Effects of Certain Growth Regulators on Low Temperature Injury of Cultivars of *Chrysanthemum morifolium*[1]

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Abstract. The growth substances Alar, gibberellin, maleic hydrazide, and phosfon were applied to *Chrysanthemum morifolium* cultivars and their effects on low temperature injury resistance determined electrolytically. Single and repeated applications of Alar and maleic hydrazide were found to reduce effectively low temperature injury, but gibberellin and phosfon applications did not affect resistance to injury.

Table 1. Index of injury from lower stem sections of 2 chrysanthemum cultivars treated with 4 growth regulators and frozen at -9.7°C (Mean of 8 Replications)

Treatment	Joanette	Ann Ladygo
Maleic hydrazide	15.4 a	5.8 a
Alar	16.1 a	8.3 ab
Phosfon	17.1 ab	11.3 b
Check	20.1 bc	7.2 ab
Gibberellin	22.4 c	8.0 ab
L.S.D.	3.3	4.5

(Means followed by the same letter are not significantly different at the 5% level).

The usefulness of garden chrysanthemum, *Chrysanthemum morifolium,* Ramat., is limited in the northeastern United States by lack of winter hardiness. Holly (7) and Widmer (13) found that soil temperatures close to -12° to -15°C killed most chrysanthemum cultivars. Boyce (1) and Iverson (9) recorded mulched and unmulched soil temperatures as low as this in Vermont -and Minnesota, respectively. An effective method of increasing winter hardiness might extend the range of outdoor grown chrysanthemums as well as many other horticultural crops.

Several growth substances have been reported to increase winter hardiness. Stewart and Leonard (12) reported that grapefruit trees treated with diethanolamine salt of 6-hydroxy-3-(2H) pyridazinone (maleic hydrazide) suffered less injury from low temperatures than did untreated trees. Granger and Hogue (6), Irving and Lanphear (8), and Kuiper (10) found N-dimethylamine succinamic acid (Alar) increased winter hardiness and frost resistance respectively. Proebsting and Mills (11) and Edgerton (4) reported that gibberellin effectively increased peach flower bud winter hardiness when applied late in the growing season. Cathey (3) reported that 2, 4-dichlorobenzyltributyl phosphonium chloride (phosfon) markedly increased winter hardiness of stem and petioles of herbaceous plants.

Rooted cuttings of *Chrysanthemum morifolium* cultivars 'Ann Ladygo' and 'Joanette'[2] were grown under long artificial photoperiods in the greenhouse from July 26 to September 26, 1967. Hardening conditions of natural short days with night temperatures of 2-4°C were initiated September 27. Day temperatures ranged from 10-16°.

Alar, maleic hydrazide, and phosfon each at 2,000 ppm, and gibberellin at 500 ppm were applied November 3 to partially hardened plants with a low-pressure sprayer, thoroughly wetting the foliage. Although flower buds were visible, petals had not yet unfolded from the buds when chemicals were applied. Samples from the lower primary stems were taken January 2 and 3, 1968, from 'Ann Ladygo' and 'Joanette', respectively. One stem segment, 1.0 cm long and 0.9-1.1 cm in diameter, was cut from each plant immediately above the soil line and placed in a test tube in an ethylene glycol refrigerator bath at 0°C and exposed to -9.7° at a freezing rate of 1.7° per hour. Resistance to low temperature injury was evaluated electrolytically (2). Injury was expressed as an index of injury on a scale of 0- 100 where 100 indicates complete killing of tissue (5).

The effect of repeated applications of Alar and maleic hydrazide on hardiness of vegetatively growing plants also was observed. Rooted cuttings of chrysanthemum 'Radiance' were potted January 29, 1968. The foliage was dipped in 2,000 ppm solutions of Alar or maleic hydrazide on February 12 and 28 and March 18. The plants were hardened in a growth chamber April 3-23 under an 8-hour photoperiod, 4.4°C night temperature and 15.6°C day temperature. Resistance of lower stem sections to injury from temperature exposures of -8.9°C and -11.1°C was determined as previously described.

Single applications of Alar or maleic hydrazide to flowering plants of 'Joanette' significantly decreased low temperature injury, compared with the check and gibberellin treatment (Table 1).

'Ann Ladygo' did not respond to Alar or maleic hydrazide treatment. Phosfon-treated plants showed significantly more low temperature injury than those treated with maleic hydrazide. Low index of injury values for 'Ann Ladygo' in all treatments indicate its increased resistance to injury.

Repeated applications of either Alar or maleic hydrazide to vegetative plants of 'Radiance' significantly reduced injury following exposure to -8.9°C (Fig. 1). Maleic hydrazide increased resistance to low temperature more effectively than Alar. Decreasing the temperature from -8.9°C to -11.1°C considerably increased injury to both the check- and alar-treated plants, but only slightly increased injury to maleic hydrazide-treated plants.

[1]Received for publication March 24, 1969. University of Vermont Agricultural Experiment Station Journal Article No.

[2]Rooted cuttings were donated by Yoder Bros. Inc., Barberton, Ohio.

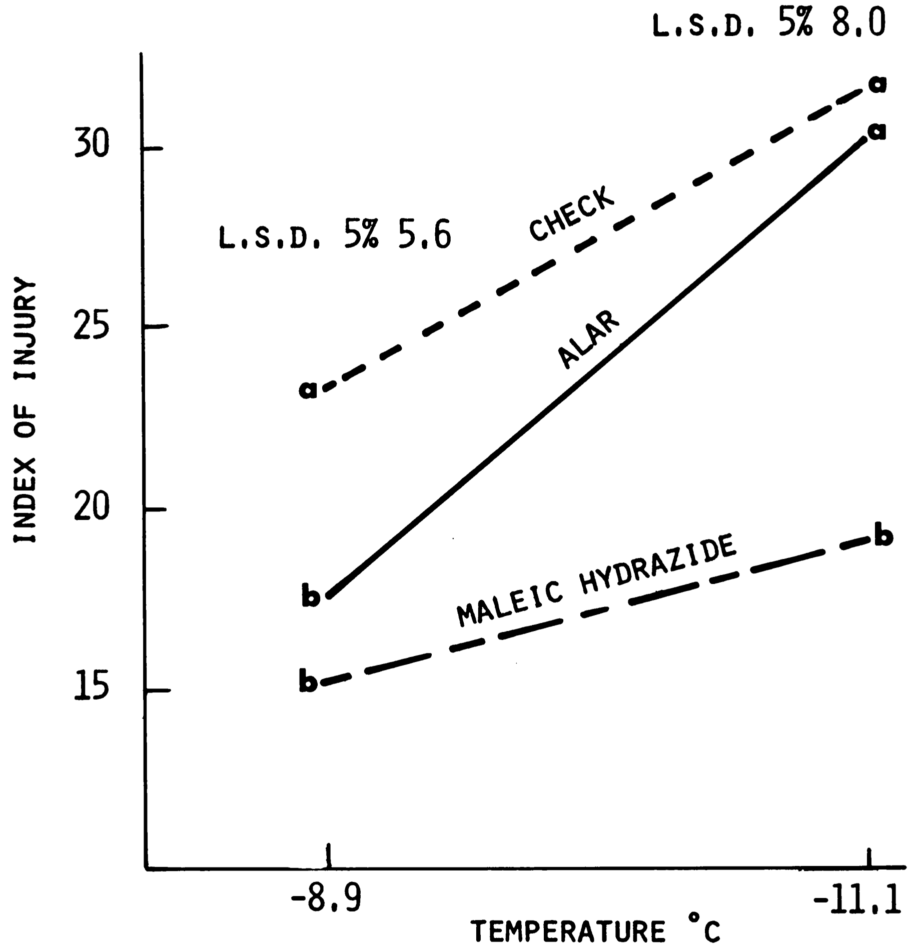

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Fig. 1. Index of injury from lower stem sections of chrysanthemum 'Radiance' dipped 3 times in 2 growth substances, hardened in a growth chamber, and frozen at 2 temperatures. (Mean of 5 replications; means followed by the same letter within a temperature exposure are not significantly different at the 5% level).

Irving and Lanphear (8) suggested that increases in resistance to low temperature injury from Alar in woody plants is due to an antigibberellin effect overcoming the antihardening effect of endogenous gibberellins. Application of gibberellin to chrysanthemums in this study, however, did not result in significant decreases in injury resistance as compared with the check. Kuiper (10) proposed that succinamic acids increase low temperature resistance by increasing the permeability of cells to water through a change in configuration of a membrane enzyme system to a more stable form, allowing more rapid movement of water to regions of extracellular freezing.

Increases in low temperature resistance due to maleic hydrazide application are difficult to explain. Cathey (3) has suggested no physiological basis other than this compound's inhibitory effect on general metabolic activity.

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