Emergence, Growth, and Freezing Tolerance of Tomato Seedlings Grown from Uniconazole-treated Seed

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Abstract. Seeds of *Lycopersicon esculentum* Mill. cv. UC 82L were treated with hypertonic priming solutions containing KNO₃ and K₂PO₄ (10 g-liter⁻¹ each), and various concentrations of uniconazole before sowing. Treatment of the seed with priming solution only hastened emergence by $\approx$ 2 days compared to untreated seed sown directly from the packet, but did not affect total emergence after 12 days. Addition of uniconazole to the priming solution had no significant effect on speed of emergence or total emergence after 12 days compared to the primed control. Seed priming plus uniconazole at 1 or 10 mg-liter⁻¹ reduced seedling height after 2 weeks by $\approx$ 20% compared to the primed control. Uniconazole had no effect on the mortality of either hardened or nonhardened seedlings exposed to below-freezing temperatures for 3 hr. These data suggest that treatment of tomato seed with hypertonic solutions containing uniconazole would be of little practical value in protecting seedlings from freeze damage. Chemical names used: (E)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-yl)penten-3-ol (uniconazole).

There is considerable interest in seed treatments that might enhance cold hardiness of seedlings. Some types of vegetable seed can be treated with a hypertonic priming so-

lution that initiates germination processes before planting but that does not permit radicle emergence due to the osmotic pressure of the solution (Ells, 1963). When planted, such primed seed exhibits hastened germination and improved uniformity of emergence in the field. Pre-plant priming of seeds could provide an opportunity for inexpensively treating seeds with compounds that confer cold hardiness. In fact, preliminary work with wheat indicates that the addition of uniconazole, a highly active triazole, to a priming solution increases subsequent seedling tolerance to low temperature (Fletcher,

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Table 1. Emergence and height of tomato seedlings treated with hypertonic priming solutions containing various concentrations (mg·liter⁻¹) of uniconazole.^a

Characteristic ^b	Seed treatment				
	Nonprimed	Primed			
		Uniconazole (mg·liter ⁻¹)			
		0	0.1	1	10
T ₁₀ (days)	6.9 b	4.6 a	4.9 a	5.1 a	5.0 a
T ₅₀ (days)	8.2 b	6.0 a	6.3 a	6.6 a	6.5 a
Seedling height (mm) after 2 weeks	21 b	24 a	23 ab	19 c	19 c

^aMeans within a row with common lower case letters are not significantly different at $P = 0.05$.

^bT₁₀ and T₅₀ = time until 10% and 50% emergence, respectively.

1989). The object of the present investigation was to determine whether the addition of uniconazole to hypertonic priming solutions would confer cold tolerance to tomato seedlings. Seedling emergence and growth were also monitored because the effects of uniconazole seed treatment on these important characteristics are unknown.

One-gram samples of 'UC 82L' tomato seed (Peto Seed Co., Woodland, Calif., lot 1152, 1988, 95% germination) were placed in petri dishes with blotters wetted with 3 ml of a hypertonic priming solution containing 10 g KNO₃/liter (99 mM); 10 g K₂PO₄/liter (47 mM) (Ells, 1963); and 0, 0.1, 1, or 10 mg uniconazole/liter (50% wettable powder formulation). Each petri dish was then sealed with polyethylene wrap and placed in a dark germinator at 24C for 6 days (Ells, 1963). At the end of the 6-day priming period, the petri dishes were opened and the seed was air-dried in the laboratory. As expected, no radicle emergence occurred during the priming treatment.

Following air-drying, the seed was sown in rows in flats containing a commercial greenhouse seedling mix [1 peat : 1 vermiculite (v/v)]. A randomized block experimental design was used with six blocks per treatment and 20 seeds per block. In addition to the primed seed, six blocks of nonprimed seed were sown directly from the packet to serve as an additional control. Flats were placed in a greenhouse with a day/night regime of $\approx 24/20^{\circ}\text{C}$. Seedling emergence was counted daily for 12 days until emergence was complete. The time for 10% (T₁₀) and 50% (T₅₀) emergence was calculated based upon regression equations obtained from the raw emergence data. The height of at least 18 randomly sampled seedlings per treatment was measured 2 weeks after sowing.

Freeze tolerance of the seedlings was evaluated 2 weeks after sowing by placing

flats in a freeze chamber. One-half of the seedlings (nonhardened) from each treatment were placed directly in the freeze chamber at -3°C for 3 hr. The remaining half (hardened) were placed in a refrigerated cooler at 5°C for 14 hr, returned to the greenhouse overnight (≈ 15 hr), and then placed in the freeze chamber at -5°C for 3 hr the following day. Flats were returned to the greenhouse and mortality was evaluated visually after 24 hr. Individual seedlings were either killed or exhibited no visible damage following freezing; no partial damage to seedlings was evident. Seedlings that were killed turned brown and fell over within a few hours after freezing.

The experiment was conducted three times and data were pooled for statistical analyses. Statistical inferences were made based upon Scheffe's test (for T₁₀, T₅₀, total emergence, and seedling height data) or confidence intervals (for mortality data at a confidence level of 5%).

Pre-plant treatment of the seed with the hypertonic priming solution hastened emergence by ≈ 2 days compared to nonprimed seed sown directly from the packet (Table 1). The T₁₀ values for emergence were ≈ 5 and 7 days for the primed and nonprimed seed, respectively. Similarly, the T₅₀ values were ≈ 6 and 8 days for the same two treatments. Although there was a slight trend for uniconazole to delay emergence, this effect was not statistically significant. Final emergence after 12 days was similar ($\approx 90\%$) regardless of treatment. Hence, neither priming nor uniconazole influenced the total number of seedlings that eventually emerged.

Addition of 1 or 10 mg uniconazole/liter to the hypertonic priming solution reduced seedling height 2 weeks after sowing by $\approx 20\%$ compared to the primed control (Table 1). We also observed that seedlings from these two treatments were darker green than

the controls. These observations are consistent with previous findings regarding the effects of triazoles on shoot elongation and chlorophyll content (Davis et al., 1988).

Regardless of whether the seedlings received a hardening period before freezing, uniconazole had no significant effect on mortality percentage following freezing. About 35% of the nonhardened seedlings succumbed to a 3-hr exposure to -3°C and $\approx 40\%$ of the hardened seedlings died following a 3-hr exposure to -5°C . In addition to these treatments, a variety of other hardening/freezing protocol was also tested, none of which indicated a significant increase in cold hardness of uniconazole-treated seedlings (data not shown). Based on our seedling height data (Table 1), the lack of response of cold hardness to uniconazole clearly is not merely due to lack of uptake of the compound by the seed. It could be argued that higher concentrations of uniconazole than those used in this study are needed to confer cold hardness. Such higher concentrations, however, would likely cause excess shoot growth inhibition and would possibly delay seedling emergence.

The temperatures required to kill the tomato seedlings were somewhat lower than we expected. Nevertheless, these data are consistent with recent findings (Anderson, 1988) that tomato seedlings froze at about -5 to -7°C , the exact temperature depending upon populations of ice-nucleation active bacteria. Thus, it appears that tomato seedlings possess more cold hardness than older and larger tomato plants that often succumb to temperatures that are just below freezing.

Our present results indicate that treatment of tomato seed with priming solutions containing uniconazole will not likely be of practical value in protecting seedlings from freezing.

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