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Leachate Nutrient Content and Growth of Two Hollies As Influenced by Controlled Release Fertilizers[1]

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Abstract

An experiment was conducted to evaluate the effects of fertilizer source, rate of application, and method of application on the release of nutrients over time using the pour-through method and to determine the growth response of *Ilex cornuta* Lindl. & Paxt. 'Burfordii' and *Ilex* × 'Nellie R. Stevens' holly to different multicoated controlled release fertilizers (CRF). Depending on the rate of application used, the three CRFs used in this study [Osmocote 17N-3P-9.9K (17-7-12), Sierrablen 17N-3P-8.3K (17-7-10), and High-N 24N-1.7P-5.8K (24-4-7)] provided adequate concentrations of nutrients for a minimum of 90 days after treatment. Fertilizer source had no effect on the growth of either holly used in this study. Good growth of 'Burfordii' and 'Nellie R. Stevens' holly was obtained at the rate of 1.5 kg N/m^3 (2.5 lb N/yd^3). Linear relationships between NO_3-N and electrical conductivity using the pour-through method were established for 'Burfordii' ((NO_3-N = 414 (electrical conductivity)) and 'Nellie R. Stevens' ((NO_3-N = −11.4 + 425 (electrical conductivity)). Results of this study indicate that the nutrient sufficiency values for liquid fertilization programs with the pour-through method need to be adjusted for use with multicoated CRFs.

Index words: *Ilex cornuta* Lindl. & Paxt. 'Burfordii', *Ilex* × 'Nellie R. Stevens', container culture, electrical conductivity, nitrate nitrogen

Significance to the Nursery Industry

Compared to liquid fertilization or the frequent application of soluble fertilizers, CRFs offer an alternative production input which is considered environmentally sound. Under nursery production conditions similar to those in south Georgia, the formulations of Osmocote, Sierrablen and High-N used in this study can be expected to provide adequate concentrations of nutrients for a minimum of 90 days after treatment (DAT) depending on rate of application. A rate of 1.5 kg N/m^3 (2.5 lb N/yd^3) was determined to be sufficient for good growth of 'Burfordii' and 'Nellie R. Stevens' holly. Results of this study showed a strong linear relationship between NO_3-N and electrical conductivity when the pour-through method was used with multicoated CRFs. Such relationships are useful for nurserymen who wish to estimate NO_3-N concentrations from EC readings when using the pour-through method.

Introduction

With current concerns regarding nutrient concentrations in runoff water from container nurseries, CRFs are an alternative to liquid fertilization programs. CRFs reduce fertilizer waste and application frequency when compared to other fertilizer systems (3, 4). Compared to alternative systems of reducing fertilizer waste, CRFs provide an option for fertility management which has been successfully used for a variety of container-grown crops (1, 7).

Multicoated CRFs[3] have gained popularity in the past decade and are recommended for the production of floricultural, foliage and woody nursery crops. Three formulations of multicoated CRFs currently on the market are Osmocote, Sierrablen and High-N. Osmocote is a homogeneous fertilizer which contains resin coated N-P-K in each prill (William Foster, private communication). Sierrablen is similar to Osmocote except that 20% of the fertilizer is uncoated. The uncoated N in Sierrablen is water soluble and is therefore immediately available for plant uptake. About 50% of the N in High-N is controlled release urea. High-N is a heterogeneous blend of several fertilizer materials.

'Burfordii' and 'Nellie R. Stevens' are fast growing and are considered two of the best landscape hollies for the southeastern United States (2). Research showed that the nutrient release rate of different multicoated CRFs was influenced by fertilizer formulation, rate and method of application over time when the pour-through method of nutrient extraction was used (6). Nutritional guidelines for use of the pour-through method with different CRFs need to be developed. This study was conducted to 1) determine the effects of fertilizer source, rate of application, and method of application on release of nutrients over time using the pour-through method, and 2) to determine the growth response of 'Burfordii' and 'Nellie R. Stevens' holly to different multicoated CRFs.

Materials and Methods

Experiments were conducted outdoors under full sun at the University of Georgia Coastal Plain Experiment Station in Tifton, Georgia. Uniform rooted liners of 'Burfordii' and 'Nellie R. Stevens' holly were potted in 2.8 l (#1) containers and treatments were applied on June 7 and 8, 1990. Potting medium consisted of milled pine bark and sand (4:1 by vol) amended with micronutrients (Micromax-Grace-Sierra Horticultural Products Co.) at 0.9 kg/m^3 (1.5 lb/yd^3) and

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dolomitic limestone at 3.6 kg/m^3 (6.0 lb/yd^3). Plants were grown in factorial combinations (eight replications) of three fertilizers [Osmocote 17N-3P-9.9K (17-7-12), Sierrablen 17N-3P-8.3K (17-7-10), and High-N 24N-1.7P-5.8K (24-4-7)], three fertilizer rates (0.9, 1.5 and 2.1 kg N/m^3) (1.5, 2.5, and 3.5 lb N/cu yd) of potting medium and two methods of fertilizer application, incorporation into the potting medium and topdressing of individual containers.

Plants were irrigated twice daily at the rate of 0.7 cm (0.25 in) water per irrigation using overhead irrigation which resulted in a leaching fraction of approximately 0.3. At 7, 30, 60, 90, and 120 days after treatment (DAT), the pour-through method (8) was used to collect container leachate from four replications in the experiment. NO_3-N concentrations were determined with an ion specific electrode. Electrical conductivity and pH of leachate samples were determined using a conductivity and pH meter, respectively. When the experiment was terminated on 5 and 6 November, 1990, measurements were taken for shoot dry weight; growth index ((Height × Width 1 × Width 2)/300); and a root rating (1 = 0–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, and 5 = 81–100% of the rootball covered with white roots).

Data for leachate analysis and growth parameters were evaluated by analysis of variance using SAS (SAS Institute, Cary, North Carolina). Linear and quadratic effects were tested for significance where appropriate.

Results and Discussion

'Burfordii' Holly. There was an interaction between fertilizer source, rate and method of application, and DAT for NO_3-N (Fig. 1 and 2) and electrical conductivity (Fig. 3 and 4). Osmocote and Sierrablen had lower NO_3-N concentrations at 30 DAT compared to 7 DAT for all rates and both methods of application (Fig. 1 and 2). High-N NO_3-N concentrations were generally not as responsive during the initial 30 day treatment period. Incorporated Sierrablen and High-N at 1.5 and 2.1 kg N/m^3 (2.5 and 3.5 lb N/yd^3) had greater NO_3-N concentrations at 60 DAT compared to the topdressed treatments. Differences in NO_3-N concentrations between 30 and 60 DAT may have been influenced by environmental conditions. The daily maximum air temperature was 2.0°C (35.3°C or 95.6°F) warmer during 31 to 60 DAT compared to 0 to 30 DAT (33.3°C or 92.0°F). Other research attributed decreased NO_3-N concentrations at 150 DAT to temperatures in container media which averaged 30.0°C (86.0°F) during the experimental period (10). Controlled release fertilizers do not maintain uniform nutrient release rates throughout the season and some are affected more by temperature than others (5). In this experiment, differences in daily maximum air temperatures may have modified the temperature of the container medium thus influencing the release of nutrients from the various fertilizers.

Electrical conductivity of the leachate (Fig. 3 and 4) over time was correlated with NO_3-N concentrations (r = 0.91) for 'Burfordii' holly. Electrical conductivity measurements have been suggested as a means of determining the need for reapplication of controlled release fertilizers (9). An electrical conductivity measurement of approximately 0.20 dS/m during the months of June and July was determined to be the critical value for determining the reapplication of Osmocote 18N-2.6P-7.6K (18-6-12) to optimize the growth of *Ilex crenata* Thunb. 'Helleri.' Using 0.20 dS/m as a base

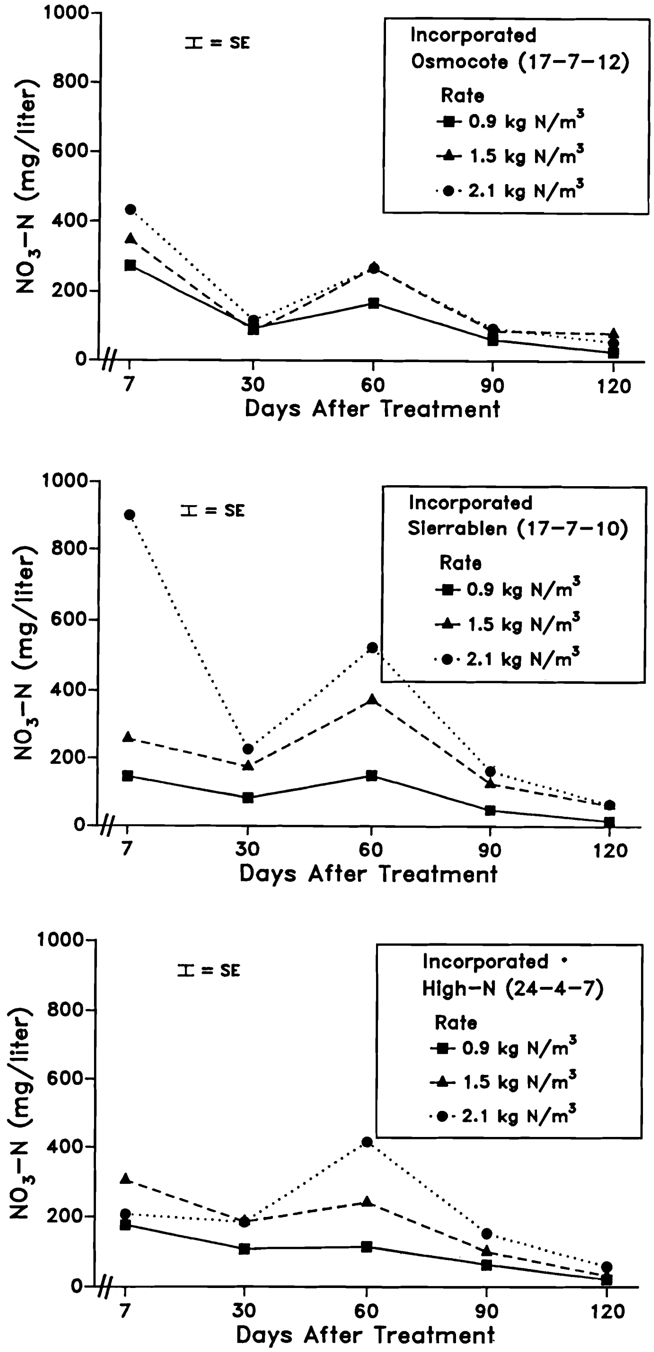

Fig. 1. Influence of incorporated fertilizer application on leachate NO_3-N concentrations as influenced by fertilizer source and rate of application at 7, 30, 60, 90, and 120 days after treatment for 'Burfordii' holly. Error bar is SE (n = 4).

value, the results of this study would indicate the possible need for reapplication of all three fertilizers at the lowest rate of application (0.9 kg N/m^3 or 1.5 lb N/yd^3) by 90 DAT (Fig. 3 and 4). All three fertilizers at the 2.1 kg N/m^3 rate (3.5 lb N/yd^3), independent of method of application, had electrical conductivity values greater than or equal to 0.20 dS/m at 120 DAT. It cannot be determined from this study whether reapplication of a CRF at 90 DAT (early September) would be beneficial to plant growth.

A significant linear relationship between NO_3-N and electrical conductivity (R^2 = 0.96, NO_3-N = 414 (electrical

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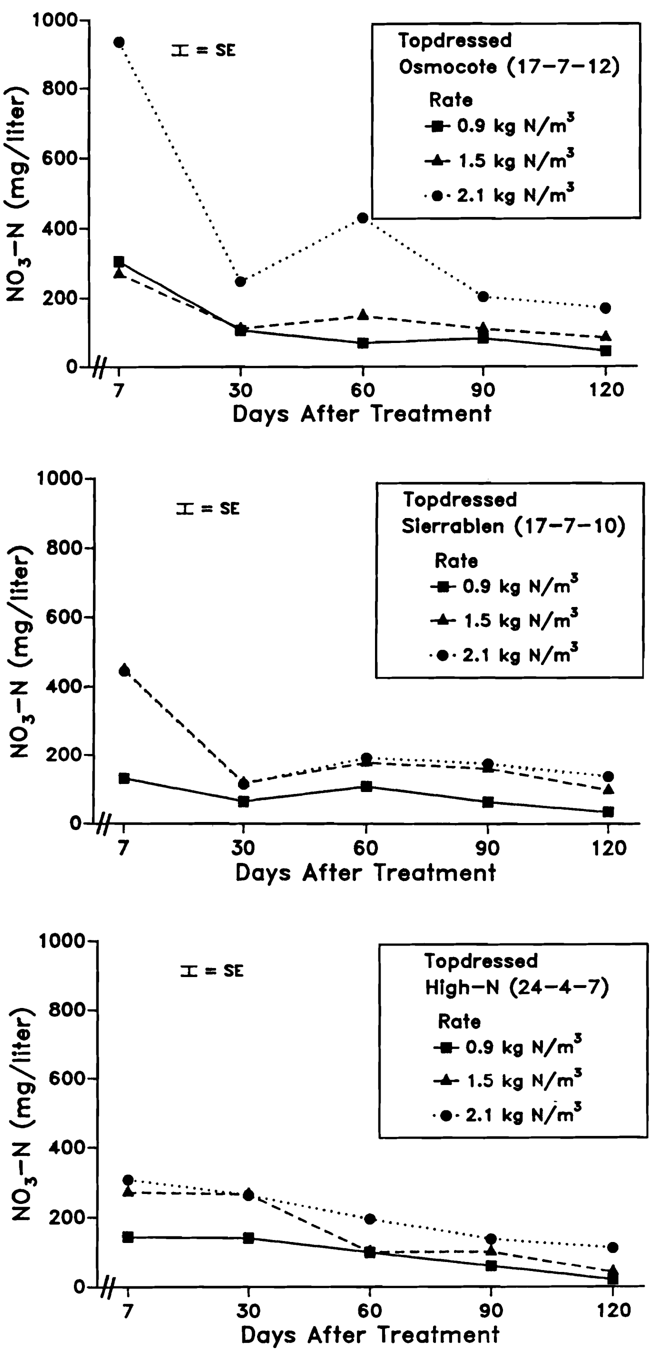

Fig. 2. Influence of topdressed fertilizer application on leachate NO_3-N concentrations as influenced by fertilizer source and rate of application at 7, 30, 60, 90, and 120 days after treatment for 'Burfordii' holly. Error bar is SE (n = 4).

conductivity)) was found for the three different multicoated CRFs used in this study (Fig. 5). Measurement of NO_3-N concentrations from container leachate with an ion specific electrode is currently beyond the testing capability of many growers. Since electrical conductivity can easily be measured with a portable conductivity meter (8), NO_3-N concentrations from container leachate can be estimated from measurements of electrical conductivity. The relationship between NO_3-N and electrical conductivity provides information which can be used by growers and researchers for the development of nutritional guidelines when CRFs are used with the pour-through method.

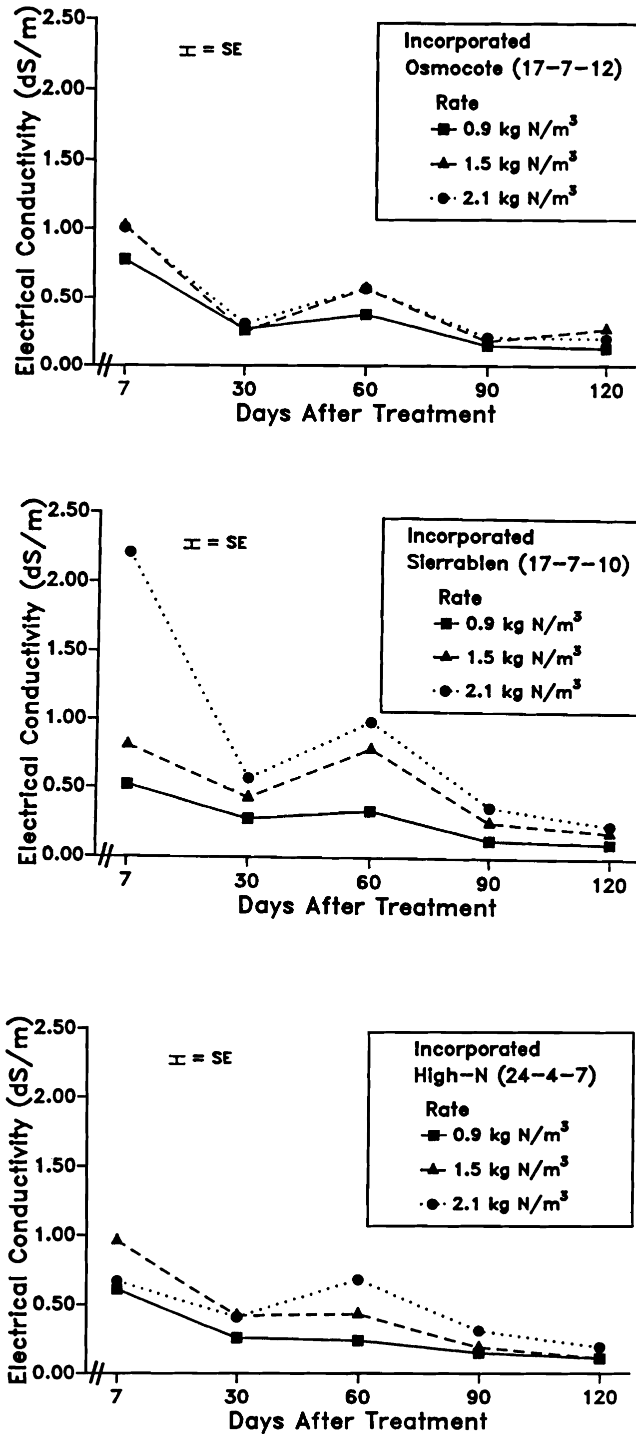

Fig. 3. Influence of incorporated fertilizer application on leachate electrical conductivity values as influenced by fertilizer source and rate of application at 7, 30, 60, 90, and 120 days after treatment for 'Burfordii' holly. Error bar is SE (n = 4).

An interaction between rate, method of application and DAT was found for medium pH (data not shown). The pH of the irrigation water during the course of this study ranged from 6.8 to 7.8. Medium pH averaged across treatments increased from 6.0 at 7 DAT to 6.5 at 120 DAT.

Growth index and shoot dry weight of 'Burfordii' holly were affected by rate of fertilizer application (Table 1). Growth index increased linearly as rate of application increased. Plants grown at 1.5 and 2.1 kg N/m^3 (2.5 and 3.5

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lb N/yd³) were 27% and 37% larger, respectively, compared to the low rate (0.9 kg N/m³ or 1.5 lb N/yd³). Shoot dry weight responded quadratically to rate. The correlation between growth index and shoot dry weight was r = 0.57. Method of application influenced shoot dry weight. Topdressed plants had 10% more shoot dry weight (30.6 ± 1.0 g) compared to plants which had fertilizer incorporated into

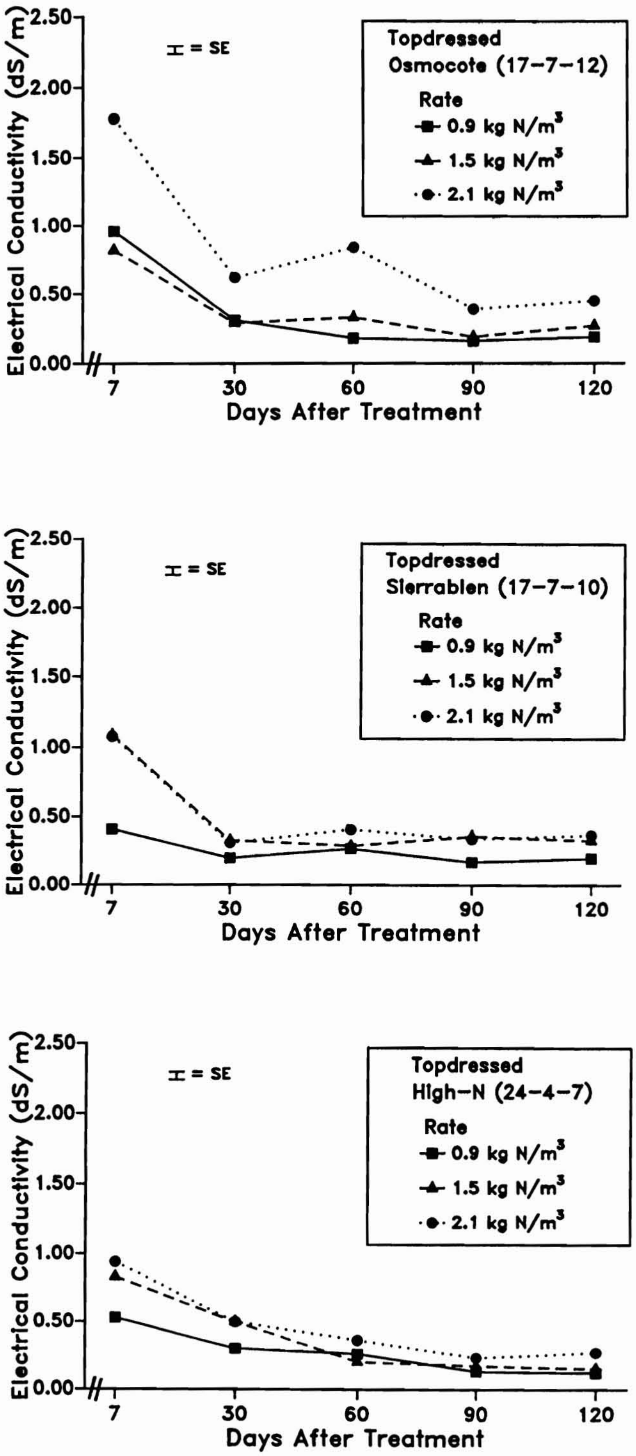

Fig. 4. Influence of topdressed fertilizer application on leachate electrical conductivity values as influenced by fertilizer source and rate of application at 7, 30, 60, 90, and 120 days after treatment for 'Burfordii' holly. Error bar is SE (n = 4).

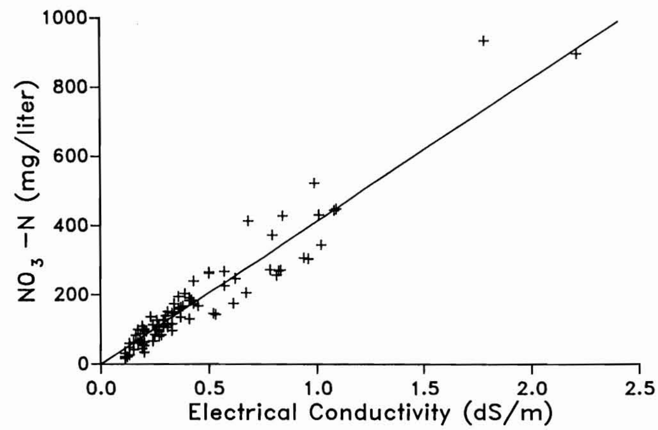

Fig. 5. Relationship between leachate NO_3-N concentration and electrical conductivity ((R^2 = 0.96, NO_3-N = 414 (electrical conductivity)) for 'Burfordii' holly. Mean values for fertilizer source, rate, method of application and day are shown.

the medium (27.8 ± 1.0 g). Root rating was not affected by any treatment.

'Nellie R. Stevens' Holly. In contrast to the four-way interaction between treatment variables for 'Burfordii' holly, there was only a rate of application by DAT interaction for NO_3-N and electrical conductivity with 'Nellie R. Stevens' (Table 2). NO_3-N concentrations and electrical conductivity in the leachate had similar trends of nutrient release to those for 'Burfordii' holly. A linear relationship between NO_3-N and electrical conductivity (R^2 = 0.96, NO_3-N = −11.4 + 425 (electrical conductivity)) was found for the interaction of rate and DAT. An interaction between rate, method of application and DAT occurred for pH (data not shown). In general, pH decreased as rate of application increased. Averaged across treatments, pH values over time were similar to those found for 'Burfordii' holly.

For 'Nellie R. Stevens' holly, growth index and shoot dry weight responded linearly to increasing rates of N application (Table 3). The growth indexes for plants grown at 1.5 and 2.1 kg N/m³ (2.5 and 3.5 lb N/yd³) were 37% and 64% larger, respectively, compared to the low rate (0.9 kg N/m³ or 1.5 lb N/yd³). While plants grown at the 1.5 and 2.1 kg N/m³ (2.5 and 3.5 lb N/yd³) rate had 20% more shoot dry weight than the 0.9 kg N/m³ (1.5 lb N/yd³), increasing the rate of N above 1.5 kg N/m³ (2.5 lb N/yd³)

Table 1. Influence of rate of fertilizer application on the growth index, shoot dry weight and root rating of 'Burfordii' holly.

Rate (kg N/m³)	Growth index[y]	Shoot dry weight (g)	Root rating[x]
0.9	705	29.0	3.6
1.5	893	27.9	3.5
2.1	966	30.6	3.9
Significance[z]			
Linear	*	ns	ns
Quadratic	ns	**	ns

[z]Significance tests: ** ≤0.01, * ≤0.05, ns >0.05.
[y]Growth index = (Height × Width 1 × Width 2)/300.
[x]Root rating (1 = 0–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, and 5 = 81–100% of the rootball covered with white roots).

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Table 2. **Influence of rate of fertilizer application over time on NO_3-N (mg/l) and electrical conductivity concentrations (dS/m) in leachate from 'Nellie R. Stevens' holly.**

Rate (kg N/m^3)	Days after treatment	NO_3-N	Electrical conductivity
0.9	7	277	0.82
	30	117	0.30
	60	134	0.32
	90	60	0.16
	120	38	0.17
1.5	7	363	0.99
	30	137	0.34
	60	210	0.44
	90	83	0.20
	120	64	0.23
2.1	7	551	1.23
	30	195	0.47
	60	335	0.73
	90	157	0.34
	120	67	0.23
Significance^z			
Rate		**	**
Day		**	**
Rate*Day		**	*

^{z}Significance tests: ** ≤0.01, * ≤0.05.

did not result in additional shoot dry weight. The correlation between growth index and shoot dry weight was r = 0.72. Root rating was not affected by rate of application (Table 2), however, incorporation of the fertilizer into the medium before potting resulted in a higher root rating (4.44 ± 0.09) compared to topdressing (4.06 ± 0.09).

Fertilizer source had no effect on the shoot growth of 'Burfordii' or 'Nellie R. Stevens' holly. Similar results were found with *Ilex* × *attenuata* Ashe 'Savannah' (6). Growth of the two hollies used in this study were influenced primarily by rate of N application. Minimum fertilizer sufficiency values of 50 mg N/liter and 0.5 dS/m have been established for liquid fertilization programs (8) and may not be directly applicable to CRFs. Since there was no difference in shoot growth due to fertilizer source, a sufficiency level can be estimated from the response of shoot growth to fertilizer rate. Using the electrical conductivity data from Fig. 3 and 4, a decrease in electrical conductivity below a base value of 0.20 dS/m at 90 DAT for the low rate of 0.9 kg N/m^3 (1.5 lb N/yd^3) resulted in a decreased growth index (Table 1) for 'Burfordii' holly compared to the 1.5 and 2.1 kg N/m^3 (2.5 and 3.5 lb N/yd^3) rates of application. A similar trend was found for 'Nellie R. Stevens' (Tables 2 and 3). This study indicates that if electrical conductivity readings drop below 0.20 dS/m by 90 DAT, a decrease in the growth of 'Burfordii' and 'Nellie R. Stevens' holly may occur. Under the experimental conditions of this study, 1.5 kg N/m^3 (2.5 lb N/yd^3) was determined to be the minimum rate of application which provided good growth of both hollies at 120 DAT. Increasing the rate of application to 2.1 kg N/m^3 (3.5 lb N/yd^3) resulted in an increased growth index of both hollies. While rate of application did not effect the growth index:shoot dry weight ratio (data not shown) of 'Burfordii' holly, an increased growth index:shoot dry weight ratio was found at the high rate of application for 'Nellie R. Stevens.' This indicates that larger plants of 'Nellie R. Stevens' holly with proportionately less dry matter were produced at the highest rate of application.

The CRFs used in this study were 12 to 14 month release formulations at 21°C (70°F). Under similar production conditions, the fertilizer formulations used in this study should provide adequate concentrations of nutrients for a minimum of 90 DAT depending upon rate of application. The relationships between NO_3-N and electrical conductivity established in this study should be useful to researchers and growers who wish to predict NO_3-N concentrations from electrical conductivity readings when using multicoated CRFs.

Table 3. **Influence of rate of fertilizer application on the growth index, shoot dry weight and root rating of 'Nellie R. Stevens' holly.**

Rate (kg N/m^3)	Growth index^y	Shoot dry weight (g)	Root rating^x
0.9	1009	33.6	4.0
1.5	1386	40.3	4.4
2.1	1653	40.3	4.3
Significance^z			
Linear	**	**	ns
Quadratic	ns	ns	ns

^{z}Significance tests: ** ≤0.01, * ≤0.05, ns >0.05.

^{y}Growth index = (Height × Width 1 × Width 2)/300.

^{x}Root rating (1 = 0–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, and 5 = 81–100% of the rootball covered with white roots).

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