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Preharvest Calcium Sprays Do Not Improve Highbush Blueberry (*Vaccinium corymbosum* L.) Quality

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Abstract. **Calcium sprays were applied to 'Bluecrop' highbush blueberry bushes between petal fall and fruit harvest. In 1992, bushes received five sprays between 18 June and 16 July that totaled 0, 1.0, 1.9 or 3.8 kg Ca/ha. Calcium was applied as $CaCl_2$ at spray concentrations of 0.08% to 0.2% Ca. Treatments in 1993 consisted of a control; 12.1 and 24.2 kg Ca/ha as $CaCl_2$; and 12.1 kg Ca/ha as the commercial product Nutrical. Calcium was applied in seven sprays between 4 June and 16 July using spray concentrations of 0.1% to 0.4% Ca. Berry samples were hand-picked, stored for 3 to 20 days, and evaluated. Treatments had no effect on the percentage of soft or rotten berries, berry firmness, or berry Ca concentrations during either year. Calcium applications increased leaf Ca concentrations. Chemical names used: calcium trihydroxyglutarate (Nutrical).**

Firmness is an important quality characteristic of fresh blueberries. Berries are often too soft if harvested when over-mature, physically damaged (bruised) during harvesting and handling, or infected by fungi that cause postharvest decay. Berries softened by bruising also are predisposed to postharvest decay (Ballinger et al., 1973). Techniques to increase or maintain blueberry firmness would be highly desirable.

Materials and Methods

Preharvest Ca sprays increased the firmness of strawberries (*Fragaria ×ananassa* Duch.) (Eaves and Leefe, 1962) and raspberries (Eaves et al., 1972). Dipping picked berries in $CaCl_2$ solutions increased the firmness of highbush blueberries (Hanson et al., 1993), but dips left an objectionable salty taste. My studies tested whether preharvest Ca sprays would enhance berry quality. Studies were conducted for 2 years in a 1979 planting of 'Bluecrop' bushes in Bloomingdale, Mich. The soil had a loamy sand texture; pH of 4.4; and P, K, Ca, and Mg levels of 207, 110, 170, and 82 kg·ha^{-1}, respectively.

In 1992, treatments supplied a total of either 0, 1.0, 1.9, or 3.8 kg Ca/ha. Calcium was applied as $CaCl_2$ in a series of five sprays between 18 June (berry diameter 3 to 6 mm) and 16 July (first ripe berries). Spray concentrations were lowest on the first application date (0%, 0.02%, 0.04%, and 0.08 % Ca for the four treatments) due to concerns about potential phytotoxicity, but later were increased to a maximum of 0%, 0.05%, 0.1%, and 0.2% Ca for the four treatments on the last date. Sprays contained no surfactant and were applied with a backpack sprayer until most leaves appeared wet, which required 370 liters·ha^{-1} on the first spray date and 560 liters·ha^{-1} when the canopy was fully developed on the last date. No phytotoxicity was observed. Treatments were replicated six times on plots of 10 bushes arranged in a randomized complete-block design.

Four 0.5-liter berry samples were hand-picked from each plot on 24 July and placed in 0.5-liter fiber containers. Samples were arranged in flats, covered with a plastic bag, and placed at 2C. Half of the samples were removed from the cooler after 2 days and were held at 18C for 1 day before evaluation. The second half was evaluated after 9 days at 2C plus 3 days at 18C.

Evaluations consisted of sorting and recording the percentage of soft berries (berry shape easily distorted by gentle pressure between fingers) and visibly moldy or rotten berries in each 0.5-liter container. The most common pathogens appeared to be *Botrytis cinerea* Pers. ex FR. and *Alternaria* sp. After sorting, the two 0.5-liter aliquots of berries were combined and placed in a rigid polyvinylchloride pipe (50 cm long, inside diameter 4 cm) with an end cap. The pipe was shaken gently to settle the berries, then dropped four times on a hard surface from 10 cm high. The compression in volume of the column of berries was calculated from its height before and after dropping. This method provided a useful comparative measure of the ability of berries to resist physical damage (Hanson et al., 1993).

The phytotoxicity of $CaCl_2$ and the chelated Ca product Nutrical (CSI Chemical Corp., Bondurant, Iowa) were tested in a separate study. Four 20- to 40-cm-long branches of 'Jersey' bushes were sprayed on 29 June 1992 to the point of drip (abaxial and adaxial leaf surfaces were wet) with water or 0.17%, 0.34%, 0.51%, or 0.68% Ca, as either $CaCl_2$ or Nutrical. Leaves were removed after 10 days, and the healthy and necrotic tissues were separated and weighed.

In 1993, higher rates of Ca and a second Ca source were tested. Treatments consisted of a nontreated control, 12.1 kg Ca/ha as $CaCl_2$, 24.2 kg Ca/ha as $CaCl_2$, and 12.1 kg Ca/ha as Nutrical. These season totals were applied in seven sprays at 5- to 7-day intervals between 4 June (petal fall to 3- to 6-mm berries) and 16 July. Spray volume and Ca concentrations were lowest on the first application date (560 liters·ha^{-1}, 0.05% and 0.1% Ca for the treatments receiving 12.1 and 24.2 kg Ca/ha) and were increased progressively to maximum levels on the last spray date (930 liters·ha^{-1}, 0.2% and 0.4% Ca). The design was a randomized complete block with six replications and four bushes per plot.

Four 0.5-liter berry samples were harvested from each plot on 21 July and 1 Aug. Berries were placed in 0.5-liter plastic "clam shell" containers, arranged in flats, wrapped loosely in plastic bags, and placed at 2C. Half of berries from the first picking were removed from the cooler after 10 days and held at 18C for 1 day before evaluation. The second half were removed from the cooler after 17 days, and held at 18C for 1 day before evaluation. Berries from the second picking were evaluated after 10 days at 2C plus 1 day at 18C or after 19 days at 2C plus 1 day at 18C. The percentage of soft and rotten berries was recorded as in 1992.

In 1993, berry firmness was measured with a instrument that squeezed individual berries between two parallel surfaces and recorded force (*g*) vs. deformation (millimeters) (Timm et al., 1993). Six berries of similar size were selected from samples harvested from each plot on 24 July (first picking), and 12 berries per plot were selected on 1 Aug (second picking). Berries were arranged on trays in 3.8-liter plastic bags, and placed in a 2C cooler. Each berry from the first picking was assessed at 4, 7, 12, 21, and 28 days after harvest and those from the second picking 17 and 24 days after harvest. Berries were allowed to warm to 18C before measurements were made, then returned to the cooler until the next evaluation date.

Leaf and fruit Ca concentrations were measured in 1992 and 1993. Thirty leaves were collected from each plot on 24 July 1992 and 21 July 1993. Leaves were rinsed briefly in tap water (electrical conductivity 0.7 dS·m^{-1}, 80 to 100 mg Ca/liter), dried at 60C for 5 to 10 days, and ground to pass through a 0.6-mm screen. Tissue was ashed at 550C and analyzed for Ca with a DC plasma emission spectrophotometer (Beckman Instruments, Fullerton, Calif.). Fruit samples, consisting of 30 to 40 mature berries, were freeze-dried, ground to pass through a 0.6-mm screen, ashed at 550C, and analyzed for Ca by atomic absorption spectrophotometry.

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Analysis of variance was conducted on all data. When F test indicated a significant treatment effect ($P = 0.05$), Tukey's least significant difference was used to separate means.

Results and Discussion

Sprays in 1992 that supplied 0, 0.9, 1.9, or 3.8 kg Ca/ha had no effect on the percentage of soft (5.9% to 10.2%) or moldy (20.7% to 28.6%) berries or compression of a column of berries (114 to 127 cm^3) measured by compression after 12 days of storage. Treatments also had no effect on these measurements after 3 days of storage, when overall means were 6.6% soft, 4.9% moldy, and 98 cm^3 for the compression tests. Treatments did not affect Ca concentrations in mature berries (310 to 346 $\mu g \cdot g^{-1}$ dry weight) or leaves (0.25% to 0.29% dry weight).

Sprays in 1993 that supplied ≤24.2 kg Ca/ha also had no effect on the percentage of moldy berries or berries rated soft by touch after 11 days storage (overall means: 1.4% moldy, 4.0% soft) or 18 days storage (0.7% moldy, 5.6% soft). Treatments also had no effect on fruit from the second commercial picking that were stored for 11 days (4.3% moldy, 10.3% soft) or 20 days (10.1% moldy, 22.5% soft). The firmness of berries from the first and second pickings also were monitored with a firmness meter for ≤28 days after harvest. Treatments had no effect on firmness measurements on any date. Firmness averaged 81 or 56 *g*/mm deformation for berries from the first and second picking, respectively. Leaf Ca concentrations were significantly higher ($P \leq 0.05$) in bushes receiving 24.2 kg Ca/ha as $CaCl_2$ (0.44% Ca dry-weight basis) and 12.1 kg Ca/ha as Nutrical (0.45% Ca) than in control plants (0.41%). Fruit Ca concentrations were not affected by treatments (overall mean: 424 μg Ca/g).

Although postharvest Ca dips have improved blueberry firmness (Hanson et al., 1993), these preharvest sprays had no effect on berry Ca levels or firmness. Postharvest dips may have been effective because the whole fruit surface is treated and higher Ca concentrations were used in the dip solutions (≤4%) than in spray solutions (≤0.4%).

Using higher spray concentrations likely would cause unacceptable necrosis to leaf tissue. Sprays containing 0% to 0.7% Ca applied to 'Jersey' bushes to the point of drip resulted in a linear increase in leaf injury [percent injury = 7.38 (percent Ca) – 0.22, $R^2 = 0.68$]. Calcium chloride and Nutrical resulted in similar levels of injury. Generally, 0.17% Ca sprays caused necrosis of ≈1% of the leaf weight, whereas 0.7% Ca solutions caused necrosis of 3% to 7% of the leaf tissue.

Whether Ca sprays would improve the quality of varieties with softer berries than 'Bluecrop' or where berries are inadvertently harvested when over-mature or bruised during harvesting or handling is not known. Tests also may be warranted on plants containing inadequate Ca levels because leaf Ca levels in these studies (0.25% to 0.45%) appeared adequate.

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