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Antitranspirants Do not Reduce Transplant Shock of Impatiens Seedlings in a Greenhouse

Marc van Iersel

ADDITIONAL INDEX WORDS. *Impatiens wallerana*, transplant shock, water relations, phytotoxicity

SUMMARY. Transplanting can result in root damage, thereby limiting the uptake of water and nutrients by plants. This can slow growth and sometimes cause plant death. Antitranspirants have been used to minimize transplant shock of vegetables. The objective of this research was to determine if antitranspirants are useful to reduce transplant shock of impatiens (*Impatiens wallerana* Hook.f.) seedlings in the greenhouse. Seedling foliage was dipped in or sprayed with antitranspirant (Vapor Gard or WiltPruf) and shoot dry mass was determined at weekly intervals. Antitranspirants reduced posttransplant growth of impatiens as compared to untreated plants, possibly because of a decrease in stomatal conductance, leading to a decrease in photosynthesis. The two dip treatments also caused phytotoxic effects (necrotic spots) on the leaves. In a second study, leaf water, osmotic and pressure potential were determined at 2, 9, and 16 days after transplant. Application of antitranspirants (as a dip or spray) decreased water and osmotic potential compared to control plants. The results of this study indicate that antitranspirants are not useful for minimizing transplant shock of impatiens under greenhouse conditions.

Plant growth following transplant can be slow because of transplant shock. Transplant shock usually is caused by damage to the root system of plants. Fine roots are especially likely to be destroyed during transplanting (Kramer, 1983). Transplant shock can cause water stress (Berkowitz and Rabin, 1988), decrease nutrient uptake (Bloom and Sukrapanna, 1990), and make plants more susceptible to disease (Moss and Main, 1989). Water stress and decreased nutrient uptake may be a direct effect of root damage, while decreased vigor can make plants more vulnerable to diseases.

Transplant shock can result in a temporary water deficit, poor growth, and sometimes plant death (Berkowitz and Rabin, 1988; Nitzsche et al., 1991). Minimizing water loss from plants can reduce transplant shock and help maintain a favorable plant water status. Antitranspirants have been used successfully to minimize transplant shock. For example, abscisic acid has been used as an antitranspirant for transplanted bell peppers (*Capsicum annuum* L.) and has the potential to reduce transplant shock and increase yield (Berkowitz and Rabin, 1988). Applying wax emulsions to bell pepper foliage helps to maintain a favorable water status, decreases leaf abscission, and increases growth (Nitzsche et al., 1991). Antitranspirants can also decrease the transpiration rate and increase the xylem pressure potential of several woody and herbaceous ornamental plants in greenhouses (Hummel, 1990).

Because antitranspirants decrease leaf conductance, they not only reduce transpiration but increase resistance to CO_2 diffusion into leaves (Nitzsche at el., 1991). When leaf conductance is a limiting factor for photosynthesis, antitranspirants will reduce photosynthesis and subsequently growth. For example, Vapor Gard (Miller Chemical and Fertilizer Corp., Hanover, Pa.), a pinolene-based antitranspirant, can reduce the photosynthesis of young apple (*Malus* ×*domestica* Borkh.) leaves (Weller and Ferree, 1978). Antitranspirants reduce stomatal conductance and transpiration, but also dry matter accumulation, of greenhouse-grown tomato (*Lycopersicon esculentum* Mill.) plants (Gu et al., 1996). The usefulness of antitranspirants in minimizing transplant shock thus depends on whether the benefits of reduced transpiration outweigh the disadvantage of reduced photosynthesis. The use of antitranspirants in greenhouses has not been very successful. Although

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antitranspirants can reduce water loss from chrysanthemums [*Dendranthema* ×*grandiflorum* (Ramat.) Kitamura], they also reduce leaf area and plant mass (Martin and Link, 1978). The leaf area and fresh mass of *Epipremnum aureum* (Linden & André) cuttings also can be reduced by antitranspirants (Wang et al., 1992).

Another potential problem with antitranspirants is the possibility of phytotoxicity (Nitzsche at el., 1991). Possible symptoms include dessication, necrosis, and leaf cupping (Sutter and Hutzell, 1984). If antitranspirant applications result in visible damage, the aesthetic value of ornamental plants can be reduced, resulting in an economic loss to the grower.

Antitranspirants can reduce the transpiration rate and wilting of impatiens (Hummel, 1990), suggesting that they may be beneficial in reducing transplant shock. However, effects on growth and plant water status have not been determined. The objectives of this research were to quantify the effects of two antitranspirants and different application methods on posttransplant growth and leaf water potential of greenhouse-grown impatiens seedlings.

Materials and methods

EXPERIMENT 1: PLANT GROWTH. 'Super Elfin Cherry' impatiens plugs in stage 4 (Styer and Koranski, 1997) were received from a commercial grower on 20 Mar. 1996 and transplanted into flats containing soilless growing mix (Metro-Mix 300; Scotts Co., Marysville, Ohio) on 21 Mar. 1996. The cell volume was 170 mL (5.7 fl oz), with 32 cells per flat. Plants were grown in a double-layer polyethylene-covered greenhouse with temperature set points of 72 °F (22 °C) and 64 °F (18 °C) for day and night, respectively. Treatments were applied at transplant, consisting of an untreated control, dipping the shoots (≈0.5 s), or spraying the shoots of plants with one of two antitranspirants. Antitranspirants were diluted in water according to label recommendations [WiltPruf; Wilt-Pruf Products, Inc., Essex, Conn., 1:10 (by volume) and Vapor Gard, Miller Chemical and Fertilizer Corp., Hanover, Pa., 1:50 (by volume)]. Both antitranspirants form a waxy film on leaves as they dry, and the labels claim potential benefits if these products are applied following transplant. In the two spray treatments, plants were sprayed to complete coverage of the leaves, while the entire shoot was submerged in antitranspirant solution in the two dip treatments. Plants were watered 1 h after transplant, to allow the antitranspirants to dry before irrigation. Plants were fertilized twice a week with a 20N–4.4P–16.6K water-soluble fertilizer (Peter's 20–10–20 Peat-Lite Special; Scotts Co.), containing 200 ppm N. Plants were watered as needed.

Four plants were harvested weekly from each flat to determine shoot dry mass until 50 d after transplant (DAT). Harvest of plants dipped in Vapor Gard was discontinued 36 DAT, because some plants died. Shoot growth rate was estimated as the first derivative of third order polynomials fitted to the shoot dry mass of the plants (Hunt, 1982). This resulted in a good fit in all cases, with an $r^2 \geq 0.93$. The experimental design was a randomized complete block with six replications and one flat of plants as the experimental unit. Shoot dry mass data were analyzed separately for each harvest date using analysis of variance. Mean separation was done with Fischer's $\text{LSD}_{0.05}$. Orthogonal contrasts were used to compare the two antitranspirants and to compare treated plants to the controls.

EXPERIMENT 2: WATER RELATIONS. Impatiens 'Super Elfin Cherry' seeds were sown in a soilless growing mix (Redi-Earth; Scotts Co.) on 5 Aug. 1996 and germinated in a laboratory. Seedlings were transferred to the greenhouse on 26 Aug. 1996 and transplanted into cell packs (32 cells/flat) filled with MetroMix 300 on 17 Sept. 1996. Treatments and plant care were similar to Expt. 1. Water and osmotic potential of the uppermost fully expanded leaf were determined at 2, 9, and 16 DAT. Leaf discs were sampled with leaf-cutter thermocouple psychrometers (Model 76-2VC, JRD Merrill Specialty equipment, Logan, Utah) and water potential was determined after the samples had equilibrated for four hours in a 77 °F (25 °C) water bath. The psychrometers were then frozen overnight to disrupt the membranes and osmotic potential was determined the next day, after the samples again had equilibrated for four hours. Water and osmotic potential were measured using a 15 s, 5 mA cooling current and psychrometer output was determined 3 s after the termination of the cooling current. Pressure potential (leaf turgidity) was calculated as the difference between water and osmotic potential.

Shoot dry mass of the plants was determined at the end of the experiment (16 DAT). The experimental design was a randomized complete block with four replications and a group of 16 plants (1/2 flat) as the experimental unit. Data were analyzed by analysis of variance and orthogonal contrasts.

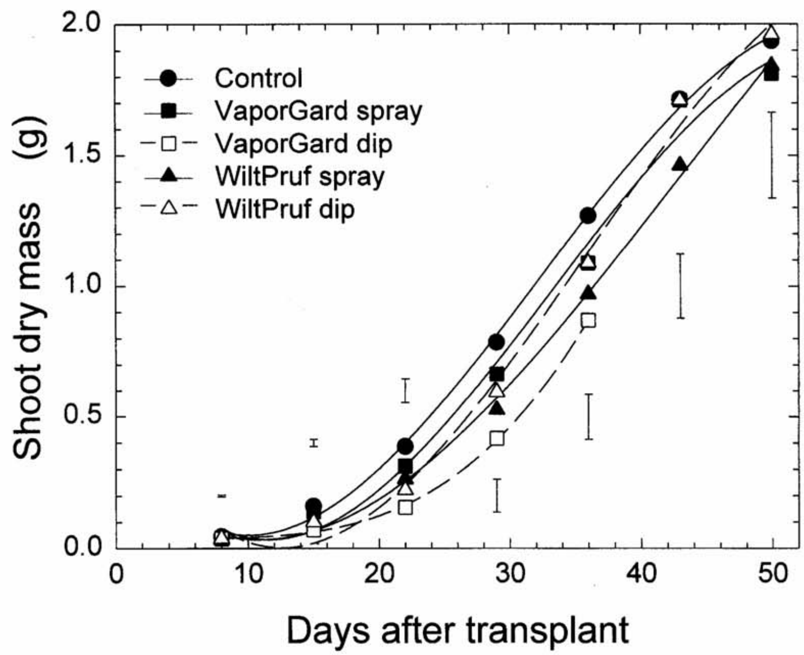

Fig. 1. The effect of antitranspirants on the posttransplant shoot dry mass of impatiens seedlings. The lines are third order polynomials that were used to calculate growth rates. Error bars represent Fischer's $\text{LSD}_{0.05}$.

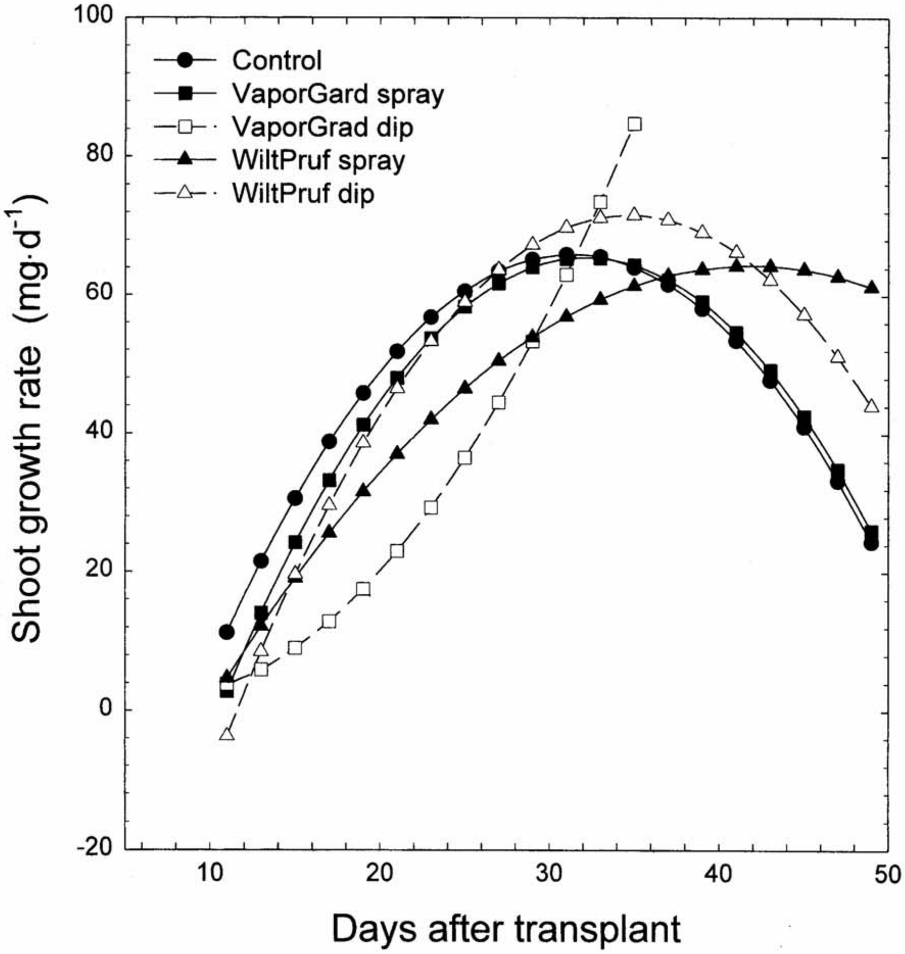

Fig. 2. The effect of antitranspirants on shoot growth rate of transplanted impatiens seedlings. Growth rates are second order polynomials, calculated as the first derivative of a third-order polynomial fitted to the dry mass versus time.

Results and discussion

PLANT GROWTH. Antitranspirants reduced shoot dry mass of impatiens transplants (Fig. 1). This reduction was significant ($P < 0.01$) and occurred as early as 8 DAT. Differences in shoot dry mass between the control and antitranspirant-treated plants remained significant until 36 DAT. Dipping shoots in antitranspirants reduced shoot dry mass more than spraying leaves from 15 to 29 DAT ($P < 0.05$). At 22 DAT, the Vapor Gard dip treatment caused a 60% reduction in shoot dry mass. The Vapor Gard dip treatment also caused about 40% mortality and, due to a lack of plants, no further data were collected from this treatment after 36 DAT. Differences in shoot dry mass among the other four treatments decreased during the latter part of experiment and shoot dry mass was similar in all remaining treatments at the end of the experiment (Fig. 1).

Differences in dry mass accumulation were reflected in shoot growth rate (Fig. 2). Control plants had the highest shoot growth rate during the first half of the experiment, while the two WiltPruf treatments (dip and spray) had the highest shoot growth rate during the latter part of the experiment. Plants in the Vapor Gard dip treatment had a low shoot growth rate during the first 25 DAT, which explains the low shoot dry mass of these plants. The high calculated growth rate from 32 to 36 DAT may have been an artifact of the regression technique, which tends to be less accurate near the start and end of the curve.

Shoot growth rate depends on the photosynthetic activity of the leaves, and would be expected to decrease after applications of antitranspirants. This normally decreases leaf conductance, and thus can slow CO_2 diffusion into leaves (Jones, 1981). Since dipping plants in antitranspirants results in better leaf coverage than a foliar spray, it is not surprising that dip treatments caused a larger initial decrease in growth than sprays. Shoot growth rates in most treatments started decreasing at 30 to 35 DAT. This coincided with the onset of flower formation.

In addition to growth reductions, antitranspirants also caused visible damage to leaves of the plants. This damage

Table 1. The effect of antitranspirant sprays or dips on water, osmotic, and pressure potential of impatiens seedlings. Due to missing data, osmotic and pressure potential do not always add up to water potential. The statistical significance (*P* value) of applying antitranspirants was determined by orthogonal contrasts.

	Potential (MPa)								
	Water			Osmotic			Pressure		
	Days after transplant								
Spray	2	9	16	2	9	16	2	9	16
Control	−0.288	−0.372	−0.270	−0.368	−0.470	−0.467	0.098	0.078	0.223
Vapor Gard dip	−0.460	−0.378	−0.280	−0.440	−0.470	−0.515	0.092	−0.018	0.235
Vapor Gard spray	−0.508	−0.450	−0.240	−0.485	−0.460	−0.412	0.010	−0.022	0.170
WiltPruf dip	−0.395	−0.422	−0.150	−0.440	−0.418	−0.372	−0.008	0.042	0.222
WiltPruf spray	−0.395	−0.388	−0.188	−0.442	−0.428	−0.330	0.042	0.042	0.140
P									
Control vs. antitranspirant	0.023	NS	NS	0.044	NS	NS	NS	NS	NS

ranged from small necrotic spots on the leaves to plant death. Symptoms were most pronounced in plants dipped in Vapor Gard, with a mortality rate of 40%. Necrotic leaf spots occurred in all antitranspirant treatments, but none of the other treatments resulted in significant mortality.

Water relations. Application of antitranspirants resulted in decreased leaf water and osmotic potential at two DAT (Table 1). This decrease in water potential may be related to phytotoxic effects and not to transpiration. Hummel (1990) showed that both Vapor Gard and WiltPruf reduce the transpiration of impatiens. Normally, reduced transpiration causes an increase in water potential, rather than a decrease. Both dip treatments resulted in necrotic leaf spots and these phytotoxic effects may have contributed to the decrease in water and osmotic potential. Although there was little visible damage from the spray treatments, subtle effects may have affected water and osmotic potential in these treatments too. There were no significant differences in water or osmotic potential at 9 or 16 DAT. There were no statistically significant differences in pressure potential (a measure of leaf turgidity), although it tended to be higher in the control treatment than in the antitranspirant treatments at 2 and 9 DAT. There were no differences in shoot dry mass at 16 DAT (results not shown), when the experiment was ended.

Conclusion

Wax-based antitranspirants did not decrease transplant shock of impatiens seedlings in a greenhouse. Antitranspirants decreased growth rate, probably because of lower leaf photosynthetic rates, and caused necrotic spots on leaves and in some cases plant death. Water and osmotic potential was decreased by antitranspirants at 2 DAT, indicating that antitranspirants do not help to maintain a favorable water status of impatiens. Cultural practices in a greenhouse normally are aimed at preventing environmental stress by maintaining optimal water and fertility levels. Therefore, transplant shock is expected to be less severe in a greenhouse than under field conditions, which helps to explain why antitranspirants do not reduce transplant shock in impatiens in a greenhouse environment.

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Root Pruning and Soil Type Affect Pecan Root Regeneration

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Additional index words. *Carya illinoensis*, transplant, taproot

Summary. Taproots of 2-year-old 'Apache' seedling pecan [*Carya illinoensis* (Wang)] trees were pruned to 1 ft (30 cm), 2 ft (60 cm), or 3 ft (90 cm) in combination with wounding treatments consisting of no wounding, scraping through pericycle tissue on one or two sides of the taproot, or longitudinally splitting the taproot for about half its length. The trees were planted in a Port silt loam soil and a Teller sandy loam soil and grown without irrigation. At the end of the first and second growing seasons, top growth was measured, trees were dug and root system regrowth was evaluated. Tree root weight and number of roots per tree decreased with increasing taproot length.

The pecan tree has an aggressive taproot system best suited to deep alluvial soils. The taproot will penetrate the soil >6 ft (2 m) unless stopped by a water table or an impervious layer, e.g., rock. The taproot is dominant over other roots in the system and reestablishes itself when removed (Smith and Johnson, 1981). Taproot pruning to various lengths stimulates top growth, root branching and growth the first year. Root reestablishment occurs first at the cut surface (Smith and Johnson, 1981). Taproot pruning also increases leaf nutrient concentration (Sparks and Madden, 1977). Other researchers have reported no effect of root pruning on tree growth after 4 years (Wood, 1996) or on trunk weight, height, root depth, and number or weight of roots after 5 years

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