Irrigation Systems and Fertilizer Affect Petunia Growth

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SUMMARY. Two experiments were conducted to compare the growth of 'Ultra White' petunia (*Petunia ×hybrida*) plants in a subirrigation system versus in a hand-watered system. In Expt. 1, petunia plants were watered with 50, 100, or 150 ppm (mg·L^{-1}) of N of Peter's 20–10–20 (20N–4.4P–16.6K) and in Expt. 2, Nutricote 13–13–13 (13N–5.8P–10.8K) type 100, a controlled release fertilizer, was incorporated into the growing substrate, prior to transplanting, at rates of 3, 6, or 9 lb/yard^3 (1.8, 3.6, or 4.5 kg·m^{-3}). In both experiments, there was no difference in petunia shoot dry mass or final flower number between the irrigation systems at the lowest fertilization rate but differences were evident at the higher fertilization rates. In Expt. 1, shoot dry mass and flower number of subirrigated petunia plants fertilized with 100 ppm of N was greater than for hand-watered plants fertilized at the same rate. However, subirrigated petunia plants fertilized with 150 ppm of N were smaller with fewer flowers than hand-watered petunia plants fertilized with 150 ppm of N. Substrate electrical conductivity (EC) concentrations for petunia plants subirrigated with 150 ppm of N were 4.9 times greater than concentrations in pots hand-watered with 150 ppm of N. In Expt. 2, subirrigated petunia plants fertilized with 6 and 9 lb/yard^3 were larger with more flowers than hand-watered plants fertilized at the same rates. Although substrate EC concentrations were greater in subirrigated substrates than in hand-watered substrates, substrate EC concentrations of all hand-watered plants were about 0.35 dS·m^{-1}. Subirrigation benches similar to those used in these experiments, appear to be a viable method for growing 'Ultra White' petunia plants. However, the use of Peter's 20–10–20 at concentrations greater than 100 ppm of N with subirrigation appeared to be detrimental to petunia growth probably because of high EC concentrations in the substrate. On the other hand, the use of subirrigation with Nutricote 13–13–13 type 100 incorporated at all of the rates tested did not appear to be detrimental to petunia growth.

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Historically, the greenhouse industry in the US has applied copious amounts of water and fertilizer to maximize crop production. However, contamination of ground water from greenhouse fertilizer runoff has become an increasingly important concern. Within the last 10 years, some growers have started to use alternative irrigation and fertilization practices to minimize fertilizer runoff into the environment (Biernbaum, 1992). There are numerous methods for managing water and fertilizer runoff in the greenhouse, including changes in both the type of irrigation system and the type of fertilizer used.

Recirculating subirrigation systems that capture and reuse the irrigation solution have been promoted as a way to reduce greenhouse fertilizer runoff while conserving water. Several reports have been published comparing subirrigation to conventional overhead irrigation systems for the growth of flowering ornamental crops such as poinsettia (*Euphorbia pulcherrima*) (Argo and Biernbaum, 1995; Dole et al., 1994), easter lilies (*Lilium longiflorum*) (Argo and Biernbaum, 1994), kalanchoe (*Kalanchoe blossfeldiana*) (Kovacic and Holcomb, 1981), new guinea impatiens (*Impatiens×hawkeri*) (Kent and Reed, 1996), geranium (*Pelargonium hortorum*) (Morvant et al., 1997), pansy (*Viola×wittrockiana*) (van Iersel, 1999), petunia (*Petunia ×hybrida*) (Klock-Moore and Broschat, 1999), and impatiens (*Impatiens wallerana*) (Klock-Moore and Broschat, 1999).

The choice of irrigation system can affect the distribution of soluble salts in the growing substrate and thus can influence the type of fertilizer and amount to use [e.g., water-soluble fertilizer (WSF) or controlled-release fertilizer (CRF)] (Morvant et al., 1997; Reed, 1996; Argo and Biernbaum, 1994; Evans et al., 1992; Barrett, 1991). Because WSF and CRF differ in the way nutrients are delivered to plants, their effectiveness could vary with the type of irrigation system used. No applicable literature was found with fertilization recommendations for petunia plants based on the type of fertilizer (WSF or CRF) and the type of irrigation system (subirrigation or hand-watered). The objective of the current study was to compare the growth of 'Ultra White' petunia plants at three fertilization rates using subirrigation or hand watering. In Expt. 1, petunia growth was compared using a WSF while in Expt. 2, petunia growth was compared using a CRF.

Materials and methods

COMMON TO BOTH EXPERIMENTS. Petunia 'Ultra White' plugs from a #392 square plug tray were transplanted into 13.5-fl oz (400-mL) round pots [4 inches (10.2 cm) diameter × 3.7 inches (9.5 cm) tall] filled with premoistened 60% sphagnum peat, 25% vermiculite, and 15% perlite (by volume) substrate amended with dolomitic limestone to a pH of 5.5. Plants were watered by hand or by using subirrigation.

Three fertilization rates (0.5×, 1×, or 1.5×, where × = standard application rate) were replicated four times over a total of 12 Ebb-Flow Benches (Midwest GroMaster, Inc. St. Charles, Ill.). Both experiments were arranged as a split plot with irrigation as the main plot and fertilization rate as the subplot. Ten pots were placed on each of the 12 benches with five pots per bench being subirrigated and the other five pots being hand-watered. Hand-watered pots were placed in a flat supported 0.8 inches (2-cm) above the bottom of another flat without holes to collect the leachate. Each hand-watered plant received about 3.4 fl oz (100 mL) of fertilizer solution (Expt. 1) or water (Expt. 2) daily to establish a 0.2 leach-

Table 1. Final petunia 'Ultra White' shoot dry mass, flower number, and quality rating of plants that were subirrigated or hand-watered with Peter's 20–10–20 (20N–4.4P–16.6K) daily at 50, 100, or 150 ppm ($mg \cdot L^{-1}$) of nitrogen (N). Within columns, mean values followed by the same letter are not significantly different according to least significant difference (LSD) test at $P = 0.05$ (N = 20).

Fertilization application rate (ppm of N)	Irrigation type	Shoot dry mass (g[z])	Flowers (no.)	Quality
50	Subirrigation	4.15 c	1.05 c	3.98 c
	Hand-watered	4.21 c	0.45 c	3.79 c
100	Subirrigation	7.06 a	3.45 a	5.00 a
	Hand-watered	6.01 b	2.95 ab	4.48 b
150	Subirrigation	6.16 b	2.05 b	4.90 a
	Hand-watered	7.16 a	3.20 ab	4.45 b

[z]28.4 g = 1 oz.

Table 2. Final petunia 'Ultra White' shoot dry mass, flower number and quality rating of plants that were subirrigated or hand-watered and fertilized with Nutricote 13–13–13 (13N–5.8P–10.8K) type 100 that was incorporated into the growing substrate before transplanting at 3, 6, or 9 lb/yard^3 (1.8, 3.6, or 4.5 $kg \cdot m^{-3}$). Within columns, mean values followed by the same letter are not significantly different according to least significant difference (LSD) test at $P = 0.05$ (N = 20).

Fertilization application rate (ppm of N)	Irrigation type	Shoot dry mass (g[z])	Flowers (no.)	Quality
3	Subirrigation	1.74 d	1.05 c	4.33 d
	Hand-watered	1.69 d	0.95 c	4.40 d
6	Subirrigation	3.36 b	5.30 a	4.45 cd
	Hand-watered	2.28 cd	1.80 bc	4.83 ab
9	Subirrigation	4.13 a	6.15 a	4.95 a
	Hand-watered	2.87 bc	2.55 b	4.70 bc

[z]28.4 g = 1 oz.

ing fraction. Daily leachate samples were collected and poured into a covered 10-gal (38-L) container. Once a week, leachate volume was recorded.

Subirrigated plants also were watered daily by flooding each bench with fertilizer solution (Expt. 1) or water (Expt. 2) to a depth of 1.0 to 1.2 inches (2.5 to 3 cm) and draining after 10 min. The fertilizer solution or water in the subirrigation tanks was not changed throughout either experiment. The volume of fertilizer solution or water used to bring tanks back to initial volume was measured weekly.

The experiments were terminated when 75% of petunia plants had at least one open flower. Final number of flowers per plant and plant quality rating were determined at this time. Quality was based on a scale of 1 to 5 with 5 = excellent and 1 = dead. Any plant with a rating of 3.5 or better was considered saleable. Shoot dry mass also was measured for each plant.

At harvest, substrate samples were collected. The surface inch of the 3.7-inch substrate column from each pot was removed to ensure that substrate samples were collected from the active root zone. Nutrients were extracted with distilled water using the saturate media extraction method (SME) (Warncke, 1986). Substrate pH and EC were determined from the extracted solution using Acumet model 20 pH/conductivity meter (Fisher Scientific, Pittsburgh). Data from both experiments were analyzed using analysis of variance (ANOVA) as well as linear and quadratic regression models to examine trends in fertilizer application rate (SAS Systems, SAS Institute, Cary N.C.).

EXPERIMENT 1. In November 1997, petunia plugs were transplanted and exposed to air temperatures of 85/68 ± 5 °F (29/20 ± 3 °C) day/night. Pots were watered daily with Peter's 20–10–20 (The Scott's Company, Marysville, Ohio) at rates of 50, 100, or 150 ppm of N. Five weeks after transplanting, petunia plants were harvested.

EXPERIMENT 2. In February 1998, petunia plugs were transplanted and exposed to air temperatures of 80/65 ± 5 °F (27/18 ± 3 °C) day/night. Prior to transplanting, Nutricote 13–13–13 type 100 [releases 80% of its nitrogen evenly over 100 d at a constant temperature of 77 °F (25 °C)] (Florikan, Sarasota, Fla.) was incorporated into the growing substrate at rates of 3, 6, or 9 lb/yard^3. Five weeks after transplanting, plants were harvested.

Results and discussion

In both experiments, final petunia shoot dry mass and flower number were greater at the 1× and 1.5× fertilization rates than at the 0.5× fertilization rate (Tables 1 and 2). In Expt. 1, for both irrigation systems, substrate EC concentrations increased as fertilizer application rate increased (Table 3). However, in Expt. 2, substrate EC was not different among the fertilization rates for hand-watered plants, but substrate EC increased as fertilization rate increased for subirrigated plants (Table 3).

In both experiments, there was no difference in petunia shoot dry mass or flower number between the irrigation systems at the 0.5× fertilization rate but differences between the irrigation systems were evident at the higher fertilization rates (Tables 1 and 2). In Expt. 1, subirrigated petunia plants fertilized with 100 ppm of N had greater shoot dry mass and more flowers than hand-watered petunia plants fertilized at the

Table 3. Final petunia growing substrate electrical conductivity (EC) concentrations for subirrigated and hand-watered substrates from Expt. 1 and Expt. 2 (N = 20).

Fertilizer application rate	Subirrigation ($dS\cdot m^{-1}$)	Hand-watered ($dS\cdot m^{-1}$)
	Expt. 1[z]	
50 ppm	1.18	0.50
100 ppm	1.43	0.71
150 ppm	3.92	0.80
Significance[y]	L	L,Q
	Expt. 2[x]	
3 lb/yard^3	0.51	0.38
6 lb/yard^3	0.63	0.34
9 lb/yard^3	0.78	0.32
Significance	L	NS
Suggested optimum range[w]	2.0–3.5	

[z]In Expt. 1, Peter's 20–10–20 (20N–4.4P–16.6K) was applied daily at 50, 100, or 150 ppm ($mg\cdot L^{-1}$) of nitrogen.
[y]L and Q indicate either a linear and/or quadratic response at $P = 0.05$ or a nonsignificant (NS) response.
[x]In Expt. 2, Nutricote 13–13–13 (13N–5.8P–10.8K) type 100 was incorporated into the growing substrate before transplanting at 3, 6, or 9 lb/yard^3 (1.8, 3.6, 4.5 $kg\cdot m^{-3}$).
[w]Suggested optimum range based on recommendations from Warncke and Krauskopf (1983).

same rate (Table 1). However, subirrigated petunia plants fertilized with 150 ppm of N had smaller shoot dry mass and less flowers than hand-watered plants fertilized at the same rate (Table 1). Substrate EC concentrations in pots subirrigated with 150 ppm of N were 1.1 times greater than the upper end of the suggested optimum and were 4.9 times greater than concentrations in hand-watered pots fertilized at the same rate (Table 3). The super optimum substrate EC concentrations may have contributed to the smaller shoot dry mass of subirrigated plants compared with plants hand-watered with 150 ppm of N. A disadvantage of using subirrigation systems is the potential fertilizer salts to accumulate in the growing substrate (Reed, 1996; Barrett, 1991). Salinity is less of a problem with hand-watered plants because leaching prevents salt buildup (Reed, 1996; Barrett, 1991).

In Expt. 2, subirrigated petunias plants fertilized with 6 and 9 lb/yard^3 were larger and had more flowers than hand-watered plants fertilized at the same rates (Table 2). Substrate EC concentrations also were greater in subirrigated pots than in hand-watered pots at all three fertilization rates (Table 3). Although all of the substrate EC concentrations in Expt. 2 were below the suggested optimum range of 2.0 to 3.5 $dS\cdot m^{-1}$, substrate EC concentrations in hand-watered pots were in the low range of 0 to 0.75 $dS\cdot m^{-1}$ (Warncke and Krauskopf, 1983).

There were no symptoms of nutrient deficiency or toxicity on any of the plants in either experiment. In both experiments, substrate pH was not different between the irrigation systems or fertilization rates (data not reported). All measured pH values were within the accepted range of 5.5 to 6.5 (Warncke and Krauskopf, 1983). All plants in both experiments also were considered to be of saleable quality with ratings greater than 3.5 (Tables 1 and 2).

Conclusions

There are numerous reported advantages to using a recirculating subirrigation system to grow bedding plants including zero fertilizer runoff, reduced water and fertilizer use, uniform watering, and less spread of disease (Newman, 1999; Reed, 1996; Barrett, 1991). If eliminating fertilizer runoff from the greenhouse is a priority, 'Ultra White' petunia plants can be successfully grown using subirrigation benches similar to those used in these experiments. However, the amount of fertilizer to apply will vary with the type of fertilizer used. Growers should be cautious of the potential for soluble salt accumulation to levels that may become detrimental to plant growth when using rates of Peter's 20–10–20 greater than 100 ppm of N. On the other hand, the use of Nutricote 13–13–13 type 100 incorporated at rates of 6 to 9 lb/yard^3 appeared to be an acceptable method for fertilizing subirrigated petunia plants.

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