MANAGING IRRIGATION BY ELECTRICAL CONDUCTIVITY

T.E. Bilderback, S.L. Warren and J.H. Daniels
Department of Horticultural Science
North Carolina State University
Raleigh, N.C.27695-7609
USA

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Abstract

In the nursery industry controlled release fertilizers (CRF) are a common method of supplying nutrients for container grown crops. However, nutrient solution concentrations in containers and product longevity are directly related to irrigation practices. Daily leaching of containers with high irrigation volume can shorten CRF longevity. When low conductivity readings from container leachates are compared to laboratory nutrient analyses, solution levels are also deficient. The hypothesis of this study was that adjusting weekly irrigation volume based on electrical conductivity could reduce excess and deficient nutrient levels in container solution and improve controlled release fertilizer longevity. The experiment was a randomized complete block design with 3 replications. A CRF (15-9-11 Osmocote Plus) was incorporated at five rates: (1) 5.0 g N; (2) 4.25 g N ;(3) 3.5 g N; (4) 2.75 g N; (5) 2.0 g N per container. Irrigation was two daily cyclic applications for a total of 800 ml per container. Irrigation volume was reduced after 10 DAI by 30% and was maintained 15 % to 30 % lower than the initial 800 ml irrigation volume throughout the study. Irrigation volume was not reduced below 400 ml since previous studies had indicated cotoneaster growth was limited below this volume. Precipitation events reduced the influence of manipulation of irrigation volume on container EC levels. Approximately 107 cm (30 in) of rainfall was received from May 30 through October 29 which was equivalent to 30 days of irrigation. Electrical conductivity was lower than target EC of 0.85 dS/m for all fertilizer application rates for the entire study. EC reading were generally similar for all fertilizer rates. The highest EC reading during the study was 0.6 dS/m. Shoot growth increased with increasing nitrogen rate at 89 DAI and 152 DAI and root dry weight increased with increasing nitrogen rate at 89 DAI. At 152 DAI all nutrient concentration decreased as fertilizer rate decreased. Foliar N levels for ≤ 3.5 g N per container dropped below suggested levels. Plant growth and foliar nutrient levels in this study under conditions of frequent and occasionally heavy rainfall show that the 4.25 or 5.0 g N/container applications were required to maximize growth but EC levels never reach expected concentrations.

1. Introduction

Controlled release fertilizers (CRF' s) are a common method of supplying nutrients for container grown crops at many commercial nurseries. However, nutrient solution concentrations, nutrient availability and product longevity are directly related to irrigation practices (Fare *et al.*, 1996; Tyler *et al.*, 1996 a & 1996b; Warren *et al.*, 1995; Shiflett *et al.*, 1994; Wright & Niemiera, 1987). Daily leaching of containers with high irrigation volumes can deplete CRF products within 100 days of application (Ruter, 1992; Yeager *et al.*, 1993; Yeager and Wright, 1982). Growers who experience poor color and growth in late summer are perplexed about how the CRF could be depleted. In addition, they are faced with how to provide fertility for the remainder of the growing season. Low electrical conductivity (EC) usually indicates solution levels are deficient (Ruter, 1992). When

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irrigation continues after water begins draining from pots, nutrients are leached from containers and the efficiency and economy of CRF's is lost (Fare *et al.* 1996; Tyler *et al.*, 1996a & 1996 b.). Several irrigation strategies for nursery container crops have been studied including management allowed deficit (MAD) (Welsh and Zajick, 1993), computer interfaced substrate moisture sensors, replacement of water based on class A evaporation pan loss, use of indicator moisture stressed plants or irrigating based upon leaching fractions (Niemiera and Leda, 1993; Shiflett, 1994, Tyler *et al.*, 1996b.).

We feel conductivity levels can be used to manage irrigation. This study monitored conductivity weekly and adjusted irrigation volume the following week based upon a target conductivity. Therefore, the objective of this study was to manage irrigation applied to a container nursery crop by monitoring EC thus achieving uniform growth of plants fertilized at increasing rates.

2. Materials and Methods

Cotoneaster dammeri Schneid. 'Skogholm' cotoneaster liners were potted into 3.8 liter containers and placed on a gravel nursery production area. The study was initiated May 30 and terminated on October 29, 1996: a duration of 152 days. Plants in containers were watered daily with 800 ml/day until irrigation treatments were begun 10 days after initiation (DAI). Cotoneaster was chosen for the study since previous studies indicated that growth is very dependent on water and nutrient resources in container substrates (Tyler, 1996a & 1996b).

2.1. Nutritional Amendments

A pine bark: washed builders sand (6:1 by volume) potting substrate was amended with 4.0 kg/m^3 of dolomitic limestone using a spiral agitator 0.8 m^3 mixer. Scotts Osmocote Plus 15.0 N - 4.0 P - 9.1 K (15-9-11) with minors was incorporated individually into each container at five rates: (1) 5.0 g N; (2) 4.25 g N; (3) 3.5 g N; (4) 2.75 g N; (5) 2.0 g N per container (1.3, 1.1, 0.9, 0.7; or 0.5 kg N/m^3) (2.2, 1.9, 1.5, 1.2 or 0.9 lb N / yd^3).

2.2. Irrigation Strategy

Irrigation was applied with two cyclic applications of approximately 400 ml (0.53 in) per container at 8 a.m. and 3 p.m. daily. Each container was irrigated by a mist spray nozzle equipped with non-drip device. This system allowed low velocity irrigation application at a precise and uniform volume. Electrical conductivity levels were measured weekly and irrigation volume was adjusted for the following week based upon leachate conductivity levels where if EC was $\leq$ 0.85 dS/m (mmhos) irrigation volume the following week was decreased by 15%; a high target EC of $\geq$ 1.75 dS/m which would have required increasing irrigation volume the following week by 15% was never reached.

2.3. Statistical Design

The experiment was a randomized complete block design. Five fertilizer rates were irrigated independently with 10 containers per fertilizer rate per irrigation line. Each irrigation line was replicated 3 times. A total of 150 containers were included in the study. All variables were subjected to analysis of variance and regression analysis.

2.4. Data Collected

Container Nutritional Levels: Container EC, pH and nutrient concentrations were evaluated using VTEM Leachate Extraction Procedure (Wright, 1986). Approximately 120 ml of water was applied to the substrate surface of 3 designated containers for each fertilizer rate 1 to 2 hours after irrigation. Leachates obtained were analyzed for electrical conductivity and pH weekly.

Plant Response: One half of the study was harvested 89 DAI, the remaining plants were harvested 152 DAI. Nitrogen, P, K. Ca, Mg and Fe leaf tissue concentrations were determined by inductively coupled plasma emission spectroscopy for plants harvested on each date.

3. Results and Discussion

3.1. *Electrical Conductivity:*

Electrical conductivity was lower than target EC of 0.85 dS/m for all fertilizer application rates throughout the entire study (Fig 1). Therefore, irrigation volume was reduced after 10 DAI by 30% and was maintained 15 % to 30 % lower than the initial 800 ml irrigation volume throughout the study. Irrigation volume was not reduced below 400 ml since previous studies had indicated cotoneaster growth was limited below this volume (Tyler *et al.* 1996a & 1996b). In Figure 1, EC is shown for the highest fertilizer application rate, 5.0 g N/container. However, EC readings were generally similar for all fertilizer rates. The highest individual container EC during the entire study was 0.8 dS/m while the highest mean EC occurred 53 DAI. Nutrient levels analyzed 89 DAI were similar for all treatments but higher fertilizer rates earlier in the study may have provided higher levels that influenced uptake and resulted in greater accumulation in plant tissue and greater growth.

Approximately 76 cm (30 in) of rainfall was received from May 30 through October 29 which was equivalent to 30 days of irrigation requirement (75 cm/3.78 l container). Heavy rainfall events were experienced in conjunction with three hurricanes that came inland in North Carolina during July, August and September. Although normal annual precipitation in Raleigh, N.C. is approximately 107 cm (42 in), rainfall averaged 2.5 cm (1.0 inch) weekly during the study. We conclude that rain events lowered EC, negating the influence of irrigation volume on container EC levels.

3.2. *Plant Growth responses:*

Shoot growth increased with increasing nitrogen rate at 89 DAI and 152 DAI, although shoot dry weight for 5.0 and 4.25 g N / pot had similar values on both dates (Table 1). Root dry weight increased with increasing nitrogen rate at 89 DAI. Percent growth increase between 89 and 152 DAI was calculated as it appeared that plants at some fertilizer rates had doubled in size between August 29 and October 29. This observation was true for 3.5, 2.75 and 2.0 g N/ container rates. Root growth was even more pronounced between the two dates with greatest percent increase occurring in the lower fertilizer application rates, which suggests that cotoneaster plants responded to low nutrient concentrations by developing greater root mass.

Foliar nutrient levels at 89 DAI were only significant for tissue N and Fe, however, both were within suggested limits (Jones *et al.*, 1991) (Table 2). At 152 DAI all nutrient concentrations decreased as fertilizer rate decreased. Foliar N levels for ≤ 3.5, 2.75 and 2.0 g N per container dropped below suggested levels. Apparently the controlled release fertilizer was depleted between 89 and 152 DAI. Ruter reported that CRF products in his study provided adequate concentrations of nutrients for a minimum of 90 days (Ruter, 1992).

In previous studies with *Cotoneaster dammeri* 'Skogholm' 3.5 g N/3.8 l container irrigated with 900 ml daily during a 100 day study produced acceptable growth of 79.0 g shoot and 18.9 g root growth. (Tyler *et al.* 1996a). At 1.75 g N/container growth was reduced to 56.3 and 14.0 g respectively. Compared to this study only 45.8 g shoot and 5.8 z root growth occurred 89 DAI in the 5.0 g N/container. It would seem that frequent rainfall combined with daily irrigation leached nutrients and EC concentrations from the containers and that on non rainy days, irrigation volume which was reduced to approximately 500 ml may have also limited growth. Ruter concluded that 5.6 g N/3.8 l pot was sufficient to provide adequate nutrients where EC concentrations were maintained between 0.5 and 1.0 dS/m for 'Burfordii' and 'Nellie R. Stevens" hollies for up to 90 DAI. Plant growth and foliar nutrient levels in our study under conditions of frequent and occasionally heavy rainfall show that the 4.25 or 5.0 g N/container applications were required to maximize growth but EC levels never reached expected concentrations above 0.85 dS/m and rarely were above 0.5 dS/m. This suggests that late in the growing season EC concentrations $\leq$ 0.5 dS/m are adequate to provide additional growth. Monitoring EC concentration in nursery containers fertilized with CRF's is a good management practice. However, weather events and precipitation affects all aspects of nursery production and therefore employing EC as the only management tool for irrigation application may not be feasible under the conditions experienced in this study. Future investigations for managing irrigation by conductivity using controlled release fertilizers would seem to require a rain event override sensor to skip irrigation on days with rainfall. Irrigation could then continue on subsequent days at volumes that did not limit growth but could provide leaching if required to reduce high EC levels.

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Table 1. Fertilizer rate effects on shoot and root dry weights of cotoneaster and the percent increase in growth between 89 and 152 days after initiation (DAI) .

Fertilizer	Shoot dry weight (g)			Root dry weight (g)		
Rate g N / pot	89 DAI	152 DAI	**%Inc**	89 DAI	152 DAI	**%Inc**
5.00	45.8	78.8	**73**	5.8	23.0	**295**
4.25	45.3	72.8	**60**	5.9	20.9	**252**
3.50	32.7	63.4	**94**	4.3	23.9	**462**
2.75	26.0	60.9	**133**	3.9	16.7	**330**
2.00	16.8	44.9	**169**	2.5	18.0	**616**
Significance						
Linear	**	**		**	NS	
Quadratic	NS	NS		NS	NS	

Table 2. Fertilizer rate effects foliar nutrient concentration of cotoneaster, 89 and 152 days after initiation (DAI) of the study.

Fertilizer Rate (g N / pot)	Foliar nutrient levels (% dry weight)						
	89 DAI		152 DAI				
	N%	Fe(mg/kg)	N%	P%	K%	Ca%	Mg%
5.00	2.9	99.3	2.3	0.19	1.2	1.9	0.34
4.25	2.8	103.7	2.3	0.18	1.2	1.8	0.37
3.50	2.7	89.7	1.9	0.15	1.1	1.9	0.36
2.75	2.6	87.7	1.7	0.14	1.0	1.8	0.39
2.00	2.5	79.0	1.6	0.13	1.0	1.8	0.39
Significance							
Linear	**	**	**	**	**	*	**
Quadratic	NS	NS	NS	NS	NS	NS	NS
Suggested Levels	2.0	50 ppm	2.0	0.2	1.0	1.0	0.3

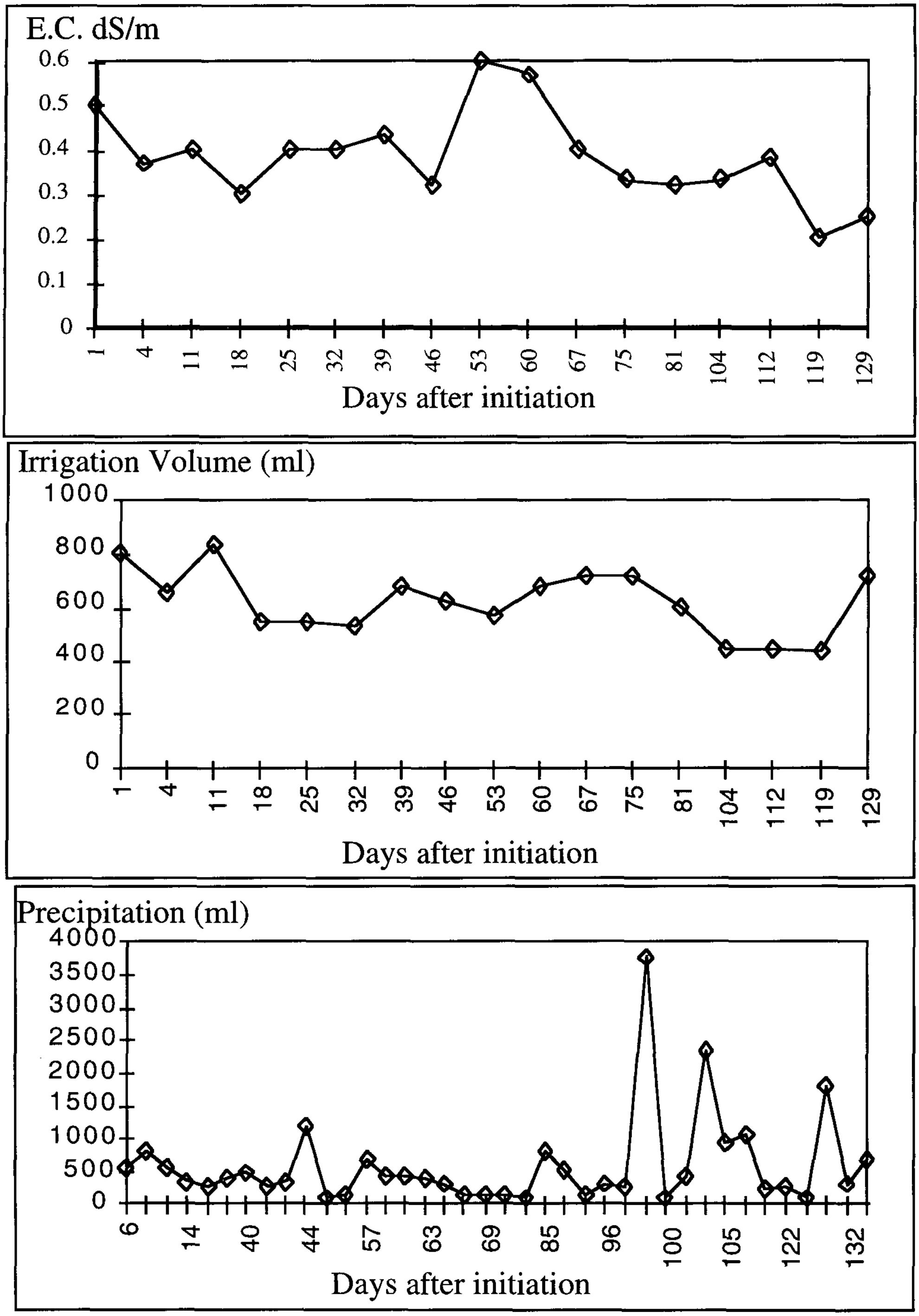

Figure 1. Electrical Conductivity of leachates, irrigation volume, and precipitation of container grown cotoneaster.