# Temperature and Photoperiod Effects on Cold Hardiness of Peach Scion-Rootstock Combinations[1]

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*Abstract.* **Eleven peach scion-rootstock combinations were evaluated for cold hardiness by controlled freezing after acclimation in controlled environments at temperatures of 20/14 or 10/4°C day/night and photoperiods of 9, 12 or 15 hours. Temperature and scion cultivar had much greater effects on cold hardiness of buds and bark than did photoperiod or rootstock. Trees held at 10/4° were more cold hardy than those held at 20/14°. 'Siberian C' scions were more cold hardy than 'Harrow Blood' or 'Elberta' scions. Short days increased cold acclimation of fruit buds at 20/14° but not at 10/4°. Rootstock influence on scion acclimation was small but some cultivar differences were apparent.**

Temperature and photoperiod are considered to be the primary factors regulating cold acclimation in woody perennial plants (3, 11). Previous winter hardiness studies with peaches have been based on collection of experimental materials from outdoors which were then evaluated by various methods for the effects of environmental factors on cold hardiness (2, 5, 8, 10). It is difficult to determine the effects of temp on cold acclimation using material from outdoors because outdoor temp may vary greatly over time. Photoperiod may regulate the timing of cold hardening but photoperiod effects could easily be modified by other environmental factors.

The role of the rootstock in determining cold hardiness has been reviewed (12) for deciduous fruit trees including peach. It was recently reported (7) that peach seedling rootstocks, especially 'Siberian C', influence cold hardiness of scion flower buds on mature trees in the field. In a recent field study with young nursery trees (1), 'Harrow Blood' and 'Siberian C' rootstocks were found to transmit more hardiness to the scion cultivar than 'Rutgers Red Leaf' rootstock.

Peach seedlings grown at the Harrow, Ontario, Research Station, Agriculture Canada, were budded to provide the following combinations for use 2 years later: 'Siberian C' scions on 'Rutgers Red Leaf', 'Bailey', 'Harrow Blood' and 'Siberian C' rootstocks; 'Harrow Blood' scions on 'Rutgers Red Leaf', 'Bailey', 'Harrow Blood' and 'Siberian C' rootstocks; and 'Elberta' scions on 'Rutgers Red Leaf', 'Bailey' and 'Siberian C' rootstocks. 'Elberta' is a commercial type but the remainder are used only as seedling rootstocks. 'Harrow Blood', 'Siberian C' and 'Bailey' are considered to be very winter hardy; 'Rutgers Red Leaf' is medium hardy; while 'Elberta' is considered to be medium-tender (5, 11).

One year after budding, nursery trees were dug in the fall and held over winter in an unheated barn with roots covered by moist peat moss. The trees were moved from Harrow to Guelph the following spring and planted in 35 cm diam plastic pots in a greenhouse soil mix. Potted plants were kept outdoors and had regular watering and nutrient feeding. In Sept., the plants were moved into a greenhouse with minimum night temp about 20°C and an 18-hr photoperiod provided by incandescent augmentation of natural light.

The plants of each cultivar were divided at random into 3 groups. One group was placed in "Controlled Environments Model E15 Tall" growth chambers in Sept. while the other 2 groups remained in the greenhouse. The controlled environment regimes were: 10/4 or 20/14°C (day/night) with 12 hr thermoperiod and 9, 12 or 15 hr photoperiod. Light intensity was 20 klux at plant top and relative humidity was 60%. One plant of each scion-rootstock combination was placed in each growth chamber. Three terminal scions, 15 – 25 cm long, were collected at random from the periphery of each plant after 10 days in the chamber and tested for cold hardiness. This was repeated at 20 and 30 days. After 30 days the 1st set of plants was removed and replaced from the greenhouse with the 2nd group which was treated similarly. The 2nd group was replaced with the 3rd after another 30 days. Twenty-seven terminal scions in all (9 separate freezing tests involving 3 scions at a time) were thus evaluated for cold hardiness for each scion-rootstock combination at each temp and photoperiod combination.

Cold hardiness of the scions was measured by subjecting them to freezing at a controlled rate to a particular temp using a liquid nitrogen system (9). The rate of freezing was 4.5°C per hr for all scion collections but the lowest temp reached was varied according to the no. of days the plants had been in the growth chamber and in the greenhouse in an effort to maximize differences in cold hardiness between cultivars. Thus the stress temp used on scions from the 1st group of trees was about −9°C at 10 days, −11° at 20 days, and −13° at 30 days. For the 2nd group the stress temp was about −13° at 10 days, −15° at 20

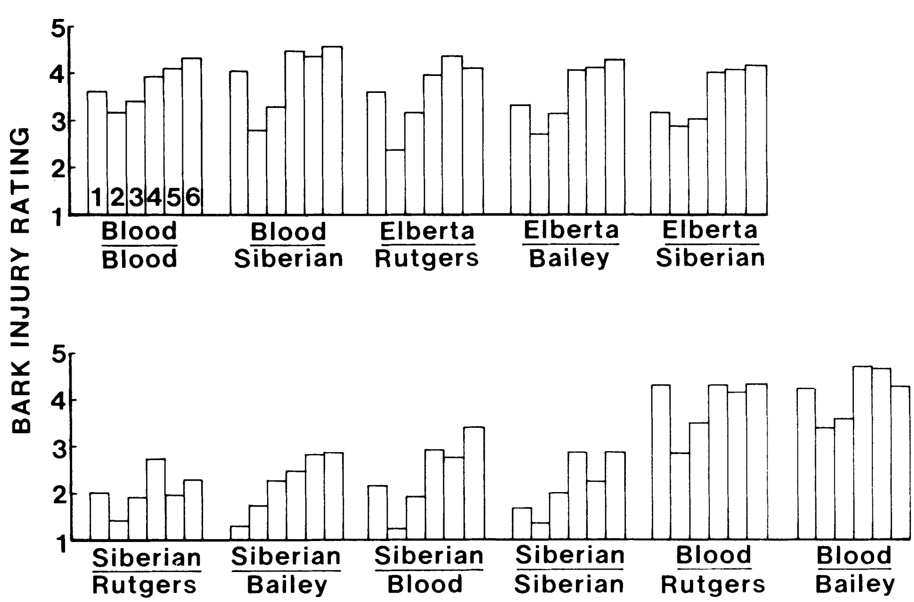


*Fig. 1.* Fruit bud mortality after freezing and thawing of 11 scion-rootstock combinations of peach as affected by temp and photoperiod. Photoperiod and temp code numbers: 1 = 10/4°C, 9 hr photoperiod; 2 = 10/4°, 12 hr; 3 = 10/4°, 15 hr; 4 = 20/14°, 9 hr; 5 = 20/14°, 12 hr; 6 = 20/14°, 15 hr. Each bar represents measurements of 27 terminal scions.

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days and $-16^{\circ}$ at 30 days. For the 3rd group the stress temp was about $-16^{\circ}$ at 10 days, $-19^{\circ}$ at 20 days, and $-18^{\circ}$ at 30 days.

Scions were held at $4^{\circ}$C for 2 days after the freezing and thawing and then evaluated for damage. Fruit buds were cross-sectioned and rated as alive or dead based on browning of the flower bud primordium. Vegetative buds were likewise evaluated but considered separately. The bark on each scion was rated for damage according to the amount of browning in which a rating of 1 (no browning) to 5 (75 to 100% browning). Comparisons of temp, photoperiod, and scion-rootstock effects were based on grand means of all scions tested from each treatment combination.

Cold acclimation of peach fruit buds was influenced more by temp than by photoperiod (Fig. 1). Greater bud hardiness was evident at $10/6^{\circ}$C than at $20/16^{\circ}$ regardless of photoperiod, scion or rootstock. The effect of photoperiod on cold acclimation of peach fruit buds was greater and more consistent at $20/16^{\circ}$ than at $10/6^{\circ}$. Cold acclimation at $20/16^{\circ}$ increased with a decrease in photoperiod while at $10/6^{\circ}$ no consistent trend was evident.

Cold acclimation of peach fruit buds was also influenced by the scion and rootstock cultivar, although the effect of the scion was substantially greater than the effect of the rootstock (Fig. 1). Fruit buds of 'Siberian C' scions were more cold hardy than 'Harrow Blood' or 'Elberta' under each temp regime and showed greater comparative cold acclimation than the other 2 at the colder temperature. Under natural outdoor acclimating conditions 'Harrow Blood' is similar in hardiness to 'Siberian C' and more hardy than 'Elberta' (11). 'Harrow Blood' may require a longer time and/or colder temperature to acclimate to the same extent as 'Siberian C' under artificial conditions.

A consistent rootstock influence on cold acclimation of scion fruit buds was not demonstrated. However, when the rootstock effects of 'Rutgers Red Leaf', 'Siberian C', and 'Bailey' on scion fruit bud hardiness were compared (Fig. 1), greater cold acclimation of scion fruit buds generally occurred with 'Rutgers Red Leaf'. 'Siberian C' was usually intermediate with 'Bailey' having the least effect. These observations from controlled environment studies differ from those previously reported for peach (1, 7) which were based on field studies under natural acclimating conditions.

Temp and cultivar effects on vegetative bud mortality followed a similar pattern to that for fruit buds (Fig. 2). Vegetative buds of 'Elberta' and 'Harrow Blood' scions were substantially less cold hardy than buds of 'Siberian C' and had a smaller acclimation response to temp. They did not respond to photoperiod at either temp. This contrasted with the fruit buds which responded to photoperiod at the warm temp. The rootstock influence on scion hardiness was similar but smaller and less consistent with vegetative buds than with fruit buds.

Bark injury (Fig. 3) was another indicator of cold hardiness and was less sensitive than fruit or vegetative buds (Fig. 1 and 2). The low temp ($10/4^{\circ}$C) environment generally resulted in less bark injury in all cultivars than the higher temp ($20/14^{\circ}$) environment. The bark of 'Siberian C' scions showed much less damage after acclimation at either temp than that of 'Harrow Blood' or 'Elberta'. Neither photoperiod nor rootstock had a consistent effect on freezing injury of bark tissue.

These experiments in controlled environments demonstrated that low-temp acclimation is a major factor in determining the cold hardiness of peach, regardless of cultivar, rootstock, or photoperiod. This finding is in agreement with other investigators (2, 5,

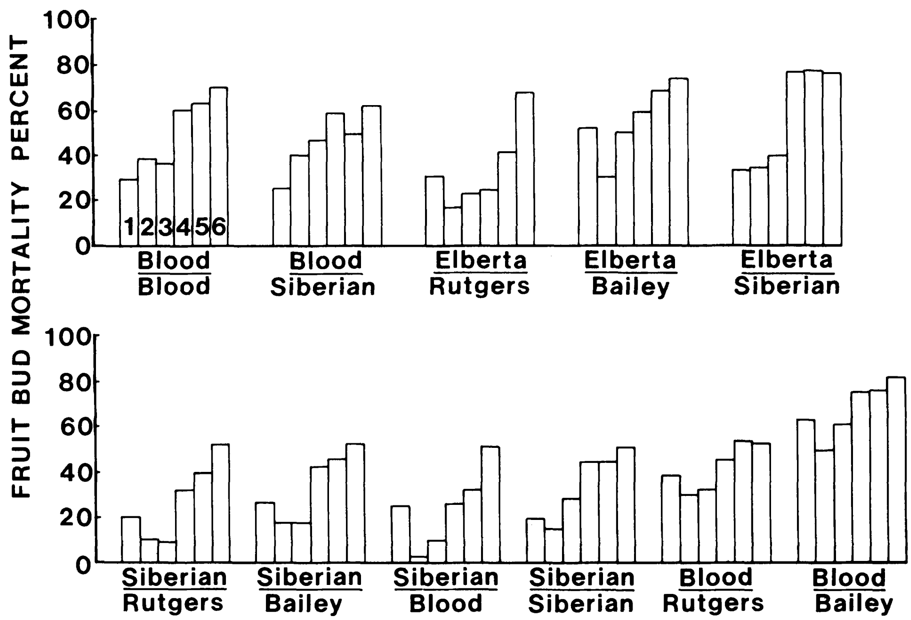


*Fig. 2.* Vegetative bud mortality after freezing and thawing of 11 scion-rootstock combinations of peach as affected by temp and photoperiod. Photoperiod and temp code numbers are as for Fig. 1.

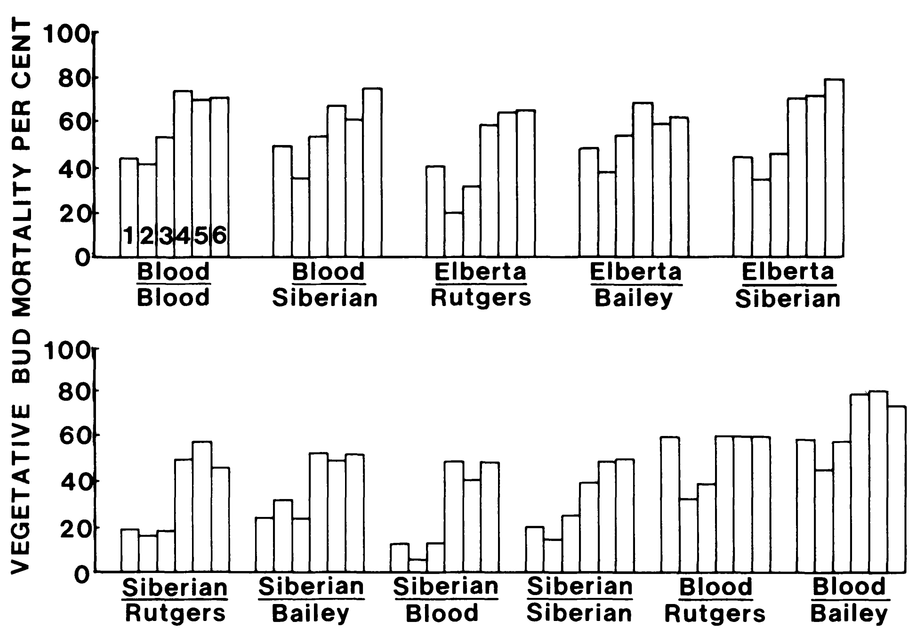


*Fig. 3.* Bark injury rating after freezing and thawing of 11 scion-rootstock combinations of peach as affected by temp and photoperiod. Ratings: 1 = No injury; 2 = Traces of browning; 3 = Browning up to 25% of bark; 4 = Browning 25-75%; 5 = Browning 75-100%. Photoperiod and temp code numbers are as for Fig. 1.

8, 10) who based their conclusions on field studies. We also showed a consistent but small effect of photoperiod on cold hardiness of peach fruit buds at the warm temp but not at the cold. Long photoperiod was associated with more bud injury than short photoperiod (Fig. 1).

Evidence for the over-riding effect of temp on photoperiod was obtained at the lower temp where the influence of photoperiod was apparently overcome or masked by a much greater acclimation response to temp. A similar response has been noted with apple (4).

The short day signal may have already been received by our plants before they were moved in Sept. from outdoors to the greenhouse since no further growth occurred. Acclimation did proceed in all material regardless of treatment and the warm temp (20°C or higher) and long photoperiod (18 hr) in the greenhouse did not over-ride or reverse it. Evidence for this was that lower freezing temp were required to produce comparable injury among plants in each successive group moved from the greenhouse to the growth chambers. Also, evidence was obtained that acclimation occurred in all plants in the growth chambers because colder freezing temp were generally required at 30 than at 20 days and at 20 than at 10 days to produce comparable injury. Similar responses were reported for apple (4).

Peaches appeared to follow the general acclimation pattern for woody plants (11). Short days promoted cold acclimation even at warm temp but low temp promoted substantially greater cold acclimation regardless of daylength.

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# Scholander Pressure Bomb Technique to Assess the Relative Leaf Water Stress of 'Orlando' Tangelo Scion as Influenced by Various Citrus Rootstocks


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*Abstract.* **A modified Scholander pressure bomb was sensitive enough to detect significant differences in relative leaf water stress among 'Orlando' tangelo (*Citrus reticulata* Blanco × *C. paradisi* Mact.) on several rootstocks. Leaf water potential for the rootstocks ranged from −7.9 bars for rough lemon (*Citrus jambhiri* Lush.) to −13.7 bars for those on trifoliata orange (*Poncirus trifoliata* Raf.). There was a diurnal pattern in leaf water stress. Modifications and procedures for the pressure bomb measurements are described.**


The Scholander pressure bomb (6) is a modification of Dixon's technique (1) to measure leaf water potential. Earlier work demonstrated that the pressure bomb was useful in evaluating water stress of 'Washington' navel and 'Valencia' orange trees (4). This study was to determine whether Scholander's pressure bomb technique could distinguish between the water uptake capacities of 'Orlando' tangelo on different rootstocks. 'Orlando' tangelo was a convenient test subject which exhibits the normal range of visual water stress responses among citrus species and hybrids in Florida.

A slightly modified Scholander pressure bomb (6) was constructed and used in the experiments (Fig. 1). A mature leaf, not exposed directly to the sun, was excised from a nonbearing twig with a razor blade just prior to testing. The leaf petiole was placed in the rubber disk (Fig. 2). Set screws on the brass ring were tightened to compress the rubber disk to form a gas-tight seal. The top of the cylinder was then tightened onto the chamber before $N_2$ was introduced into the chamber through the intake valve E (Fig. 1). The operator used a magnifying lens to observe the first appearance of free liquid at the cut ends of the xylem tissue. Then, the pressure cylinder was shut off and the pressure reading was

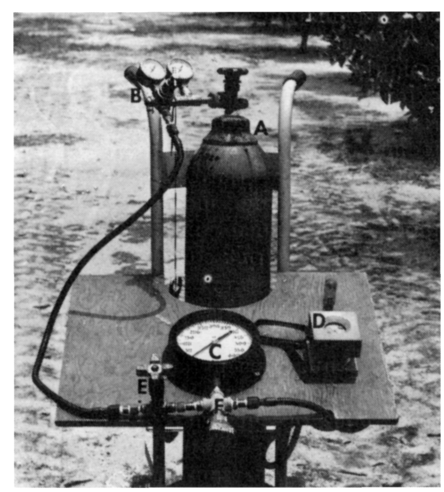


*Fig. 1.* Portable pressure bomb apparatus consisting of $N_2$ tank (A), pressure regulator (B), gauge to measure chamber pressure (C), chamber with leaf inserted (D), valve to pressurize chamber (E), and purge valve (F).

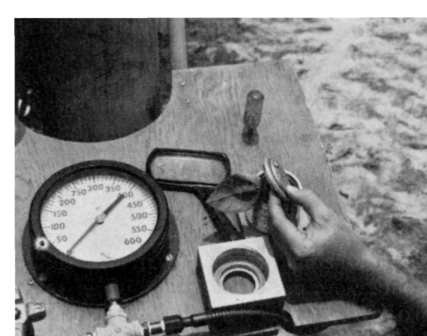

*Fig. 2.* Pressure bomb showing leaf inserted through cover of chamber.


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