Effects of Tween® 20 on growth and drought tolerance of coleus 'Wasabi' (*Plectranthus scutellarioides*)©

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INTRODUCTION

Water is essential for drinking, personal hygiene, power production plants, and agricultural food and animal production. Some 97.5% of the global water supply is unusable salt water. From the remaining 2.5% of fresh water, only a third can be withdrawn from the environment for use. Roughly 70% of all the fresh water drawn from the environment is used for irrigated agriculture (Seckler et al., 1998). Because irrigated agriculture consumes such a large percentage of the available fresh water, optimizing irrigation efficiency in all sectors of horticulture and agriculture is critical. Moe and Rheingans (2006) estimated that 50% less water could be used for irrigation if highly efficient irrigation practices were adopted.

One way that water use efficiency (WUE) on the physiological level can be enhanced is by decreasing the transpiration rate while increasing or maintaining a steady state of carbon fixation on a leaf level basis. Yang (2008) discovered that by applying 100 ppm of the non-ionic surfactant Tween® 20 (polyoxyethylene sorbitan monolaurate, $C_{58}H_{114}O_{26}$) with irrigation water, it was possible to decrease the transpiration rate in *Impatiens hawkerii* 'Celebrate Salmon' grown in soilless media by roughly 50% while maintaining the same growth as the control plants. The same experiment was repeated in a hydroponic system with the same impatiens species with the addition of *Spathiphyllum floribundum* 'Viscount' with similar results. In a different study, Kubik and Michalczuk (1993) showed that foliarly applied Tween® 20 could decrease transpiration rates in strawberry plants.

Water use efficiency does not intrinsically equate to drought tolerance. The objective of this study was to determine effects of Tween® 20 on drought tolerance in response to altered transpiration rates. Coleus was selected as the study plant because it readily wilts under drought stress making it an ideal plant to observe. A second goal of this study was to determine if product application frequency would affect drought stress. A final goal was to compare the performance of Tween® 20 with that of two similar commercially available soil conditioning products: Aqua-Gro® L with PsiMatric Technology and Hydretain® ES Plus. Both of these products advertise that they can reduce watering by up to 50%, which is similar to what was discovered with Tween® 20. If Tween® 20 does not outperform the established products it may have limited market viability.

MATERIALS AND METHODS

Plant material

Single rooted cuttings of coleus [*Plectranthus scutellarioides* (L.) R.Br. 'Wasabi' (syn. *Solenostemon scutellarioides* 'Wasabi')] from Tagawa Greenhouses, Brighton, Colorado were transplanted into 16.5 cm (6.5-in) azalea pots filled with Fafard 3b. Immediately after transplanting into azalea pots all plants were watered in with a 200 ppm 20-10-10 liquid fertilizer until water was uniformly leached from the pots.

Chemical materials

Three low toxicity, organic chemicals were tested in this project for their effect on plant growth, drought tolerance, and soil moisture retention. Tween® 20, a nonionic surfactant, was the primary product being investigated. Hydretain® and Aqua-Gro® L, commercially sold and used as soil conditioners, were included in the experiment to

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compare with Tween® 20. Concentrations of 100 ppm Tween® 20; 320 ppm Hydretain®; and 100 ppm Aqua-Gro® L were selected for this experiment based on previous research and product labels.

Irrigation

Plants were irrigated through a drip irrigation system. Each product was injected into a drip irrigation system with a D14MZ2 Dosatron injector (Dosatron, USA). Uniform water output was accomplished with 3.2 gph Woodpecker pressure compensating emitters (Netafim™). At each irrigation event, plants were watered for 60 s providing an output of 200 mL.

Experimental design

The experimental design was a two-way factorial with repeated measurements on soil moisture. Plants were arranged on a single greenhouse bench in a completely randomized block design. The two factors investigated were product type and the application timing of the product. Plants were either treated with Tween 20, Aqua-Gro L, Hydretain, or no product (control). The second factor was timing of application. For each product type, the product was applied only during the first irrigation event (after the initial watering), applied at every irrigation event, or only applied on the last irrigation event before the period of drought stress. A third factor was to take soil moisture measurements at multiple times throughout the experiment. The experiment consisted of 10 treatments, including the control (Table 1). The treatments were designed based on three different drought tolerance products (Tween 20, Hydretain, and Aqua-Gro L) and three different application times (every irrigation, initial irrigation only, and final irrigation only) giving a total of 3×3 = 9 treatments plus the control (no drought tolerance product) = 10 treatments.

Table 1. Visual symptoms of drought based on a 0-3 scale. 0 = no wilt; 1 = minor wilt; 2 = moderate wilt; 3 = severe wilt.

		Drought rating		
Product	**Irrigation**	**Mean**	**Mean difference (± SD)**	***P***
Control	Control	2.60	-	-
Aqua-Gro L	Everytime	2.46	-0.1429 ± 0.85	0.66
	First	2.46	-0.1429 ± 0.85	0.66
	Last	2.46	-0.1429 ± 0.85	0.66
Hydretain	Everytime	3.00	0.4286 ± 0.84	0.19
	First	2.89	0.2857 ± 0.85	0.38
	Last	2.75	0.1429 ± 0.85	0.66
Tween 20	Everytime	2.89	0.2857 ± 0.85	0.38
	First	3.00	0.4286 ± 0.85	0.19
	Last	2.75	0.1429 ± 0.85	0.66

1. Timeline.

Beginning 2 days after plants were transplanted and initially watered in, plants were irrigated once in the morning, every other day for a period of 9 days equaling a total of five irrigation events during the 9-day period. The final day of irrigation doubled as the initiation of the drought phase of the experiment. Including the final day of irrigation, the drought phase of the experiment lasted 10 days. On the tenth day plants were observed and given a drought rating based on visual symptoms of wilt. Above ground shoots were harvested to determine dry weight. Plant size index was measured the day after the final irrigation by averaging the plant height, width at widest point, and width perpendicular to widest point.

2. Soil moisture retention and evapotranspiration.

Soil moisture readings were taken twice a day on the day plants were irrigated: once at

7:00 A.M. prior to irrigation and once at 11:00 A.M., which was 2 h after irrigation. Soil moisture data was not taken on the days in between irrigation events. Beginning on the final day of irrigation, soil moisture readings were collected at 7:00 A.M. daily for 10 days until the termination of the experiment. Evapotranspiration for a given day was calculated by subtracting the 7:00 A.M. from the 11:00 A.M. reading of the previous day.

RESULTS AND DISCUSSION

Drought tolerance

In physiological studies one of the most common tools used to quantify drought or other ecophysiological stress is the chlorophyll fluorescence meter. It was our original intent to utilize this tool, however malfunctions occurred and it could not be used. Plants were rated on a visual scale of 0-3, 0 being no signs of drought and 3 being heavy signs of drought (Figure 1). On the 10th day after the last watering, visual ratings were given to plants and there was no difference among any treatments or the control (Table 1).

Figure 1. Visual drought rating (left to right). 0 = no wilt; 1 = minor wilt (1-2 leaves); 2 = moderate wilt (3-5 leaves); 3 = heavy wilt (majority of leaves).

Evapotranspiration

Evapotranspiration (ET) was measured by taking the soil moisture content after irrigation one day and then subtracting from it the soil moisture content taken two days later immediately prior to the next irrigation. The difference in soil moisture content was the percent water by volume lost from ET. There were no overall differences or differences on a daily basis between treatments (Figure 2). A soil moisture sensor is considered a good tool for gauging when to water, but it is not capable of precise measurements, therefore in future studies, ET will be measured gravimetrically.

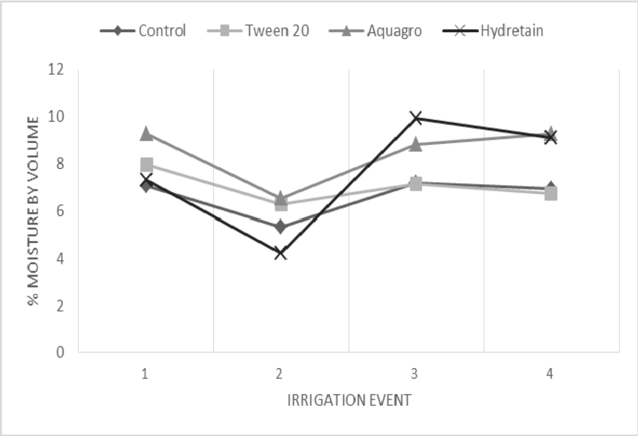

Figure 2. Evapotranspiration was measured as the time in between irrigations events which were 42 h apart.

Size index and dry weight

No differences were noted between treatments for both size index and dry weight (Table 2). This result is not altogether surprising because the products are not expected to be hormonal in nature. One exception is Tween 20 which was reported to influence synthesis of auxins and gibberellins in pea epicotyl segments (Stowe, 1958).

Table 2. Size index was measured by averaging the height + width at widest point + width perpendicular to widest point. Dry weight was measured after drying in oven at 77°C for 40 h.

Treatment		Size index			Dry weight (g)		
Product	**Time[1]**	**Mean**	**Mean difference (± SD)**	***P***	**Mean**	**Mean difference (± SD)**	***P***
Control	Control	17.52	-	-	1.86	-	-
Aqua-Gro L	Everytime	17.38	-0.14 ± 3.15	0.91	1.77	-0.09 ± 0.47	0.63
	First	16.95	-0.57 ± 3.16	0.634	1.76	-0.10 ± 0.47	0.58
	Last	16.52	-1.00 ± 3.16	0.41	1.69	-0.17 ± 0.47	0.34
Hydretain	Everytime	18.76	1.24 ± 3.16	0.30	1.96	0.10 ± 0.47	0.58
	First	18.76	0.33 ± 3.16	0.78	1.91	0.06 ± 0.47	0.75
	Last	18.76	-1.05 ± 3.16	0.38	1.76	-0.10 ± 0.47	0.58
Tween 20	Everytime	18.76	2.00 ± 3.16	0.0992	2.1	0.24 ± 0.47	0.179
	First	18.76	0.14 ± 3.15	0.9052	1.7	-0.16 ± 0.47	0.383
	Last	18.76	0.05 ± 3.15	0.9683	1.83	-0.03 ± 0.47	0.874

[1] The product was either applied only during the first irrigation event (First) (after the initial watering), applied at every irrigation event (Everytime), or only applied on the last irrigation event (Last) before the period of drought stress.

Drought soil moisture retention

Soil moisture content measured on a daily basis during the drought period of ten days was not different between treatments (Figure 3).

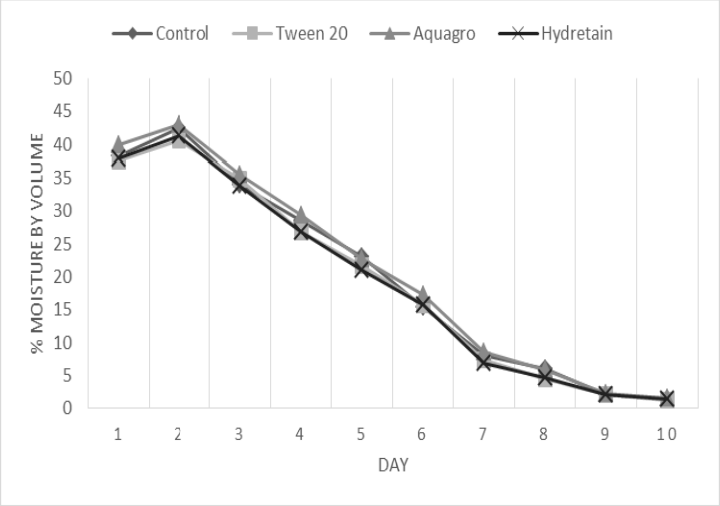

Figure 3. Soil moisture content (SMC) measured as % water by volume. Measurements taken at 7:00 daily for ten days. SMC was measured with a Delta T HH2 soil moisture sensor (Delta T Devices).

No significant differences

Measurements of soil moisture retention and evapotranspiration could be performed much more precisely in the future. Having measured these, especially ET with the soil moisture sensor, there may be error due to a lack of precision. In future studies, an IRGA photosynthesis machine will be utilized to measure leaf gas exchange. In addition, future studies will also include measurements of leaf water potential and photosystem II efficiency under drought conditions. The concentrations of product applied could also be increased to an extent and still be within label recommended rates which could make a difference in future results.

Literature cited

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