Evaluating Potential Plant Health Strengtheners©

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Plant strengtheners are increasing in popularity in the agronomic industry, and recently some chemical companies have expressed interest in exploring use of these products with ornamental crops. In our study, two fungicides were evaluated as potential drought tolerance enhancers using Impatiens walleriana Super Elfin Series XP White. Pageant (pyraclostrobin + boscalid), a conventional fungicide, and Regalia® (extract of Reynoutria sachalinensis), an organic fungicide, were applied weekly as a foliar spray to plants grown in soilless substrate maintained at selected moisture contents (85%, 70%, 55%, 40%, and 25% volumetric water content (VWC) in Expt. 1; and 85%, 55%, and 25% VWC in Expts. 2 to 4. Daily VWC was determined by creating a soil moisture curve based on the relationship between the soil moisture reading and actual VWC. In all four experiments, daily VWC, final growth indices, shoot dry weight, and root dry weight were measured. Use of Pageant applied at a 1.0X rate to well-watered impatiens (85% VWC) had greater shoot growth compared to all other rates and substrate VWCs, Expt. 2. In Expt. 3 the use of Regalia as a foliar spray did result in greater root dry weights compared to the nontreated, however there was no rate 5 moisture interaction.

INTRODUCTION

In recent years there has been increasing interest in the use of plant strengtheners to increase or induce plant tolerance to environmental stresses. By definition, a plant strengthener protects the plant by stimulating resistance or defense mechanisms or by outcompeting the attacking organism for space and food (European Commission, 2001). Ideally plant strengtheners need to be low risk and provide an adequate benefit such as a yield increase or reduced irrigation use. Typical plant strengtheners on the market include, but are not limited to, herbicides, fungicides, insecticides, and antitranspirants. Traditionally, these are referred to as crop health protectants, and aid plant growth by preventing or attacking unwanted

organisms. Fungicides, particularly the strobilurins, have recently been evaluated as potential plant strengtheners.

In 2009, BASF added "plant health" to their Headline fungicide (pyraclostrobin) after approval by the EPA (BASF, 2009). Additionally, in 2010 they launched Intrinsic™ brand fungicides into the turf and ornamental market not only for protection against fungi but also added plant health benefits. This brand of fungicide includes two separate brands; Honor® SC Intrinsic™ brand (pyraclostrobin + boscalid) and Insignia® SC Intrinsic™ brand (pyraclostrobin). Honor SC Intrinsic brand includes two fungicides with two target sites: complex III of fungal respiration (pyraclostrobin) and complex II in fungal respiration (boscalid). BASF reported improved turf health after application of Honor Intrinsic by alleviating drought/moisture and temperature extremes (BASF, 2010).

There has also been research with polyamines as potential stress enhancers. Polyamines are low-weight polycations found in all living organisms (Kaur-Sawhney et al., 2003) and have been shown to increase chilling tolerance in cucumber (Zhang et al., 2009). Additionally, foliar-applied abscisic acid (ABA) has been shown to reduce water loss and extend shelf life in impatiens, seed geranium, petunia, marigold, salvia, and pansy (Waterland et al., 2010).

Although it is known that some fungicides stimulate growth and may improve plant health in agronomic crops (Balba, 2007), little research has evaluated these fungicides for similar effects with ornamentals. Therefore, our objectives with this study were to evaluate the effects of two potential plant strengtheners for increasing plant tolerance to drought using *Impatiens walleriana* Super Elfin Series XP White (impatiens): a strobilurin (Pageant) and an organic fungicide (Regalia®).

MATERIALS AND METHODS

Plant Material and Culture. On 5 May 2010, a crop of *I. walleriana* 'Super Elfin XP White' were potted from 285-plug tray into 6-in. azalea containers for Expts. 1 and 2. All containers were filled to the rim with Sunshine Mix #1 and lightly tapped twice on a hard surface to reduce air pockets. After potting, impatiens were watered thoroughly and placed in a controlled-environment greenhouse [70 °C/65 °C (day/night) temperatures] located on Mississippi State University's North Farm research station. A second crop was potted in similar manner on 24 June 2010 for Expts. 3 and 4.

Substrate Properties. Physical properties of the Sunshine Mix #1 were determined according to the method of Hidalgo et al. (2001), with the substrate providing 90.9% total porosity, 28.3% air space, 62.6% water holding capacity, and 0.11 g/cc bulk density. Volumetric water content was determined according to the WATERSCOUT SM100 Soil Moisture Sensor instructions by Spectrum Technologies, Inc. and fit to a regression model, yielding the equation VWC = 0.00076503*MW – 0.79736 (MW represents target mass wetness defined as a percentage).

Experimental Treatments and Design. Experiment 1 was initiated on 14 June 2010 by recording VWC and watering each container to its designated VWC: 85% (control), 70%, 55%, 40%, and 25%. Four rates of Pageant (boscalid + pyraclostrobin), based on 3.04 oz per 100 gal, were used: 0, 0.5X (0.43 g/gal), 1.0X (0.86 g/gal), and 1.5X (1.29 g/gal). Foliar applications of Pageant were made once

a week 3 h after watering containers to their designated VWC. Experiment 1 was conducted using a randomized complete block design with a 5 × 4 factorial treatment design with 6 single-pot replications per treatment combination. Experiment 2 was initiated on 27 July 2010 and conducted in similar manner to Expt. 1, except that, based on results from Expt. 1, five moisture levels were reduced to three moisture levels: 85%, 55%, and 25%. Expt. 2 was conducted using a randomized complete block design with a 3 × 4 factorial with 6 single pot replications. Experiment 3 was initiated on 27 July 2010 by recording VWC and watering each container to one of three designated moisture levels: 85% (control), 55%, and 25% VWC. Four rates of Regalia (extract of *Reynoutria sachalinensis*) were used, based on the recommended label rate of 64 oz per 50 gal: 0, 0.5X (18.927 mL/1 gal), 1.0X (37.854 mL/gal), and 1.5X (56.781 mL/gal). Regalia was applied as a foliar spray once a week 1.5 h after watering containers to the designated VWC. Experiment 4 was initiated on 7 Sept 2010, and conducted in similar manner to Expt. 3.

Harvesting, Data Collection, and Data Analysis. Initial VWC, daily VWC, final growth index (FGI) [(height + width at widest point + width perpendicular)/3], shoot dry weight (SDW), and root dry weight (RDW) data were collected. Shoots were harvested by cutting the entire plant at the soil line to remove the entire upper portion of each plant. Roots were harvested by first soaking the container with substrate and roots in a 17.7-L container filled with tap water. After soaking for a minimum of 8 h, substrate was washed from the roots over a screen to catch all fallen roots. Further washing removed all remaining small pieces of substrate from the roots. Shoots and roots were oven-dried in a forced air drier at 65 °C for 72 h. Data were analyzed with the GLIMMIX procedure of SAS (version 9.2), with mean separation according to the Holm-Simulation method (alpha = 0.05).

RESULTS

Experiment 1. Differing rates of Pageant had no affect on FGI or SDW. However, the use of Pageant at the 1.0X rate resulted in greater RDW compared to the 0.5X and 1.5X rates. Additionally, VWC effects were seen with FGI, SDW, and RDW, indicating that grown with lower VWC levels averaged less growth than plants grown with higher VWC levels (Table 1). For example, substrate held at 25% VWC resulted in significantly less growth compared to all other treatments, which was similar to previous findings by Blaunusa et al. (2009). There was no significant rate × moisture interaction.

Experiment 2. Weekly application of Pageant did not have a significant effect on FGI, SDW, or RDW (Table 1). Conversely, VWC did have a significant effect on FGI, SDW, and RDW, with greater growth associated with higher VWC. In Expt. 2, there was a rate × moisture interaction with SDW (Fig. 1). After four 1.0x applications of Pageant, plants in containers maintained at 85% VWC had a greater SDW compared to nontreated and fungicide-treated plants. However, Pageant applied at the 1.0X rate to water-stressed plants (55% and 25% VWC) produced no differences in shoot dry weight compared to nontreated plants. These results were similar to previous reports with wheat, which showed increased water-use efficiency after application of pyraclostrobin to well-watered plants, but not water-stressed plants (Nason et al., 2007).

Experiment 3. Differing rates of Regalia had no effect on FGI and SDW (Table 2). However, the use of Regalia at the 0.5X rate resulted in greater RDW compared to the 0.0X rate (nontreated). There was a significance difference with containers maintained at 85% VWC compared to 55% and 25% VWC; however, there was no rate × moisture interaction.

Experiment 4. There was a rate effect seen with FGI when Regalia was applied at 0.5X (16.7 cm) and 1.0X (16.0 cm) rates, compared to the 1.5X (13.1 cm) rate (Table 2). Additionally, there was a rate effect seen with SDW, indicating that plants treated with Regalia at the 1.5X rate had significantly less growth over the 28 days compared to all other rates. Similar to Expt. 3, VWC was a significant factor in impatiens growth, having more growth associated with higher VWC.

DISCUSSION

Based on results from Expt. 2, Pageant applied at a rate of 1.0X to well watered (85%) impatiens enhanced shoot growth. However, Pageant applied to containers maintained at 55% and 25% VWC did not appear to enhance growth of impatiens. Furthermore, since results from only one of two of our experiments indicated an added benefit after applying a strobilurin fungicide, further research should be conducted with ornamental crops, especially since there are multiple reports indicating yield increases in agronomic crops (Zhang et al., 2010).

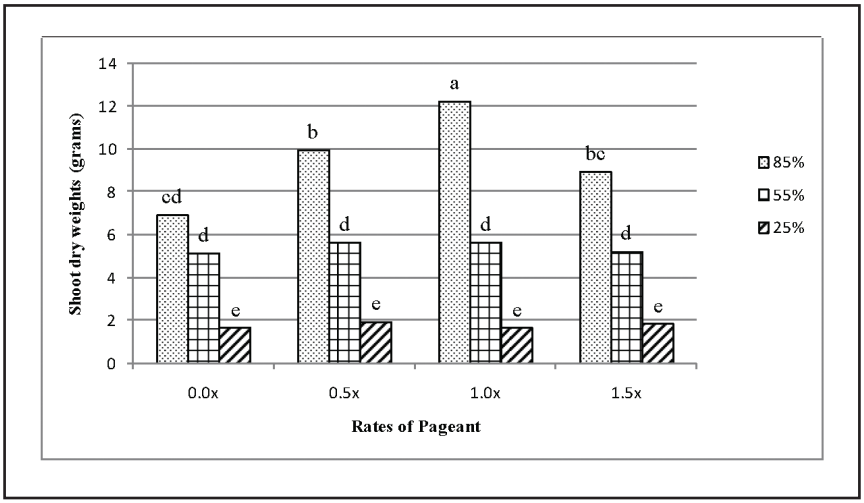

Figure 1. Effect of different rates of Pageant applied as a foliar spray on shoot dry weight of *Impatiens* grown in soilless substrate maintained at different volumetric water contents. Means with the same letters are not statistically different according to the Holm-Simulation method for mean comparisons, alpha = 0.05.

Table 1. Growth of *Impatiens walleriana* 'Super Elfin XP White' after weekly foliar applications of four rates of Pageant to plants grown in soilless substrate maintained at different volumetric water contents.

	Experiment 1, June 2010			Experiment 2, July 2010		
Rates[Z]	FGI[Y] (cm)	SDW[X] (g)	RDW[W] (g)	FGI (cm)	SDW (g)	RDW (g)
0.0X	20.4 A[V]	5.5 a	0.43 ab	22.0 a	4.5 b	0.24 b
0.5X	19.6 a	4.7 ab	0.35 c	22.4 a	5.8 ab	0.36 ab
1.0X	20.5 a	5.4 ab	0.47 a	23.3 a	6.5 a	0.65 a
1.5X	19.2 a	4.5 b	0.40 bc	22.7 a	5.3 ab	0.42 ab
Moisture level[T]						
85%	25.6 a	9.2 a	0.70 a	29.6 a	9.5 a	0.62 a
70%	22.4 b	6.9 b	0.50 b	23.9 b	5.4 b	0.44 b
55%	20.1 c	4.9 c	0.42 b	14.4 c	1.7 c	0.19 c
40%	17.5 d	2.9 d	0.30 c	-	-	-
25%	14.1 e	1.2 e	0.15 d	-	-	-
Effects						
rate	0.3852[S]	0.1116	0.0158	0.8882	0.1723	0.082
moisture	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
rate*moist	0.8045	0.2937	0.5375	0.1068	0.0081	0.165

[Z]Rates of fungicide applied weekly, based on recommended label rate: Pageant 0.0X, 0.5X (0.43 g/gal), 1.0X (0.86 g/gal) and 1.5X (1.29 g/gal).

[Y]FGI – final growth indices [(height + width + perpendicular width)/3].

[X]SDW – shoot dry weight, oven dried for 72 hours @ 65 °C.

[W]RDW – root dry weight, oven dried for 72 hours @ 65 °C.

[V]Means (within a column) with the same letters, within moisture level or rate are not statistically different according to Holm-Simulation method for mean comparison, alpha = 0.05.

[T]Percent moisture level containers were maintained based on volumetric water content.

[S]*p* value.

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Table 2. Growth of *Impatiens walleriana* 'Super Elfin XP White' after weekly foliar applications of four rates of Regalia to plants grown in soilless substrate maintained at different volumetric water contents.

	Experiment 3, July 2010			Experiment 4, September 2010		
Rates[Z]	FGI[Y] (cm)	SDW[X] (g)	RDW[W] (g)	FGI (cm)	SDW (g)	RDW (g)
0.0X	21.9 A[V]	5.6 a	0.49 b	15 a	2.6 a	0.30 ab
0.5X	23 a	6.4 a	0.74 a	16.7 b	2.6 a	0.45 a
1.0X	23.8 a	6.3 a	0.67 ab	16 aa	2.7 a	0.47 a
1.5X	21.3 a	5.7 a	0.57 ab	13.1 b	1.5 b	0.16 b
Moisture level[T]						
85%	29.8 a	10.4 a	0.86 a	18.5 a	4.1 a	0.47 a
55%	24.1 b	5.9 b	0.60 b	15.8 b	2.4 b	0.36 b
25%	13.6 c	1.7 c	0.41 c	11.3 c	0.5 c	0.20 c
Effects						
rate	0.6117[S]	0.925	0.0128	0.0028	0.0165	0.0991
moisture	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
rate*moist	0.6563	0.4524	0.7961	0.7022	0.4169	0.8878

[Z]Rate of fungicide applied weekly, based on recommended label rate: Regalia 0.0X, 0.5X (18.927 mL/gal), 1.0X (37.854 mL/gal and 1.5X (56.781 mL/gal).

[Y]FGI – final growth indices [(height + width + perpendicular width)/3].

[X]SDW – shoot dry weight, oven dried for 72 h @ 65 °C.

[W]RDW – root dry weight, oven dried for 72 h @ 65 °C.

[V]means (within a column) with the same letters, within moisture level or rate are not statistically different according to the Holm-Simulation method for mean comparisons, alpha = 0.05.

[T]Percent moisture level containers were maintained based on volumetric water content.

[S]*p* value.

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