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Effect of Fertilizer and Irrigation on Leachate Levels of NH_4-N, NO_3-N, and P in Container Production of *Nephrolepis exaltata* 'Fluffy Ruffle'[1]

C.A. Conover and R.T. Poole[2]
University of Florida
Institute of Food and Agricultural Sciences
Central Florida Research and Education Center
2807 Binion Road
Apopka, FL 32703

Abstract

Nitrogen leaching into surficial aquifers continues to become more of a problem in several areas of the U.S., and thus potential for regulation of foliage plant producers is increasing. A factorial experiment evaluated liquid and controlled-release fertilizer sources at three irrigation levels [100, 200, or 300 ml (3.4, 6.8, or 10.2 oz) per 15 cm (6 in) pot twice weekly] for NH_4-N, NO_3-N, and P in leachate. Samples were collected weekly for 12 weeks beginning the last week of September. Plant grade and top fresh weights were similar for all treatments, but large variations occurred in NH_4-N, NO_3-N, and P levels in leachate due to irrigation level. Increasing irrigation level above 100 ml (3.4 oz) twice weekly resulted in increases of NO_3-N present in leachate, with levels as high as 126 mg/pot observed toward the end of November. NH_4-N levels were affected by irrigation during the first seven weeks of the experiment but, after week 2, were lower than one mg/pot. Phosphorus levels ranged from 0.9 to 5.7 mg/pot in leachate with responses to irrigation treatment throughout the experiment.

Index words: controlled-release fertilizer, foliage plant production, liquid fertilizer, nitrate nitrogen, surficial aquifer

Species used in this study: 'Fluffy Ruffle' fern (*Nephrolepis exaltata* (L.) Schott 'Fluffy Ruffle')

Significance to the Nursery Industry

Concern over nitrogen runoff into surface aquifers and leaching into ground water may lead to regulation of current production practices employed by plant producers. Limited information is available on best management practices (BMP's) for greenhouse production to ensure leaching of N into surficial aquifers does not exceed permitted standards. This experiment provides information regarding plant quality and leachate concentrations from foliage plant production using a liquid vs. a controlled-release fertilizer and three irrigation levels. These results can be used to help formulate BMP's for the foliage plant production industry.

Introduction

Both liquid and controlled-release fertilizers can be used effectively during foliage plant production (3, 4, 5, 8, 10, 14, 23) and the amount of irrigation necessary to produce quality plant material has been studied (3, 7, 17). Other research has evaluated the area of surficial aquifer (ground water) contamination caused by leachates from agricultural systems (1, 6, 9, 11, 12, 19, 20, 21, 22), including runoff water studies from container-grown crops (18). However, little research has been conducted regarding leachate quality from potted foliage plant production. This study was established to determine leachate levels of NH_4-N, NO_3-N, and P, and effects on plant quality when using a liquid vs. a controlled-release fertilizer and different irrigation levels during production of 'Fluffy Ruffle' fern.

[1]Received for publication June 23, 1992; in revised form September 14, 1992. Published as Florida Agricultural Experiment Station, Journal Series No. R-02474.

[2]Center Director and Professor, Environmental Horticulture and Professor, Plant Physiology, respectively.

Materials and Methods

Rooted liners of *Nephrolepis exaltata* 'Fluffy Ruffle' were planted into 15 cm (6 in) pots using Vergro Container Mix A without superphosphate (Verlite Company, Tampa, FL 33610) consisting of peat:vermiculite:perlite (2:1:1 by vol) with a water-holding capacity by volume of 72.8 percent and a pH range of 5.8 to 6.5. Plants were placed in a shaded glasshouse where they received 380 $\mu mol \cdot s^{-1} \cdot m^{-2}$ (2000 ft-c) maximum light intensity at plant level with temperatures varying between 20–35°C (68–95°F) depending upon ambient temperature. Based on previous research (16), irrigation was scheduled twice weekly for all plants at 100, 200, or 300 ml (3.4, 6.8, or 10.2 oz) of deionized water per 15 cm (6 in) pot at each irrigation. Fertilizer treatments were either 0.3 g 24N-3.5P-13.3K (0.01 oz 24-8-16) Peters Tropical Foliage Formulation (Grace/Sierra, Milpitas, CA 95035) given as 50 ml (1.7 oz) of fertilizer solution combined with the remainder of the irrigation amount one time per week or 5 g 19N-2.6P-10K (0.2 oz 19-6-12) controlled-release Osmocote (Grace/Sierra) per 15 cm (6 in) pot per 3 months. These rates were estimated to be equivalent based on 95% Osmocote release at the end of three months. Single pots were used as experimental units and there were five replications per treatment. Experiment initiation was September 26, 1988 and termination was December 19, 1988.

Before each irrigation, each pot was placed in a beaker just large enough to hold the pot by the rim so that leachate could be collected. All leachate collected from each pot was stored at 4°C (40°F), then combined with other leachate for the week from the same pot. Weekly, quantity of total leachate for each pot was measured and recorded, then pH and electrical conductivity (EC) analyses were run on site. Upon completion of these analyses, a 20-ml polyethylene scintillation vial was used to send a sample of the leachate from each pot to the Institute of Food and Agricultural Sciences' Analytical Research Lab at the University of Florida, Gainesville for analysis, using RFA methodology, for mg/L of NH_4-N, NO_3-N, and P. Vials containing samples were frozen immediately after on-site analyses if the analytical lab could not schedule the analyses until a later time and storage times varied for weekly samples. Plant grade (based on a scale of 1 = dead; 2 = poor quality, unsalable; 3 = fair, salable; 4 = good; and 5 = excellent quality) and top fresh weight were determined at experiment termination. Data were statistically analyzed with analysis of variance or general linear models procedures using Statistical Analysis System (SAS) software. Conversion of pH to hydrogen ion concentration was performed before statistical analysis was done, but results are reported as pH.

Results and Discussion

Plant grades and top fresh weight were not affected by fertilizer source or irrigation level and all plants were of satisfactory commercial quality, indicating that the irrigation regime and fertilizer levels utilized were adequate for production of marketable plants.

Interactions between fertilizer source and irrigation level were sporadic for 4 of the 5 leachate variables measured and occurred in only 12 instances of 60 possible incidents. There was no observed interaction between fertilizer source and irrigation level for NO_3-N. Because interactions were limited and variable, no explanation seemed plausible and data are not shown.

The treatment which had the most consistent effect on all leachate measurements was irrigation level. Although irrigation levels had no significant effect on pH for weeks 1, 2, 3 or 8, every other week showed linear and/or quadratic relationships. Since pH remained relatively stable throughout the duration of the experiment, data are not shown.

Irrigation level effect on electrical conductivity (EC) of the medium leachate (Table 1) was linear at the 0.1% level week 2 (when the range of EC averages for irrigation levels was lowest for the entire experiment) and week 3, and both linear and quadratic at the 0.1% level for weeks 4–12, indicating that medium moisture levels either had not stabilized or exchange sites were not saturated during the first three weeks. These results, combined with the total volume of leachate per pot (Table 1), show that excess water application will leach fertilizer ions, thus creating the potential for surficial aquifer contamination.

Leachate samples for weeks 4, 7, 8 and 10 showed no significant response of NO_3-N (mg/pot) to irrigation level (Table 2). Content of NO_3-N in the leachate showed a linear increase as irrigation was increased (weeks 1, 2, 8, 9, 10 and 11) while the other half of the time the response was quadratic and increased as irrigation was increased from 100 to 200 ml, but decreased as irrigation went from 200 ml to 300 ml (weeks 3, 4, 5, 6, 7 and 12). Data variability may indicate environmental effects due to variation in evapotranspiration as a result of cloudy versus sunny high temperature days and resulting high or low leachate levels. Fertilizer type effect on NO_3-N content of leachate was inconsistent. For weeks 4, 5 and 6 the NO_3-N was significantly higher from the controlled-release fertilizer, while in week 10 it was significantly higher from liquid fertilizer

Table 1. Weekly average electrical conductivities and total volumes of the leachate from medium containing *Nephrolepis exaltata* 'Fluffy Ruffle' over three months at three irrigation levels.

	Electrical Conductivity ($dS \cdot m^{-1}$)											
	Week											
Treatment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Irrigation Level												
[ml per 15 cm (6 in) pot per irrigation]												
100	2.02	1.41	4.82	5.27	6.16	8.85	9.60	6.72	5.44	4.27	4.50	4.14
200	1.73	1.28	3.20	2.65	2.70	3.30	3.36	1.66	1.56	1.43	1.42	1.16
300	1.85	1.12	1.96	1.68	1.45	1.88	2.10	1.02	1.05	0.93	0.86	0.66
Significance												
Linear	NS[z]	***	***	***	***	***	***	***	***	***	***	***
Quadratic	NS	NS	NS	***	***	***	***	***	***	***	***	***
	Total Leachate Volume (ml/pot)											
Irrigation Level												
[ml per 15 cm (6 in) pot per irrigation]												
100	8	118	132	138	128	152	81	90	123	106	60	51
200	126	408	409	418	398	413	250	327	270	322	293	300
300	294	645	709	671	677	656	422	572	448	584	547	521

[z]*** or NS = significant at the 0.1% level or not significant.

Table 2. Weekly average amounts over a 3-month period of NO_3-N (mg/pot) leached from medium containing *Nephrolepis exaltata* 'Fluffy Ruffle' irrigated at three different levels and supplied with either liquid or controlled-release fertilizer.

Treatment	NO_3-N (mg/pot) Week 1	2	3	4	5	6	7	8	9	10	11	12
Irrigation Level												
[ml per 15 cm (6 in) pot per irrigation]												
100	2	20	23	33	38	60	26	44	47	56	30	36
200	16	50	57	37	62	54	28	50	59	59	62	68
300	29	62	51	31	52	40	26	52	126	62	96	48
Fertilizer Type												
Liquid[z]	19	41	42	31	44	46	27	50	56	65	80	56
Controlled release[y]	20	47	45	37	57	56	27	47	99	53	46	46
Significance												
Irrigation Level												
Linear	***[x]	***	***	NS	**	***	NS	NS	*	NS	*	NS
Quadratic	NS	NS	**	NS	***	NS	NS	NS	NS	NS	NS	*
Fertilizer Type	NS	NS	NS	*	*	*	NS	NS	NS	*	NS	NS

[z]Peters Tropical Foliage Formulation at 0.3 g 24N-3.5P-13.3K (24-8-16 at 0.01 oz) per 15 cm (6 in) pot per week given as 50 ml (1.7 oz.) of the irrigation of each pot per week.

[y]Osmocote 19N-2.6P-10K at 5 g (19-6-12 at 0.2 oz.) per 15 cm (6 in) pot per 3 months.

[x]NS, *, **, or *** = not significant, or significant at the 5%, 1%, or 0.1% level, respectively.

(Table 2) (though there was wide variability in the treatment samples).

Increasing irrigation level increased NH_4-N (mg/pot) content of the leachate slightly (Table 3) mainly during weeks 1 and 2. Variability of leachate NH_4-N appears to indicate that the second irrigation level was adequate to leach NH_4-N, which may be bound to the medium at lower saturation levels. Fertilizer source effect on NH_4-N in the leachate occurred every other week beginning with week 4 and was consistently lower from the controlled-release fertilizer (Table 3). Once again, as was observed with leachate NO_3-N, a wide range occurred in treatment samples.

Phosphorus leaching (mg/pot) increased linearly with irrigation level for every week (Table 4), but irrigation level effects were also quadratic for weeks 4, 6, 7 and 8. These data plainly show the effect of phosphorus removal from media with excessive irrigation. The leachate concentration of P was well above the 0.1 mg/L level believed to be sufficient for eutrophic algae growth (21) and could affect surface waters if runoff occurred. Fertilizer type was significant for P leachate content only for weeks 8, 10 and 12, where P content was lower from the controlled-release fertilizer (data not shown).

Since both fertilizer rates tested were only slightly higher than the recommended fertilizer rate for *Nephrolepis* grown between 285 and 665 $\mu mol \cdot s^{-1} \cdot m^{-2}$ (1500 and 3500 ft-c) and minimum night and day temperatures of 18 and 24°C (65 and 75°F), respectively, (2) and plant grade and top fresh weight were not different nor leachate contents consistent, foliage plant producers who are applying the rec-

Table 3. Weekly average amounts over a 3-month period of NH_4-N (mg/pot) leached from medium containing *Nephrolepis exaltata* 'Fluffy Ruffle' irrigated at three different levels and supplied with either liquid or controlled-release fertilizer.

Treatment	NH_4-N (mg/pot) Week 1	2	3	4	5	6	7	8	9	10	11	12
Irrigation Level												
[ml per 15 cm (6 in) pot per irrigation]												
100	0.1	1.2	0.3	0.3	0.7	0.1	0.1	0.4	0.2	0.1	0.0	0.0
200	4.2	3.6	0.8	0.1	0.4	0.3	0.6	0.2	0.2	0.6	0.2	0.1
300	8.5	2.3	0.2	0.0	0.4	0.6	0.6	0.5	0.6	0.6	0.2	0.1
Fertilizer Type												
Liquid[z]	8.0	2.2	0.4	0.3	0.6	0.6	0.5	0.6	0.5	0.8	0.2	0.1
Controlled-release[y]	3.7	2.6	0.5	0.0	0.4	0.1	0.4	0.1	0.2	0.0	0.1	0.0
Significance												
Irrigation Level												
Linear	***[x]	NS	NS	*	NS	*	**	NS	NS	NS	*	NS
Quadratic	NS	*	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer Type	**	NS	NS	*	NS	**	NS	***	NS	*	NS	*

[z]Peters Tropical Foliage Formulation at 0.3 g 24N-3.5P-13.3K (24-8-16 at 0.01 oz) per 15 cm (6 in) pot per week given as 50 ml (1.7 oz) of the irrigation of each pot per week.

[y]Osmocote 19N-2.6P-10K at 5 g (19-6-12 at 0.2 oz) per 15 cm (6 in) pot per 3 months.

[x]NS, *, ** or *** = not significant, or significant at the 5%, 1% or .1% level, respectively.

Table 4. Weekly average amounts of phosphorus (mg/pot) leached from medium containing *Nephrolepis exaltata* 'Fluffy Ruffle' over three months at three irrigation levels.

Treatment	Phosphorus (mg/pot) Week 1	2	3	4	5	6	7	8	9	10	11	12
Irrigation Level												
[ml per 15 cm (6 in) pot per irrigation]												
100	0.0	0.9	0.9	1.5	1.5	2.0	0.9	1.6	1.8	2.1	1.4	1.4
200	0.9	2.8	3.4	3.8	3.8	4.8	2.7	3.6	3.2	4.1	3.5	3.8
300	2.3	4.0	4.0	4.2	4.7	4.6	2.5	4.1	4.9	4.9	5.7	4.0
Significance												
Linear	***[z]	***	***	***	***	***	***	***	**	***	**	**
Quadratic	NS	NS	NS	***	NS	***	***	*	NS	NS	NS	NS

[z]NS, *, **, or *** = not significant, or significant at the 5%, 1%, or 0.1% level, respectively.

ommended rates directly to the pot surface have no reason to switch from the present method of choice since no benefit will be achieved by going from liquid fertilizer to controlled-release fertilizer or vice-versa. However, findings from this preliminary experiment show that increasing the irrigation level above 100 ml (3.4 oz) per 15 cm (6 in) pot twice weekly does increase the NO_3-N and P present in the leachate, even though there is no difference in plant quality or top fresh weight with the added irrigation. Therefore, this information on increased leachate concentrations of NO_3-N and P with higher irrigation rates should alert growers that the common practice of watering plants until leaching occurs must be modified, especially since earlier research has shown that it is unnecessary to leach short-term foliage crops (15) and, in fact, overwatering has been shown to have detrimental effects in some foliage crops (13).

In summary, based on the levels of P, NH_4-N, and NO_3-N in the leachate from the medium containing *Nephrolepis exaltata* 'Fluffy Ruffle' and plant grade and top fresh weight of those plants, growers should employ irrigation practices that will reduce the amount of leachate from the pots while still providing sufficient water to the plants. By reducing or eliminating leaching from the pots, growers can utilize liquid or controlled-release fertilizers at recommended or, preferably, lower rates since fewer nutrients will be lost through leaching. These practices would allow savings on fertilizer costs while reducing risk of contaminating surficial aquifers.

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