Effect of Fertilizer Concentration on Growth of Double Impatiens

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ADDITIONAL INDEX WORDS. *Impatiens wallerana*, flood benches, fertilization

SUMMARY. Double impatiens (*Impatiens wallerana* Hook.) 'Blackberry Ice' (variegated-leaf) and 'Purple Magic' (green-leaf) were grown on flood benches and irrigated with 50, 100, 200, or 300 mg·L^{-1} (ppm) N to study the effect of fertility on growth and development. Electrical conductivity (EC) levels at week 9 were similar for both cultivars at each fertilizer rate, except for the 100 mg·L^{-1} N where EC levels of 'Blackberry Ice' were more than double those of 'Purple Magic'. This indicated that the nutrient demands were less for 'Blackberry Ice' and fertilization rates lower than 100 mg·L^{-1} N would be required. After nine weeks, plants grown with 100 mg·L^{-1} N had a 22% larger plant diameter than plants grown with either 50 or 200 mg·L^{-1} N. Fertilization rates of 50 mg·L^{-1} N resulted in plants which were covered with a higher percentage of blooms per unit of leaf area, but the plants were smaller. Plant tissue dry weight (leaf, bud, stem, and total) increased to the highest level at 100 mg·L^{-1} N, then decreased with further increases in fertilization rate. For maximum shoot growth with flood irrigation, growers should apply 100 mg·L^{-1} N when growing 'Purple Magic' double impatiens and a fertilization rate between 50 and 100 mg·L^{-1} N for 'Blackberry Ice'.

Providing the necessary mineral elements in the appropriate concentration is important for optimal growth of ornamental plants. Electrical conductivity (EC) levels increase when there is insufficient leaching during irrigation or too much fertilizer is applied. Symptoms of high EC include slow growth, limited root development and plants that appear stunted (Devitt and Morris, 1987; Miller et al., 1981). New Guinea impatiens (*Impatiens* sp. hybrids) display a rippled or wavy leaf surface as symptoms of an excessive fertilization rate (Hartley, 1995; Judd and Cox, 1992). The authors also have observed rippled or cupped leaves on variegated cultivars of double impatiens (*Impatiens wallerana*), geraniums (*Pelargonium* ×*hortorum* L.H. Bailey), and lantana (*Lantana camara* L.) when grown at fertilization rates of 200 to 300 mg·L^{-1} (ppm) of N while green-leaved cultivars show no leaf distortion. Thus fertilization requirements for optimal growth of double impatiens may vary by cultivar. The objectives of this study were to determine the effect of increased rates of fertility on plant growth and development of double impatiens and to develop fertilization recommendations for growers of those plants.

Material and methods

Rooted cuttings of double impatiens cultivars Blackberry Ice (variegated-leaf type) and Purple Magic (green-leaf type) were potted into 0.6-L (0.16-gal), 10-cm-diameter (4-inch), square pots on 7 Feb. 1997. The root substrate contained 2 soil : 5 sphagnum peat : 3 perlite (by volume) and was amended with ground dolomitic limestone to pH 5.1. Plants were grown under the natural occurring photoperiod (lat. 42 °N) with day / night temperature set points of 24 / 18 °C (75 / 64 °F). The plants were grown on flood benches and irrigated as needed with Excel 15–5–15 Cal–Mag (Scotts, Marysville, Ohio) (15N–2.1P–12.5K) at a rate of 50, 100, 200, or 300 mg·L^{-1} N. Nutrient solutions were replaced every 6 to 7 d.

A completely randomized design of eight treatment combinations (two cultivars × four fertilizer treatments)

Journal paper J-18071 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Project 3345, and supported by Hatch Act and State of Iowa funds. This research was funded in part with a grant from the Iowa Nursery and Landscape Assoc. Research Corp. and the North Carolina Agricultural Research Service (NCARS), Raleigh. Use of trade names in this publication does not imply endorsement by the NCARS of products named nor criticism of similar ones not mentioned. Thanks to Ball Seed Co. for supplying the cuttings and Andrew Schmitz for technical assistance. The cost of publishing this paper was defrayed in part by payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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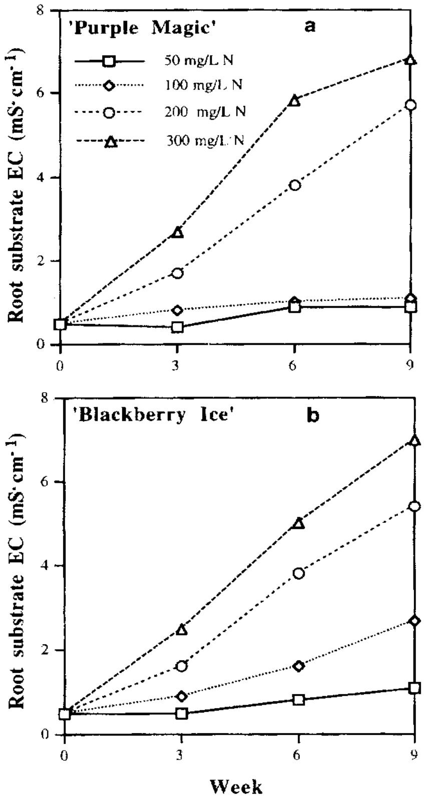

Fig. 1. Root substrate electrical conductivity (EC) levels of (a) 'Purple Magic' and (b) 'Blackberry Ice' double impatiens fertilized with 50, 100, 200, or 300 mg·L^{-1} (ppm) N on flood benches. EC levels were significant at $P \leq 0.001$ and LSD (α = 0.05) was 0.39 mS·cm^{-1} for the fertilizer concentration × cultivar × week interaction. Values are means of five replications.

was used. Beginning on 7 Feb. and continuing every 3 weeks until 22 Apr., total plant height measured from the pot rim to the top of the plant and plant diameter (measured at the widest dimension and turned 90°, and averaged) were recorded for five single-plant replications within each treatment. The shoots were destructively harvested and plant fresh weight was also recorded for each replicate. The root substrate samples were collected from each replicate by removing the top 2-cm (0.8-inch) layer of substrate and combining the remaining substrate for analysis. The root substrate was analyzed at each sampling date for pH (epoxy Ag / AgCl electrode; Cole-Parmer, Vernon Hills, Ill.), EC (Cole-Parmer, Vernon Hills, Ill.), NO_3-N (Smith and Scott, 1991) (QuikChem AE; Lachet, Milwaukee, Wis.), NH_4-N (QuikChem AE), and P, K, Ca, and Mg were determined using an inductively coupled Ar plasma emissions spectrophotometer (IRIS / AP Duo; Thermo Jarrel Ash, Frankin, Mass.).

LEAF-TISSUE NUTRIENT CONCENTRATION. Five replicates of each cultivar from each fertilizer rate were sampled for nutrient concentration on 22 Apr. Plants were harvested and divided into leaf, stem and flower portions, dried in a forced-air oven at 67 °C (153 °F) for 72 h. Dry weight was measured and the tissue ground to pass through a 20-mesh Wiley Mill. Ground leaf tissue samples (100 mg) were dry ashed and the dry ash dissolved in 7 mL aqua regia (Jones et al., 1991) and diluted with distilled water to a volume of 35 mL for analysis. Concentrations of P, K, Ca, Mg, B, Mo, and Zn were determined using an inductively coupled Ar plasma emissions spectrophotometer (IRIS / AP Duo). Ground leaf tissue samples (100 mg) were digested by micro-Kjeldahl (Nelson and Sommers, 1980) and analyzed for N by a QuikChem AE (Smith and Scott, 1991).

Data for the plant tissue and leaf tissue nutrient levels were analyzed using analysis of variance by general linear model procedures (SAS Institute, Cary, NC). Means were separated by least significant differences (LSD) at $P \leq 0.05$.

DATA ANALYSIS. Plant dry weight and leaf-tissue nutrient concentration values were regressed using the PROC REG procedure (SAS Institute, Cary, N.C.) to determine the best fit linear or quadratic model for each element. Variables in the model were fertilizer concentration (conc) and indicator variables for cultivar (cult), with the full model being as follows:

$\text{Concentration}_i = ß_0 + ß_1\text{Cult}_2 + ß_2\text{Conc} + ß_3\text{Conc} \times \text{Cult}_2 + ß_4\text{Conc}^2 + ß_5\text{Conc}^2 \times \text{Cult}_2$, where Concentration_i = fertilizer concentration (50, 100, 200, or 300 mg·L^{-1} N); i = variable being regressed (N, P, K, Ca, Mg, B, Mo, Zn, dry weight); Cultivar_2 = 1 if cultivar = 'Blackberry Ice', 0 otherwise (for 'Purple Magic'); $ß_k$ = estimated coefficients (k = 0 to 5).

Terms of the model were judged to be significant or nonsignificant and included in the final model based on a comparison of F values at α = 0.05.

Results and discussion

ROOT SUBSTRATE NUTRIENT LEVELS. The root substrate EC levels were significantly different among the fertilizer concentrations and both cultivars over time ($P \leq 0.001$) with levels increasing as the fertilizer concentration increased (Fig. 1). EC levels at week 9 were similar for both cultivars at each fertilizer rate, except for the 100 mg·L^{-1} N where EC levels of 'Blackberry Ice' were more than double those of 'Purple Magic'. EC levels for 'Purple Magic' were similar with 50 and 100 mg·L^{-1} N, indicating the plants were using the additional nutrients provided at the 100 mg·L^{-1} N rate. The higher EC levels with 100 mg·L^{-1} N for 'Blackberry Ice' when compared to 'Purple Magic' indicated that cultivar differences in nutrient demands vary and fertilization rates lower than 100 mg·L^{-1} N would be required for 'Blackberry Ice'. Although only one green-leaved and one variegated-leaved cultivar were compared, these results may indicate that nutrient demands of variegated-leaved double impatiens are less than green-leaved cultivars. The increase in EC levels at the fertilization rates ≥200 mg·L^{-1} N indicated neither cultivar utilized all of the available nutrients and those rates were excessive.

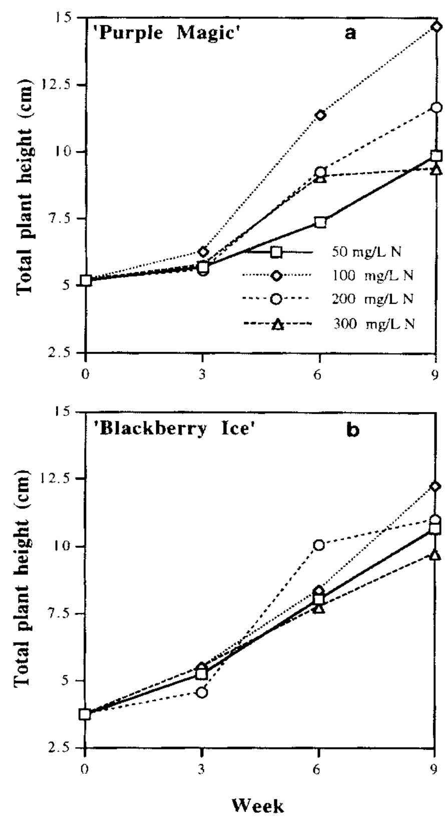

Fig. 2. Total plant height of (a) 'Purple Magic' and (b) 'Blackberry Ice' double impatiens fertilized with 50, 100, 200, or 300 mg·L^{-1} (ppm) N on flood benches. Total plant height was significant at $P \leq 0.01$ and LSD (α = 0.05) was 1.18 cm (0.46 inch) for the fertilizer concentration × cultivar × week interaction. Values are means of five replications.

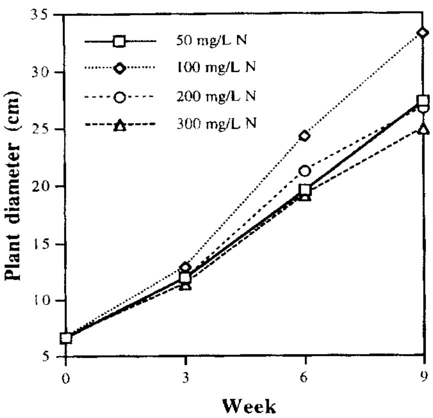

Fig. 3. Plant diameter of double impatiens fertilized with 50, 100, 200, or 300 mg·L^{-1} (ppm) N on flood benches. Plant diameter was significant at $P \le 0.001$ and LSD ($\alpha = 0.05$) was 1.29 cm (0.5 inch) for the fertilizer concentration × week interaction. Values (average of both cultivars) are means of 10 replications.

Similar accumulations of excess fertilizer salts when fertilization rates exceeded the amount required by the plant have been reported on New Guinea impatiens (Kent and Reed, 1996) and several foliage plant species (Campos and Reed, 1993; Poole and Conover, 1992). Levels of N, P, K, Ca, and Mg in the root substrate also accumulated as the fertilizer concentration increased (data not shown).

PLANT GROWTH. Total plant heights were significantly different among the fertilizer concentrations and cultivars over time ($P \le 0.01$) with 100 mg·L^{-1} N resulting in the tallest plants (Fig. 2). Total plant heights at week nine were similar for both cultivars at each fertilizer rate, except for 100 mg·L^{-1} N where 'Purple Magic' plants were 20% taller than 'Blackberry Ice'. 'Purple Magic' plants grown with the 200 mg·L^{-1} N were the next tallest plants, while plants grown with 50 or 300 mg·L^{-1} N were the shortest. 'Blackberry Ice' plants grown with 50 or 200 mg·L^{-1} N were similar in height and the shortest plants resulted from 300 mg·L^{-1} N.

Plant diameter was significantly affected by fertilizer concentration over time ($P \le 0.001$) (Fig. 3). Differences in plant diameter occurred only after 6 weeks of growth, with smaller plant growth resulting with 50 or 300 mg·L^{-1} N. After 9 weeks, plants grown with 100 mg·L^{-1} N were 22% larger than plants grown with either 50 or 200 mg·L^{-1} N. Fertilization rates of 50 mg·L^{-1} N resulted in plants which were covered with a higher percentage of blooms per unit of leaf area (visual observations), but the plants were smaller. Similar reductions in plant diameter, due in part to a reduction in leaf size as the N fertilization rate increased, were reported by Kent and Reed (1996) for New Guinea impatiens.

There was significant quadratic interaction among the fertilizer concentrations and cultivars ($P \le 0.001$) for plant tissue dry weight (leaf, bud, stem, and total) (Table 1). 'Purple Magic' plants had a greater dry weight than 'Blackberry Ice' over all the fertilization rates. Plant tissue dry weight (leaf, bud, stem, and total) increased to the highest level at 100 mg·L^{-1} N, then decreased as fertilization rate increased. Judd and Cox (1992) reported a similar reduction in New Guinea impatiens dry weight with root substrate EC levels >1.5 mS·cm^{-1}. The greater dry weight with green plants compared to variegated plants is in agreement with Sadof and Raupp (1991) who reported green plants had a higher mean relative growth rate, but a lower amount of new leaf area per each new unit of plant biomass that accumulated when compared to variegated plants.

LEAF TISSUE NUTRIENT CONCENTRATION. Leaf tissue concentrations of N, P, and K exhibited a quadratic interaction among the fertilizer concentrations and cultivars ($P \le 0.001$) (Table 2). Leaf tissue concentrations of N, P, and K increased with the fertilization rate, however, levels were higher for 'Blackberry Ice' than 'Purple Magic' over all fertilization rates. Higher tissue N concentration was in agreement with Sadof and Raupp (1991) who reported elevated N in the phloem of variegated plants compared to green plants. Tissue Ca concentrations were similar for both cultivars and levels decreased as the fertilizer rate increased. The decrease in leaf tissue Ca concentrations may be attributed to the antagonistic relationship between K and Ca. Competition from increased rates of K has been reported to decrease Ca content in poinsettias (*Euphorbia pulcherrima* Willd.) (Strømme et al., 1994; Whipker and Hammer, 1997)

Conclusions

Fertilization rates of 50 mg·L^{-1} N resulted in plants which were smaller than plants fertilized with 100 mg·L^{-1} N. Fertilization rates of 200 to 300 mg·L^{-1} N resulted in an accumulation of fertilizer salts in the root substrate and a reduction in plant growth. For maximum shoot growth, growers should apply 100 mg·L^{-1} N when growing 'Purple Magic' double impatiens on flood benches. Because 'Blackberry

Table 1. Regression coefficients of models for plant tissue dry weight of 'Purple Magic' (PM) green-leaf and 'Blackberry Ice' (BI) variegated-leaf double impatiens fertilized with 50, 100, 200, or 300 mg·L^{-1} (ppm) N on flood benches (28.35 g = 1.0 oz).

Tissue and cultivar	Regression equation	R^2	Adjusted R^2	Regression F statistic
Leaf (g)		0.612	0.568	13.8
PM	$y = 2.09^{***} + 0.22\ (conc)^{***} - 0.00007\ (conc^2)^{***}$			
BI	$y = 2.09^{***} + 0.21\ (conc)^{**} - 0.000045\ (conc^2)^{*}$			
Bud (g)		0.809	0.793	50.8
PM	$y = 3.14^{***} + 0.0089\ (conc)^{*} - 0.000038\ (conc^2)^{***}$			
BI	$y = 2.10^{***} + 0.0089\ (conc)^{*} - 0.000038\ (conc^2)^{***}$			
Stem (g)		0.661	0.623	17.1
PM	$y = 1.17^{***} + 0.019\ (conc)^{***} - 0.00006\ (conc^2)^{***}$			
BI	$y = 1.17^{***} + 0.0062\ (conc)^{***} - 0.000022\ (conc^2)^{***}$			
Total (g)		0.727	0.704	31.9
PM	$y = 7.14^{***} + 0.038\ (conc)^{***} - 0.00014\ (conc^2)^{***}$			
BI	$y = 4.64^{***} + 0.038\ (conc)^{***} - 0.00014\ (conc^2)^{***}$			

*,**,***Significant regression equation terms at $P \le 0.05$, 0.01, or 0.001, respectively.

Table 2. Regression coefficients of models for leaf tissue macro- and micronutrient concentration of 'Purple Magic' (PM) green-leaf and 'Blackberry Ice' (BI) variegated-leaf double impatiens fertilized with 50, 100, 200, or 300 mg·L^{-1} (ppm) N on flood benches.

Element (%) and cultivar	Regression equation	R^2	Adjusted R^2	Regression F statistic
N (%)		0.691	0.665	26.8
PM	$y = 3.57^{***} + 0.0169\ (conc)^{***} - 0.000032\ (conc^2)^{**}$			
BI	$y = 3.95^{**} + 0.0169\ (conc)^{***} - 0.000032\ (conc^2)^{**}$			
P (%)		0.750	0.721	26.2
PM	$y = 0.133^{*} + 0.0046\ (conc)^{***} - 0.00001\ (conc^2)^{***}$			
BI	$y = 0.133^{*} + 0.0069\ (conc)^{***} - 0.000017\ (conc^2)^{**}$			
K (%)		0.800	0.783	48.0
PM	$y = 1.01^{***} + 0.0087\ (conc)^{**} - 0.00001\ (conc^2)^{*}$			
BI	$y = 1.81^{***} + 0.0087\ (conc)^{**} - 0.00001\ (conc^2)^{*}$			
Ca (%)		0.331	0.314	18.8
Both cultivars	$y = 4.34^{***} - 0.0000046\ (conc^2)$***			
Mg (%)		0.346	0.271	4.6
PM	$y = 0.85^{***} + 0.001\ (conc)^{*} - 0.000004\ (conc^2)^{**}$			
BI	$y = 0.754$** $+ 0.001\ (conc)^{*} - 0.000002\ (conc^2)^{**}$			
B (mg·L^{-1})		0.738	0.717	33.9
PM	$y = 54.52^{***} + 0.35\ (conc)^{***} - 0.0006\ (conc^2)^{**}$			
BI	$y = 64.78^{***} + 0.35\ (conc)^{***} - 0.0006\ (conc^2)^{**}$			
Mo (mg·L^{-1})		0.771	0.758	62.2
Both cultivars	$y = 30.89^{***} - 0.15\ (conc)^{***} + 0.0002\ (conc^2)^{*}$			
Zn (mg·L^{-1})		0.270	0.230	6.8
PM	$y = 65.53^{***} + 0.13\ (conc)^{**}$			
BI	$y = 87.51^{***} + 0.13\ (conc)^{**}$			

*,**,***Significant regression equation terms at $P \leq 0.05$, 0.01, or 0.001, respectively.

Ice' plants have a lower growth rate and higher accumulation of fertilizer salts in the root substrate than 'Purple Magic' plants, fertilization rates slightly lower than 100 mg·L^{-1} N would be recommended with flood benches. General grower recommendations suggest applying 33% to 50% less fertilizer to flood bench grown plants than hand-watered plants (Reed, 1996). Therefore, assuming this applies to double impatiens, adjusting the 100 mg·L^{-1} N recommended fertilization rate of flood bench irrigated plants to hand-watering would result in a recommended hand-watering irrigation rate of 150 to 200 mg·L^{-1} N, with the lower range suggested for 'Blackberry Ice'.

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