

Effect of Primocane Suppression Date on 'Marion' Trailing Blackberry. II. Cold Hardiness

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Abstract. Primocanes of 'Marion' trailing blackberry plants were suppressed by cutting them off at ground level in either late April, May, June, or July 1991 and 1992. An unsuppressed control was included in which primocanes were not cut. A single cane was removed from each replication of the five primocane suppression dates at monthly intervals from mid-November to mid-February 1991-92, and from mid-November to mid-January 1992-93. One-node samples were exposed to controlled freezing at temperatures of 4, -6, -9, -12, -15, and -18C in November through February. In December and January, the -6 temperature was replaced with -21C. After 5 days at room temperature following freezing, growing point, budbase, vascular, and pith tissues were evaluated for tissue browning on a 1 to 5 scale. The LT₅₀ developed for each suppression date was compared to the control. July-suppressed plants were generally hardiest for all tissues. June-suppressed plants were somewhat less hardy than July-suppressed plants, while April-, May- and unsuppressed plants were comparable and least hardy. Cane tissues of July-suppressed and unsuppressed plants had a higher level of soluble carbohydrates than other suppression dates.

'Marion' is the most widely grown trailing blackberry cultivar in Oregon (Strik, 1992). Over 1500 ha are in production, almost all of which are located in the Willamette Valley. 'Marion' is valued for its exceptional fruit quality, but winter injury can be a serious production problem. Since 1950, severe winter conditions have reduced the crop by a minimum of 25% on six occasions. In December 1990, temperatures as low as -18C in parts of the Willamette Valley reduced the 1991 'Marion' crop by 70% (Bell et al., 1992).

Crop losses occur primarily as a result of damage to the overwintering primocanes. In particularly severe conditions, the entire primocane can be killed by cold temperatures. More typically, budbreak along the cane is erratic, and a reduced percentage of nodes produce fruitful laterals. Damage to the root system and subsequent long-term effects on plant performance have not been documented in *Rubus* spp.

Site factors or microclimate play an important role in determining the level of injury, but cultural practices can also have an impact. Winter-trained fields of 'Marion' tend to have less cold injury than summer-trained fields (Bell et al., 1992). Studies of red raspberry suggest that plant spacing and fertilization can affect hardiness (Jennings et al., 1964), while damage to leaves by pests or other factors can lower carbohydrate reserves in cane and bud tissues and reduce hardiness (Doughty et al., 1972).

Although primocane suppression is a common cultural practice, there has been no study of its effect on hardiness of 'Marion'. Lawson and Wiseman (1983) found that there was no apparent effect of primocane suppression date on hardiness of 'Glen Clova' raspberry. However, their observations were informal, and primocane suppression was carried out within a limited time frame. The present study was initiated to study the effect of primocane suppression at different dates over a 4-month period on the hardiness of 'Marion' primocanes.

Materials and Methods

A 7-year-old planting of 'Marion' blackberry on a Latôurell loam soil at the North Willamette Research and Extension Center in Aurora, Ore., was used. Plants were spaced at 2.4 m within rows spaced 3.1 m apart. Weed control, irrigation, and fertilization followed standard commercial practice.

Primocane suppression. The primocane suppression treatment involved cutting all primocane growth at ground level with pruning shears (Lawson and Wiseman, 1983). Primocanes were removed on a single occasion in either late April, May, June, or July 1991 and 1992. A control treatment was included in which primocanes were not cut. These treatments will be referred to as April-, May-, June-, and July-suppressed, or unsuppressed, respectively. All primocanes produced by the plants following the suppression treatment were allowed to grow for the rest of the season. Canes were trained within the row and left on the ground through the winter. This is standard practice for winter-trained fields of trailing blackberry. Five single-plant replicates were used for each suppression date.

Controlled freezing. At monthly intervals from mid-November to mid-February 1991-92, and from mid-November to mid-January 1992-93, a single cane was cut from each of the five replications of each primocane suppression treatment. Canes were cut at ground level and 0.6-m sections at the basal and terminal ends discarded. The remaining cane was cut into 60-cm sections and placed in a plastic bag on ice for transport to the laboratory.

Cane sections were cut into 5-cm, one-node samples, wrapped in moist cheesecloth, and then sealed in aluminum foil. These freeze packs were used for each of six test temperatures: a 4C control, -6, -9, -12, -15, and -18C. In December and January, the -6C temperature was deleted and -21C added. The freeze packs were placed overnight in a programmable freezer (Forma Scientific, Marietta, Ohio) at -2C, and the following morning the temperature was lowered by 3C/h. Temperature within the freeze packs was monitored by thermocouples attached to a DAS 8 data acquisition and interface board. After freezing, the packs were placed in a 4C refrigerator overnight to defrost, and the following day were put in plastic bags at room temperature for 5 days before evaluation.

Hardiness evaluation. Samples were visually evaluated for tissue browning. A 1 to 5 scale was used, with 1 indicating moist, green, apparently undamaged tissue, and 5 being blackened or

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dead tissue. Vascular, budbase, growing point, and pith tissues were evaluated separately. Vascular tissue was rated by scraping away the bark. Budbase, growing point, and pith were evaluated by splitting the cane section lengthwise through the center of the bud.

To develop an LT_{50} for the data, separate samples were simultaneously frozen and then evaluated for both budbreak and browning. Regression analysis was used to relate the browning rating of each tissue to percent budbreak. The browning rating required for 50% budbreak for each tissue was then derived from these data. A separate regression analysis was used to relate temperature to browning for each replication of the main experiment. The browning rating developed with the budbreak data was entered into this equation to produce an LT_{50} for each tissue on the different suppression dates. Since it was the effect of primocane suppression date on hardiness that was of interest, the LT_{50} for each replication of the suppression dates was subtracted from that of the control so as to express hardiness as degrees more or less hardy than the control.

Soluble carbohydrates. In February 1993, a single cane was cut from each replication of the suppressed and unsuppressed plants for quantitative soluble carbohydrate extraction. Six-node segments were removed from the base and tip with the remaining cane cut into 5-cm samples, 10 of which were randomly selected for carbohydrate extraction. Samples were freeze-dried and ground to pass a 40-mesh screen. Each 100-mg ground sample was placed in 5 ml of a 12 methanol : 5 chloroform : 3 water solution for 10 min before centrifugation at $220\times g$ for 5 min. The supernatant was then decanted into a second test tube. This procedure was repeated twice more, until no green color was present in the supernatant. To achieve phase separation, 9 ml of distilled H_2O was added to the accumulated 15 ml of supernatant before centrifugation for 10 min at $800\times g$ (Haissig and Dickson, 1979). Five milliliters of fluid was drawn from the upper methanol-sugar layer and diluted to 100 ml. A 1-ml aliquot of the latter was combined with 1 ml 5% phenol and 5 ml concentrated H_2SO_4 for colorimetric analysis of sugar content at 490 nm (DuBois et al., 1956).

Data analysis. The data consisted of hardiness ratings for each replication of suppression date, tissue, and sampling date relative to the control. These data were compared by analysis of variance (SAS, 1988) for the main effects of year, tissue type, primocane

suppression, and sampling date, and their interactions. Mean separations were done with the Waller-Duncan k ratio test. Soluble carbohydrate data were also compared by analysis of variance, with mean separation by the Waller-Duncan test.

Results

There was a significant effect of year, suppression date, and tissue type on hardiness at $P=0.05$. There was no significant effect of sampling date on hardiness, so data were pooled over all sampling dates within each year. Four- and three-way interactions were not significant. Of the two-way interactions, only year by tissue was significant. Tissues of July-suppressed plants were, in most cases, significantly more hardy than those of earlier-suppressed or unsuppressed plants in both years (Table 1). June-suppressed plants showed a level of hardiness similar to, or somewhat lower than, that of July-suppressed plants. In most cases, tissues of unsuppressed, April-, and May-suppressed plants showed a comparable level of hardiness (Table 1).

Soluble carbohydrate content of July- and unsuppressed plants were significantly higher than that of the other three suppression treatments (Table 2).

Discussion

The effect of the physiological age of the cane on hardiness in either raspberry or blackberry has received little attention. Lawson and Wiseman (1983) found no effect of primocane suppression date on winter injury of 'Glen Clova' raspberry primocanes. However, their experiment involved removing canes at much earlier times during their development and their results were strictly observational.

Our findings that June- and July-suppressed plants showed greater hardiness relative to those suppressed at earlier dates are contrary to expectations and the idea that well-matured tissues are the hardest. However, our findings from controlled freezing experiments were well supported by observations in the field, where later-suppressed plants consistently showed less susceptibility to damaging freezes during the course of this study than earlier-suppressed or unsuppressed plants. In fact, these late-suppressed plants showed no damage from cold spells that reduced budbreak of earlier- and unsuppressed plants up to 30% (data not shown). Thus, yields of June-suppressed plants can exceed those of earlier- or unsuppressed plants in years when cold injury occurs (Bell et al., 1994).

The reason for the increased hardiness of later-suppressed plants is not clear. Although Wample and Bary (1992) linked soluble carbohydrate concentration to hardiness in grape, they pointed out that this relationship was tenuous and that other factors

Table 1. Effect of primocane suppression date on hardiness ($^{\circ}C$) of primocane tissues of 'Marion' blackberry relative to control (negative value indicates increased hardiness). Means averaged over collection dates within year.

Suppression date	Tissue			
	Vascular	Budbase	Growing point	Pith
1991-92				
Control	0.0 AB ²	0.0 A	0.0 A	0.0 A
April	-0.1 AB	-0.6 AB	-0.7 AB	-0.7 AB
May	0.2 A	-0.3 AB	-1.5 BC	-0.3 A
June	-0.8 B	-1.7 BC	-2.1 CD	-3.1 B
July	-2.4 C	-2.3 C	-3.2 D	-6.1 C
1992-93				
Control	0.0	0.0 A	0.0 a	0.0 A
April	-0.3	-1.3 AB	-1.1 ab	-1.5 AB
May	0.0	-1.5 AB	-1.1 ab	-2.6 B
June	-0.8	-2.6 B	-2.4 b	-4.8 C
July	-1.7	-5.9 C	-3.0 b	-6.5 C

²Mean separation within columns and year by Waller-Duncan test, $P=0.05$ (lower case letters) or 0.01 (upper case letters).

Table 2. Effect of primocane suppression date on soluble carbohydrate content of primocane tissues of 'Marion' blackberry. Mean of five replications.

Suppression date	Carbohydrate content (mg/100 mg dried tissue)
Control	17.1 a ²
April	13.7 b
May	14.6 b
June	14.2 b
July	18.4 a

²Mean separation by Waller-Duncan test. Means followed by the same letter are not significantly different at $P=0.05$.

were likely involved. In this study, evidence of such a relationship in 'Marion' blackberry was not shown. A starch extraction was not done in this study, although Gagnon et al. (1990) found a positive correlation between starch content and cold hardiness of crown tissues of strawberry. Further work on starch content and qualitative analysis of soluble sugars may provide some answers.

If vigor of the planting can be maintained, a new production system emphasizing late cane suppression may offer a means to stabilize the supply of 'Marion' blackberry by reducing yield losses to winter injury.

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