University of Guelph, ON, have selections in advanced stages of testing which are likely to be named in the next few years. These will have improved fruit size and disease resistance combined with winter hardiness.

Eastern Canada is fortunate that despite a small acreage of raspberries, there is a relatively large breeding effort. This will support the industry in the future and as improved cultivars are released, I feel sure that there will be a gradual increase in the acreage of raspberries grown.

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Longitudinal Bark Cracking on Trunks of Young Asian Pear Trees in Response to a Rapid Drop in Winter Temperature[1]

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Abstract

Freeze-induced longitudinal trunk bark cracking on young Asian pear (*Pyrus pyrifolia* (Burm.) Nak.) trees was evaluated following a rapid drop in temperature to -21°C in February 1989. Scion cultivars were '20th Century,' 'Chojuro,' 'Hosui,' 'Kikusui,' 'Niitaka,' 'Okusankichi,' 'Seigyoku,' 'Shinko,' 'Shinseiki,' and 'Tsu Li' on Old Home x Farmingdale (OHF) 51, OHF 97, OHF 217, OHF 282, and OHF 333 rootstocks. There was no rootstock effect on bark cracking. The scion cultivar effect was highly significant, however. Cracking of 'Okusankichi' trunks (47% of the trees) was significantly greater that 'Kikusui,' 'Shinseiki' or 'Tsu-Li' which had no cracking. Other cultivars were intermediate between these extremes. Cracked trees were significantly larger in trunk circumference than uncracked trees. Cracked trees had significantly lower trunk circumference relative growth rates during 1989 than uncracked trees. Freeze-induced cracks appeared to be related to the size of the tree within a given scion cultivar.

Introduction

Rapid temperature declines during the dormant season can cause widespread damage to woody plants, especially when the temperature decline begins well above freezing (2, 11). Following a sudden temperature drop, the outer layers of bark and the wood cool most rapidly and are subjected to appreciable tangential tension, which causes marked shrinkage and cracking (11). Damage in the form of longitudinal trunk bark cracks has been reported on several forest species (11), cherries (11), apples (1, 5, 9, 10) and peach (1) and may increase the plant's susceptibility to disease (11).

We noted longitudinal trunk bark cracking in an experimental planting of young Asian pear trees following exposure to rapid, wide temperature changes during February 1989. Since the orchard included trees of several scion cultivar and rootstock combinations, we were interested in differences that might be associated with such variables. Comparative information on cold hardiness of Asian pear cultivars appears to be lacking in the literature.

Materials and Methods

The planting, composed of 10 Asian pear (*Pyrus pyrifolia* (Burm.) Nak.) cultivars on 5 rootstocks, was established in the spring of 1985 at the Washington State University Royal Slope Research Unit near Othello, Washington. Scion cultivars were '20th

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Century,' 'Chojuro,' 'Hosui,' 'Kikusui,' 'Niitaka,' 'Okusankichi,' 'Seigyoku,' 'Shinko,' 'Shinseiki,' and 'Tsu Li.' Rootstocks were Old Home x Farmingdale (OHF) 51, OHF 97, OHF 217, OHF 282 and OHF 333. The trees of each scion/rootstock combination were planted in each of 4 replicate blocks in a randomized complete block design (7). Trees were uniformly fertilized and pruned. Further details of this planting were published previously (6, 7).

On 27 February 1989, fresh, longitudinal cracks in the bark of the trunks or lower scaffold branches of some trees were noted. These cracks apparently developed as a result of wide temperature fluctuations during the first week of February.

Treatments were ranked according to the percentage of trees of a given scion/rootstock combination that had fresh, longitudinal cracks on the trunk or on lower scaffold branches. We applied Friedman's nonparametric two-way analysis (8) because unequal variances among treatment effects precluded the use of ANOVA. Multiple comparisons were based on Friedman rank sums as described by Hollander and Wolfe (3).

We examined the relationship between trunk circumference and freeze-induced cracking by testing the null hypothesis that trees which cracked had the same trunk circumference as trees which did not crack. We examined the effect of cracks on subsequent growth by testing the null hypothesis that trees which cracked had the same mean relative growth rate (4) as trees which did not crack Mean relative growth rate was calculated as

$$R = (\ln C_2 - \ln C_1)/(1989\text{-}1988),$$

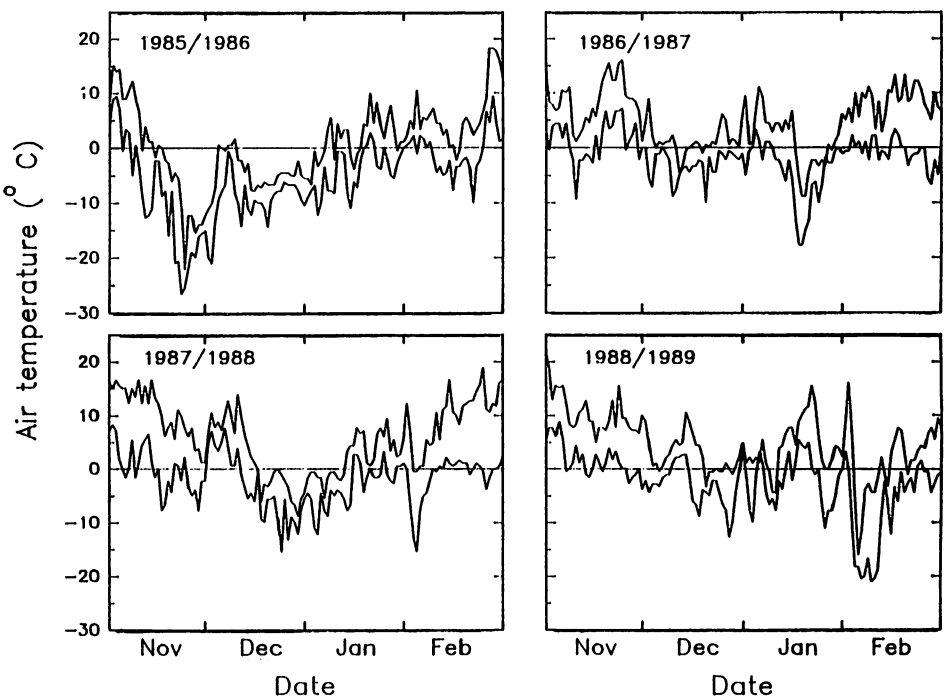

Figure 1. Daily maximum and minimum air temperatures during the dormant season at the Washington State University Royal Slope Experimental Unit near Othello, Washington, from 1985 to 1989.

where C_1 and C_2 are the trunk circumferences measured at the end of the growing season in 1988 and 1989, respectively.

No occurrences of bark cracking have been noted since 1989. Consequently, only one year's data are available.

Results

At the start of the cold period (31 January), daytime maximum temperature was 16°C (Figure 1). On 2 February, the maximum temperature was -7°C. Corresponding minimum temperatures were -1°C and -18°C. although the minimum temperature subsequently dropped to -21°C on 7 February before a warming trend occurred.

The analysis of ranks indicated that neither rootstock nor the rootstock x scion interaction significantly affected freeze-induced bark cracking in these Asian pear trees. The scion cultivar, however, had a significant effect on cracking ($P \leq 0.0001$). The multiple comparison of rank sums for scion cultivars indicated that 'Okusankichi' had a significantly higher percentage of trees with cracks than did 'Kikusui,' 'Shinseiki,' or 'Tsu Li,' which had no cracking (Table 1). Cracking on other cultivars was intermediate between these extremes, but was not significantly different from the extremes.

Cracked trees had a significantly larger ($P \leq 0.0001$) mean trunk circumference (16.0 cm) than uncracked trees (14.5 cm). Within scion cultivars, there was a consistent tendency for the larger trees to crack, but the difference was statistically significant only with 'Okusankichi,' 'Seigyoku' and 'Shinko' (Table 1).

Trees that cracked had a significantly smaller ($P = 0.0173$) mean relative growth rate (2.4 mm cm^{-1} yr^{-1}) during the 1989 growing season than uncracked trees (2.8 mm cm^{-1} yr^{-1}). Absolute growth in circumference, however, did not differ ($P = 0.9548$) between cracked (4.26 cm) and uncracked (4.24 cm) trees.

Table 1. Mean trunk circumference of four year-old trees of seven Asian pear cultivars, grown in central Washington state, that had cold-induced cracks in the bark, and for trees that did not have cracks, in February 1988. Within a cultivar, circumferences followed by the same letter are not significantly different ($P \leq 0.05$).

Cultivar	Circumference (cm) of cracked trunks	Circumference (cm) of uncracked trunks
'20th Century'	19.9 a	16.2 a
'Chojuro'	15.4 a	14.5 a
'Hosui'	16.7 a	15.3 a
'Niitaka'	13.2 a	12.1 a
'Okusankichi'	17.1 a	14.9 b
'Seigyoku'	15.9 a	13.8 b
'Shinko'	15.4 a	13.5 b

In February 1989, the circumference of '20th Century' trunks was the largest, although not significantly larger than 'Okusankichi' or 'Hosui' (Table 2). 'Niitaka' trunks were significantly smaller than all other cultivars. 'Tsu Li' and 'Niitaka' had the highest mean relative growth rate in 1989, and there were few significant differences among the remaining cultivars (Table 2).

Trunk cracks appeared to heal during the 1989 growing season. No subsequent ill effects related to cracking have been noted.

Discussion

While lower minimum temperatures had occurred earlier (e.g., -27°C in November, 1985) in the life of the planting (Figure 1) with no significant damage, the temperature decrease in 1985 was much more gradual (changes of 7° and 6°C of the maximum and minimum temperatures, respectively, over a 48 hour period) than during the 1989 episode (changes of 23° and 17°C of maximum and minimum temperatures, respectively, over a 48 hour period). While other environmental factors may have influenced damage, the rapidity of temperature change and the high temperature (16°C) just prior to the change appear to be fac-

Table 2. Percentage of freeze-induced trunk cracking in February 1989 and the associated Friedman rank sums, the mean trunk circumference (Feb. 1989), and mean relative growth rates in 1989 of four-year-old trees of ten Asian pear cultivars grown in central Washington state. Within a column, Friedman rank sums ($P \leq 0.033$) and other means ($P \leq 0.05$) followed by the same letter are not significantly different.

Cultivar	Sample size	Percentage cracked	Friedman rank sum*	Circumference of trunk (cm)	Mean relative growth rate (mm cm^{-1} yr^{-1})
'Okusankichi'	55	47.3	39 a	15.9 ab	2.7 bc
'Shinko'	59	32.2	35 ab	14.1 c	2.0 d
'Niitaka'	39	20.5	29 ab	12.3 d	3.5 a
'Seigyoku'	81	13.6	27 ab	14.1 c	3.0 b
'Chojuro'	55	9.1	21 ab	14.6 bc	2.4 cd
'Hosui'	36	11.1	20 ab	15.4 abc	2.3 cd
'20th Century'	66	3.0	16 ab	16.3 a	2.4 cd
'Kikusui'	60	0.0	11 b	14.7 bc	2.4 cd
'Shinseiki'	66	0.0	11 b	14.6 bc	2.1 d
'Tsu Li'	45	0.0	11 b	14.4 c	4.0 a

*Friedman rank sums (Hollander and Wolfe, 1973) rather than cracking percentages are used to compare cracking between cultivars.

tors contributing to the damage (11) noted here.

The similar genetic background of the rootstocks (all Old Home x Farmingdale) may account for a lack of rootstock effect on damage.

It is of considerable interest, and not surprising, that scion cultivars differed in damage. Both within (Table 1) and across cultivars, however, the damage appeared to be related to tree size, with the larger trees cracking more than the smaller trees. Since the relationship between trunk circumference and freeze-induced cracking was consistent regardless of whether the cultivar was one of the largest, e.g., 'Okusankichi,' of the smallest, e.g., 'Shinko' and 'Seigyoku,' it would be premature to make recommendations regarding which cultivars should be planted in regions where freeze-induced cracking may pose a significant problem.

The lower mean relative growth rate of the cracked trees was probably also a function of their size. When the absolute growth rate was the same, as occurred with cracked vs. uncracked trees, the larger trees had the smaller mean relative growth rate. The lower relative growth rate of cracked trees, therefore, was not necessarily the direct result of the damage caused by the cracks.

Since no subsequent damage has been observed, we were not able to determine if the order of damage observed in this episode is consistent or that any specific cultivar should be used where winter cold damage is a hazard. Additional testing, perhaps using artificial freezing equipment, is necessary to reach definite conclusions on this question.

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Comparison of the Physical, Chemical and Sensory Characteristics of Five Raspberry Cultivars Evaluated Fresh and Frozen

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Abstract

The physical, chemical and sensory characteristics of five raspberry cultivars ('Newburg,' 'Taylor,' 'Latham,' 'Festival' and 'Boyne') harvested at the red-ripe stage were evaluated at harvest and after 1, 6 and 9 months of frozen storage at -20°C. 'Newburg' was preferred for flavor ($p \leq 0.05$) over 'Festival,' 'Latham' and 'Boyne' and was significantly higher ($p \leq 0.05$) in pH, % soluble solids and total sugars than 'Boyne' after 1, 6 and 9 months frozen storage. 'Boyne' was the least preferred for color and texture ($p \leq 0.05$) at 6 and 9 months of frozen storage and was significantly less ($p \leq 0.05$) red (lower chroma value) than the other cultivars. Values for 'Taylor,' 'Latham' and 'Festival' fell between 'Newburg' and 'Boyne.'

Introduction

Raspberry growers in the State of Maine are interested in the selection of red raspberry cultivars suitable for preservation by freezing, which maintain sensory quality during frozen storage. Reports in the literature regarding fresh and frozen raspberries include the effect of harvest methods (11), postharvest storage conditions (10) and type of freezant (13). Other publications are related to the selection of cultivars which are suitable for freezing and fresh market (3, 5-7, 9). In some instances, chemical analyses (titratable acidity, pH, soluble solids, total sugars), color measurements and compression were a part of these studies (5-7).

This investigation was designed to evaluate the physical, chemical and sensory properties of several raspberry varieties at harvest and following one, six and nine months of frozen storage. The interrelationships of physical, chemical and sensory characteristics in this research may prove useful for evaluating the quality of raspberry cultivars adapted to growing conditions in other geographic areas.

Materials and Methods

Five cultivars of red raspberries ('Boyne,' 'Festival,' 'Latham,' 'Newburg,' and 'Taylor') grown at the University of Maine's Highmoor Farm, Monmouth, ME under traditional cultivation methods were harvested at red-ripe stage (9) and directly transported on ice to the Department of Food Science laboratories (within 2 hours of harvest). The fresh raspberries were cleaned and prepared for

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