HORTSCIENCE 33(4):644–646. 1998.

Use of an Antitranspirant to Minimize Winter Injury on Nonflooded Cranberry Bogs

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Additional index words. *Vaccinium macrocarpon*, cryoprotectants, desiccation, winter kill, winter protection

Abstract. **The benefit of applying an antitranspirant for protection of cranberry (*Vaccinium macrocarpon* Ait.) vines exposed to desiccating conditions was evaluated at four different sites, two sites per year, for a period of 1 year each. Overall, plots receiving one fall application of an antitranspirant produced more berries and greater total fruit mass the following year than did nontreated plots. Overall dry leaf mass was not significantly affected. At one site, treated plots had more flowering uprights and more flowers per upright per unit of ground area than the nontreated plots. For cranberry growers who cannot maintain a winter flood, one fall application of pinolene (Vapor Gard) may offer some protection against winter injury. Further research is needed to document long-term yield effects as well as to clarify the role of the antitranspirant in protecting exposed vines and floral buds against adverse winter conditions. Chemical name used: di-1-p-menthene (pinolene).**

The American cranberry is a low-growing, nondeciduous, perennial vine that is susceptible to desiccation during typical winters throughout much of the production area. Winter injury can occur when very cold temperatures, strong winds, and frozen soils occur simultaneously (Cross, 1966). A common cultural practice is to flood the vines for the winter months (DeMoranville and Demoranville, 1997). The winter flood acts as a protective barrier that minimizes vine exposure to conditions that promote desiccation (Eck, 1990).

In order to maintain a winter flood, cranberry beds must have an impermeable layer in the subsoil. This layer, which does not occur in all beds, is typically determined by the natural geologic structure of the bog. Other factors, such as low water reservoir capacity or low annual rainfall, may also influence the ability to maintain a flood. With increased demand for cranberry fruit and few suitable sites for new plantings, growers are forced to build beds on sites that are highly permeable. Although fruit production may be high on these sites, winter flooding may be impossible. Unless consistent snowfalls provide a uniform, insulated cover, exposed plants will be susceptible to winter injury.

Results from research investigating the use of antitranspirants or cryoprotectants to prevent freezing injury on commercial crops have been variable. Improved freezing resistance has been reported in grapevine (*Vitis labruscana* Bailey) bud and leaf tissue (Himelrick et al., 1991) with cryoprotectants. Dieback of cold-stored sycamore (*Platanus occidentalis* L.) seedlings (Filer and Nelson, 1987) was reduced following treatment with antitranspirants. However, freezing injury was not prevented by the use of antitranspirants or cryoprotectants in several peach (*Prunus persica* L.) varieties (Aoun et al., 1993; Matta et al.,1987; Reiger and Krewer, 1988). Cold hardiness of blackberry (*Rubus* spp.) was not improved by application of an antitranspirant (Strik et al., 1994). Variable results with antitranspirants on nursery stock (Fitzpatrick et al., 1986) and on containerized conifer seedlings (Simpson, 1984) have also been reported.

Previous research with antitranspirants in cranberry focused on evaluation of fruit rot control (Sandler, 1995) and retention of fungicide residues on fruit surfaces (Sandler and Kusek, 1994). No studies evaluated the efficacy of antitranspirants on the prevention of winter injury. The objective of this experiment was to determine if a fall application of an antitranspirant (Vapor Gard; Miller Chemical and Fertilizer Corporation, Hanover, Pa.) would reduce cold injury in exposed cranberry vines.

Materials and Methods

Four commercial cranberry bogs in southeastern Massachusetts were selected for postharvest treatment with pinolene (as commercial preparation "Vapor Gard" = 96% pinolene in 4% inert ingredients). Nontreated areas were established by covering small (150 × 210 cm) sections of the bog with tarpaulins prior to application. The tarps were removed shortly after application. Treated areas were designated as 150 × 210-cm sections in close proximity to the tarped areas. At all four sites, plots were replicated six times in a completely randomized treated/nontreated pairs arrangement.

Two locations were treated and evaluated in 1994–95, two different locations in 1995–96. Pinolene was applied at the label rate of 9.3 $L \cdot ha^{-1}$ at all sites. A spray volume of ≈930 and 2800 $L \cdot ha^{-1}$ was applied to plots treated by boom sprayer and chemigation, respectively. Site location, cranberry cultivar, mode of application, sampling dates, and prevailing climatic conditions at the time of application are presented in Table 1.

Shoot samples were collected from all plots just prior to treatment to provide baseline data. Initial (Sites 1 and 2) pretreatment evaluations were made by collecting a large number of random uprights. Fifty flowering and 50 vegetative uprights were sorted from each sample and weighed. In order to more accurately estimate leaf mass per unit of ground area, the protocol was changed for all subsequent evaluations. All vines within a 15-cm-diameter ring were clipped at the soil surface. The number of uprights that flowered or were vegetative the previous season, total number of uprights, and the number of rooted runners present in the sample were determined.

The samples were dried for 24 h at 60 °C. All leaves (approximate leaf production from the previous two seasons) were removed and weighed. Samples were collected from random spots in the treated/nontreated paired plots again in the spring (posttreatment) and evaluated in a similar fashion. Minimal new shoot growth had occurred at the time of the spring sampling; however, the buds had extended enough to discern between floral and vegetative buds. Leaves collected in the spring

Table 1. Cultivar, location in southeastern Massachusetts, date, and conditions during application of pinolene to cranberry, and date of sampling.

	Site			
	1	2	3	4
Cultivar	Early Black	Early Black	Ben Lear	Howes
Location	Brewster	Barnstable	Wareham	Falmouth
Mode of application	Chemigation	Chemigation	Chemigation	Boom sprayer
Date of application	11/9/94	11/29/94	11/6/95	11/1/95
Temperature (°C)	10	10	9	12
Wind conditions	Calm	Calm	Calm	Slight
Date of 2nd sampling	5/18/95	5/18/95	4/30/96	5/7/96

Received for publication 9 June 1997. Accepted for publication 4 Nov. 1997. I express my gratitude for the excellent technical assistance provided by E. Little, J. Mason, and R. Richards, and for constructive comments on the manuscript by W. Autio, T. Bewick, J. Davenport, C. DeMoranville, and B. Strik. The cooperation of cranberry growers B. Handy, K. Mann, M. Mann, D. Ross, E. Silva, and R. Thatcher is gratefully acknowledged. Reference to a proprietary product does not imply approval or recommendation of the product by the Univ. of Massachusetts to the exclusion of other products that may be suitable. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

represented those that remained attached to the uprights throughout the winter. Leaf tissue was weighed and the data were expressed as dry mass per 100 cm^2 of ground area.

During the third and fourth week of August in the year following treatment, 100 random uprights per plot were evaluated visually to determine the numbers of pedicels and developing fruit. Subsequently, percentage fruit set (number of fruit divided by the number of flowers or pedicels) was calculated. Means were calculated for fruit number, flower number, and percentage of fruit set by pooling data from the 100 evaluated uprights from each plot.

In the year following treatment, plots were harvested during the first week of September. A 900-cm^2 area was randomly selected for each plot and all berries within this area were collected. The fruit was stored at 5 °C in paper bags and visually evaluated for field rot within 1 week. To approximate the size of berries collected during commercial harvesting, very small fruit were removed prior to evaluation by passing the berries through a 5.6-mm sieve (U.S.A. Standard Testing Sieve, No. 3.5; Fisher Scientific Co., Mentor, Ohio). Rotten fruit sorted during the initial evaluation were designated as field-rotted berries. Berries were assessed for fruit rot, counted, and weighed, and the field-rotted berries discarded. The remaining healthy fruits were placed back into storage at 5 °C. The percentage of the fruit with storage rot was determined 8 weeks postharvest.

Since our intention was to conduct the same treatments in several areas, site was not considered to be a main effect, but rather as replications of treatment. Likewise, since the study was repeated for a second year (at two sites different from the first year) for the sole purpose of collecting more data utilizing the same procedure, year was not considered to be a main effect. The occurrence of different cultivars in the study was related to the site selections and thus was not included as a main effect. Data were analyzed using SAS (1988) analysis of variance procedure. Effect of treatment (treated vs. nontreated paired plots) was determined by F test ratios for upright (fall and spring samplings) and fruit parameters (posttreatment sampling only). The significance of the interaction of treatment and sampling time for the various vine (upright) parameters was also tested.

Results and Discussion

Overall, the evaluation of vine samples collected before treatment (baseline data) revealed that treated and untreated plots had similar numbers of flowering and vegetative uprights per unit area, number of runners (data not shown), and similar leaf dry mass per unit area (Table 2). Posttreatment evaluation showed no overall differences for the vine parameters, fruit parameters (except yield), and percentage fruit rot (data not shown). Leaf dry mass was not significantly affected by treatment (Table 2). The effect of sampling date was highly significant for leaf dry mass ($P < 0.001$), but the effects of treatment and interaction of treatment and sampling date were not. However, the number of fruit produced, as well as the total yield, was greater in the treated plots than in the nontreated plots over all sites (Table 2).

The number of fruiting uprights per unit ground area is one of several important predictors of cranberry yield (Eaton and Kyte, 1978). To explain the increase in berry number, the number of flowering uprights per 100 cm^2 of ground area was calculated for fall and spring samplings (Site 3 only). Sites 1 and 2 could not be evaluated accurately since the fall sampling technique was not collected from a known unit of ground area (see Materials and Methods). Site 4 was a newly planted field and was disproportionately vegetative compared to a typical established planting. Cultural techniques that promote runner growth (to enhance ground establishment of the cranberry vines) at the expense of flowering uprights are recommended for new plantings in Massachusetts (DeMoranville et al., 1997). Thus, very few flowering uprights were recovered from vine samples from Site 4.

Only data from Site 3 were used to calculate the number of flowering uprights and the number of flowers per unit of ground area. Prior to treatment, the density of flowering uprights and the numbers of flowers per upright (assessed posttreatment) were similar in treated and nontreated plots (Table 3). In the spring sampling, however, the densities of both flowering uprights and flowers were greater in treated plots than in untreated plots. Berry number was also significantly higher in treated plots. The increase in the numbers of flowering uprights and flowers per unit area at Site 3 may therefore explain the overall increase in berry number in treated areas.

Cranberry shoots accumulate nonstructural carbohydrates in the spring (Hagidimitriou and Roper, 1994). Thus, one would expect that leaf dry masses of healthy shoots (those with no or minor winter injury or desiccation), would be greater than those of injured shoots in the spring. In this study, overall dry leaf mass tended to be higher in plots treated with one application of pinolene (Table 3), but these differences were not statistically significant. Variability may have been introduced by inherent site-to-site differences, exacerbated by the inclusion of a new planting site. Yield expectations, as well as upright composition, are typically very different in new vs. established plantings (Eck, 1990).

In cranberry production areas where a winter flood cannot be maintained, one fall application of pinolene at 9.3 $L \cdot ha^{-1}$ may offer some protection against winter injury. Treated plots yielded more berries with a greater total fruit mass. The long-term impact of vine exposure to winter desiccation is not fully understood. Note that the yield from this small subsample of unflooded production sites (even the treated plots) was still under the state average of 15.2 $Mg \cdot ha^{-1}$ (Davis et al., 1996).

This study was not designed to document the long-term impact of the treatment on leaf loss (leaf-drop) or yield. In perennial crops such as cranberry, long-term research at multiple sites is needed to document the efficacy of any product or management strategy (DeMoranville, 1989). Since yield component data could only be assessed at one site, more research is needed to explain the reason for the overall increase in yield observed in this study. The increase in flowers and flowering uprights per unit of ground area needs to documented over a larger sample size as well as over several years. Further inquiry could be made to determine if antitranspirants protect floral initials or other meristematic tissues that are exposed to harsh conditions.

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Table 2. Effect of one postharvest application of pinolene in November on leaf dry mass of cranberry shoots and overall fruit productivity the following year. Means are averages for 24 replications (all sites combined).

	Leaf dry mass (g/100 cm^2 ground area)		Yield	
	Fall[z]	Spring	(No./100 cm^2 ground area)	Fruit $Mg \cdot ha^{-1}$
Treated	2.2	3.1	14.4	14.1
Nontreated	2.5	3.1	11.3	11.1
Significance	NS	NS	**	**

[z]Prior to treatment.

NS, **Nonsignificant or significant at $P = 0.01$, respectively.

Table 3. Effect of one postharvest application of pinolene in 1995 on yield components of cranberry at Site 3 in 1996. Means are averages for six replications.

	Flowering uprights (No./100 cm^2 ground area)		No. flowers	No./100 cm^2 ground area	
	Fall[z]	Spring	per upright	Flowers	Fruit
Treated	2.9	8.2	3.13	26.1	6.1
Nontreated	2.0	2.0	3.07	6.5	0.7
Significance	NS	*	NS	*	*

[z]Prior to treatment.

NS, *Nonsignificant or significant at $P = 0.05$, respectively.

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