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Nitrate, Phosphate, and Potasium Leaching from Two Species of Container-grown Foliage Plants Fertilized by Different Methods

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Environmental contamination from nitrate and phosphate has become an important concern in many areas of the United States. Nitrate levels greater than 10 ppm in drinking water are considered unsafe for humans (U.S. Environmental Protection Agency, 1982) and phosphate is often associated with algal blooms and eutrophication of lakes and ponds (Wetzel, 1975). Although phosphate is considered to be rather immobile within many soils, it is much more readily leached from container media composed of pine bark, spaghnum peat, vermiculite, or sand (Yeager and Barrett, 1984; Marconi and Nelson, 1984). Nitrate is readily leached from container media (Handreck and Black, 1984). Although K is not usually considered an environmental pollutant, leaching losses of K from the soil may affect plant growth and quality.

Fertilizers are often applied at high rates to tropical foliage plants, yet little is known about the leaching of nutrients from the containers into the environment. Controlled release fertilizers have been used to reduce nutrient loss from leaching. Although many studies (see Maynard and Lorenz, 1979) have compared growth and quality of ornamental plants fertilized with controlled release, liquid, or soluble granular fertilizers, no studies to date have used the same nutrient sources and ratios in their fertilizer treatments. Such comparisons are less valid due to N, P, and K source differences, as well as slightly different elemental ratios among the various fertilizer treatments. The purpose of this study was to determine the total amounts of nitrate, phosphate, and K leached from container-grown tropical foliage plants during a 6 month production period and to determine if fertilization method affects the amounts of these nutrients leached during that time.

Materials and Methods

Liners of areca palm (*Chrysalidocarpus lutescens* H. Wendl.) from seed and *Spathiphyllum* Schott. 'Mauna Loa Supreme' from tissue culture were planted into 3.5-liter polypropylene containers using a 5 pine bark: 4 sedge peat: 1 sand medium (by volume) amended with 880 g Micromax, a complete micronutrient blend (Grace-Sierra Hort. Prod., Milpitas, CA) and 4.9 kg of dolomite/ m3, hereafter referred to as the "container medium'. Pots containing one plant each were fertilized with a total of 7.65 g N, 1.37 g P, and 4.5 g K/container/6 months, or no fertilizer (control). Four fertilizer treatments utilizing the same raw material (uncoated 21N-3P-12K prills derived from ammonium nitrate, ammonium phosphates, calcium phosphates, and potassium sulfate, Grace-Sierra Hort. Prod.) were applied in the following manner: 1) liquid form (LF) --1.4 g of prills dissolved in 50 ml of water and applied weekly to the medium surface of each container, 2) soluble granular fertilizer (SGF)-- 6.1 g of prills applied monthly to the medium surface of each pot, 3) lightly-coated controlled release fertilizer (LCCRF)--13.4 g of Osmocote 19N-3P-10K (3-4 month release at 20C) applied every two months to the surface of the medium, and 4) heavily-coated controlled release fertilizer (HCCRF)-- 45.0 g of Osmocote 17N-3P-10K (12-14 month release at 20C) applied once to the surface of the medium. Each treatment was replicated ten times.

This experiment was performed under typical subtropical production nursery conditions. The palms were grown in a shadehouse having a maximum PPFD of 840 uE.m-2.sec-1 and spathiphyllum under 225 uE.m-2.sec-1. All plants received about 2 cm of water from overhead irrigation daily. The water used for irrigation contained .54 ppm nitrate, <.5ppm phosphate, .83 ppm potassium, and 41.5 ppm calcium. All leachates were collected from each container by setting the growing container on a 15 cm azalea pot inverted within a 4-liter polyethylene bucket. This system excluded virtually all non-pot irrigation and rain water from the leachate collection container. The accumulated leachates from each container were measured for volume weekly and a sample analyzed for nitrate using a nitrate electrode, phosphate using the ascorbic acid method, and K using atomic absorption spectrophotometry. Total mg of each nutrient ion leached per week was calculated from the total volume and sample ion concentrations. At the end of the 6 month production cycle shoot dry weight was determined for each plant. Data were analyzed using analysis of variance with mean separation by the Waller-Duncan k-ratio method.

Results and Discussion

Nitrate leached per week from the container medium fertilized with SGF decreased rapidly from nearly 350 mg for week 1 to about 10 mg for week 5. Reapplication during week 5 (Fig. 1) resulted in a rapid increase followed by another decline 4 weeks later. Subsequent oscillations were considerably reduced in amplitude. Container media fertilized with LF weekly showed generally increasing nitrate leaching up through week 6, followed by smaller peaks approximately every 2-4 weeks. Container media fertilized with LCCRF leached from 50-100 mg nitrate /week except during weeks 6, 13, 17, and 22, when somewhat more nitrate was leached, presumably in response ot higher rainfall during those weeks (Fig. 1). HCCRF-fertilized container media also showed considerable weekly variation in nitrate leached, although nitrate leaching generally decreased over time. This trend toward reduced leaching over time for these controlled release fertilizers may be due to increased plant uptake by the larger plants, coupled with a reduced release rate from these fertlizers. Hershey and Paul (1982) described a similar trend in pot chrysanthemums. These data suggest that reducing concentrations of soluble fertilizers during the first part of the growing cycle could significantly reduce nitrate leaching losses without reducing plant growth.

Leached phosphate from the container medium generally increased over time for all fertilizer treatments, although leachate phosphate from LCCRF and HCCRF declined after week 22 (Fig. 1). Leachate phosphate was almost always higher for LF and SGF than for the two controlled release formulations.

K leached per container fertilized with LF gradually increased to a maximum of about 190 mg K at week 6, but from weeks 8-22 remained relatively constant at about 40-80 mg/week (Fig. 1). After week 22, K leached from all fertilizer treatments decreased to less than 25 mg K/week, presumably in response to increased plant uptake at that time. As with nitrate and phosphate, K leached from SGF-fertilized container media peaked every 4 weeks as it was reapplied. The height of these peaks decreased somewhat over time as plant size and uptake increased. The LCCRF-fertilized containers showed rather low (<50 mg K/wk), but constant K leaching except for a higher peak at weeks 6 and 7. Potassium leached from the HCCRF-fertilized containers at higher rates than LCCRF for the first 16 weeks, but at lower rates thereafter. Similar responses were reported by Rathier and Frink (1989) and Cox (1993) for nitrate leaching from a single application versus multiple applications of controlled release fertilizers.

Leaching data from this experiment generally indicated variable rates of nitrate, phosphate, and K leaching over time for most of the fertilization methods. Unusually high rainfall starting on week 6 resulted in much larger amounts of all three ions being leached from these containers, but other factors also may have contributed to the week to week variation. Based on these data, it appears that leachate sampling at any one time may not be a good predictor of total nutrient leached during the production cycle.

After six months, dry weights of spathiphyllum grown in the container medium and fertilized by the four methods were equivalent, and all fertilizer treatments produced much larger plants than the unfertilized controls (Table 1). For areca palms, however, plants fertilized with LF were larger than those fertilized with SGF. The controlled release fertilizers produced palms equal in size to those grown with LF, but no better than those receiving SGF. Thus, in terms of plant growth response, there was relatively little difference among fertilization methods in the container medium.

The total amount of nitrate leached from the container medium was significantly greater for both spathiphyllum (Table 1) and areca palms (data not shown) fertilized with SGF. LF produced the second most nitrate in the leachate for both species and the controlled release fertilizers the least. The percentage of N lost to leaching in the container medium ranged from 28% for LCCRF to 52% for SGF.

Relatively little phosphate leached from any fertilizer treatment. Since phosphate should not be retained, plant utilization or precipitation must be responsible for the majority of phosphate losses. From 11 to 28% of the applied phosphate was lost due to leaching from the containers. Leachate phosphate amounts did differ among the fertilizer treatments, however. Among fertilizer treatments, LCCRF resulted in the least phosphate leaching for both species.

For both species, the highest amounts of K leached from containers fertilized with SGF (Table 1). Liquid fertilization resulted in significantly less K leaching than SGF, and LCCRF resulted in the least.

This study showed that nitrate, phosphate, and potassium leaching losses from a typical foliage plant nursery are substantial. Assuming a density of 80,000 pots/ha, use of SGF in the container medium would result in annual losses of 666 kg of nitrate, 49.4 kg of phosphate, and 337 kg of potassium/ha. Use of controlled release fertilizers can significantly reduce these leaching losses, however. These data support the findings of Yeager and Cashion (1993) that leachate nitrate concentrations vary considerably during the production period and sampling at any given time will probably yield misleading results in terms of overall nitrate or phosphate input into the environment. Furthermore, leachate volume must also be considered in order to determine the total amount of nitrate or other ion input into the environment.

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Table 1. Spathiphyllum and areca palm dry weights and total nitrate, phosphate, and potassium leached per spathiphyllum container over six months when grown in a pine bark, sedge peat and sand medium and fertilized by four different methods.

	Spathiphyllum	Areca palm			
Method	dry wt	dry wt	Nitrate	Phosphate	Potassium
	(g)	(g)	(mg)	(mg)	(mg)
Control	0.8[bz]	28.5[a]	13[e]	3[e]	75[e]
LCCRFY	31.3[a]	77.0[ab]	2226[d]	156[d]	847[d]
SGF	27.5[a]	73.9[b]	4160[a]	309[b]	2106[a]
LF	29.7[a]	92.9[a]	3710[b]	382[a]	1747[b]
HCCRF	32.6[a]	75.0[ab]	2655[c]	237[c]	1256[c]

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[z]Mean separation within columns by Waller-Duncan k-ratio method, k=100.

[y]LCCRF=Lightly-coated Controlled Relesae Fertilizer, SGF=Soluble Granular Fertilizer, LF=Liquid Fertilizer, and HCCRF=Heavily-coated Controlled Release Fertilizer.

[Figure]