Cryoprotectants Influence Freezing Resistance of Grapevine Bud and Leaf Tissue

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Abstract. Several cryoprotectant chemicals were tested for their ability to increase the freeze resistance of grapevine (Vitis labruscana Bailey) leaf and dormant bud tissue. DuPont Surfactant WK, ethylene glycol, and BRIJ 35 were effective in lowering the low-temperature exotherm (LTE) in ‘Concord’ grape buds below controls by 5.4, 5.1, and 3.9°C, respectively, in March. Measurements taken in April showed BRIJ 35 and Surfactant WK to be notably superior to the other products, giving LTEs 14.1 and 12.2°C below controls, respectively. Ethylene glycol, Frostguard, and Frost Free were less effective. LTEs were also significantly decreased in grape leaf disks 4.1°C by BRIJ 35, 2.1°C by Frostguard, and 0.4°C by Frost Free treatments. Chemical name used: trimethylhydroxypolyethoxyethanol (DuPont Surfactant WK).

Winter injury of grapevine buds and spring freeze damage to developing grape shoots are serious problems in temperate climate vineyards. One possible approach to increasing the winter hardiness of dormant grape buds or developing shoot tissue is the use of chemicals that might reduce or prevent injury (Rieger, 1989). The use of cryoprotectants has been examined on various crops (Howell and Dennis, 1981). These cryoprotectants have typically been a high-molecular-weight surfactant material. In general, cryoprotectant chemicals have given some positive but inconsistent responses in increasing winter hardiness or providing protection from frost damage. Results of evaluations of Frost Free by Matta et al. (1987) and Rieger and Krewer (1988) on peach, plum, and almond suggested that this material was ineffective for spring frost protection on early blooming Prunus species.

The objective of this experiment was to evaluate the potential cryoprotectant activity of several chemicals on grapevine dormant buds and grape leaf tissue.

A diverse group of chemicals with potential cryoprotectant properties was tested. Ethylene glycol is a polyhydric alcohol and has been shown to be an effective freezeprotecting agent in a variety of situations (Doebbler, 1966). DuPont Surfactant WK (DEPEG) is a water-soluble surface-active agent designed for use in weedkilling sprays to increase the contact activity of certain herbicides. It has been shown to modify the cold hardiness and frost tolerance in several crops ranging from blackcurrants to apples. Another tested nonionic surfactant, BRIJ 35, is the ICI Americas’ equivalent of the Australian compound Teric 12A23B tested by Wilson and Jones (1983). Frost Free is also a nonionic surfactant plus urea whose active ingredients are a block polymer made from polyoxyethylene glycol and polyoxypropylene. The final product tested was Frostguard, which apparently contains an undisclosed sugar as the cryoprotectant along with zinc sulfate, phosphoric acid, and copper sulfate.

Fall application. For each treatment six mature ‘Concord’ grapevines were sprayed to runoff in the field on 8 Oct. and again on 22 Nov. 1986 with the following chemicals: DuPont Surfactant WK, 1% v/v (DuPont de Nemours, Wilmington, Del.), ethylene glycol, 1% v/v (Fisher Chemical, Rochester, N.Y.); and BRIJ 35 1% w/v (ICI Americas, Wilmington). Well-matured, exterior dormant canes ≈7 to 8 mm in diameter were collected from each vine during subfreezing weather on 3 Mar. 1987 and transferred to the laboratory in plastic bags covered with ice and held in an insulated ice chest. Buds from node positions 4 through 12 from the base were then prepared and their primary bud cold hardiness was evaluated using a microcomputer-based differential thermal analysis as described by Wolf and Pool (1980, 1987).

Spring application. Dormant ‘Concord’ grapevines similar to those used in the fall experiment were sprayed to runoff in the field on 12 Apr. 1987 with the following chemicals: DuPont Surfactant WK 1% v/v, ethylene glycol 1% v/v, BRIJ 35 1% w/v, Frostguard 1% v/v (Custom Chemicals, Fresno, Calif.), and Frost Free 0.25% w/v (Plant Products Corp., Vero Beach, Fla.). Actively growing 1-year-old potted ‘Concord’ grapevines that were growing in a heated greenhouse were similarly sprayed with the same chemicals on 12 Apr. All treatments for field and greenhouse experiments were replicated six times. Dormant canes were collected from field-treated vines, transferred, and prepared as previously described, while potted plants were brought intact to the laboratory 1 day after treatment. About 24 h after the chemical spray treatments had been applied to young, fully expanded grape leaves, intervalen leaf disks 8 mm in diameter were removed by use of a paper punch. Leaf disks were placed on dry thermoelectric modules and exposed to the same freezing process as were the grape buds. Cryoprotectant effects were evaluated by comparison of the low-temperature exotherms of primary buds and leaf disk tissue in the various treatments. Twelve samples were frozen for each of the treatments.

‘Concord’ buds treated in the fall with Surfactant WK, ethylene glycol, and BRIJ 35 were found in spring to be 5.4, 5.1, and 3.9°C more hardy than the controls, respectively (Table 1). The results for Surfactant WK, ethylene glycol, and BRIJ 35 were encouraging but may not be significant at other times during the dormant season as bud hardiness can change rapidly in response to environmental factors (Damborska, 1978; Pierquet and Stushnoff, 1980; Proebsting et al., 1980; Quamme, 1986).

The experiment started in the spring examined the effect of two more chemicals on the cold hardiness of dormant buds in addition to their influence on the freezing resistance of grape leaf tissue. The buds used in this experiment had decreased substantially in hardiness since the previous evaluation 6 weeks earlier, with control bud exotherms increasing from −25 to −9.5°C. Freezing resistance was improved significantly over controls by 14.1°C with BRIJ 35, and 12.2°C with Surfactant WK treatment (Table 1).

For leaf disks, BRIJ 35 demonstrated the best cryoprotectant properties, with ethylene glycol and Frostguard also showing promise. Freezing resistance was improved over controls by 4.1°C with BRIJ 35, 2.1°C with Frostguard, and 1.8°C with ethylene glycol.

These results are preliminary, indicating that cryoprotectant chemicals may increase winter hardiness in grapevine dormant buds and freezing resistance in developing grape shoots. Further work is needed to elucidate the effectiveness of these chemicals as they relate to time after treatment under field conditions and effectiveness on leaf and shoot tissues that developed in the field and various physiological and environmental factors.

Literature Cited

Doebbler, G.F. 1966. Cryoprotectant compounds. Review and discussion of structure and func-
Table 1. Effect of cryoprotectant treatments on low-temperature exotherms (C) of grapevine primary bud and leaf tissues.

<table>
<thead>
<tr>
<th>Exotherm test date</th>
<th>Tissue</th>
<th>Cryoprotectant</th>
<th>Ethylene glycol</th>
<th>Surfactant WK</th>
<th>BRIJ 35</th>
<th>Frostguard</th>
<th>Frost Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Mar.*</td>
<td>Bud</td>
<td>Control</td>
<td>−19.8 a</td>
<td>−24.9 b</td>
<td>−25.2 b</td>
<td>−23.7 b</td>
<td>---</td>
</tr>
<tr>
<td>13 Apr.*</td>
<td>Bud</td>
<td>−9.5 a</td>
<td>−11.5 a</td>
<td>−21.7 b</td>
<td>−23.6 c</td>
<td>−12.1 a</td>
<td>−12.9 a</td>
</tr>
<tr>
<td>13 Apr.*</td>
<td>Leaf</td>
<td>−2.0 a</td>
<td>−3.8 b</td>
<td>−1.7 a</td>
<td>−6.1 e</td>
<td>−4.1 b</td>
<td>−2.4 a</td>
</tr>
</tbody>
</table>

*Chemicals applied to dormant vines in the field on 8 Oct. and 22 Nov. 1986.
*Mean separation within rows by Duncan's multiple range test, P = 0.05.
*Chemicals applied to dormant vines in the field on 12 Apr. 1987.
*Chemicals applied to potted, greenhouse-grown vines on 12 Apr. 1987.


