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Hardiness of Apple and Peach Trees in the NC-140 Rootstock Trials[1]

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Abstract

Artificial freezing tests were conducted to determine the effect of rootstocks on scion hardiness. 'Starkspur Supreme Delicious' scion wood was obtained from M.7 EMLA, M.9 EMLA, M.26 EMLA, MAC 9, and OAR 1 trees in the 1981 NC-140 rootstock trial located at New Franklin, Missouri on 8 Dec. 1986. 'Redhaven' scion wood from the 1984 NC-140 peach planting was collected on 14 Jan. and 2 Mar. 1987. Peach rootstocks evaluated in freezing tests included Bailey, Damas 1869, GF 655-2, GF 677, Halford, Lovell, Siberian C, and own-rooted 'Redhaven.' Overall, phloem and xylem of MAC 9 trees were more susceptible to winter injury than all other rootstocks except OAR 1 when injury ratings were averaged across a range of low temperatures. Cambial mortality was observed at -32.6°C in MAC 9 trees whereas mortality in M.7 EMLA trees occurred at -35.8°C. GF 655-2 suffered greater phloem injury than Bailey, GF 677, and own-rooted 'Redhaven' trees at -31°C in Dec. However, xylem tissue of Bailey, GF 655-2, and GF 677 exhibited greater injury than that of Damas 1869 and Lovell at -31°C in Dec. Peach rootstocks did not differ in flower bud hardiness in Jan., but Lovell was more cold resistant than all other rootstocks except Damas 1869 in Mar.

Introduction

Several researchers have reported that rootstocks influence the cold hardiness of the scion (3, 7, 8, 11). Layne et al. (5) found that Siberian C peach seedlings induced earlier scion defoliation and dormancy in autumn than Harrow Blood, Rutgers Red Leaf, and Veteran seedling rootstocks. Scion buds on Siberian C were also 1.3°C hardier than those on other rootstocks. Chaplin and Schneider (2) reported that seedling peach rootstocks differed in scion hardiness in early winter.

Clonal rootstocks also affect the hardiness of apple trees (3, 9, 10, 12). Sako (8) ranked the YP (Yltoinen Piikkio) rootstock as very hardy, A2 as moderately hardy, M.7 as less hardy, and M.9 as susceptible to frost injury. Other researchers (7, 10) have also evaluated the winter hardiness of the Malling rootstocks. The purpose of this study was to assess the relative hardiness of selected peach and apple rootstocks in the NC-140 regional project.

Materials and Methods

Apple and peach plantings were established at the Horticultural Research Station located near New Franklin, Missouri and maintained according to the guidelines established by the NC-140 committee (6). Tissue for the artificial freezing tests was collected from the 1981 apple planting on 8 Dec. 1986. Twenty, 2 year-old spurs with approximately 8 cm of adjacent stem tissue were collected from each tree. The rootstocks selected for this experiment included M.7 EMLA, M.9 EMLA, M.26 EMLA, MAC 9, and OAR 1. 'Starkspur Supreme Delicious' was the scion cultivar on all rootstocks. Tissue from the 1984 peach planting was obtained on 14 Jan. and 2 Mar. 1987. Eighteen, 3-node samples were collected from the middle portion of the 1 year-old growth on each tree. The scion cultivar was 'Redhaven' and the rootstocks evaluated were Bailey, Damas 1869, GF 655-2, GF 677, Halford, Lovell, Siberian C, and own-rooted 'Redhaven' trees. Five, 1 tree replicates of each rootstock were evaluated. Rootstocks were arranged in a randomized complete block design in the apple and peach plantings.

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All tissue collected from the field was placed in sealed polyethylene bags, packed in ice, and transported to the laboratory. Samples were then placed in cheesecloth moistened with distilled water and wrapped in aluminum foil. Control samples were stored in sealed polyethylene bags in a chamber at 2°C while the other tissue was cooled in a Tenney Jr. programmable freezing chamber at a rate of 3°C/hr. During freezing, the moistened cheesecloth seeded the tissue with ice at approximately -1°C. A 22 gauge copper constantan thermocouple was included in each sample for temperature monitoring and the output was recorded on a Honeywell Electronik 112 multipoint recorder. Ten samples of each apple rootstock were removed from the freezer at 4° intervals from -17 to -45°C. Peach tissue collected in Jan. and Mar. was removed from the chamber at 3° intervals from -19° to -40°C and -9° to -24°C, respectively. Samples were then thawed slowly at 2°C for 48 hr. After thawing, the tissue was incubated at 100% relative humidity and 25°C for 7 days. Stem samples were then cross-sectioned and examined for oxidative browning under a dissecting microscope. Phloem and xylem injury of samples collected in Dec. and Jan. was rated on a scale of 1 (no browning) to 5 (100% browning). The linear statistical model for the stem data contained the main effect of rootstock, temperature, and the interaction of the 2 factors. To insure homogeneity of variance, data were not included in the analysis when tissue injury ratings of all rootstocks were identical. In apple samples, the temperature at which 100% browning occurred in the cambial zone was recorded, data were subjected to an analysis of variance, and means were compared by LSD. Oxidative browning in the buds was recorded and the modified Spearman-Karber equation (1) was used to calculate T_{50} values for apple buds collected on 8 Dec. 1986 and peach buds obtained on 14 Jan. and 2 Mar. 1987. T_{50} values from each sampling date were subjected to an analysis of variance.

Results and Discussion

The weather was warm with abundant rainfall during the autumn of 1986 (Fig. 1). However, on 13 Nov. 1986 the temperature dropped from -0.6°C to -14.4°C. Following this low temperature episode, the weather was mild for the rest of the winter with little precipitation.

In spite of the freezing temperatures in Nov., the apple spur and stem tissue stored at 2°C did not exhibit any injury. Spur buds subjected to artificial freezing tests had T_{50}'s in the range of -29° to 31°C, but there were no significant differences among rootstocks in bud injury (Table 1). The cambium of 'Starkspur Supreme Delicious' on MAC 9 was injured at a warmer temperature than that on M.7 EMLA. No cambium survival was observed in any of the rootstocks below -36°C. Gogoleva (4) reported that fusiform initials in the cambial zone acclimated slowly in the autumn. After the cambium had acclimated, ray initials were injured at -45°C, while some fusiform initials survived -60°C. However, after a period of warm temperatures, the fusiform initials and the adjacent phloem were the most susceptible to winter injury. In our study,

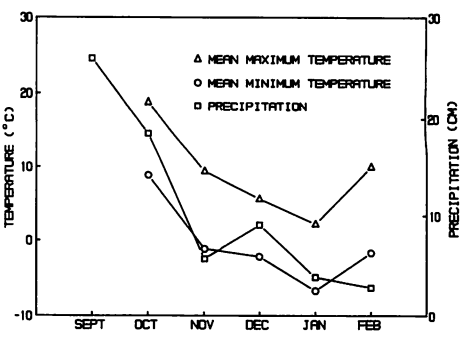

Fig. 1. Precipitation and mean monthly air temperatures from Sept. 1986 to Feb. 1987 at New Franklin, Missouri.

Table 1. Influence of apple rootstocks on hardiness and yield.[z]

Rootstock	T_{50} of spur buds (-°C)	Mortality of cambium (-°C)[x]	Oxidative browning ratings[w] phloem -37°C	phloem -41°C	xylem -33°C	Yield/tree (kg)
M.7 EMLA	30.2	35.8	2.4	2.3	2.3	1.4
M.9 EMLA	31.4	35.0	2.2	2.3	2.4	3.4
M.26 EMLA	29.0	34,6	2.1	2.6	2.2	4.8
MAC 9	30.6	32.6	2.8	3.0	3.0	6.8
OAR 1	29.4	33.0	2.7	2.8	2.9	2.0
LSD (0.05)	NS	2.9	0.6	0.6	0.6	4.9

[z]Means represent 5 replications of each rootstock.
[y]Temperature at which 50% of the buds were dead.
[x]Temperature at which cambial mortality (browning rating = 5) was observed.
[w]Rating scale 1 (no injury) to 5 (100% oxidative browning).

specific cell types in the cambial zone were not examined, but cambial injury occurred at warmer temperatures than that observed by Gogoleva in the USSR.

There were no significant differences in phloem injury at test temperatures of -17 to -33°C. At -37°C, the phloem of M.26 EMLA samples was hardier than that of MAC 9 (Table 1). However, scion wood from M.7 EMLA and M.9 EMLA exhibited less phloem damage than that of MAC 9 at -41°C. M.26 EMLA and M.7 EMLA had less xylem injury than MAC 9 at -33°C, but rootstocks did not differ in xylem damage at any other test temperature. Both the phloem and xylem tissue of MAC 9 trees had higher oxidative browning ratings than those of M.7 EMLA, M.9 EMLA, and M.26 EMLA when the ratings from all the test temperatures were averaged (Fig. 2). Although the pooled data does not assign a specific injury rating to the tissue, it revealed that the phloem and xylem of MAC 9 trees were more susceptible to winter injury than that of other rootstocks over a range of temperatures. OAR 1 was the only rootstock that did not differ from MAC 9 in xylem and phloem hardiness when the injury ratings for all temperatures were pooled.

MAC 9 trees produced greater yields than M.7 EMLA trees in 1986 (Table 1). Other researchers (6) reported that MAC 9 trees were precocious and produced such large crops that vegetative growth was adversely reduced. Heavy crop loads may also negatively influence the cold resistance of fruit trees (7, 11). Thus, the low temperature injury observed in the MAC 9 stem tissues may be associated with the heavy production even though the crop load of trees was adjusted by hand thinning.

Peach buds and stem tissues stored at 2°C did not exhibit any oxidative browning. The only temperature at which differences in phloem and xylem injury were observed was -31°C (Table 2). At this temperature, the phloem of peach scions on GF 655-2 exhibited greater tissue browning than that on Bailey, GF 677, and own-

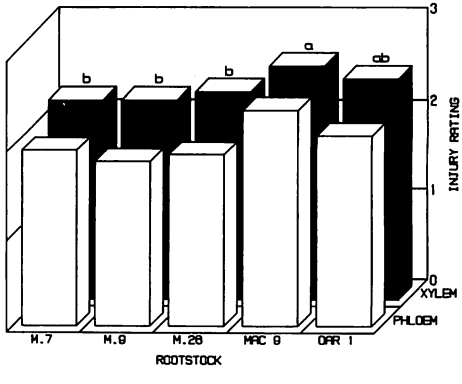

Fig. 2. The effect of apple rootstocks on the phloem and xylem of 'Starkspur supreme Delicious' scion wood when injury ratings from all test temperatures were pooled.

Table 2. Influence of peach rootstocks on hardiness and yield.[z]

Rootstock	Oxidative browning ratings at -31°C[y]		Flower bud T_{50})-°C)[x]	
	phloem	xylem	14 Jan.	2 Mar.
Bailey	2.6	4.4	19.1	11.1
Damas 1869	3.0	3.6	19.8	13.5
GF 655-2	3.6	4.4	19.4	11.3
GF 677	2.8	4.6	19.3	10.4
Halford	3.0	4.0	19.2	10.2
Lovell	3.0	3.6	19.9	14.7
Redhaven (own-rooted)	2.8	4.2	19.6	9.9
Siberian C	3.2	4.0	20.2	11.1
LSD (0.05)	0.7	0.7	NS	2.3

[z]Means represent 5 replications of each rootstock.
[y]Tissue collected on 14 Jan. 1987. Rating scale 1 (no injury) to 5 (100% oxidative browning).
[x]Temperature at which 50% of the buds were dead.

rooted 'Redhaven' trees. Xylem of Bailey and GF 655-2 trees suffered greater injury than that of Damas 1869 and Lovell trees. The average of phloem and xylem injury ratings from all test temperatures were similar to those reported for each tissue at -31°C. Rootstocks did not affect flower bud hardiness in Jan., but did influence frost tolerance in Mar. Flower buds from Lovell trees were hardier than those from all other rootstocks. Buds from Damas 1869 had greater cold tolerance than those from Bailey and Siberian C. The least hardy buds were from GF 677, Halford, and the own-rooted 'Redhaven' trees.

Results from this study indicated that the apple and peach rootstocks in the NC-140 plantings influenced the stem hardiness of the scions when subjected to artificial freezing tests on 8 Dec. 1986 and 14 Jan. 1987, respectively. The phloem and the xylem of MAC 9 trees were more susceptible to low temperature injury than all apple rootstocks except OAR 1 when oxidative browning ratings from all test temperatures were averaged. The peach rootstock, GF 655-2 had high oxidative browning ratings in both the xylem and phloem at -31°C. GF 677 and Bailey also had extensive xylem damage, but had low phloem injury ratings at -31°C. Scions of apple and peach rootstocks collected in Dec. 1986 and Jan. 1987, respectively, did not differ in flower bud hardiness. The freezing test conducted on 2 Mar. 1987 revealed that flower buds from Lovell trees were more cold resistant than those from all other trees except Damas 1869. Thus, peach rootstocks may exert a greater influence on flower bud hardiness in early spring than in mid-winter.

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Comparison of Early Performance and Fire Blight Susceptibility of 12 Early Season Apple Cultivars[1]

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Abstract

In 1981, 12 cultivars of early season apples on M.9/MM.106 or M.9/MM.111 interstems were established at 2 locations in southern Ohio. The influence of the rootstocks on tree performance were minimal, with trees on M.9/MM.111 being slightly smaller and having lower yields and yield efficiency at Ripley. No rootstock differences were expressed at Jackson. 'Discovery' and 'Akane' were tardy in coming into production and had low yields compared to other cultivars. Highest yielding cultivars were 'Ozark Gold,' 'Gala,' and 'Earliblaze' and these cultivars also tended to have relatively high productive efficiecy by yield per trunk cross-sectional area. 'Jonamac' in both plantings tended to be small, efficient trees with good fruit quality. Severe fire blight infections occurred in both plantings. While 'Viking' showed very little infection, the following cultivars exhibited severe infection in one or both plantings: 'Tydemans Red,' 'Discovery,' 'Paulared,' 'Earliblaze,' and 'Jonamac.'

Introduction

Much of the fruit in the midwest and eastern United States is marketed by direct sales through farm markets or u-pick. Generally, these operations are interested in extending their marketing season with early season apple cultivars that may overlap with vegetables or small fruit. Although summer or early season apple cultivars have been described in the past (2, 7, 8, 9), few direct comparisons of performance have been published to assist in making cultivar decisions. As expected, early season cultivars vary widely in susceptibility to pests and are often considered relatively sensitive to fire blight (1, 5).

Materials and Methods

In the spring of 1981, plantings of 12 early ripening cultivars were established at the Ohio Agricultural Research and Development Center branches at Jackson and Ripley. The following cultivars were included in the planting: 'Akane,' 'Discovery,' 'Earliblaze,' 'Gala,' 'Jerseymac,' 'Jonamac,'

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