Research Updates

Controlled-release Fertilizers Affect Nitrate Nitrogen Runoff from Container Plants

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Summary. Container plant runoff $\text{NO}_3\text{-N}$ levels varied with sampling time and were periodically higher than the 10-ppm federal drinking water standard during 4.5 months following fertilizer application, even though controlled-release fertilizers Nutricote 18N-2.6P-6.6K Osmocote 18N-2.6P-10K, Prokote 20N-1.3P-8.3K, and Woodace 19N-2.6P-10K were used. Leachate collected from containers had a higher $\text{NO}_3\text{-N}$ level than runoff regardless of sampling time. Leachate $\text{NO}_3\text{-N}$ ranged from 278 ppm for Nutricote 3.5 months after application to 6 ppm for Prokote 1 week after application.

Controlled-release fertilizers are used commonly in container plant production because of their long-term nutrient release and thus infrequent applications. A recent survey of container nurseries in six states revealed that $\text{NO}_3\text{-N}$ in runoff from production beds averaged 8 ppm for nurseries using only controlled-release fertilizers and 20 ppm for nurseries using controlled-release fertilizers supplemented with solution fertilizers (Yeager et al., 1992). Runoff $\text{NO}_3\text{-N}$ from beds of nurseries using only controlled-release fertilizers periodically exceeded the 10-ppm federal drinking water standard (U.S. Environmental Protection Agency, 1982) if sample collection followed fertilizer application by a couple of weeks. Rathier and Frink (1989) noted that controlled-release fertilizer applications should be staggered to minimize $\text{NO}_3\text{-N}$ runoff; however, runoff $\text{NO}_3\text{-N}$ levels have not been documented for most controlled-release fertilizers. The purpose of this study was to determine $\text{NO}_3\text{-N}$ levels and duration in runoff from container plants fertilized with controlled-release fertilizers and grown under common nursery conditions.

Materials and methods

Three liners of *Viburnum odoratissimum* with shoots averaging 26 cm were potted 21 June 1990 with a 2 pine bark : 1 Canadian peat : 1 builders' sand (by volume) medium in each 18-liter container. The potting medium was amended with dolomitic limestone at $4.2 \text{ kg}\cdot\text{m}^{-3}$ and micronutrients were incorporated separately for each fertilizer treatment. Plants received two applications, each 2 weeks apart, of a 200-ppm N solution made from a 20N-8.7P-16.7K water-soluble fertilizer (Grace-Sierra, Fogelsville, Pa.)

beginning 1 month prior to controlled-release fertilizer applications. On 30 Aug. 1990, the following complete fertilizers were surface-applied to each container: 1) Nutricote Total 18N-2.6P-6.6K (Plantco, Ontario, Canada); 2) Osmocote 18N-2.6P-10K (Grace-Sierra, Milpitas, Calif.); 3) Prokote 20N-1.3P-8.3K (O.M. Scott and Sons, Marysville, Ohio); or 4) Woodace 19N-2.6P-10K (Vigoro Industries, Fairview Heights, Ill.). Nutricote granules were pushed just below the media surface; control containers received no fertilizer. Controlled-release fertilizers and micronutrient amendment rates per manufacturers' recommendations are given in Table 1.

Seven replicate containers for each fertilizer treatment were spaced equally on each of five platforms (one platform per fertilizer treatment) at Amerson Nurseries, Inc., Terra Ceia, Fla. Platforms constructed of $1.2 \times 2.4\text{-m}$ sheets of exterior plywood were lined with double sheets of black polyethylene and set on concrete blocks (Fig. 1). Platforms were slanted toward one corner so runoff could be collected in a $12.5 \times 12.5 \times 60\text{-cm}$ plastic trough via an opening 2.5 cm high $\times$ 5 cm wide in the platform rim. Plants were watered as needed with Nelson Whizhead (L.R. Nelson Corp., Peoria, Ill.) overhead sprinklers (0.8 cm per application). Irrigation water contained 0.2 ppm $\text{NO}_3\text{-N}$ and $\text{NH}_4\text{-N}$. Every other week for the first 4.5 months after fertilizer application and monthly thereafter until 13 Mar. 1991, runoff from each platform was collected following irrigation and cessation of drainage. Runoff volume was measured and an aliquot-filtered and rushed to the Extension Soil Testing Laboratory (ESTL), Gainesville, Fla., for $\text{NO}_3\text{-N}$ and $\text{NH}_4\text{-N}$ determinations. Nitrate N ($\text{NO}_3\text{-N}$) was determined by cadmium reduction and ammoniacal nitrogen ($\text{NH}_4\text{-N}$) by NH_3 reaction with alkaline phenol and hypochlorite (U.S. Environmental Protection Agency, 1983). Fertilizers were reapplied 26 Mar., as described previously, with one exception; the Nutricote distributor requested that 21.5 g of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ be surface-applied to each container fertilized again with Nutricote. Runoff was collected as described previously, except samples were taken weekly for the first 3 weeks after reapplication, then every other week until

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Table 1. *Treatments applied to Viburnum odoratissimum and growth indices for plants grown in 2 pine bark : 1 Canadian peat : 1 builders' sand (by volume) medium in 18-liter containers. Fertilizers were applied initially on 30 Aug. 1990 and reapplied 26 Mar. 1991.*

Complete fertilizer ^a	Fertilizer (g/container)	N (g/container)	Micronutrient amendment	Micronutrients (g/container)	Growth indices ^b (months after initial fertilization)	
					6.5	13
Nutricote Total 18N-2.6P-6.6K	82.5	14.9	Nutritrace	50.4	50 ± 3.2	75 ± 4.1
Osmocote 18N-2.6P-10K	110	19.8	Micromax	25.2	55 ± 5.8	79 ± 6.5
Prokote Plus 20N-1.3P-8.3K	106	21.2	Step	33.6	54 ± 7.6	85 ± 5.1
Woodace 19N-2.6P-10K	150	28.5	Perk	33.6	52 ± 5.5	87 ± 5.6
Control	---	---	---	---	32 ± 6.6	31 ± 5.5

^aComplete fertilizers were surface-applied and growth medium was amended with the respective micronutrient product.

^bAverage growth index [(height + avg. width)/2] ± SE of the mean for seven container plants.

Fig. 1. *Diagram of platforms used for runoff collection. Platforms constructed of 1.2 × 2.4-m sheets of exterior plywood, lined with double sheets of black polyethylene, and set on concrete blocks.*

6 Aug., when samples were taken monthly until experiment termination on 5 Nov. 1991. One hour after irrigation, leachates from three containers for each fertilizer treatment were collected by elevating the containers above a collection vessel and pouring 500 ml of distilled water over the medium surface for each container and allowing leachate to drain completely (Yeager et al., 1983). The leachate collection procedure was repeated every other week during April, once in May, and monthly during July through October. An aliquot of runoff from each platform and leachate from each of three containers per platform was rushed to ESTL for NO₃-N and NH₄-N analyses. Container leachate pH was determined for samples of 2 Apr. through 1 Oct. Height and two widths perpendicular to each other were determined 13 Mar. and 1 Oct. 1991 (13 months after initial fertilization) for the seven plants per fertilizer treatment. A growth index was calculated by adding the height and average width and dividing by two. At experiment termination (5 Nov. 1991), a sample of fertilizer granules was removed from each of three containers for each fertil-

izer and percent N remaining in granules was determined (AOAC, 1990). Average monthly minimum and maxi-

mum temperatures (Stanley, 1991, 1992) were 18 and 30°C, respectively, and average monthly rainfall (Stanley, 1991, 1992) was 12 cm during Sept. 1990-Oct. 1991 for Bradenton, Fla. (lat. 27°30'N, long. 82°29'W (C.D. Stanley, personal communication) located 13 km southeast of the experimental site.

Results and discussion

Growth indices were similar 6.5 months after the initial fertilizer application (Table 1). After 13 months, growth indices for the fertilizers were positively correlated ($r = 0.91$) with grams of N applied per container and were indicative of the fact that 8.8%, 9.6%, 10.7%, and 17.4% of N from Nutricote, Osmocote, Prokote, and Woodace remained in the granules.

Fig. 2. *Runoff NO₃-N levels for Nutricote 18N-2.6P-6.6K (large open square), Osmocote 18N-2.6P-10K (+), Prokote 20N-1.3P-8.3K (small open square), and Woodace 19N-2.6P-10K (*), surface-applied to V. odoratissimum grown in a 2 pine bark : 1 Canadian peat : 1 builders' sand medium in 18-liter containers supported on a platform 1.2 × 2.4 m and receiving 0.8 cm of overhead irrigation each application. Controlled-release fertilizers were applied 30 Aug. 1990 and the control (x) was not fertilized.*

Nitrate N level in runoff 3 weeks (18 Sept.) after initial application was highest for Prokote (33 ppm), followed by Woodace (24 ppm), Osmocote (11 ppm), and Nutricote (3 ppm) (Fig. 2). A second surge of $\text{NO}_3\text{-N}$ release for Woodace occurred 2 months after application (30 Oct.), with 33 ppm $\text{NO}_3\text{-N}$ in runoff. Nitrate N runoff levels for Nutricote remained below 5 ppm following the initial fertilizer application, except for the 16 Jan. 1991 sample, where all treatments exhibited an unexplainable increase in $\text{NO}_3\text{-N}$ levels in runoff. Nitrate N levels on 16 Jan. were 8 ppm for Osmocote, 13 ppm for Prokote, 19 ppm for Nutricote, and 39 ppm for Woodace. Nitrate N levels in runoff were <1 ppm for all fertilizer treatments on 12 Feb. 1991, 5.5 months after the first fertilizer application. Runoff $\text{NO}_3\text{-N}$ concentrations continued to fluctuate after the second fertilizer application (26 Mar. 1991), with levels >10 ppm recorded for Prokote and Woodace on 30 Apr. (1.2 months after fertilizer application); Osmocote, Prokote, and Nutricote on 25 June (3 months after fertilizer application); Osmocote on 23 July (4 months after fertilizer application); and Nutricote on 6 Aug. (4.5 months after fertilizer application) (Fig. 3). Runoff $\text{NH}_4\text{-N}$ levels were 15 ppm or less during the experiment (data not

Fig. 3. Runoff $\text{NO}_3\text{-N}$ levels for Nutricote 18N-2.6P-6.6K (large open square), Osmocote 18N-2.6P-10K (+), Prokote 20N-1.3P-8.3K (small open square), and Woodace 19N-2.6P-10K (*), surface-applied to *V. odoratissimum* grown in a 2 pine bark : 1 Canadian peat : 1 builders' sand medium in 18-liter containers supported on a platform 1.2 × 2.4 m and receiving 0.8 cm of overhead irrigation each application. Controlled-release fertilizers were applied 26 Mar. 1991 and the control (x) was not fertilized. Data for 9 Apr. was similar to 2 Apr. and is not shown.

Fig. 4. Leachate $\text{NO}_3\text{-N}$ levels for Nutricote 18N-2.6P-6.6K (large open square), Osmocote 18N-2.6P-10K (+), Prokote 20N-1.3P-8.3K (small open square), and Woodace 19N-2.6P-10K (*), surface-applied to *V. odoratissimum* grown in a 2 pine bark : 1 Canadian peat : 1 builders' sand medium in 18-liter containers. Controlled-release fertilizers were applied on 26 Mar. 1991 and the control (x) was not fertilized.

shown), and were less than or equal to runoff $\text{NO}_3\text{-N}$ levels for 38 of 44 samples collected after 16 Apr. 1991. Lower $\text{NH}_4\text{-N}$ than $\text{NO}_3\text{-N}$ levels in runoff could have been due, in part, to nitrification (Niemiera and Wright, 1987).

Leachate $\text{NO}_3\text{-N}$ levels were

higher than runoff $\text{NO}_3\text{-N}$ levels at each sampling (Fig. 4). This was probably due to dilution of runoff, because an average of 7000 ml of runoff were collected from each platform after irrigation; whereas only 500 ml of water were applied to each container for leachate collection. Leachate $\text{NH}_4\text{-N}$ (Fig. 5) exhibited a pattern similar to that of $\text{NO}_3\text{-N}$ (Fig. 4), and total N ($\text{NO}_3\text{-N} + \text{NH}_4\text{-N}$) was >75 ppm, an adequate level (Wright and Niemiera, 1985), for all leachate collections except 2 Apr., 14 May, 3 Sept., and 1 Oct. for Prokote and Woodace; 9 July for Woodace; and 2 Apr. for Nutricote. Container leachate total N levels for Osmocote were not below 75 ppm during the experiment, and $\text{NO}_3\text{-N}$ levels remained above 63 ppm 6.2 months after application. However, in a previous experiment, Yeager et al. (1989) found that, 1.7 months after Osmocote 18N-2.6P-10K was surface-applied, leachate $\text{NO}_3\text{-N}$ levels were below 15 ppm when azalea plants were grown in 3-liter containers with a medium of the same components and ratios as used in our experiment, but irrigated as needed with 2.5 cm of water. Leachate pH in our study averaged 6.6, 6.4, 6.5, and 6.4 for Nutricote, Osmocote, Prokote, and Woodace, respectively.

Our data indicate that run off $\text{NO}_3\text{-N}$

Fig. 5. Leachate $\text{NH}_4\text{-N}$ levels for Nutricote 18N-2.6P-6.6K (large open square), Osmocote 18N-2.6P-10K (+), Prokote 20N-1.3P-8.3K (small open square), and Woodace 19N-2.6P-10K (*) surface-applied to *V. odoratissimum* grown in a 2 pine bark : 1 Canadian peat : 1 builders' sand medium in 18-liter containers. Controlled-release fertilizers were applied 26 Mar. 1991 and the control (x) was not fertilized.

N levels for Nutricote 18N-2.6P-6.6K, Osmocote 18N-2.6P-10K, Prokote 20N-1.3P-8.3K, and Woodace 19N-2.6P-10K were >10 ppm at some time during 4.5 months following fertilization. However, when using these data to make management decisions, it is important that $\text{NO}_3\text{-N}$ levels were usually <10 ppm $\text{NO}_3\text{-N}$ for most of the sampling times. We suggest that nursery operators should sample runoff every other week when these fertilizers are used to obtain a realistic representation of $\text{NO}_3\text{-N}$ in runoff. For example, sampling runoff once or twice during the summer could reveal high $\text{NO}_3\text{-N}$ levels when, in fact, levels were low for the majority of time. Runoff $\text{NO}_3\text{-N}$ levels were consistently less than container leachate $\text{NO}_3\text{-N}$ levels, and there was no apparent relationship between runoff and leachate $\text{NO}_3\text{-N}$. Therefore, nursery operators should

monitor container media leachate to ensure nutrient levels are adequate for growth in addition to monitoring runoff.

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