the 3-day cycle and good bud break occurred in the continuous chilling control and the 6 and 9 day cycles. With 'Redhaven' no LB break was evident in the 1 day cycle while the 3, 6, and 9 day cycles responded similar to the continuous chilling control. From these data it was concluded that chilling (4°-6°) accumulated during the 20 to 40 hrs prior to the onset of high temperature was susceptible to high temperature negation.**

It has been shown that long periods of chilling (5-7 days) followed by high temperature (11-12 days) did not result in negation of the chilling effect (3). However, complete chilling negation by high temperature was shown to occur in peach plants exposed to 16 hr of chilling cycled with 8 hr of exposure to temperatures of 21° or greater (2). The degree of chilling negation induced by temperature regimes of various lengths in which high temperatures (⩾21°) are alternated with chilling (4°) temperatures is unknown.

Vernalization seems to show a similar response to that of dormant buds. 'Petkus' rye needs 42 days at 4°C to be vernalized, however, alternating 4° equally with 20° in a diurnal cycle during vernalization resulted in complete devernalization, even though the plant received 42 days at 4°. Temperature cycles in which 3, 4, or 7 days of 4° preceeded a 1 day exposure to 20° resulted in a diminished devernalization effect as time of exposure to 4° increased (6). These data were explained by a time dependent fixation of the vernalization process (7).

The effect of the length of an alternating temperature cycle on chilling negation by high temperatures in dormant peach buds was examined in view of the significance of the fixation of the chilling effect in analyzing climatic effects on bud rest, especially under warm temperature conditions.

Materials and Methods

'Redhaven' and 'Redskin' plants produced from rooted cuttings as described earlier (1, 2) were used. Temperature conditions of 4°C (±0.2°) or 6° (±0.3°) in the dark and 24° (±1.5°) under continuously cool white fluorescent light were used. The temperature treatments examined are listed in Table 1.

The plants (24 per treatment) in treatments 2, 3 and 4 were moved by carts from the low temperature condition into a laboratory with cool white fluorescent lighting while treatment 1 plants were maintained in a growth chamber and the temperature was cycled automatically. Light intensity at plant level in treatment 1 was 4800 lux and 540 lux for the remaining treatments.

In all 4 cyclic treatments the plants were exposed to 3 levels of weighted chilling hours. A total of 600, 900 or 1200 chilling hours were applied to 'Redhaven' and 500, 750, and 1150 for 'Redskin'. Each cycle was repeated until the plants were exposed to the designated number of weighted chilling hours. Another group of plants of each variety was exposed to continuous chilling at 4°C in the dark for the same chilling durations. Bud temperature change on transfer from one temperature condition to the other was recorded using copper constantan thermocouples. Constant temperature levels were reached in the buds 7 to 14 min after transfer. On the last date bud counts were taken, those plants that were exposed to the greatest chilling levels in each cultivar and cycle treatment were divided into 3 groups and each group treated with either 0, 50, or 150 mg/liter of GA_3. A surfactant, 0.02% X-77, (Colloidal Products Corp. Pataluma, Cal.) was added. Six to 8 single plant replicates were used for each treatment. Bud break was determined after 30 days of forcing at 24° in continuous light.

Results

The level of LB opening following the accumulation of 500, 750, and 1150 chilling hours for 'Redskin' and of 600, 900, and 1200 chilling hours for 'Redhaven' is shown in Fig. 1.

Bud break levels increased with increased chilling exposure over 600 and 750 chilling hours with 'Redhaven' and 'Redskin', respectively. Although 'Redskin' plants received 1150 chilling hours, bud break did not occur in plants exposed to the 1 day cycle and a very low bud break level for those exposed to the 3 day cycle. There were no differences in bud break between plants exposed to the 6 or 9 day cycles and the continuous

Table 1. The experimental procedure of the various cyclic treatments.

Treatment	Cycle Length (days)	Duration of exposure to chilling at 4°C (days)	Duration of exposure to high temp at 24°C (days)	No. of times cycle was repeated for 1200 hr chilling
1	1	2/3[z]	1/3	75
2	3	2	1	25
3	6	4	2	12.5
4	9	6	3	8

[z]Chilling applied at 6°C.

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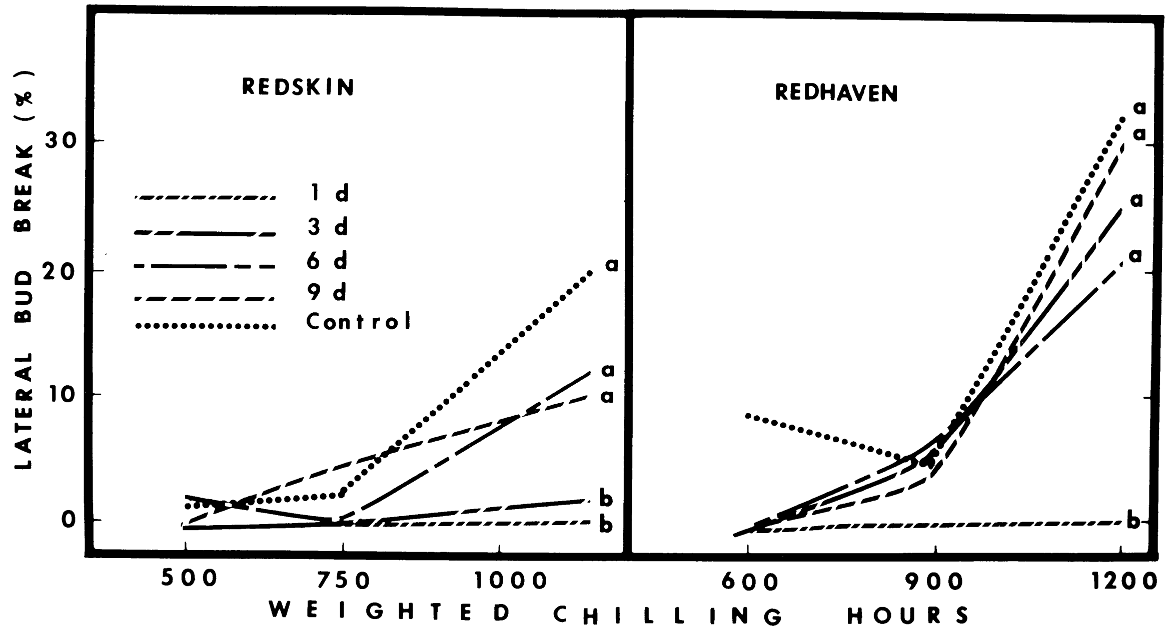

Fig. 1. The effect of temperature cycle duration on bud break of lateral leaf buds in 2 peach cultivars following exposure to increasing chilling. In all cyclic treatments 2/3 of cycle was maintained at low temperature (4 to 6°C) and 1/3 of cycle at high temperature (24°). Bud break at continuous 4° (control) was added for comparison.

chilling control. On the other hand, LB break did not occur in 'Redhaven' plants exposed to the 1 day cycle, but plants exposed to the 3, 6, and 9 day cycles were not significantly different from the continuous chilling control. These data show that high temperature negation of the chilling effect is dependent upon cycle length with reduced effect in the longer cycles. In order to quantitatively evaluate the rate of chilling negation, the data of Fig. 1 were plotted as % negation of chilling (Fig. 2). Percent negation (y) was calculated from the formula: $y=[100 - (x \cdot 100/z)]$ where x is the level of bud break

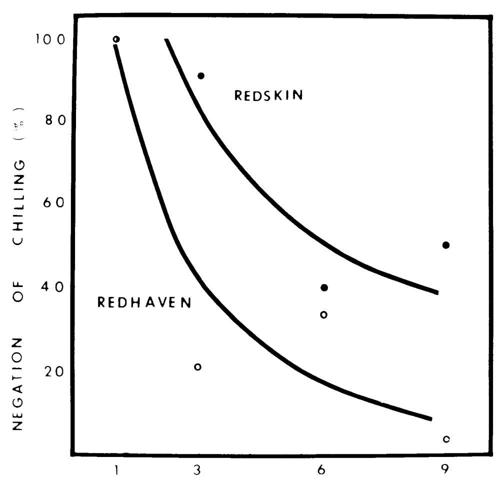

Fig. 2. The effect of cycle duration on chilling negation effect by high temperatures with 'Redhaven' and 'Redskin' peach lateral leaf buds. Data were taken after accumulation of 1200 weighted chilling hours for 'Redhaven' and 1150 for 'Redskin'. In all cycles 2/3 of cycle was maintained at low temperature and 1/3 at high temperature. % reversion of chilling was calculated from the formula: $y = [100 - (x \cdot 100/z)]$ where x = the level of bud break observed and z the level of bud break in the corresponding continuous chilling.

in the chilling cycle treatment and z the level of bud break in the continuous chilling treatment. Zero negation corresponds to the continuous chilling control and 100% negation equals 0 bud break. It is evident that although the degree of chilling negation decreased with cycle length in both cultivars, at the same cycle length the degree of negation was greater with 'Redskin' than with 'Redhaven'.

The effect of GA_3 on the rate of bud break was examined for the 4 cycles after the accumulation of 1200 and 1150 chilling hours for 'Redhaven' and 'Redskin', respectively (Fig. 3). Lateral bud break was enhanced by GA_3 only with 'Redskin' in the 3 day cycle. In a few cases reduced LB break resulted from the GA_3 treatments. 'Redhaven' terminal bud (TB) break was increased in all cycles by GA_3 except in the 9 day cycle treatment. On the other hand, 'Redskin' TB did not show a significant response to GA_3 regardless of cycle length.

The increase of the temperature cycle from 1 to 3 days markedly increased TB break in both cultivars. In all cases where a negative effect was shown on LB break an enhancement of TB opening was evident.

Discussion

The 1-day cycle (8 hr, 24°C:16 hr, 6°) differed from the other cycles by having a 6° rather than a 4° low temperature exposure and a greater light intensity exposure during the high temperature portion of the cycle. The small low temperature differences to which the 1 day and other cycles were exposed have been shown to have similar chilling efficiencies (3). A negative influence of light intensity on peach bud break although possible, is only of small effect (5). Also, it has previously been shown (3) that 'Redhaven' peach buds exposed in the dark to a similar daily cycle gave similar results as did the 1 day cycle treatment in our study. Thus, the difference in light intensity and low temperature between the one day and other cycles essentially would not effect the behavior of resting buds.

Although no bud break occurred in 'Redhaven' when the cycle consisted of 8 hr of 24° followed by 16 hr at 6°, a 2-day low (48 hr) to 1-day high (24 hr) temperature cycle caused a

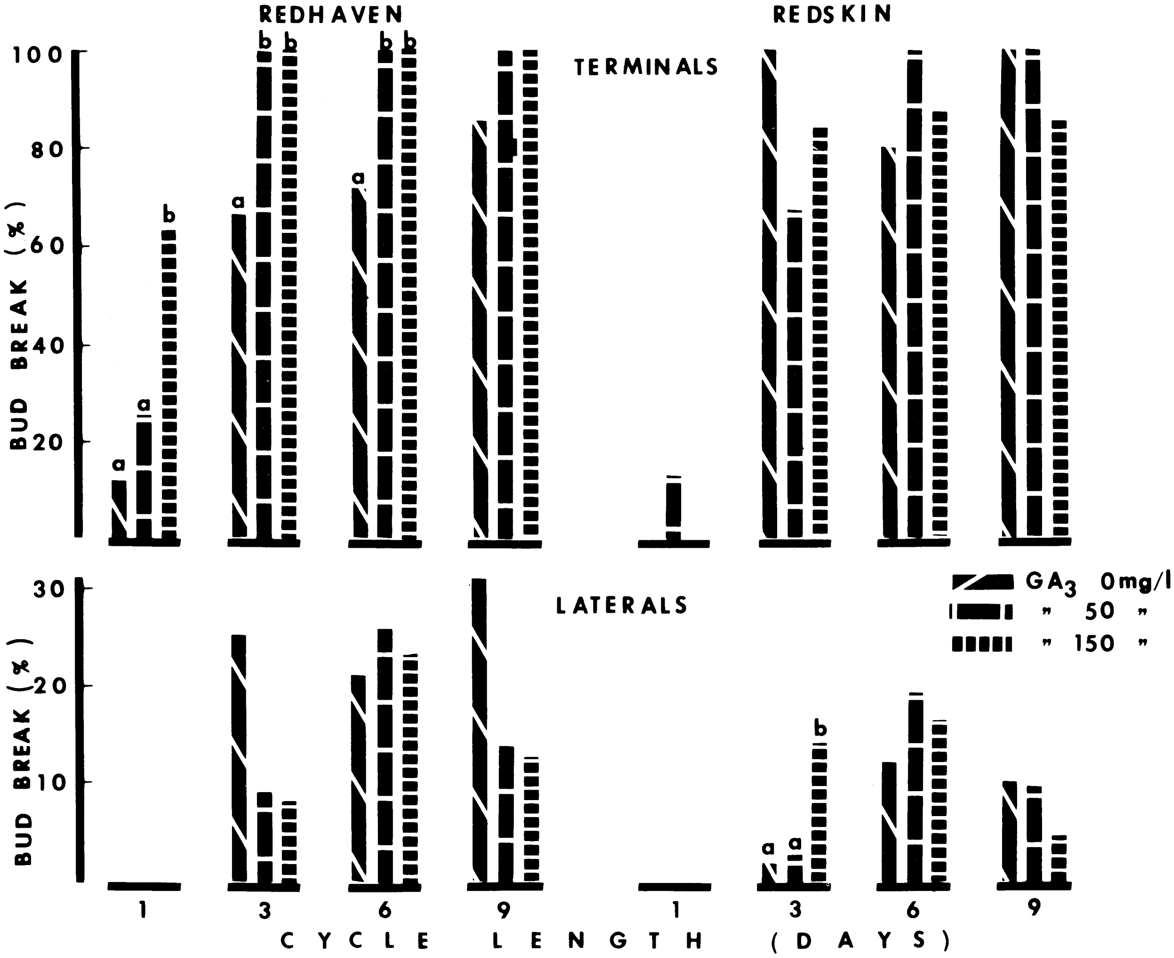

Fig. 3. The effect of GA_3 and cycle duration on rate of lateral and terminal bud break in 2 peach cultivars. 'Redhaven' plants were exposed to 1200 and 'Redskin' to 1150 weighted chilling hours. GA_3 at 0, 50, and 150 mg/liter was applied at transfer to forcing conditions. Bud break data were taken after 30 days at 24°C. Means without letters or followed by the same letter within the same temperature cycle treatment are not statistically different according to Duncan's multiple range test 5% level.

significantly greater number of buds to force. This has to be interpreted as a chilling fixation effect that took place during the 2-day chilling exposure in which a portion of the accumulated chilling was not negated by the high temperature portion of the cycle. This fixed chilling portion is probably that accumulated early in the low temperature portion of the cycle. With 'Redskin' the 3-day cycle showed a greater chilling negation value than 'Redhaven'. Only, under the conditions imposed by the 6 day cycle did an obvious fixation of the chilling effect take place. This difference between the 2 cultivars is probably the result from genetic variation in response to temperature or from a difference in stage of rest since 'Redskin' has a higher chilling requirement than 'Redhaven' (2) thus, its buds were in a less advanced stage of rest than 'Redhaven' buds. Although the reason for the difference in behavior between the 2 cultivars cannot be unequivocally proven, it should be pointed out that both cultivars are descendents of J. H. Hale (8). Should the stage of rest development have an effect on the rate of fixation of the chilling effect, a reduced negative effect will be evident when exposed to the same high temperature at a later stage of rest. Such a phenomenon was indicated by Vegis (9) who refers to a widening of maximum temperature range, with an advanced stage of rest, in which bud development will occur. Also, a stage dependent response for a decrease in the devernalization effect of high temperature proportioned to the previous vernalization duration was shown for 'Petkus' winter rye (6, 7).

For comparative purposes, theoretical high temperature negation curves within a range of 16 to 48 possible chilling negation hr in 4 hr increments are plotted in Fig. 4. These curves represent the degrees of chilling reversion for each cycle length assuming the previous 16, 20, 24, 28, 32, 40, 44, or 48 hr of chilling were negated by exposure to high temperature as a ratio of the total chilling applied in every cycle. By comparing Fig. 2 to Fig. 4, 'Redhaven' seems to follow closely the 20 chilling hour negated curve of Fig. 3 while 'Redskin' the 40-44 chilling hour negation curve. Since these data were obtained from only 4 temperature cycles, these values should be regarded as approximations. From these data it can be seen that between 20 to 40 chilling hours can be negated by high temperature influxes and the negation will occur following a 10 to 20 hr period of exposure to temperatures of 24°C.

When analyzing the effect of temperature on rest development under conditions of high temperature cycled with low temperature, the period of chilling duration and the frequency of high temperature infusion during the chilling period are of prime importance. Occasional high temperature influxes would have little effect on bud rest, but frequent influxes following short periods of chilling would undoubtedly result in prolonged dormancy.

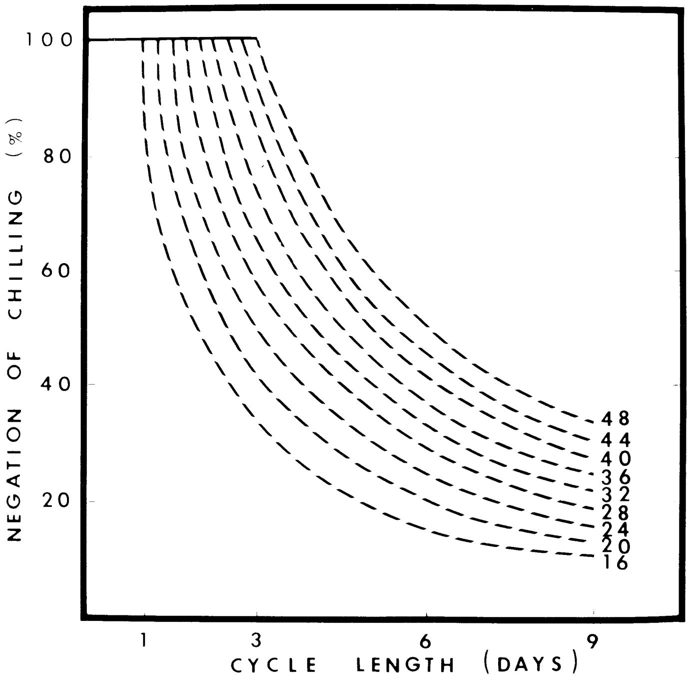

Fig. 4. Theoretical chilling negation curves induced by high temperature as a function of cycle duration for various chilling negation efficiencies. The unlabeled numbers within the figure represent the quantity of theoretical chilling hours that are sensitive to negation. In all cyclic treatments high:low temperature ratio was 1:2.

The inhibition of LB break by GA_3 could be indirect due to enhanced TB break by GA_3 and hence to a correlative inhibition of the laterals by apical dominance (4). This effect could in part be responsible for a poor initial lateral bud break under insufficient chilling as in 'Redskin' in the 3 day cycle reducing further the level of potential bud break.

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ERRATUM

In the paper, Effect of Preharvest Antitranspirant Sprays on the Size and Quality of 'Delicious' Apples at Harvest by Stephen S. Miller (*J. Amer. Soc. Hort. Sci.* 104(2):204-207. 1979), lines 2 and 3 in the third paragraph of the introduction should read: "A 1.0% wax emulsion applied to 'Delicious' and 'Golden Delicious' apples had no effect on fruit size (13); ..."