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Evaluation of Zeolite-based Soilless Root Media for Potted Chrysanthemum Production

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SUMMARY. Chrysanthemum [*Dendranthema × grandiflorum* (Ramat.) Kitamura] growth and nutrient leaching of three clinoptilolite-based root media—NZ, EZ1, and EZ2—were compared to the performance of control plants grown in Sunshine Mix #2 [3 peat : 1 perlite (v/v)]. The control received 210 mg·L⁻¹ N from an 18N-4P-15K soluble fertilizer at each irrigation. NZ contained untreated zeolite and received the same soluble fertilizer as the control but leached lower concentrations of NH₄-N, K, and PO₄-P during most of the production cycle compared to the control. EZ1 was formulated to provide N, P, and K as fertilizer nutrients and produced plants similar to the control based on ratings, height, width, and dry mass, but not fresh mass, at harvest

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when the fertilizer rate was half of that applied to the control—105 mg·L⁻¹ N. EZ2 did not receive P or K from soluble fertilizer and produced plants similar to the control based on rating, height, and dry mass, but not width or fresh mass, with soluble fertilizer input reduced to N alone. Tissue N, P, and K concentrations of plants grown in EZ1 and EZ2 were lower than those of control plants. With further refinements, these zeolite-based products show promise for decreasing nutrient leaching during crop production and allowing for application of lower rates of soluble fertilizers.

Zeolites are a class of naturally occurring crystalline minerals that have high buffering and cation-exchange capacities (CEC). Zeolites retain cations in their crystalline lattice tetrahedral framework, which has fixed negative charge arising from isomorphous substitution during mineral formation (Ming and Mumpton, 1989). The naturally occurring cations on a zeolite can be removed or exchanged by contacting the zeolite with a concentrated cation solution. These newly exchanged nutrient cations may then be slowly released by ion exchange reactions during greenhouse crop production.

Zeolite properties have been exploited to grow agronomic and horticultural crops. The zeolite clinoptilolite (Cp) was found to improve sand-based golf greens by sorbing applied NH₄ and slowing its nitrification, thus decreasing NO₃ leaching through sand (Ferguson et al., 1986). Zeolites have been studied as a growth medium component for use in food production on a lunar base (Ming, 1989). Cp was shown to increase the availability of PO₄ from rock phosphate for wheat by serving as a sink

for Ca, thereby speeding PO₄ release (Allen et al., 1995). Hershey et al. (1980) demonstrated that a Cp source containing predominantly exchangeable K was able to supply the required K for producing a 3-month chrysanthemum crop. Cp dominated by other exchangeable cations (e.g., Na, Ca) can also be enriched with K before incorporation into the root medium and provide adequate release of this nutrient during chrysanthemum production (Williams and Nelson, 1997). Proper processing of raw zeolites and blending with other select minerals enhances their value and may result in a soilless root medium that allows growers to produce high-quality plants with less soluble fertilizer application and less nutrient losses in greenhouse effluent.

The objectives of this study included 1) assessing potted chrysanthemum growth in nutrient-enriched zeolite amended media compared to a conventional soilless medium; 2) assessing the nutrient-supplying capacity of nutrient-enriched zeolite amended media for a chrysanthemum crop; and 3) measuring nutrient loss in leachate from nutrient-enriched zeolite amended media compared to a conventional peat-based medium.

Materials and methods

TREATMENT MEDIA. Six treatments, each consisting of a different root medium (NZ, EZ1, EZ2, or control) and irrigation solution (distilled water, N, or N-P-K) combinations are defined in Table 1. Boulder Innovative Technologies, Inc. (Louisville, Colo.), prepared the Cp-based medium components and technical cooperator, ZeoponiX, Inc. (Mason City, Ill.), formulated and provided the test mixes (NZ, EZ1, and EZ2) for five of the treatments. Each of the zeolite-based media consisted of 56

sphagnum peat : 19 perlite : 25 Ca- and K-predominant Cp mined by St. Cloud Mining Co. (14 × 40 mesh; Truth or Consequences, N.M.) (v/v). Medium NZ contained raw natural zeolite; medium EZ1 contained enriched zeolite formulated to provide N, P, and K; and medium EZ2 contained enriched zeolite formulated to provide P and K. These were compared to a control treatment (Table 1) grown in Sunshine Mix #2 [Fisons Horticulture Inc., Vancouver, B.C.; 75 peat : 25 perlite (v/v)] and fertigated with an N-P-K fertilizer solution. All fertilizer solutions were made with distilled water, and the pH was adjusted by adding 0.5 N H₂SO₄ or NaOH until the endpoint of 6.5 was reached. All N-containing fertilizers had a 2 NH₄ : 3 NO₃ ratio.

CULTURAL PRACTICES. The experimental design was a randomized complete block with six treatments, three blocks (replications), and two pots per experimental unit, totaling 36 pots. Rooted cuttings of potted 'Sunny Mandalay' chrysanthemum (Yoder Brothers, Inc., Barberton, Ohio) were planted on 12 Sept. 1996 in Urbana, Ill., with one cutting per 10-cm standard round, green, plastic pot. One of the six treatments, EZ1/0F, was a fallow pot and so cuttings were not planted for this treatment (Table 1). The medium volume was 500 cm³ and the depth was 10 cm. All treatment root media were amended with 0.9 g·L⁻¹ of Micromax micronutrients (Scotts Co., Marysville, Ohio). Pots were spaced on 30-cm centers. Greenhouse night and day temperatures were set at 17 and 25 °C, respectively. Plants received 2 weeks of long days (incandescent lighting from 2200 to 0200 HR) followed by 8 weeks of natural short days. Plants were pinched 2 weeks after planting to leave seven nodes, and lateral flower buds were

Table 1. Root medium and fertilizer constituents of each treatment. The contents of zeolite-based root media remained proprietary information. The control (C) medium was a commercially available sphagnum peat : 1 perlite (v/v) potting medium amended with micronutrients.

Treatment	Medium	Water-soluble fertilizer	Fertilizer sources
NZ/N-P-K	NZ	210 mg·L ⁻¹ N from 18N-4P-15K	4.5 mM KNO ₃ , 1.5 mM NH ₄ H ₂ PO ₄ , 4.5 mM NH ₄ NO ₃ , 1.5 mM MgSO ₄
EZ1/0 N-P-K	EZ1	Distilled water	None
EZ1/0.5 N-P-K	EZ1	105 mg·L ⁻¹ N from 18N-4P-15K	2.25 mM KNO ₃ , 0.75 mM NH ₄ H ₂ PO ₄ , 2.25 mM NH ₄ NO ₃ , 1.5 mM MgSO ₄
EZ1/0F	EZ1	Distilled water	Fallow pots (no plants); watered same schedule as EZ1/0 N-P-K
EZ2/N	EZ2	210 mg·L ⁻¹ N from 18N-0P-0K	6.0 mM NH ₄ NO ₃ , 1.5 mM Ca(NO ₃) ₂ , 1.5 mM MgSO ₄
C/N-P-K	C	210 mg·L ⁻¹ N from 18N-4P-15K	4.5 mM KNO ₃ , 1.5 mM NH ₄ H ₂ PO ₄ , 4.5 mM NH ₄ NO ₃ , 1.5 mM MgSO ₄

removed 4 weeks after pinching to allow one inflorescence per axillary branch to develop. Plants of one block were weighed daily throughout the experiment, and when the mass of pots declined by 25% to 35% of container capacity due to water loss, all plants in that treatment were fertigated. Fertigation was done so that the leaching fraction was consistently maintained between 30% to 40%. Leachate was collected on days 0 (planting date), 5, 9, 14, 21, 35, 49, 63, and 70 by setting pots over 600-mL glass beakers, fertigating, combining solutions from both pots in an experimental unit, and transferring to 25-mL vials. Phenylmercuricacetate was added to each sample to prevent microbial growth, and samples were stored at 5 °C.

LEACHATE ANALYSES. Phosphate P, $\text{NO}_3\text{-N}$, and $\text{NH}_4\text{-N}$ analyses were performed on the leachate solutions using a UV-VIS spectrophotometer (Shimadzu UV-1601, Columbia, Md.). The analysis for $\text{PO}_4\text{-P}$ was performed following the procedures of Chapman and Pratt (1961) for concentrations $>10 \text{ mg}\cdot\text{L}^{-1}$ or Murphy and Riley (1962) for concentrations $<10 \text{ mg}\cdot\text{L}^{-1}$. Nitrate N analyses were performed following the procedures of Cataldo et al. (1975) and $\text{NH}_4\text{-N}$ analyses were performed using procedures of Chaney and Marbach (1962). Potassium, Ca, Mg, Na, and S analyses were conducted by A & L Great Lakes Laboratories (Fort Wayne, Ind.) using inductively coupled plasma (Fisons 3560, Dearborn, Mich.). Electrical conductivity (EC) and pH were measured using a pH/EC meter (model 695, EXTECH Instruments, Waltham, Mass.).

GROWTH MEASUREMENTS. Height and width measurements were taken weekly starting 1 week after pinch. Height was measured from the rim of the pot to the top of the foliage canopy. Width was the average of two measurements taken at right angles to each other with the foliage spread perpendicular to the stem. At harvest, one rating per two plants in an experimental unit was subjectively assigned by the researchers after consideration of overall appearance, foliage color, number and size of flowers, uniformity, and shape using a scale of 1 to 10 (10 = the best plants). Fresh mass and dry mass (dried for a minimum of 48 h at 70 °C) of the total above-ground plant shoots were also measured at harvest. Harvest was determined as the time when the crop had all flowers open.

TISSUE ANALYSES. Tissue samples

consisted of the youngest, fully expanded leaves at midcrop, or halfway through the production cycle (day 42), and the entire above-ground shoot at harvest (day 84). Plant tissue was washed for 30 s in 0.2 N HCl and rinsed for 60 s in distilled water. Tissue was dried at 70 °C and then ground in a stainless-steel Wiley mill to a particle size $<1 \text{ mm}$ (20-mesh screen). Tissue analyses of N, P, K, Ca, Mg, Na, S, Fe, Mn, B, Cu, Zn, and Al were conducted by A & L Great Lakes Laboratories.

STATISTICAL ANALYSES. Statistical analyses were performed on the data using analysis of variance, and means were separated using least significant differences (PROC ANOVA and PROC GLM, SAS Inst., Cary, N.C.). A single standard error was calculated for each graph of leachate solution results.

Results and discussion

NZ ROOT MEDIUM. Plants grown with treatment NZ/N-P-K were not different from the control plants (C/N-P-K) in rating, height, and dry mass. Width and fresh mass of plants grown with NZ/N-P-K were less than those of control plants (Table 2). Tissue data indicated that results from NZ/N-P-K did not differ from C/N-P-K in N, P, and K tissue levels at midcrop or harvest with the exception of tissue K level at the end of the crop (Table 3). The concentration of total N leached from NZ/N-P-K was slightly less than the concentration leached by C/N-P-K, but N-leachate over time was similar in the two treatments (Fig. 1A). Treatment NZ/N-P-K leached significantly less NH_4 than C/N-P-K during most of the production cycle (Fig. 1B). The concentration of NO_3 in the leachate for NZ/N-P-K was similar to that for C/N-P-K (Fig. 1C). Leachate $\text{PO}_4\text{-P}$ from NZ/N-P-K fluctuated similarly to that from C/N-P-K, although the concen-

tration was significantly less from NZ/N-P-K for about half the production time (Fig. 1D). The largest difference in the leachate data between NZ/N-P-K compared to C/N-P-K is that substantially less K was leached by systems with NZ (Fig. 1E).

Tissue Na levels were significantly higher in NZ/N-P-K plants compared to C/N-P-K plants at midcrop, but not at harvest (Table 3). The NZ/N-P-K treatment resulted in the highest Na levels in the leachate of all six treatments (Fig. 1F). Because natural zeolite contains Na as a balancing cation, adding cations in fertilizer solution may displace Na on the exchange sites and increase the concentration leached. High levels of Na may reduce plant growth by damaging roots through increased soluble salts in the root medium solution or by antagonizing uptake of nutrient cations. In this study, growth with NZ/N-P-K was only marginally reduced (width and fresh mass) (Table 2). It does not seem likely that Na had an adverse effect because the tissue Na levels are low and K, Ca, and Mg tissue concentrations were similar to or greater than those from C/N-P-K (Table 3). In addition, EC values were lower from NZ/N-P-K from 9 through 49 d compared to C/N-P-K (Fig. 1G). Thus, these data suggest that any Na released from the NZ medium did not inhibit growth.

Because NZ/N-P-K and C/N-P-K received the same soluble fertilizer, the decrease in concentration of leached ions must be due to chemical qualities of NZ medium. The decrease in leached NH_4 and K was likely due to the high CEC of Cp and its ability to retain cations (Weber et al., 1983). The reduced leaching of $\text{PO}_4\text{-P}$ by NZ/N-P-K treatment was possibly due to $\text{PO}_4\text{-P}$ retention along edge charges of Cp. Tissue nutrient levels in plants grown

Table 2. Growth data measured at harvest (day 70). Ratings were assigned by researchers after comparing overall appearance, foliage color, number and size of flowers, uniformity, and shape using a scale of 1 to 10 (10 = the best plants).

Treatment ^a	Rating	Ht (cm)	Width (cm)	Fresh mass (g)	Dry mass (g)
NZ/N-P-K	9.3	17.4	14.5	115.5	17.9
EZ1/0 N-P-K	9.5	15.8	15.2	73.2	14.6
EZ1/0.5 N-P-K	8.7	16.5	15.8	108.7	17.5
EZ2/N	9.8	17.0	14.5	89.5	17.4
C/N-P-K	8.7	16.8	17.3	134.8	20.4
LSD(0.05)	0.9	1.5	1.6	13.5	3.5

^aTreatment EZ2/0F is not included because no plants were grown in this treatment.

with NZ/N-P-K were similar to C/N-P-K, except that tissue K was lower from NZ/N-P-K than C/N-P-K at the end of the crop. These results suggested that NZ medium did not substantially reduce availability of nutrients. The NZ medium did not adversely affect pH. Levels stayed at 4.5 to 5.5 over the course of production in leachate from NZ/N-P-K plants (Fig. 1H). These pH levels were always similar to or above that from plants treated with C/N-P-K (Fig. 1H). NZ medium effectively decreased nutrient leaching and potential environmental contamination while still resulting in quality plant growth.

EZ1 ROOT MEDIUM. EZ1 root medium produced plants similar to C/N-P-K in height and rating, but lower in width, fresh mass, and dry mass, when no water soluble fertilizer was provided during irrigation (Table 2). Tissue data at midcrop showed that plants grown with EZ1/0 N-P-K had significantly lower tissue N, P, K, Zn, Mn, and Cu levels than C/N-P-K plants, but the levels still met minimum critical tissue concentrations for potted chrysanthemum of 4.0%, 0.2%, and 4.0%, and 5, 25, and 5 $\mu\text{g}\cdot\text{g}^{-1}$, respectively (Mills and Jones, 1996) (Table 3). At harvest, the tissue N level of plants with EZ1/0 N-P-K did not meet the N sufficiency level of 4.0% cited by Mills and Jones (1996). However, their standard was based on leaf samples, whereas whole shoot samples were collected at harvest in this experiment, resulting in dilution of nutrient concentration by stem and flower

tissue. Still, plants that were provided nutrients solely from EZ1 medium did not have a N concentration similar to C/N-P-K.

Growth data show that EZ1 medium supplemented with half the water-soluble fertilizer rate (105 $\text{mg}\cdot\text{L}^{-1}$ N) (EZ1/0.5 N-P-K) produced plants similar to C/N-P-K in rating, height, width, and dry mass, but lower in fresh mass (Table 2). EZ1/0.5 N-P-K resulted in similar tissue levels as C/N-P-K for midcrop N, P, and K (Table 3). Harvest tissue N, P, and K levels from EZ1/0.5 N-P-K were significantly less than C/N-P-K, although the minimum critical N, P, and K levels of 4.0%, 0.2%, and 4.0% (Mills and Jones, 1996) were still met.

The leachate data showed that fallow pots filled with EZ1 medium released an increasing concentration of total N in the leachate through 30 d (Fig. 1A). Treatments EZ1/0 N-P-K and EZ1/0.5 N-P-K leached less total N than EZ1/0F (fallow pots) and C/N-P-K, which is expected because the fallow pots lacked a plant for N uptake and C/N-P-K had 210 $\text{mg}\cdot\text{L}^{-1}$ N from 18N-4P-15K applied. The concentration of NH_4 leached by treatments containing EZ1 medium decreased over time (Fig. 1B). The concentration of NO_3 leached from EZ1/0 N-P-K and EZ1/0F increased dramatically at 12 d and then decreased slowly during the remaining production cycle (Fig. 1C). This pattern is probably due to the microbial conversion of NH_4 to NO_3 .

The concentration of $\text{PO}_4\text{-P}$ leached by EZ1 medium was considerably lower than from NZ/N-P-K medium for most of the production cycle (Fig. 1D). Although less P was leached from EZ1, the plants still received sufficient P as seen in midcrop and harvest tissue data as compared to Mills and Jones (1996) standards. The levels of K leached from treatments with EZ1 medium remained constant at $\approx 25 \text{ mg}\cdot\text{L}^{-1}$ K (Fig. 1E). Sodium levels leached from treatments with EZ1 medium decreased during the production cycle and were lower than from NZ and EZ2 media (Fig. 1F). The EC measured in solutions collected from treatments with EZ1 medium varied (Fig. 1G). The EC of EZ1/0 N-P-K started high and then decreased to nearly 0, EZ1/0.5 N-P-K decreased then leveled off at $\approx 1 \text{ mmhos}$, and EZ1/0F decreased, increased sharply, and then decreased again. In summary, EZ1 root medium can produce plants that are similar in growth to those from C/N-P-K with half the concentration of soluble fertilizer. If no supplemental water-soluble fertilizer is supplied to EZ1 medium, the data suggest that N was a limiting factor.

EZ2 ROOT MEDIUM. EZ2 medium produced plants similar to the control in height and dry mass when fertilized with 210 $\text{mg}\cdot\text{L}^{-1}$ N from 18 N-0P-0K soluble fertilizer applications (Table 2). Plants grown with EZ2/N were rated highest although they had a lower fresh mass and smaller width than the control. At midcrop, EZ2/N resulted in similar N and K tissue concentrations

Table 3. Tissue nutrient content (dry mass basis) of youngest fully expanded leaves collected at midcrop (day 42) and of whole above-ground plant tissue at harvest (day 70) from chrysanthemum plants grown with zeolite-based root media and controls.

Treatment ^a	N	P	K	S	Mg	Ca	Na	B	Zn	Mn	Fe	Cu	Al
	$\mu\text{g}\cdot\text{g}^{-1}$												
	%												
	Midcrop												
NZ/N-P-K	8.25	1.43	5.65	0.42	0.65	1.82	0.05	41	253	306	100	28	38
EZ1/0 N-P-K	6.98	1.09	5.14	0.54	0.60	1.27	0.01	52	117	429	110	24	44
EZ1/0.5 N-P-K	8.18	1.40	5.49	0.46	0.72	1.49	0.02	76	133	428	103	26	38
EZ2/N	8.08	0.91	6.06	0.43	0.63	1.65	0.02	45	126	425	104	23	40
C/N-P-K	8.31	1.43	5.92	0.45	0.73	1.38	0.03	45	398	669	151	28	38
LSD(0.05)	0.24	0.21	0.57	0.07	0.16	0.40	0.01	10	91	158	48	4	25
	Harvest												
NZ/N-P-K	5.89	1.11	4.80	0.33	0.50	1.62	0.06	29	300	378	87	19	42
EZ1/0	3.32	0.60	4.54	0.33	0.44	1.12	0.02	34	128	364	53	15	21
EZ1/0.5 N-P-K	5.61	1.02	4.94	0.38	0.60	1.14	0.03	48	171	382	90	16	38
EZ2/N	5.68	0.61	4.78	0.31	0.51	1.40	0.03	34	174	320	148	16	24
C/N-P-K	6.08	1.17	5.65	0.37	0.57	1.04	0.05	31	322	542	88	18	26
LSD(0.05)	0.25	0.09	0.23	0.09	0.09	0.20	0.02	13	70	105	101	4	16

^aTreatment EZ2/0F is not included because no plants were grown in this treatment.

Fig. 1. Nutrient concentrations, electrical conductivity (EC), and pH in the leachate solutions collected during greenhouse production of potted chrysanthemum with zeolite-based root media and the control. The bar to the right of the letter represents the standard error for the graph. (A) Total N ($\text{NH}_4\text{-N} + \text{NO}_3\text{-N}$) ($\text{SE} = \text{mean} \pm 8.9$), (B) $\text{NH}_4\text{-N}$ ($\text{SE} = \text{mean} \pm 2.8$), (C) $\text{NO}_3\text{-N}$ ($\text{SE} = \text{mean} \pm 8.7$), (D) $\text{PO}_4\text{-P}$ ($\text{SE} = \text{mean} \pm 5.0$), (E) K ($\text{SE} = \text{mean} \pm 10.1$), (F) Na ($\text{SE} = \text{mean} \pm 1.7$), (G) EC ($\text{SE} = \text{mean} \pm 0.07$), and (H) pH ($\text{SE} = \text{mean} \pm 0.12$). ■ = NZ/N-P-K; ● = EZ1/0 N-P-K; ▲ = EZ1/0.5 N-P-K; ◆ = EZ1/0P; □ = EZ2/N; and ○ = C/N-P-K (control).

compared to C/N-P-K plants. At harvest, EZ2/N resulted in plants with significantly lower N, P, and K levels than C/N-P-K plants, but the minimum critical tissue concentrations of 4.0%, 0.2%, and 4.0% for N, P, and K, respectively (Mills and Jones, 1996), were surpassed (Table 3). The treatment EZ2/N resulted in adequate N, P, and K with only N being applied as water-soluble fertilizer. Thus, EZ2 medium provided adequate P and K for chrysanthemums without additional water-soluble fertilizer applications.

The concentration of total N in the leachate from EZ2/N was similar to that from C/N-P-K (Fig. 1A). Leachate NH_4 concentration from EZ2/N was less than from C/N-P-K (Fig. 1B), while leachate NO_3 concentration was greater from EZ2/N than from C/N-P-K (Fig. 1C). Some NH_4 was likely retained by the Cp in EZ2 medium, and this would decrease the concentration recovered in the leachate. The concentration of $\text{PO}_4\text{-P}$ leached by EZ2/N was near zero until 35 d and then increased to $\approx 28 \text{ mg}\cdot\text{L}^{-1}$ $\text{PO}_4\text{-P}$ at harvest (day 70) (Fig. 1D). The $\text{PO}_4\text{-P}$ in leachate EZ2/N was lower than in the leachate from NZ/N-P-K or EZ1/0.5 N-P-K treatments for most of the production cycle. A significantly lower concentration of K was leached by EZ2/N than C/N-P-K (Fig. 1E). Because $\text{PO}_4\text{-P}$ and K were not provided as water-soluble fertilizer applications, the lower leachate levels of these ions are expected. Treatment EZ2/N first released $\approx 23 \text{ mg}\cdot\text{L}^{-1}$ Na, and by harvest Na decreased to $13 \text{ mg}\cdot\text{L}^{-1}$ (Fig. 1F).

EZ2/N provided enough $\text{PO}_4\text{-P}$ and K to produce plant growth which exceeded commercial expectations of height and width for medium-grade potted chrysanthemums (Hamrick, 1989) while decreasing the water-soluble fertilizer input by the grower. Also, less $\text{PO}_4\text{-P}$ and K were leached from the pots compared to conventional fertilization methods, so environmental contamination from these nutrients was reduced. Smaller plant widths and fresh mass may have been due to the lower $\text{PO}_4\text{-P}$ levels although tissue P concentrations met minimum critical levels. The larger volume and width from C/N-P-K could be attributed to luxury consumption of P—a larger plant was produced, but the sprawling form and lack of uniformity decreased consumer appeal.

Conclusions

In summary, using conventional constant liquid fertilization practices, NZ/N-P-K would successfully lower leachate concentrations of NH_4 , PO_4 , and K during crop production, and thus decrease environmental contamination from these nutrients while still producing quality plants. EZ1 supplemented with a 50% reduced water-soluble fertilizer rate ($105 \text{ mg} \cdot \text{L}^{-1} \text{ N}$ from 18N-4P-15K) produced plants similar to control plants based on all growth measurements except fresh mass. EZ2, which received N alone in water-soluble fertilizer, decreased leaching of PO_4 and K while providing adequate levels of these nutrients for growth of commercial quality, although some growth measurements and tissue nutrient concentrations were less than control plants. With further refinements, these zeolite-based products show promise for decreasing nutrient leaching during crop production and for resulting in crop quality comparable to current commercial standards while substantially reducing grower inputs of nutrients and labor required to fertilize.

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Varying Fertigation Volume Modifies Growth of Processing Tomato Transplants Produced in the Greenhouse and Affects Leaching from Plug Trays

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ADDITIONAL INDEX WORDS. mineral, leaching, growing medium, *Lycopersicon esculentum*

SUMMARY. Tomato (*Lycopersicon esculentum* Mill) seedlings given 0.3 to 0.4 L/tray per day of a mineral solution containing (in $\text{mg} \cdot \text{L}^{-1}$) 150N-47P-216K-64Ca-40Mg maintained optimal height at 10 to 13 cm for Ontario processing tomato transplants. Seedlings given greater fertigation volumes were too tall and spindly to use as transplants. Transplants given 0.2 L of water per tray per day were very short (6 cm) compared to those receiving 0.3 to 0.4 L. As fertigation volume was increased from 0.2 to 0.7 L, shoot N remained constant while root N increased. Shoots had about a 3-fold higher level of N, P, and K than the roots. Calcium and magnesium were similar in roots and shoots. Mineral leaching from the trays was 1% of the total volume applied for the 0.4-L and 4% for the 0.7-L treatment.

Controlling seedling height in the greenhouse is an important aspect of processing tomato transplant production for ease of plant handling in the transplanting

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