Effects of Maintained Substrate Water Contents from Transplant to Early Stage of Potted Impatiens©

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INTRODUCTION

In the first few weeks of bedding plant production, growers rarely irrigate so as to bring the substrate up to container capacity (the point at which the substrate can hold no more water against gravity). Research has been carried out to determine effects of substrate water content on bedding plant growth. Van Iersel et al. (2010) determined effects of substrate water content on petunia (*Petunia ×hybrida*). The substrate was maintained at or above substrate volumetric water contents (VWC; cm^3 water/cm^3 substrate) of 5%, 10%, 15%, 20%, 25%, 30%, 35%, and 40%. Shoot dry weight increased quadratically with VWC. There was a little increase in shoot dry weight between 25% and 40% VWC. All plants were well-watered uniformly for the first nine days after being transplanted into the containers, and it took nine days after irrigation treatment initiation for the substrate to reach the 5% VWC target. The substrate water content maintained during the first nine days is not reported. Furthermore, substrate water content at container capacity was not reported. Therefore, it is not known how 40% VWC (the wettest treatment) compares to container capacity in the substrate and container used in the study.

Although growers do not regularly irrigate to container capacity in early stages of bedding plant production, growers differ on the ideal substrate moisture content for early stages of bedding plant production. It is commonly assumed that drier substrates cause roots to grow deeper into the container.

The objectives of this research were 1) to determine the effects of substrate water content on *Impatiens ×walleriana* 'Xtreme Red' in early production stages when not thoroughly watered in at potting and 2) to determine depth of root growth within the container at varying substrate water contents.

MATERIALS AND METHODS

This study took place at the Paterson Greenhouse Complex on the campus of Auburn University. On 9 July 2015, Fafard 3B was amended with 3.6 $kg.m^3$ (6 $lbs.yd^3$) of 3-4 month Osmocote Plus 15-9-12 (15N-3.9P-10K, Scotts Co., Maryville, OH). Six 15.2 cm (6 in.) containers (Dillen Products, Middlefield, OH) were filled loosely to the brim and dropped 5 times on a table to settle the substrate to the lip 1.6 cm (0.625 inch) below the brim. The containers were then weighed and minor adjustments were made to bring the mass of added substrate to each container to 322 g (11.7 oz). After the six containers were filled, remaining substrate was sealed in a container to maintain the moisture content. Containers were watered until the substrate held no more water and were allowed to drain for 1 hr in a dark room to container capacity. Containers were weighed, placed in a forced air drying oven at 60° C (140° F) for two days, and weighed again. It was determined that the containers held 136 g (4.8 oz) dry substrate, and the average gravimetric water content (GWC; grams water/grams substrate) at container capacity was 81%. On 14 July 2015, forty 15.2 cm (6 in.) containers were filled with 332 g (11.7 oz) of the Fafard 3B substrate that had been sealed. *Impatiens ×walleriana* 'Xtreme Red' that were sown on 15 June 2015 in a 200-cell plug tray were acquired from Young's Plant Farm, Inc. (Auburn, AL). Ten plugs were randomly pulled from the flat to determine the average fresh weight per plug (4.1 g). One plug was transplanted into each container. Containers were placed in a temperature controlled greenhouse maintained between 18° C (64° F) and 34˚ C (93° F) for

the duration of the experiment. Each container was weighed to determine the volume of water needed to bring the container to a target GWC of 80%, 76%, 72%, 68%, or 64%. Although substrate GWC at container capacity was 81%, a target GWC of 80% was selected as the highest target GWC in order to prevent leaching. The weight of each container at its target GWC was calculated by dividing the dry weight of Fafard 3B in each container by 1 minus the target GWC and adding the empty container weight and the average plug fresh weight [136.2 g ÷ (1-Target GWC) + empty container weight + 4.1 g]. The volume of water needed to bring each container to its target weight was slowly distributed evenly across the surface using a 60 mL (2.12 oz) syringe directly after placing containers in the greenhouse. This process was repeated daily between 8:00AM and 10:00AM to bring each container to the Target GWC. Each treatment had eight replications. The experimental design was a Completely Randomized Design, and containers were spaced 20 cm (7.9 in.) center to center on a greenhouse bench. Plant size was recorded weekly by calculating size indices for all plants [(height + widest width + perpendicular width) ÷ 3)]. Four plants per treatment were harvested three weeks after potting (WAP) on 4 August 2015. Shoots were harvested and placed in a forced air drying oven at 60^{o} C (140^{o} F) until dry to determine shoot dry weights. The harvested containers were hand watered until substrate could hold no more water and left to sit in a dark, cool room for 2 hours. The containers were then weighed to determine the weight at container capacity. Substrate pH and electrical conductivity (EC) were measured using leachate samples collected using the pour-through method. Containers were placed in a freezer at -2^{o} C (28.4^{o} F). On 6 August 2015 the average shoot weight for each treatment was calculated and added to the formula for the target weights in place of the initial plug weight. The remaining plants were harvested in a similar manner 6 WAP on 25 August 2015. Once root balls were thoroughly frozen, a machete and rubber mallet were

used to divide root balls in half top from bottom. Root balls averaged 8 cm (3.2 in.) in height from top to bottom. Roots were washed and dried in a forced air drying oven at 60° C (140° F) until dry and weighed to determine root dry weights. All data were analyzed using regression analysis within JMP statistical software (SAS Institute Inc., Cary, NC).

RESULTS AND DISCUSSION

Size index increased linearly and quadratically with target GWC 1 and 2 weeks after potting (WAP) (Table 1). Size index increased linearly at the 0.05 α level with target GWC 3, 4, and 5 WAP. However, by 6 WAP there was a strong quadratic relationship ($\alpha = 0.001$) between size index and target GWC. Size indices 6 WAP ranged from 20.0 to 21.9 among plants in target GWC treatments between 64% and 76% and sharply increased to 27.2 among plants in the 80% target GWC.

Shoot dry weight 3 WAP ranged from 0.65 to 0.75 g among plants in target GWC treatments between 64% and 76% and sharply rose to 1.18 g in the 80% target GWC treatment (Table 2). Roots of all plants were present only in the top 4 cm (1.57 inch) of the root ball 3 WAP. As a result, only total root dry weight is presented. There was no regression response between root dry weight and target GWC 3 WAP.

Shoot dry weights 6 WAP responded linearly and quadratically to target GWC at the 0.001 α level (Table 3). The average weights increased from 4.35 to 6.50 g between 64% and 76% target GWC treatments and sharply rose to 9.33 g at the 80% target GWC treatment. There was no response for top dry root weight or total dry root weight to target GWC. However, bottom dry root weight increased linearly and quadratically with target GWC at the 0.05 α level. There was significantly greater root dry weight in the bottom half of containers in the 80% target GWC treatment compared to all other treatments.

Varying target GWC levels also affected the pH and EC levels in the substrate 3 WAP and 6 WAP (Table 4). At 3 WAP there was a strong linear and quadratic response in respect to pH and target GWC at the 0.001 α level. The pH decreased linearly from 5.62 at the 64% target GWC treatment to 5.14 at the 76% target GWC level and sharply decreased to 4.73 at the 80% target GWC treatment. There was no response between EC levels and target GWC 3 WAP. There was a quadratic relationship at the 0.05 α level between pH and target GWC in the 6 WAP. Substrate pH ranged between 4.48 and 5.25. There was a quadratic response at the 0.01 α level between substrate EC and target GWC. EC ranged from 5.12 to 6.56 $mS \cdot cm^{-1}$ between 64% and 76% target GWC treatments, while substrate EC measured only 1.85 $mS \cdot cm^{-1}$ in the 80% target GWC treatment.

Total irrigation volume applied per plant increased linearly and quadratically at the 0.001 α level (Table 5). Irrigation volume applied per plant increased 12% between 64% and 68% target GWC, 13% between 68% and 72% target GWC and 5% between 72% and 76% target GWC. However, irrigation volume applied per plant increased 30% between 76% and 80% target GWC. Leachate volumes of 4 mL or less were collected in the 80% target GWC treatment during the first ten days of the experiment (data not shown).

Size index 6 WAP, shoot dry weight 3 WAP, shoot dry weight 6 WAP, and bottom root dry weight had significant increases between 76% and 80% target GWC. As stated earlier, growers typically do not irrigate to container capacity. Although containers in the 80% target GWC treatment were irrigated to a level close to container capacity daily, the substrate dried considerably between irrigation events due to high daily temperatures. Results may differ at cooler temperatures. A moisture characteristic curve was developed for Fafard 3B using the modified long column method in order to relate GWC to VWC (Altland et al., 2010). Target

GWC levels of 64%, 68%, 72%, 76% and 80% relates to VWC levels of 7%, 12%, 20%, 32%, and 47%, respectively. In the study by Van Iersel et al. (2010), shoot dry weights increased little between 25% and 40% VWC, while shoot dry weight in our study increased significantly between target GWC levels of 76% and 80% which relates to VWC levels of 32% and 47%. While plants in our study were irrigated once per day in order to bring substrate up to the target GWC, plants in the study by Van Iersel et al. (2010) were irrigated on-demand when substrate water content dropped below the set VWC level. As a result, substrate in the 76% target GWC treatment dropped to a GWC as low as 72% between irrigation events which is equivalent to a VWC of 25%. Substrate water contents at this level resulted in significantly less plant growth.

In this study, maintaining low substrate moisture contents directly after transplanting resulted in significantly smaller plants as soon as 2 WAP. Lower substrate water contents did not result in a higher percentage of total root growth in the bottom half of the container. Results may differ in cooler temperatures and with more frequent irrigation events.

Literature Cited

Altland, J.E., J.S. Owen and W.C. Fonteno. 2010. Developing moisture characteristic curves and their descriptive functions at low tensions for soilless substrates. J. Amer. Soc. Hort. Sci. 135:63-567.

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Table 1. Size indicies of *Impatiens ×wallerina* 'Xtreme Red' as affected by target gravametric water content (GWC).

Target GWC	1 WAP[z]	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP
64%	4.0	6.7	10.9	14.4	19.3	20.0
68%	4.4	7.5	11.3	15.5	19.5	20.4
72%	4.6	7.8	11.1	16.2	20.7	21.3
76%	4.5	8.1	11.8	16.4	20.8	21.9
80%	4.9	9.1	12.8	17.4	22.6	27.2
Significance[y]	L***Q**	L***Q***	L*	L*	L*	L***Q***

[z]Weeks after potting.

[y] Regression response non-significant (NS), linear (L), or quadratic (Q) at the 0.05 (*), 0.01(**), or 0.001 (***) level.

Table 2. *Impatiens ×wallerina* 'Xtreme Red' shoot and root weights as affected by target gravimetric water content (GWC) 3 weeks after potting.

Target GWC	Shoot Dry Weight (g)	Root Dry Weight (g)
64%	0.65	0.90
68%	0.73	0.55
72%	0.75	0.50
76%	0.68	0.40
80%	1.18	0.55
Significance[z]	L*Q**	NS

[z] Regression response non-significant (NS), linear (L), or quadratic (Q) at the 0.05 (*), 0.01(**), or 0.001 (***) level.

Table 3. *Impatiens ×wallerina* 'Xtreme Red' shoot and root weights as affected by target gravimetric water content (GWC) 6 weeks after potting.

			Roots	
Target GWC	Shoot Dry Weight (g)	Dry Weight Top (g)	Dry Weight Bottom (g)	Dry Weight Total (g)
64%	4.35	5.20	0.15	5.35
68%	4.63	3.53	0.78	4.30
72%	5.67	6.60	0.67	7.27
76%	6.50	5.08	0.23	5.30
80%	9.33	6.23	2.10	8.33
Significance[z]	L***Q***	NS	L*Q*	NS

[z] Regression response non-significant (NS), linear (L), or quadratic (Q) at the 0.05 (*), 0.01(**), or 0.001 (***) level.

Table 4. Substrate pH and EC as affected by target gravimetric water content (GWC) 3 and 6 weeks after potting.

	3 WAP[z]		6 WAP	
Target GWC	pH	EC ($mS \cdot cm^{-1}$)	pH	EC ($mS \cdot cm^{-1}$)
64%	5.62	5.55	5.25	5.44
68%	5.53	6.17	5.04	6.56
72%	5.47	7.98	4.76	5.21
76%	5.14	5.95	4.48	5.12
80%	4.73	6.73	5.09	1.85
Significance[y]	L***Q***	NS	Q*	L*Q**

[z] Weeks after potting.

[y] Regression response non-significant (NS), linear (L), or quadratic (Q) at the 0.05 (*), 0.01(**), or 0.001 (***) level.

Table 5. Total average irrigation volume applied per plant as affected by target gravimetric water content (GWC) from 17 July 2015 to 24 August 2015 on *Impatiens ×wallerina* 'Xtreme Red.'

Target GWC	Irrigation Volume (mL)
64%	2134
68%	2392
72%	2696
76%	2843
80%	3690
Significance[z]	L***Q***

[z] Regression response non-significant (NS), linear (L), or quadratic (Q) at the 0.05 (*), 0.01(**), or 0.001 (***) level.