Fruit Varieties Journal 40(4):144-146 1986

Bud Mortality and Phloem Injury of Six Blackberry Cultivars Subjected to Low Temperatures[1]

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Abstract

A tissue viability test was conducted to evaluate midwinter hardiness of 'Cherokee,' 'Comanche,' 'Cheyenne,' 'Shawnee,' 'A-1172,' and 'Darrow' blackberry buds and phloem tissue. 'Cheyenne,' 'Cherokee,' and 'Shawnee' buds had T_{50} values of -23.1, -23.5, and -23.9°C, respectively. At -34°C, 'Darrow' had the greatest bud hardiness, but the phloem tissue exhibited severe injury.

Introduction

Four productive, erect-growing blackberry cultivars have been released from the breeding program of the Arkansas Agricultural Experiment Station (9, 10, 11, 12). 'Cherokee' and 'Comanche' were released in 1974, 'Cheyenne' in 1977, and 'Shawnee' in 1984. These cultivars have produced quality fruit with high yields. Moore et al. (12) reported that 'Shawnee' had greater total yield over a 3 year period than 'Cherokee,' 'Comanche', or 'Cheyenne.' The latter cultivars did not differ in yield in this study. However, lower yields were recorded for 'Comanche' when grown in northern states following low winter temperatures (personal communication, J. N. Moore, 1985). Lack of cold hardiness could limit production of these cultivars in other regions of the United States.

Many studies have been conducted on low temperature injury of tree fruits and grapes (1, 2, 3, 5, 6, 13, 14, 15, 16, 17, 18, 21, 22), but there is a paucity of data on the cold hardiness of blackberries. Moore and Brown (8) visually rated 12 blackberry cultivars for low temperature injury following a record cold period during Jan. 1970. 'Darrow' and 'Hedrick' were the most hardy, while 'Dallas,' 'Humble,' 'Brazos,' and 'Wells Beauty' exhibited the most winter injury. More recently, Kraut and Walsh (7) evaluated the cold hardiness of 3 thornless blackberry cultivars. 'Dirksen' plants had the least cane dieback and the highest yield, 'Hull' plants were intermediate, and 'Smoothstem' exhibited the most plant injury and had the lowest yield. 'Dirksen' buds were as much as 6°C hardier than those of 'Smoothstem' during late winter. The relative cold hardiness of the erect-growing blackberry cultivars from the University of Arkansas breeding program has not been reported. The objective of this study was to evaluate midwinter hardiness of buds and phloem of 6 blackberry cultivars.

Materials and Methods

Blackberry wood was obtained from the University of Arkansas Fruit Substation at Clarksville, Arkansas on 7 Jan. 1985. Lateral wood from the upper 30 cm of pruned plants was removed from 'Comanche,' 'Cherokee,' 'Cheyenne,' 'Shawnee,' 'Darrow,' and 'A-1172.' 'A-1172' is a promising thornless erect blackberry currently being evaluated for fruit quality and yield. Two-node sections of wood were removed from the middle portion of lateral canes. Samples were placed in cheesecloth moistened with distilled water, wrapped in aluminum foil, and stored at -7°C for 24 days. During freezing,

[1]Contribution from the Missouri Agricultural Experiment Station, Journal Series No. 10107.
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the wet cheesecloth seeded the wood with ice at approximately -1°C. On 31 Jan. 1985, samples were placed in a Tenney, Jr. freezing chamber equipped with a linear temperature programmer and cooled at a rate of 2.8°C/hr. A 22 gauge copper-constantan thermocouple was included in samples for temperature monitoring. Thermocouple output was recorded on a Leeds and Northrup Model G multipoint recorder. Four replications of each cultivar were removed from the freezer at 3° intervals from -7° to -34°C. After samples were removed from the freezing chamber, they were placed in thermos bottles precooled to -7°C and allowed to thaw for 48 hrs. at 2°C. Samples were then unwrapped and incubated at 100% relative humidity and 25°C for 7 days. Buds and phloem were then examined for oxidative browning under a dissecting microscope. Tissue injury was rated on a scale of 1 (no discoloration) to 5 (complete browning).

The modified Spearman-Karber equation (4) was used to calculate T_{50} values of blackberry buds. Since complete bud mortality was not observed in all cultivars, data were also subjected to a chi square test. Phloem data were analyzed as a completely randomized design in which the linear statistical model contained the main effect of cultivar, temperature, and the interaction of the 2 factors. To insure homogeneity of variance, data were not included in the analysis when ratings of cultivar injury were identical.

Results and Discussion

The mean maximum and minimum temperatures for Nov. 1984 were 14.5 and 3.1°C with 175 mm of rainfall. In Dec. 1984, average maximum and minimum temperatures were 13.2 and 3.5°C with 183 mm of precipitation. On 25 Dec., the temperature dropped from 18°3C to -6°C. This was the only major fluctuation in temperature in the 2 months immediately preceding the experiment.

Storage of the blackberry samples at -7° for 24 days probably increased the cold hardiness of buds and the phloem. Other researchers (19, 20) have artificially hardened experimental samples of several woody species at temperatures between -3°C and -10°C for 24 days to induce maximum freezing resistance. Thus, storage at -7°C for 24 days prior to testing likely caused blackberry cultivars to be near their maximum hardiness.

The T_{50} values for 'Cheyenne,' 'Cherokee,' and 'Shawnee' were -23.1, -23.5, and -23.9°C, respectively. In the Spearman-Karber equation, the temperature at which 100% mortality occurred is utilized in the calculation. Since 'A-1172,' 'Comanche', and 'Darrow' had live buds at -34°C, a T_{50} value could not be determined (Table 1).

'Darrow' had the greatest bud survival across all temperatures. Bud mortality was not observed until 'Darrow' samples were subjected to -34°C, whereas 'Cherokee' had 100% mortality at -28°C. 'Shawnee' exhibited greater bud injury than all other cultivars at -22°C. 'Comanche' and 'Darrow' had significantly greater bud survival than the other cultivars at -31°C.

Phloem injury was not observed at temperatures above -19°C (data not shown). 'Darrow' and 'Cherokee' had greater phloem injury than 'Comanche,' 'Cheyenne,' and 'Shawnee' at -22°C (Table 2). At -31°C, 'Comanche' had less tissue damage than any of the

Table 1. Total bud mortality of blackberry cultivars at selected temperatures.[z]

Cultivar	Temperature (°C)				
	-22	-25	-28	-31	-34
Cherokee	2b[y]	4bc	8a	8a	8a
Cheyenne	0b	4bc	5ab	6a	8a
Comanche	2b	6ab	2bc	2b	6ab
Shawnee	6a	3bc	6a	8a	8a
A-1172	0b	3bc	7a	7a	7a
Darrow	0b	0c	0c	0b	3b

[z]Eight buds per cultivar were examined at each temperature.
[y]Separation in columns by chi square test ($p = 0.05$).

Table 2. Oxidative browning in the phloem of blackberry cultivars at selected temperatures.[z]

Cultivar	Temperature (°C)				
	-22	-25	-28	-31	-34
Cherokee	2.5[y]	1.8	2.8	4.5	4.3
Cheyenne	1.3	1.5	3.0	4.0	4.8
Comanche	1.0	3.0	2.8	2.5	3.8
Shawnee	1.3	1.8	2.5	3.3	3.5
A-1172	2.0	2.3	5.0	4.3	4.3
Darrow	2.3	2.5	3.8	3.5	5.0
LSD (0.05)	.7	.7	.7	.7	.7

[z]Means represent 4 replication of each cultivar.
[y]Rating scale 1 (no injury) to 5 (100% oxidative browning.)

other cultivars. 'Darrow' and 'Cheyenne' had greater phloem injury than 'Comanche' and 'Shawnee' at -34°C. In other studies, xylem tissue of blackberries exhibited less injury than phloem at -17 to -34°C (Warmund, unpublished data).

Results of viability tests on blackberry cultivars collected during midwinter and preacclimated at -7°C indicated that 'Darrow' had greater bud hardiness than the cultivars released from the Arkansas breeding program. However, 'Darrow' exhibited poor phloem hardiness at low temperatures. 'Cherokee,' 'Cheyenne,' and 'Shawnee' buds had similar T_{50} values, whereas those of 'Comanche' appeared more tolerant of low temperatures.

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