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Cambial Browning of Cold Injured Peach Nursery Trees

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Abstract

One year old peach trees in nurseries at McMinnville, Tenn. were exposed to -11 C on 5 Nov. 1991 prior to digging. Nursery owners were concerned about the relationship of tree cambial browning to potential tree performance after planting. A color scale showing discolored cambium of peach nursery trees was developed to rate injury. Cambial browning was rated on trees of nine cultivars with chill hour requirements ranging from 175 to 1050. Cultivars with less than a 500 chill hour requirement had higher ratings. 'Harbrite' trees in size grades of 30 to 90 cm height had less cambium browning than trees in grades of 90 to 152 cm height. 'Redglobe' trees exposed in a programmable freezer to -24C soon exhibited slight cambium browning (rating = 1.6), however severe browning was evident on trees exposed to -30C or -35C. 'Redglobe' trees exposed to ≤ -24C did not differ in height, trunk diameter or dry weight at the end of the growing season. Trees died that had been exposed to -30 or -35C. In a similar experiment, 'Juneprince' trees exposed to -18C had slight cambium browning (rating = 1.2) but the trees died. While cambial browning may be an indicator of tree injury, the relationship between the degree of browning and injury may be specific to cultivars or chill requirement.

Introduction

Peach trees in commercial nurseries at McMinnville, Tenn. were exposed to an early autumn (5 Nov. 1991) freeze of -11 C prior to digging. Cold damage was apparent on some trees as indicated by browning of the cambium and xylem. The nursery owners were concerned about the relationship of cambial browning to potential tree performance after planting.

Stergios and Howell (2) reported that tissue browning and tree growth were reliable tests of cherry tree viability following freeze damage. Ratings of trunk cambial browning have been reported to correlate very highly with peach tree survival (3). Cain and Anderson (1) rated browning of inner bark and xylem tissues as an indicator of cold injury to peach cultivars. Yavada et al. (4) published a visual rating scale to evaluate tissue injury in orchard peach trees.

The objectives of this research were 1) to develop a visual scale for nurserymen to rate tissue discoloration, 2) to determine if browning was related to nursery tree size, 3) to determine if tissue browning differed among cultivars, and 4) to relate cambial browning to potential growth of trees.

Materials and Methods

A visual cambium browning scale (1 = no injury (no discoloration) to 6 = severe injury (dark brown) was developed after sampling a number of peach trees and photographing the discoloration. Copies of the color scale are available by contacting the authors.

Experiment 1. On 13 December 1991, five trees each of 'TropicSweet,' 'Flordastar,' 'Flordaking,' 'Idlewild,' 'La White,' CVN-1BJ, 'Harbrite,' 'Redhaven,' and 'La Premier' were sampled at random from the 91 to 122 cm tall grade at Cumberland Valley Nursery (McMinnville, Tenn.) storage facility (4-9C) and transported to The University of Tennessee at Knoxville. The cultivars had diverse chilling requirements, ranging from 175 hours to 1050 hours (Table 1). The June-budded trees had been exposed to a freeze of -11 C on 5 Nov. 1991 prior to digging. On 17 Dec. 1991, diagonal cuts were made on tree trunks 1) at 8 cm above the graft union and 2) mid point between graft union and apex. Discoloration of the cambium was rated using the browning scale.

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Experiment 2. Five June-budded trees each of 'Harbrite' and CVN-1BJ were selected at random from the nursery storage in each of six size (height) grades: 1) 30 to 45 cm, 2) 46 to 60 cm, 3) 61 to 76 cm, 4) 77 to 90 cm, 5) 91 to 121 cm, and 6) 122 to 152 cm tall. Cambial browning of trees was rated at 8 cm above the graft union on 18 Dec. 1991.

Experiment 3. In mid-Dec. 1992, June-budded trees of 'Redglobe' on 'Lovell' rootstock (30 to 46 cm height) were exposed in a programmable freezer to -6C (minimum field exposure temperature), -15, -18, -24, -30, or -35C. The temperature in the freezer was lowered at 3 C/h with trees held at the treatment temperature for 15 min before removal. The roots were kept above freezing (3 to 11 C) by enclosing in an insulated box having thermostatic controlled heating coils. A subsample of five trees per freeze treatment were rated one day after cold exposure for cambial browning at mid trunk. A second subsample of five trees was held in a cooler at 2C ± 1C and cambium browning rated 23 Feb. 1993. In a third subsample, five trees per cold treatment were planted in a nursery on 30 Mar. in a randomized complete block design. Trees were dug 23 Nov. and partitioned into shoot and root components. The partitioned parts were dried at 70C to constant weight in a forced air convection oven.

Experiment 4. In an experiment similar to Expt. 3, 'Juneprince'/Lovell peaches were exposed during 11-15 Jan. 1993 to cold treatments of -9, -12, -15, -18, -24, -30, or -35C. Subsamples of five trees/treatment were rated for cambial browning the day after treatment. A second subsample of five trees per cold treatment was held in a cooler at 2C ± 1C and cambium browning rated 23 Feb, 1993. In the third subsample, five trees per cold treatment were stored in the cooler, then planted and measured as were trees in the subsample in Expt. 3.

Results and Discussion

Peach cultivars of similar size differed in development of cambial browning following an autumn freeze that occurred before the June-budded trees were dug from the nursery (Table 1). Cultivars with the low chilling requirements of 175 to 450 hrs had a higher cambial browning rating from the autumn freeze than cultivars with more than 500 hours chilling requirement. Cambial discoloration was very similar in all cultivars having greater than 500 hours chilling requirement, though 'La Premier' tended to have slightly more browning. Ratings taken in the mid-trunk (height) region were similar to those taken 8 cm above the graft union, thus choice of rating site within that region does not appear critical. Trees of similar size on Lovell and Nemaguard rootstocks did not differ in browning (data not shown).

The most vigorous trees (122 to 152 cm tall) in the nursery had the highest cambial browning ratings (most discoloration). However, trees in grades less than 91 cm tall did not differ in discoloration of the cambium (Table 2). Thus, an orchardist may benefit

Table 1. Cambial browning of peach cultivars exposed to -11 C in the nursery, 5 Nov. 1991.

Cultivar	Chilling requirement (hrs)	Cambial Browning[z] Lower trunk[y]	Cambial Browning[z] Mid-trunk[x]
TropicSweet	175	5.0a[w]	5.1 a
Flordastar	225	4.6 a	4.5 b
Flordaking	450	4.9 a	4.7 ab
Idlewild	550	2.5 bc	2.6 d
La White	650	2.0 d	2.0 e
CVN-1BJ	750	2.1 cd	2.0 e
Harbrite	850	2.6 bc	2.4 de
Redhaven	950	2.2 cd	2.1 e
La Premier	1050	3.0 b	3.1 c

[z]Cambial browning scales 1 = none, 6 = severe browning. Rated on Dec. 16, 1991.
[y]Eight cm above graft union.
[x]Midpoint between graft union and terminal.
[w]Mean separation by Duncan's multiple range test. Values in columns followed by the same letter are not significantly different at $P \leq 0.05$.

Table 2. Effect of tree size on cambial browning of CVN-1BJ and 'Harbrite' peach trees exposed to -11 C in the nursery, 5 Nov. 1991.

Tree height (cm)	Trunk diameter (cm)	Cambial Browning[z] Lower trunk[y]	Mid-trunk[x]
30 to 45	0.36 f[w]	2.0 c	2.0 b
46 to 60	0.45 e	2.0 c	2.0 b
61 to 76	0.60 d	2.0 c	2.0 b
77 to 90	0.74 c	2.1 bc	2.1 b
91 to 121	0.95 b	2.2 b	2.2 b
122 to 151	1.27 a	3.3 a	3.4 a

[z]Cambial browning scales 1 = none, 6 = severe browning. Rated on Dec. 16, 1991.
[y]Eight cm above graft union.
[x]Midpoint between graft union and terminal.
[w]Mean separation by Duncan's multiple range test. Values in columns followed by the same letter are not significantly different at $P \leq 0.05$.

from avoidance of planting large trees in years following a severe early autumn freeze.

June-budded 'Redglobe' trees exposed to controlled freezing conditions in December exhibited browning of the cambium the following day (Table 3). Trees exposed to -24C had slightly more cambial browning (rating = 1.6), but grew as well as trees exposed to warmer temperatures and showed no injury. Trees with cambial ratings ≥4 were dead and had broken trunks after the following summer. Dry weight of those trees was not determined. Thus 'Redglobe' nursery trees may exhibit slight cambial browning from autumn freezes but appear to recover and grow normally the next year. The cambium of trees kept in cool, moist storage until late Feb. were slightly darker than those evaluated in December. This was probably associated with desiccation stress of bare-rooted trees in storage.

'Juneprince' trees exposed to minimum temperatures of -9 to -15 C exhibited no cambial browning the day after cold treatment, and the trees grew normally the following summer (Table 4). Trees exposed to -18C had very slight browning of the cambium (rating = 1.2) the day following cold treatment, but trees died the following summer. The browning ratings increased as temperature exposure was lowered from -18 to -35C. Ratings were generally higher in Feb. following cool storage.

In summary, a color scale of cambium browning has been developed that nurserymen can use in future evaluations of cold damage. Peach cultivars having low chilling requirements were more easily damaged in the nursery by an early autumn freeze than cultivars with higher chilling requirements. The largest trees in the nursery were damaged the most by the freeze. Cultivars differed in their ability to recover from browning of the cambium associated with a freeze.

Table 3. The effect of cold exposure in the laboratory on cambial browning and growth in the field of 'Redglobe'/Lovell peach trees.

Temperature[z] (C)	Cambial Browning[y] Dec. 92[x]	Feb. 93[w]	Cumulative tree dry wt. (g)[v] Stem	Stem + roots
- 6	1.0 c[u]	1.2 b	403 a	724 a
-15	1.0 c	1.2 b	399 a	802 a
-18	1.0 c	1.0 b	350 a	643 a
-24	1.6 c	---	428 a	772 a
-30	4.0 b	5.6 a	(dead)	(dead)
-35	5.4 a	6.0 a	(dead)	(dead)

[z]Cold treatment, 14-18 Dec. 1992.
[y]Cambial browning scale: 1 = none, 6 = severe browning. Rating taken at midpoint between graft union and terminal.
[x]Trees in subsample 1 were rated the day following cold treatment.
[w]Trees in subsample 2 were rated ≈ 10 weeks after cold treatment.
[v]Trees in subsample 3 were planted 30 Mar. and grown until 24 Nov. 1993.
[u]Mean separation by Duncan's multiple range test. Values in columns followed by the same letter are not significantly different at $P \leq 0.05$.

Table 4. The effect of cold exposure in the laboratory on cambial browning and growth in the field of 'Juneprince'/Lovell peach trees.

Temperature[z] (C)	Cambial Browning[y] Jan. 93[x]	Cambial Browning[y] Feb. 93[w]	Cumulative tree dry wt. (g)[v] Stem	Cumulative tree dry wt. (g)[v] Stem + roots
- 9	1.0 c[u]	1.2 c	558 a	975 a
-12	1.0 c	1.0 c	397 a	695 a
-15	1.0 c	1.2 c	383 a	800 a
-18	1.2 c	1.6 c	(dead)	(dead)
-24	2.6 b	3.6 b	(dead)	(dead)
-30	4.2 a	5.6 a	(dead)	(dead)
-35	4.8 a	5.8 a	(dead)	(dead)

[z]Cold treatment, 11-15 Jan. 1993.
[y]Cambial browning scale: 1 = none, 6 = severe browning. Rating taken at midpoint between graft union and terminal.
[x]Trees in subsample 1 were rated the day following cold treatment.
[w]Trees in subsample 2 were rated ≈ 4 weeks after cold treatment.
[v]Trees in subsample 3 were planted 30 Mar. and grown until 24 Nov. 1993.
[u]Mean separation by Duncan's multiple range test. Values in columns followed by the same letter are not significantly different at $P \leq 0.05$.

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Root System of Plum Trees on Standard and Dwarfing Rootstocks

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Abstract

Root mass and root distribution of 'Edinburg' plum trees, grafted on clonal rootstock VVA-1 (hybrid of *Prunus tomentosa* and *P. cerasifera*), rooted stem cuttings of *Prunus tomentosa*, and seedlings of *P. cerasifera*, were studied to the depth of one meter in sod-podzolic soil. Trees on VVA-1 and *P. tomentosa* rootstocks were 1.5 to 3 times smaller than on *P. cerasifera*. The root system of *P. tomentosa* was very weak. Specific mass of fibrous roots of VVA-1 was twice that of *P. cerasifera*. Yield efficiency of 'Edinburg' trees on rootstock VVA-1 was twice that of trees on *P. cerasifera*.

Introduction

Production of high density plantings of plum in modern orchards has increased interest in dwarfing plum rootstocks. Putov (8, 9) first produced such rootstocks at the Altay Research Station (Barnaul, Altay region, Russia). A dwarfing rootstock Pixy was introduced by the East Malling Research Station (11, 12, 14, 15). High yields of plum trees grafted on seedlings of *Prunus tomentosa* (*Microcerasus tomen-*

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