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Two Putative Cryoprotectants do not Provide Frost and Freeze Protection in Tomato and Pepper

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Abstract. **A commercially available cryoprotectant (50% propylene block copolymer of polyoxyethylene, 50% propylene glycol; trade name FrostFree) and an antitranspirant (96% di-1-p-menthene, i.e., pinolene, a terpenic polymer, 4% inert; trade name Vapor Gard) were evaluated for their ability to protect 'Pik Red' tomato *(Lycopersicon esculentum* Mill.) and 'Keystone Resistant Giant #3' pepper *(Capsicum annuum* L.) plants during frost and freeze occurrences in the field. Tests were conducted during four spring and two fall seasons. Protection from these products was not observed under field conditions when minimum air temperature reached -3.5C and -1.0C on separate occasions. Yields for treated and untreated plants were similar. Neither cryoprotectant injured the foliage in the absence of cold events.**

High prices for early season produce encourage vegetable growers to plant as soon as soils have warmed. Although knowledge of the average last frost or freeze date and the short-term temperature forecast can be used in making planting decisions to avoid frost or freeze damage, instances do occur when temperatures drop to damaging levels after transplanting. Irrigation systems designed to meet drought needs are not always suitable for frost protection, and traditional heating systems cannot be justified economically. Therefore, economically feasible alternative frost protection options are needed. Several chemical products have been marketed and promoted as inexpensive and effective in preventing crop damage from frost or freeze.

Rieger (1989) conducted an extensive review of chemicals used to increase cold hardiness and delay spring budbreak in horticultural crops. Previous work has shown that antitranspirants did not decrease freeze damage to developing peach *(Prunus persica* Batsch) fruits (Matta et al., 1987; Rieger and Krewer, 1988), young citrus trees (Burns, 1970, 1973) or tropical foliage plants (Fitzpatrick et al., 1986). Rieger and Krewer (1988) reported that Protec (Delacar Corp., Tavares, Fla.), an antitranspirant, increased mortality of almond and plum blossoms exposed to -4.4C. Call and Seeley (1989) reported that the antitranspirant Wilt-Pruf (Wilt Products, Greenwich, Conn.) significantly reduced the T50 for 'Johnson Elberta' peach flower buds, but through delay of dehardening, which could not be applied to vegetable transplants. Previous work on the croyoprotectant FrostFree (Plant Products, Vero Beach, Fla.) found it ineffective in increasing survival of ovaries of various *Prunus* spp. (Matta et al., 1987; Rieger and Krewer, 1988). Vapor Gard (Miller Chemical and Fertilizer, Hanover, Pa.), an antitranspirant, is sold to retard transpiration and maintain healthy foliage, but the label also specifies that it can be used to protect from cold dessication. However, we found no refereed results of using these materials on vegetable crops.

The objective of this study was to evaluate these two commercially available materials for frost and freeze protection of pepper and tomato transplants under field conditions. FrostFree is 50% propylene block copolymer of polyoxyethyene, 50% propylene glycol, and Vapor Gard is 96% di-l-p-menthene (i.e., pinolene, a terpenic polymer, 4% inert). Use of a field study over one in a controlled environment was justified because antitranspirants are hypothesized to act as barriers to external nucleators (Levitt, 1980). The antitranspirant film on the surface of the leaves is thought to impede the frost that forms on the surface from providing a nucleator for water inside the plant. Inability to make frost form on the plants in a controlled chamber negates the use of such a chamber in testing the Vapor Gard material.

'Pik Red' tomatoes and 'Keystone Resistant Giant #3' peppers were seeded in the greenhouse and grown to transplant stage (two true leaves). The plants were fertilized twice in the greenhouse with 20N-20P-20K fertilizer (3.75 g/liter Peters Fertilizer Products, W.R. Grace, Fogelsville, Pa.), No preconditioning by water or fertilizer reduction was carried out.

Plants were transplanted at the Central Crops Research Station near Clayton, N.C., on a Typic Paleudult with 0.3% humic matter and pH 5.3. A randomized complete-block design with four replicates was used. Transplanting occurred as early as possible in advance of the average last frost date for Clayton (7 Apr., SD = 12 days). Pepper plants were spaced 30 cm and tomato plants 45 cm in 1.5-m-wide ridges. Each plot consisted of one row 4.5 m long. The Fall 1987 test was initiated when a frost was forecast within the next 5 days. The Fall 1988 test was initiated to precede the average first fall frost by one SD (25 Oct., SD = 10 days).

FrostFree was evaluated in the springs of 1987-90 and in Fall 1987 and 1989. Six treatments were imposed during 1987-89, with applications to the plants of ($kg \cdot ha^{-1}$): 1) 0.7 one day before transplanting, 2) 0.7 immediately after transplanting, 3) and 4) 0.7 or 1.3 when a frost or freeze was imminent (usually the day before), 5) 0.3 immediately after transplanting and 0.3 repeated when a frost or freeze was imminent and 6) no cryoprotectant (left dry). In 1990, a control or one of two treatments, 1.1 $kg \cdot ha^{-1}$ applied to the plants either 1 day before transplanting or when frost or freeze was immiment, was used. Vapor Gard was evaluated in Spring 1989 and 1990 and Fall 1989. The two treatments consisted of a pretransplant application to the plants at 1.0 $kg \cdot ha^{-1}$ and a 1.0 $kg \cdot ha^{-1}$ application when a frost or freeze was imminent and a control that was left dry. Manufacturer's guidelines for FrostFree specify reapplication every 10 days. This necessitated multiple applications in Fall 1989. FrostFree and Vapor Gard were applied with a CO, backpack sprayer pressurized at 276 kPa to deliver 375 liters of spray solution/ha.

Air temperature in the field was measured by three Taylor maximum-minimum self-

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Table 1. Planting date, date of cold event, minimum air temperature during event, hours below 0C, maximum and minimum air temperature of 3 days before event, and average percent dead plants on untreated pepper and tomato transplants and transplants treated with two cryoprotectants during eight below-freezing temperature events.

Planting date	Date of cold event	Minimum temp (°C)	Hours below 0C	Temp 3 days before event[z] (°C)		Dead (%)	
				Maximum	Minimum	Pepper	Tomato
17 Nov. 1987	21 Nov. 1987	−3.4	9	12.3	0.9	81	97
				11.8	4.6		
				21.0	8.9		
	22 Nov. 1987	−4.2	13	4.6	−3.4	96	100
				12.3	0.9		
				11.8	4.6		
27 Mar. 1989	2 Apr. 1989	−0.7	1	12.7	2.1	0	0
				26.7	7.5		
				25.9	16.7		
	11 Apr. 1989	−0.3	1	9.9	3.9	0	0
				15.8	6.3		
				8.5	1.1		
	12 Apr. 1989	−0.8	1	9.9	−0.3	0	0
				9.9	3.9		
				15.8	6.3		
	24 Nov. 1989	−4.1	11	4.8	−0.8	100	100
				6.6	1.2		
				17.2	3.5		
12 Mar. 1990	21 Mar. 1990	−0.7	3	15.5	2.4	17	44
				22.5	7.4		
				20.8	10.6		
	8 Apr. 1990	−0.1	1	15.0	4.3	20	39
				28.2	12.7		
				24.7	6.2		

[z]Listed in order of 1, 2, and 3 days before cold event, respectively.

registering (mercury-in-glass) thermometers (Model no. 5458, Taylor Scientific, Arden, N.C.) exposed to simulate crop temperature. Air temperature, radiation, dewpoint (frostpoint), wind speed, and soil temperature were measured by the North Carolina Agricultural Research Service Weather Data Acquisition System located nearby on the experiment station. Sensor readings were taken every 15 sec by an onsite computer (Model no. 2200, California Computer Systems, San Jose, Calif.) and transferred daily to disk storage. The air temperature sensor was a shielded, aspirated thermistor (model no. 100325, Climatronics Bohemia, N.Y.). Although not located in the field where this test was conducted, air temperatures had been previously observed to be within 0.5C during radiation frost occurrences. These automatically recorded temperatures were used to document the hours below freezing.

Mortality was assessed by counting the number of dead plants 1 day after each low temperature event (temperatures did not drop below freezing during all nights evaluated). During the events observed, the plants either were killed or sustained less than a 10% injury rating; thus, we rated the plants only as being dead or alive. At harvest, fruit were sorted and weighed according to U.S. no. 1 and 2 grade standards for size and defects (U.S. Dept. Agr., 1976, 1989). The culls were also weighed. Analyses of variance were performed on the damage assessments and yield data.

During this study, 13 cold nights (events) occurred, of which eight provided appropriate weather conditions to evaluate the cryoprotectants. Frost formed during all but the 21 Mar. 1990 event. During five of these events (21 and 22 Nov. 1987, 24 Nov. 1989, 21 Mar. and 8 Apr. 1990) transplants were killed (Table 1). The number of killed plants was similar regardless of treatment ($P < 0.01$, see percent dead plants in Table 1). Analysis of yield data was only possible for the spring tests. In only one of these tests were significant differences in yield observed ($P = 0.05$). Yield of U.S. no. 1 grade tomatoes was increased by the application of Vapor Gard before the occurrence of the predicted freezing temperatures in Spring 1989. However, freezing damage was absent in all of the treatments that spring; thus, the difference was not related to freezing damage avoidance.

The 13 low-temperature events that were experienced provide evidence that these materials are ineffective below -3.5C (21 and 22 Nov. 1987, 24 Nov. 1989). The lack of significant differences in damage during the nights of 21 Mar. and 8 Apr. 1990 also support the conclusion that no protection is gained at temperatures just below freezing. This casts serious doubt that any protection would be provided in the range of -1.0 to -3.0C, but temperatures in this range were not tested in this study.

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