Plant Growth Retardant Drench Efficacy Is Not Affected by Substrate Containing Parboiled Rice Hulls

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ADDITIONAL INDEX WORDS. ancymidol, paclobutrazol, uniconazole, calibrachoa, pansy

SUMMARY. **Parboiled rice hulls have become a more common component of soilless growing substrates. While there have been reports that some organic substrate components reduce the efficacy of plant growth retardant (PGR) drenches, the influence of rice hulls on PGR drenches is unknown. 'Callie Deep Yellow' calibrachoa (*Calibrachoa* ×*hybrid*) and 'Delta Orange Blotch' pansy (*Viola wittrockiana*) were planted in containers filled with substrate containing (v/v) 80% peat and 20% perlite or parboiled rice hulls. After planting, 2.5-fl oz drenches containing deionized water or ancymidol, paclobutrazol, or uniconazole were applied to plants grown in each substrate. Plant growth retardants, but not substrate, affected growth rate, and final stem length of calibrachoa and plant height of pansy. There were no differences in regression model coefficients between substrates within PGR applications for plant height (pansy) or stem length (calibrachoa) over the course of the experiment. Paclobutrazol (2.0 or 4.0 ppm) and uniconazole (1.0 or 2.0 ppm), but not ancymidol (1.0 or 2.0 ppm) suppressed final stem length of calibrachoa. Final height of pansy was suppressed by each concentration of paclobutrazol and uniconazole and 2.0 ppm ancymidol, but not 1.0 ppm ancymidol. Based on these results, rice hulls did not reduce PGR drench efficacy when included as a substrate component comprising (v/v) 20% of a substrate.**

A common cultural practice in greenhouse production is to apply plant growth retardants (PGRs) to produce uniform, compact, and marketable plants. Plant growth retardants can be applied in several ways, including foliar sprays, substrate drenches, liner dips, or bulb, tuber, and rhizome soaks or dips (Barrett, 2001; Blanchard and Runkle, 2007; Currey and Lopez, 2010; Whipker and McCall, 2000). However, the majority of applications are made as a foliar spray or substrate drench (Gent and McAvoy, 2000). Drenches provide more uniform results and increase the duration of effectiveness compared with foliar sprays (Boldt, 2008; Ecke et al., 2004; Gent and McAvoy, 2000). However, the efficacy of PGR drenches can be affected by the amount of a.i., solution volume applied, and substrate components (Barrett, 2001; Barrett et al., 2009).

Root substrates for containerized crops are commonly soilless mixes comprised of various organic and inorganic materials (Nelson, 2003; Raviv and Lieth, 2008). Vermiculite and perlite are common inorganic components, while peat and pine bark are common organic components of soilless substrates used in the production of potted greenhouse crops (Dole and Wilkins, 2004; Fonteno, 1996). Numerous studies have reported that PGR drench efficacy is reduced when organic components are included in substrates, including pine bark (Barrett, 1982; Bonaminio and Larson, 1978; Million et al., 1998a, 1998b; Newman and Tant, 1995; Tschabold et al., 1975) and river waste [a plant product dredged from anaerobic aquatic environments (Benedetto and Molinari, 2007)].

A growing trend among producers is to identify alternative substrate components. Parboiled rice hulls have been identified as an alternative substrate component and are an agricultural byproduct that requires little processing to produce a suitable substrate component (Buck and Evans, 2010; Evans, 2008; Evans and Gachukia, 2004; Holcomb et al., 2008; Sambo et al., 2008). However, there is no information on the effects of parboiled rice hulls on PGR drench efficacy. Our objective in this study was to identify what impact a substrate containing rice hulls as a component would have on PGR applications for controlling plant height or stem length of containerized greenhouse crops.

Materials and methods

On 25 Feb. 2009, a 51-cell tray of 'Callie Deep Yellow' calibrachoa and a 125-cell tray of 'Delta Orange Blotch' pansy were delivered from a commercial liner producer (C. Rakers & Sons, Litchfield, MI) to Purdue University in West Lafayette, IN (lat. 40°N). Plants were transplanted into 4.5-inch-diameter round containers (36.6 inch^3 volume) filled with substrates composed of (v/v) 80% sphagnum peat and 20% perlite (Fafard 1P Mix; Conrad Fafard, Agawam, MA) or parboiled rice hulls (Fafard Custom RHM; Conrad Fafard) on 27 Feb. 2009. These proportions were chosen because substrates containing (v/v) 20% to 25% rice hulls are the maximum recommended proportions based on university tests and producer experience (Evans, 2008).

On 10 Mar. 2009, a single 2.5-fl oz drench was applied to each substrate. For calibrachoa, drenches were solutions containing deionized water

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The use of trade names in this publication does not imply endorsement by Purdue University of products named nor criticism of similar ones not mentioned.

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
29.5735	fl oz	mL	0.0338
2.54	inch(es)	cm	0.3937
16.3871	inch3	cm3	0.0610
1	ppm	mg·L–1	1
(°F – 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

(control), 1.0 or 2.0 ppm ancymidol (Abide; Fine Americas, Walnut Creek, CA), 2.0 or 4.0 ppm paclobutrazol (Bonzi; Syngenta Crop Protection, Greensboro, NC), or 1.0 or 2.0 ppm uniconazole (Concise; Fine Americas). For pansy, drenches were solutions containing deionized water (control), 1.0 or 2.0 ppm ancymidol (Abide), 0.5 or 1.0 ppm paclobutrazol (Bonzi), or 0.5 or 1.0 ppm uniconazole (Concise).

Plants were irrigated with acidified water supplemented with 15N–2.2P–12.5K water-soluble fertilizer (Excel 15–5–15 Cal-Mag; Scotts, Marysville, OH) to provide 200 ppm nitrogen. Irrigation water was supplemented with 93% sulfuric acid (Ulrich Chemical, Indianapolis) at 0.08 ppm to reduce alkalinity to 100 ppm and pH to a range of 5.7 to 6.0.

The plants were grown in a glass-glazed greenhouse with exhaust fan and evaporative- pad cooling, radiant hot water heating, and retractable shade curtains controlled by an environmental computer (Maximizer Precision 10; Priva Computers, Vineland Station, ON, Canada). The greenhouse temperature set point was 18 ± 1 °C with a 16-h photoperiod (0600–2200 HR) consisting of natural daylengths with supplemental lighting. High-pressure sodium lamps delivered a supplemental photosynthetic photon flux (*PPF*) of 100 $\mu mol \cdot m^{-2} \cdot s^{-1}$ at plant height [as measured with a quantum sensor (LI-COR Biosciences, Lincoln, NE)] from 0600 to 2200 HR. Environmental data are reported in Table 1.

Plant height (pansy) or length of the longest stem (calibrachoa) was measured from the surface of the substrate to the top of the plant (pansy) or end of the main stem (calibrachoa) on the date of chemical applications and weekly thereafter (Figs. 1 and 2), with final measurements taken 6 weeks after applications (Tables 2 and 3). Flowering data were not collected because plants had visible flower buds at the time of the drench. For each species, the experiment employed a completely randomized design in a factorial arrangement, with substrate (two levels) and PGR (seven levels) as factors. There were eight replicates (individual plants) per treatment. Analyses of variance, pairwise comparisons between treatments using Tukey's honestly significant difference (HSD) test at $P \leq 0.05$, and regression analysis were performed using SPSS (version 17.0; SPSS, Chicago).

Table 1. Average daily greenhouse air temperature (ADT) and daily light integral (DLI) during each month for calibrachoa and pansy grown in two different substrates and drenched with plant growth retardant solutions.

Month	ADT [mean ± SD (°C)][z]	DLI ($mol \cdot m^{-2} \cdot d^{-1}$)
February	16.9 ± 0.5	15.1
March	18.8 ± 1.0	18.3
April	18.9 ± 0.8	17.4

[z](1.8 × °C) + 32 = °F

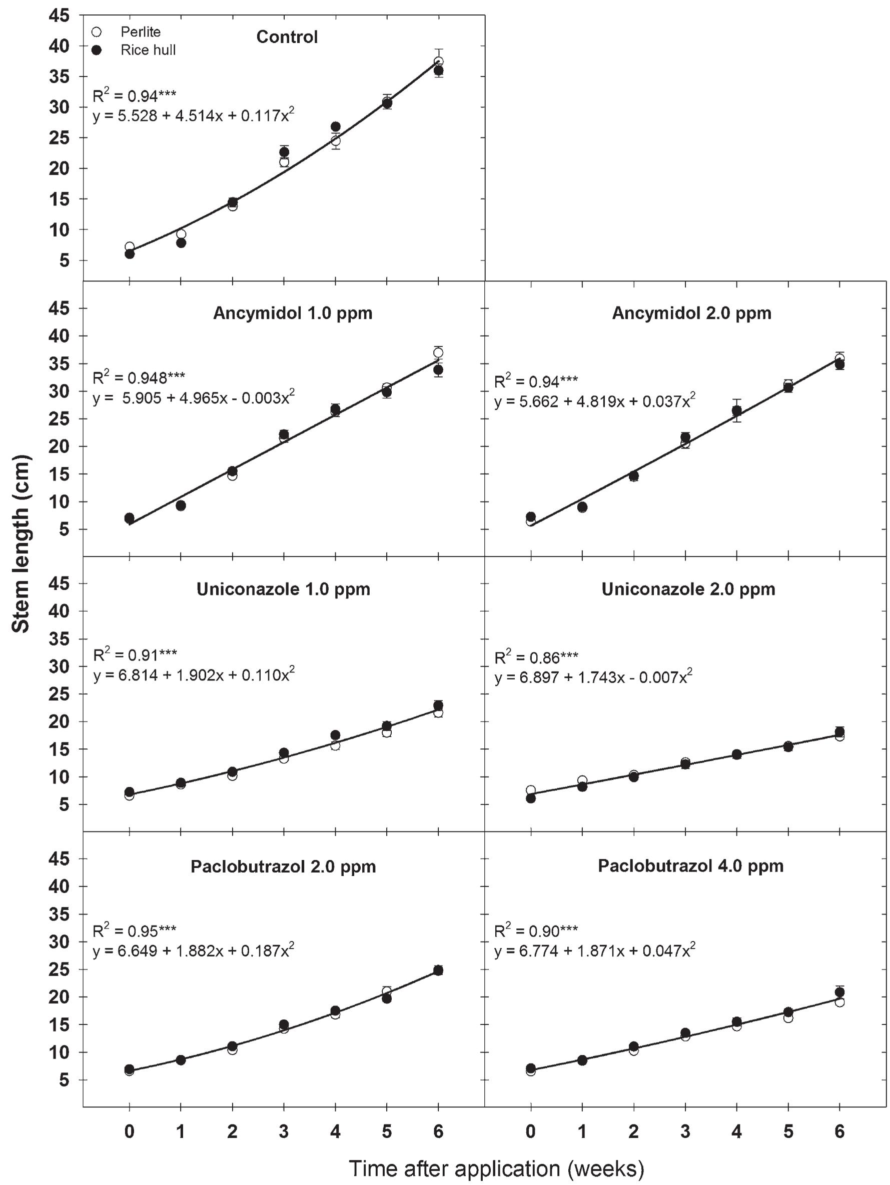

Fig. 1. Relationship between time after application and stem length of calibrachoa grown in substrates composed of (v/v) 80% peat and 20% perlite (perlite) or rice hulls (rice hull) and treated with deionized water (control) or plant growth retardant drenches. Each symbol represents the mean of eight plants, and the error bars represent SE. Equations for regression lines presented with corresponding R^2 are for data pooled across substrates. ***Significant at $P \leq 0.001$; 1 cm = 0.3937 inch; 1 ppm = 1 $mg \cdot L^{-1}$.

Results and discussion

CALIBRACHOA. Plant growth retardants, but not substrate, affected

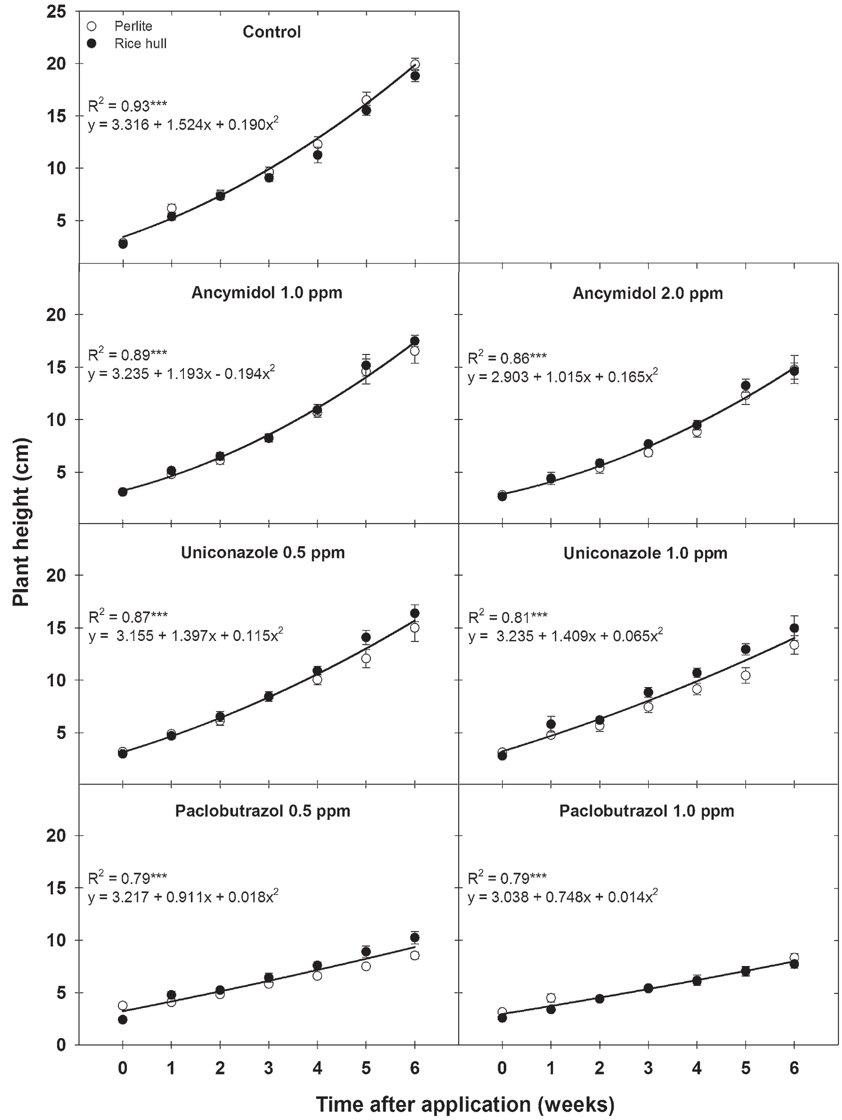

Fig. 2. Relationship between time after application and plant height of pansy grown in substrates composed of (v/v) 80% peat and 20% perlite (perlite) or rice hulls (rice hull) and treated with deionized water (control) or plant growth retardant drenches. Each symbol represents the mean of eight plants, and the error bars represent SE. Equations for regression lines presented with corresponding R^2 are for data pooled across substrates. ***Significant at $P \leq 0.001$; 1 cm = 0.3937 inch; 1 ppm = 1 mg·L^{-1}.

Table 2. The effect of substrate and plant growth retardant (PGR) drenches on 'Callie Deep Yellow' calibrachoa stem length 6 weeks after applications.

		PGR concn (ppm)[y]					
		Ancymidol		Paclobutrazol		Uniconazole	
	Control	1.0	2.0	2.0	4.0	1.0	2.0
Substrate[z]	Stem length (cm)[y]						
Perlite	37.4	36.9	35.9	24.7	19.1	21.6	17.3
Rice hull	36.0	33.9	34.8	24.9	20.9	22.9	18.2
	36.7 a[x]	35.4 a	35.3 a	24.8 b	20.0 cd	22.3 bc	17.8 d
Substrate	NS[w]						
PGR	***						
Substrate × PGR	NS						

[z]Substrates composed of (v/v) 80% sphagnum peat and 20% perlite (perlite) or rice hulls (rice hull).
[y]1 ppm = 1 mg·L^{-1}, 1 cm = 0.3937 inch.
[x]Within-row means followed by different lower case letters are significantly different by Tukey's honestly significant difference (HSD) test at $P \leq 0.05$.
[w]NS, *, **, *** indicates not significant or significant at $P \leq 0.05$, 0.1, or 0.001, respectively.

the pattern of growth over time and final stem length (Fig. 1; Table 2). When regression models for stem length over time were fitted for both substrates, within each PGR application there were no significant differences between corresponding equation coefficients for each substrate (Fig. 1). Therefore, the pattern of growth was the same for calibrachoa treated with the same PGR applications, regardless of substrate. Ancymidol did not suppress stem length, while both concentrations of paclobutrazol and uniconazole did (Table 2). Plants treated with 2.0 or 4.0 ppm paclobutrazol were 11.9 and 16.7 cm shorter, respectively, than control plants. Applying 1.0 or 2.0 ppm uniconazole produced plants with stems 14.4 and 18.9 cm shorter, respectively, than control plants.

Pansy. Similar to calibrachoa, the rate of growth and plant height of pansy 6 weeks after applications was affected by PGR, but not substrate (Fig. 2; Table 3). There were no significant differences in equation coefficients between regression models for substrates within PGR applications for plant height over time (Fig. 2). Therefore, as with calibrachoa, substrate did not interact with PGR to affect the pattern of growth over time within a PGR application. Final plant height was not significantly suppressed when treated with 1.0 ppm ancymidol, while plants treated with 2.0 ppm ancymidol were 4.7 cm shorter than control plants (Table 3). When 0.5 and 1.0 ppm paclobutrazol were applied, plant height was 10.0 and 11.3 cm shorter, respectively, than control plants. Similarly, plant height was suppressed by 3.7 or 5.2 cm compared with control plants when 0.5 or 1.0 ppm uniconazole, respectively, was applied.

We present results here to provide new insight into substrate and PGR interactions, with special reference to rice hulls. There were no differences in plant height or stem length growth patterns of pansy and calibrachoa, respectively, over the course of the experiment between plants grown in either substrate given the same PGR application. Additionally, there was no difference in final plant height or stem length of pansy or calibrachoa, respectively, between plants grown in standard or rice hull substrate when given identical PGR applications.

Table 3. The effect of substrate and plant growth retardant (PGR) drenches on 'Delta Orange Blotch' pansy plant height 6 weeks after applications.

		PGR concn (ppm)[y]					
		Ancymidol		Paclobutrazol		Uniconazole	
	Control	1.0	2.0	0.5	1.0	0.5	1.0
Substrate[z]	Plant ht (cm)[y]						
Perlite	19.9	16.5	14.8	8.5	8.4	15.0	13.4
Rice hull	18.8	17.5	14.6	10.3	7.8	16.4	15.0
	19.4 a[x]	17.0 ab	14.7 bc	9.4 d	8.1 d	15.7 bc	14.2 c
Substrate	NS[w]						
PGR	***						
Substrate × PGR	NS						

[z]Substrates composed of (v/v) 80% sphagnum peat and 20% perlite (perlite) or rice hulls (rice hull).
[y]1 ppm = 1 $mg \cdot L^{-1}$, 1 cm = 0.3937 inch.
[x]Within-row means followed by different lower case letters are significantly different by Tukey's honestly significant difference (HSD) test at $P \leq 0.05$.
[w]NS, *, **, *** indicates not significant or significant at $P \leq 0.05$, 0.1, or 0.001, respectively.

Based on our results, producers may employ PGR drench strategies that have previously been used for plants grown in substrate comprised of peat and perlite for plants grown in substrate containing peat and rice hulls at the proportions used in this study.

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