Plant Growth Stimulator Effects on Post-transplant Growth and Flowering of Petunia and Impatiens Plugs

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ADDITIONAL INDEX WORDS. growth regulators, biostimulants, root growth

SUMMARY. Various growth stimulators have been reported to improve plant growth. Some of these are formulated to improve root growth, which would be particularly beneficial for reestablishing transplants. Three commercially available plant growth stimulators—PGR IV (MicroFlo, Lakeland, Fla.), Roots2 (Lisa Products Corp., Independence, Mo.), and Up-Start (The Solaris Group, San Ramon, Calif.)—were tested to quantify their effect on post-transplant growth of petunia (*Petunia × hybrida* Hort. Vilm.-Andr.) and impatiens (*Impatiens wallerana* Hook.f.) seedlings and to assess their value for the greenhouse industry. Seedlings were transplanted from plug flats into larger 5.6-fl oz (166-cm³) containers and treated with 1.1 fl oz (31 mL) of growth stimulator per plant (22 fl oz/ft²). Applications were made immediately after transplant. None of the treatments affected root mass at any time. Up-Start (2 fl oz/gal) increased final shoot dry mass by ≈20% compared to the control plants. The increase in shoot growth by Up-Start most likely is caused by the fertilizer it contains. Up-Start also increased flowering of petunia from 34 to 40 days after transplant. PGR IV (0.5 fl oz/gal) and Roots2 (1.28 fl oz/gal) did not affect dry mass of the plants. PGR IV increased the number

of flowers of petunia and impatiens, but this effect occurred well after the plants were marketable. Roots2 caused a small delay in early flowering and an increase in late flowering of petunia but had no effect on flowering of impatiens. Since the effects of the growth stimulators was either due their fertilizer content (Up-Start) or occurred after the plants would have been sold (PGR IV, Roots2), none of the growth stimulators appears to be beneficial for bedding plant producers.

Many new growth stimulators (including biostimulants, growth regulators, and vitamins) are available to commercial growers. Seaweed products, for example, have been reported to improve plant growth, increase yield, and enhance nutrient uptake of a variety of plants (Crouch and Van Staden, 1994). A foliar spray containing extracts of the seaweed *Ecklonia maxima* increased post-transplant root and shoot growth of marigold (*Tagetes patula* L.) and cabbage (*Brassica oleracea* L. var. capitata) (Aldworth and van Staden, 1987). Another organic biostimulant, Roots2, increased pod dry mass of green bean (*Phaseolus vulgaris* L.) (Russo and Berlyn, 1992) and stimulated root and shoot growth of a variety of species, while decreasing the fertilizer requirements by 50% (Russo and Berlyn, 1990).

PGR IV, a mixture of indolebutyric acid and gibberellic acid, has been reported to increase root growth, dry matter production, and yield of cotton (*Gossypium hirsutum* L.) (Livingston et al., 1993; Oosterhuis et al., 1996). Oertli (1987) reviewed the effects of exogenous vitamin applications on

plants and reported that vitamins can have a variety of beneficial effects on plants, including increased yield, stimulation of root formation, induction of flowering, and protection against air pollutants. Ascorbic acid (vitamin C) helped protect plants against environmental stress and air pollutants because of its antioxidative properties (Smirnoff, 1996). Thiamine hydrochloride (vitamin B₁) was reported to stimulate the growth of isolated pea roots (Bonner and Devirian, 1939). However, more recent findings showed that thiamine hydrochloride does not have any effect on the color, vigor, or reestablishment of vegetable transplants (Kontaxis and Cox, 1984).

Although it has been suggested that growth stimulators may be valuable on agronomic and horticultural crops (Oertli, 1987; Russo and Berlyn, 1990), they are not commonly used in the greenhouse production of bedding plants. The objective of this study was to quantify the effect of PGR IV, Roots2, and Up-Start on the root and shoot growth and flowering of impatiens and petunia and to assess their value in the greenhouse production of these crops. These growth stimulators were selected because, according to their labels, they promote root growth, which may be helpful in minimizing the effects of transplant shock. Specifically, according to the label, PGR IV “can result in increased root mass, earlier fruit initiation, increased fruit retention, increased nutrient utilization, and higher yields.” The Up-Start label states that it “aids in early root formation, stronger root development, and promotes a greener, more vigorous plant,” while Roots2 claims to “promote rapid root growth and re-

Table 1. The trade name, manufacturer, and active ingredients of the biostimulants used in this study.

Biostimulant	Manufacturer	Active ingredients
PGR IV	Microflo, Lakeland, Fla.	Indolebutyric acid (0.0028%) Gibberellic acid (0.0030%)
Roots2	Lisa Products, Independence, Mo.	Peat humic substances (7.0%) Kelp extracts (3.0%) Thiamine (0.3%) Ascorbic acid (3.0%) α-Tocopherol (0.1%) Myo-inositol (0.5%) Glycine (1.0%)
Up-Start	Solaris Group, San Ramon, Calif.	KNO ₃ (6.5%) NH ₄ H ₂ PO ₄ (17%) Thiamin (vitamin B ₁ , 0.01%)

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Fig. 1. Growth stimulator effects on the post-transplant shoot dry mass of petunia and impatiens seedlings. *Significant differences at $P < 0.05$ between any of the treatments and the control plants.

generation for seedlings, cuttings, installation, and transplanting.”

Materials and methods

Full-grown plugs (stage 4, Styer and Koranski, 1997) of ‘Super Elfin Pink’ impatiens (*Impatiens wallerana*) and ‘Ultra White’ petunia (*Petunia × hybrida*) were obtained from a commercial grower. Plants were transplanted into 5.6 fl oz (166 cm³) black plastic cell packs, 32 cells/flat, filled with a peat-based growing mix (MetroMix 300; Grace Horticultural Products, Cambridge, Mass.) on 21 Mar. 1996. Plants were fertilized twice per week with a 20N-4.4P-16.6K water-soluble fertilizer (20-10-20 Peat-Lite Special; Scotts Co., Marysville, Ohio) solution containing 200 ppm nitrogen.

Plants were drenched with water (control) or a growth stimulator immediately after transplant. The stimulators used in this study are PGR IV, Roots2, and Up-Start. Manufacturers and active ingredients are listed in Table 1. Growth stimulators were applied at the following rates: Roots2 at 1.28 fl oz/gal (1:100 dilution or 10 mL·L⁻¹), PGR IV at 0.5 fl oz/gal (3.9 mL·L⁻¹), and Up-Start at 2 fl oz/gal (15.6 mL·L⁻¹). These concentrations of Roots2 and Up-Start are recommended for bedding plants on the labels of these products. PGR IV is not labeled for use on bedding plants and the used concentration is recom-

mended for fruit crop transplants. All growth stimulators were applied at 22 fl oz/ft² (1 L/flat, 7 L·m⁻²).

Shoot and root dry mass were determined weekly and biweekly, respectively. Roots were washed thoroughly to remove the growing medium. All plant material was dried at 160 °F (70 °C) for a minimum of 72 h. The experimental design was a randomized complete block with five replications and repeated measures. The experimental unit was a flat with 32 plants. A logarithmic transformation of the data was performed to stabilize the variances and transformed data were used for analysis of variance. Means of the transformed data were separated using Fisher’s protected LSD_{0.05}. The data for both species were analyzed separately.

Results and discussion

Up-Start was the only growth stimulator that increased shoot growth of petunia and impatiens (Fig. 1). In petunia, this effect was apparent as early as 7 d after transplant (DAT), while the growth stimulating effect of Up-Start on impatiens did not occur until 35 DAT. Up-Start also improved their appearance, as Up-Start-treated plants had darker green leaves than those in the other treatments. PGR IV and Roots2 did not significantly affect the growth of petunia or impatiens. Root growth of the plants was not affected by the plant growth stimulators at any time (data not shown).

The shoot growth stimulating effect of Up-Start may be attributed to the 3N-4.4P-2.5K fertilizer it contains and not the thiamine chloride (vitamin B₁). Other studies, with salvia and vinca, have shown that vitamin B₁ alone did not affect plant growth, while Up-Start did (van Iersel, unpublished data). This suggests that the increased shoot growth of Up-Start-treated plants was due to the extra fertilizer these plants received. Kontaxis and Cox (1984) also suggested that reports of improved plant development by thiamin hydrochloride-containing

Fig. 2. Flowering of petunia (A) and impatiens (B) as affected by different growth stimulators. *Significant differences at $P < 0.05$ between any of the treatments and the control plants.

growth stimulators was caused by the fertilizer in these growth stimulators.

Up-Start also increased flowering of petunia from 34 to 40 DAT, while PGR IV and Roots2 increased flowering of petunia during the last week of the experiment (42 to 46 DAT) (Fig. 2). This is similar to the findings of Russo and Berlyn (1992), who found that the biostimulant Roots (similar to Roots2) had no effect on vegetative growth of green bean but increased its pod production. PGR IV was the only growth stimulator that increased flowering of impatiens. The flowering-promoting effect of PGR IV and Roots2 occurred when the plants were flowering vigorously, ≈ 10 d after the optimal marketing period for these crops. Thus, this study indicates that these growth stimulators are not of significant value to commercial growers, although the growth stimulators may improve plant performance after transplanting into the landscape.

Applying Up-Start resulted in larger plants with darker leaves. Since this may have been the result of the fertilizer component of Up-Start, similar results could probably have been achieved with higher fertilizer rates. Based on the results of this study, the use of Up-Start for greenhouse production of bedding plants does not seem beneficial, because higher fertilizer rates are less expensive than Up-Start applications.

All growth stimulators used in this study were developed to promote root growth, which may help minimize transplant shock. However, none of them significantly affected root growth under the conditions of this experiment. Since growing conditions in greenhouse production of bedding plants are designed to limit stress and optimize growth, transplant shock may be minimal. Therefore, these compounds may be more beneficial in the landscape, where environmental conditions are less favorable to the plants and transplant shock generally is more severe.

Literature cited

- Aldworth, S.J. and J. van 'Staden. 1987. The effect of seaweed concentrate on seedling transplants. *S. Afr. J. Bot.* 53:187-189.
- Bonner, J. and P.S. Devirian. 1939. Growth factor requirements of four species of isolated roots. *Amer. J. Bot.* 26:661-665.
- Crouch, I.J. and J. van Staden. 1994. Commercial seaweed products as biostimulants in horticulture. *J. Home Consumer Hort.* 1:19-76.
- Kontaxis, D.G. and D. Cox. 1984. Effect of vitamin B₁ on vegetable transplants. *Calif. Agr.* 38(9):15-16.
- Livingston, S.D., R.D. Parker, and J.A. Landivar. 1993. An evaluation of urea and PGR IV for maintaining yield potential of cotton subjected to water damage or nitrogen uptake deficiencies. In: *Proc. 1993 Beltwide Cotton Conferences*, vol. 3. Natl. Cotton Council Amer., Memphis, p. 1342-1343.
- Oertli, J.J. 1987. Exogenous application of vitamins as regulators for growth and development of plants—A review. *Z. Pflanzenernähr. Bodenk.* 150:375-391.
- Oosterhuis, D.M., A. Steger, and D. Zhao. 1996. Cotton seed treatment with plant growth regulators to enhance growth and yield. In: *Proc. Plant Growth Regulat. Soc. America. 23rd Annu. Meeting*, p. 282. (Abstr.)
- Russo, R.O. and G.P. Berlyn. 1990. The use of organic biostimulants to help low input sustainable agriculture. *J. Sustainable Agr.* 1:19-42.
- Russo, R.O. and G.P. Berlyn. 1992. Vitamin-humic-algal root biostimulant increases yield of green bean. *HortScience* 27:847.
- Smirnoff, N. 1996. The function and metabolism of ascorbic acid in plants. *Ann. Bot.* 78:661-669.
- Styer, R.C. and D.S. Koranski. 1997. Plug and transplant production. A grower's guide. Ball Publishing, Batavia, Ill.

Abscisic Acid as a Potential Deciduous Fruit Tree Nursery Stock Defoliant

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ADDITIONAL INDEX WORDS. ABA, apple, European pear, defoliation, *Malus × domestica*, nursery practices, *Pyrus communis*

SUMMARY. Abscisic acid (ABA) was tested as a defoliant for nursery trees of 'Bartlett' pear (*Pyrus communis* L.) and the apple (*Malus × domestica* Borkh.) cultivars Imperial Gala, Gibson Golden Delicious, Scarlet Spur Delicious, Law Red Rome, Granny Smith, Braeburn, and Red Fuji. ABA was sprayed once or twice, with 1 intervening week, at 500, 1000, or 2000 ppm. Percentage defoliation was assessed at 1-week intervals for 4 weeks. For all cultivars, two applications of 2000 ppm ABA ranked among the most effective treatments for rapid defoliation; this treatment led to at least 95% defoliation for all cultivars. For many cultivars, however, other treatments caused similar defoliation percentages by digging time. All tested cultivars were effectively defoliated (>80%) by two 1000-ppm applications ABA or one 2000-ppm application. One or two 500-ppm applications effectively defoliated 'Bartlett', 'Gibson Golden Delicious', and 'Law Red Rome'. Nursery managers, therefore, need to consider a range of ABA concentrations and alternative application protocols to obtain optimum benefit from ABA. Although ABA shows promise as a defoliant, it lacks government approval for commercial use.

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