Production and Postproduction Performance of Two New Guinea *Impatiens* Cultivars Grown with Controlled-release Fertilizer and No Leaching

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Abstract. The objectives of this study were to determine 1) the minimum controlled-release fertilizer (CRF) rate and the lowest constant medium moisture required to produce the highest quality plants and 2) if this production system affected quality of these plants under two postproduction light levels. Two New Guinea *impatiens* (*Impatiens* sp. hybrids) 'Illusion' and 'Blazon' (Lasting Impressions Series) differing in salt tolerance were grown for 42 days with a CRF at three rates (3.3, 6.6, or 9.9 g/pot) and two medium moisture levels (low or high) without leaching. The high moisture level (tension setpoints of 1 to 3 kPa) and 6.6 g of CRF/pot produced optimum biomass. Low medium moisture (tension setpoints of 4 to 6 kPa) reduced leaf area, leaf number, leaf N content, root, stem, and leaf dry masses as CRF rate increased from low to high for 'Illusion'. Similar results in 'Blazon' were observed as CRF rates increased from 3.3 to 6.6 g. Biomass decreased no further at the high rate of 9.9 g/pot. Biomass increased in both cultivars under high medium moisture when CRF rates increased from 3.3 to 6.6 g. Biomass of 'Illusion' decreased at 9.9 g/pot, although no symptoms of salt sensitivity were observed (i.e., leaf tip burn). 'Blazon' maintained a similar biomass when amended with 9.9 or 6.6 g CRF/pot, although electrical conductivity (EC) in the medium was 5.9 dS·m⁻¹ in the upper half and 4.1 dS·m⁻¹ in the lower half of the medium at the end of production. Growth of 'Illusion' responded more favorably to postproduction light levels that were similar to those of production regardless of treatment imposed during production. Similar biomass responses occurred for 'Blazon' regardless of the postproduction light level.

The establishment of minimum fertilizer and water requirements for the production of a greenhouse crop has become increasingly important to growers as they are faced with higher water and fertilizer costs, mandatory reduction of runoff water, and governmental fines for contaminating surface water and groundwater. One method of reducing water and fertilizer use is to reduce leaching. Recent studies have shown that high-quality greenhouse crops can be grown with little or no runoff by maintaining the soil moisture at a constant level (Kiehl et al., 1992; Lieth and Burger, 1989). Constant soil moisture levels can be maintained with the use of a tensiometer-based computer irrigation system. However, crops sensitive to soluble salts may exhibit reduced biomass production or higher mortality rates during production or postproduction when grown under this system, due to the lack of leaching and subsequent soluble salt accumulation.

Using controlled-release fertilizer (CRF) instead of water-soluble fertilizer (WSF) for container-grown plant production can effectively limit the loss of nutrients that are leached from growing media (Rathier and Frink, 1989; Sharma, 1979). However, several studies have shown that nutrient loss through leachate is not uniform during the entire growth period (Cox, 1993; Hershey and Paul, 1982; Rathier and Frink, 1989). These studies demonstrated that the largest loss of N in leachate occurred during the early part of the production cycle. The nutrient loss in runoff can be prevented by growing plants without leaching. Lieth and

Burger (1989) showed that marketable chrysanthemums could be grown with a leaching fraction (LF) of 0 by maintaining a constant soil moisture. Ku and Hershey (1991) grew poinsettias at several LFs and demonstrated that the medium electrical conductivity (EC) in the lower third of the container reached 8.9 dS·m⁻¹ at a LF of 0 without adversely affecting height, shoot fresh and dry masses, and leaf and bract areas. Chrysanthemums and poinsettias are considered salt-tolerant crops and, therefore, might perform well without leaching. The performance of a greenhouse crop with a higher salt sensitivity grown with a LF of 0 has not been studied.

The irrigation and nutritional requirements of New Guinea *impatiens* have not been extensively studied. New Guinea *impatiens* are reported to have a relatively low nutritional requirement, especially in micronutrients (Erwin et al., 1992). In fact, New Guinea *impatiens* growers recommend that the practice of adding micronutrients to the medium should be significantly decreased or completely eliminated. It is also recommended that the pH of the medium remain between 5.8 and 6.4 due to the high availability of most micronutrients at pH levels lower than 5.8 (Erwin et al., 1992). Further studies have shown that growth of New Guinea *impatiens* is suppressed at medium EC of 1.5 dS·m⁻¹ or higher and that root rot and chlorosis become major problems at these levels (Judd and Cox, 1992). Therefore, the use of CRFs has been discouraged due to the possibility of soluble salt accumulation. Published information on New Guinea *impatiens* is limited and therefore minimum fertilizer and water requirements have not been adequately established for this crop.

The first objective of this study was to determine the minimum fertilizer and medium moisture level for two cultivars of New Guinea *impatiens*—a salt-sensitive and a salt-tolerant cultivar—when grown under two constant medium moisture levels and amended with three rates of CRF. The second objective was to determine the extent that this production method affected plant performance when plants were placed under two postproduction light levels.

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Materials and Methods

Production phase. Rooted cuttings of New Guinea impatiens 'Illusion' and 'Blazon', two cultivars differing in salt tolerance (Ed Mikkelsen, personal communication), were transplanted into 1.5-L containers using Redi-Earth Peat-Lite medium (Grace Sierra, Milpitas, Calif.) on 15 July. A container capacity of 71% was determined on four pots. Micromax Plus Amendment Mix 0N-1.8P-0K (Grace Sierra, Milpitas, Calif.) was incorporated into the medium at a rate of 6.0 kg·m⁻³. Plants were grown under 75% shade in a glasshouse at the Univ. of California South Coast Research and Extension Center in Irvine, Calif. The average photosynthetically active radiation (PAR), as measured with a PAR quantum sensor (LI-COR, Lincoln, Neb.), was 350 μmol·m⁻²·s⁻¹ at the plant canopy level during midday under cloudless conditions. Temperature setpoints were 24 °C maximum day/20 °C minimum night and were continuously monitored with a temperature sensor (Q-Com Corp., Irvine, Calif.).

Each cultivar was grown under six treatment combinations consisting of three fertilizer rates (3.3, 6.6, or 9.9 g/pot) and two medium moisture levels (low or high). Nutricote Type 100 (a 100-d release formulation), 14N-6.2P-11.6K (Plantco Inc., Brampton, Ontario, Canada), was incorporated into the medium at a rate of 3.3, 6.6, or 9.9 g/pot, representing 0.5, 1, and 1.5 times the recommended rate. Fertilizer was weighed for each pot and incorporated into the medium before transplanting. Transplants were allowed to establish for 28 d before constant medium moisture levels were begun. During this acclimation period, plants were watered as needed by overhead irrigation until leaching started.

Soil tension was controlled and monitored with GEM III computer software and tensiometers (Q-Com Corp.). Individual treatments were monitored by placing a tensiometer in the center of a representative pot of that treatment, with the ceramic tip 2.5 to 5.0 cm from the bottom of the pot. To ensure that the medium in all containers were at similar moisture levels at installation, all plants were watered to container capacity. The two moisture levels consisted of the following maximum/minimum soil tension

setpoints: 1 to 3 kPa (high) or 4 to 6 kPa (low). These setpoints were determined by constructing a moisture release curve for the medium and represent 92% to 69% and 58% to 43% of the total moisture content of the medium (Fig. 1). The irrigation system consisted of solenoid valves, black polyethylene irrigation tubing, and 1-ml·s⁻¹ drip emitters. The distribution uniformity of the irrigation system was >95% at the beginning of the experiment. Water flow through main water line was monitored with a Signet 2530 digital flowmeter (George Fischer, Tustin, Calif.). The average total amount of water applied to each pot was calculated based on the recorded irrigation run time for each treatment by the computer and average flow rates for each treatment (Table 1).

Fig. 1. Moisture release curve calibrated for Redi-Earth Peat-Lite potting medium.

The production phase lasted 70 d, at the end of which the following data were collected from selected plants for each treatment: shoot and root dry mass, number of leaves, leaf area, macronutrient and micronutrient content of leaf tissue, and EC of the medium in the upper and lower halves of the container. Elemental foliar analyses were determined from the total leaf mass per plant (DANR Analytical Lab., Davis, Calif.). Leaf area was measured with an area meter (LI-3100; LI-COR). Shoots and roots were dried at 65 °C in a forced-air oven for 3 d to determine dry masses. Medium samples were taken from the upper and lower halves based on the height of the medium. Medium EC was determined by the saturated paste method (Bunt, 1988; Hershey, 1989).

Postproduction phase. Immediately following the completion of the production phase, the remaining plants of both cultivars were transferred to a lathhouse under two irradiance levels. The two irradiance levels were obtained by shade from the lathhouse alone or shade from the lathhouse by adding 50% shade cloth. Light levels under 50% shade cloth were similar to production light levels. PAR was continuously monitored under the 50% shade cloth with a quantum sensor, and at midday (1300 to 1400 hr) ranged between 263 and 389 μmol·m⁻²·s⁻¹. Light levels under the lathhouse alone were twice those under the 50% shade cloth as verified by a portable light meter (LI-185; LI-COR). The average high/low temperatures were 25.7/13.8 °C for the lathhouse plus shade cloth and 25.1/14.1 °C for the lathhouse alone.

Table 1. Calculated average amount of water applied in liters to each individual container over the last 42 d of a 70-d production phase for 'Illusion' and 'Blazon' impatiens based on total run time and average flow rate. Plants were grown at three rates of controlled-release fertilizer (CRF) and two medium moisture levels. Tension setpoints were 4 to 6 kPa for the low moisture level and 1 to 3 kPa for the high moisture level.

CRF (g/pot)	Illusion		Blazon	
	Moisture level			
	Low	High	Low	High
	<i>H₂O (L)/pot</i>			
3.3	3.3	3.6	3.3	3.7
6.6	3.1	7.4	2.3	7.3
9.9	2.6	5.1	2.5	4.8

Table 2. Leaf area and leaf number of New Guinea impatiens 'Illusion' and 'Blazon' grown at three rates of controlled-release fertilizer (CRF) and two medium moisture levels for the last 42 d of a 70-d production period. Tension setpoints were 4 to 6 kPa for the low moisture level and 1 to 3 kPa for the high moisture level. Means are based on eight plants.

Treatment		Illusion		Blazon	
CRF (g/pot)	Moisture level	Leaf area (cm ²)	Leaf no.	Leaf area (cm ²)	Leaf no.
3.3	High	1147 ± 70.4 ^z	126 ± 8.5	1190 ± 84.3	134 ± 9.2
3.3	Low	1274 ± 58.9	142 ± 5.1	1105 ± 85.0	128 ± 11.3
6.6	High	1782 ± 57.5	162 ± 8.3	1538 ± 55.3	154 ± 8.5
6.6	Low	897 ± 98.6	104 ± 8.7	812 ± 62.3	101 ± 9.0
9.9	High	1008 ± 143	123 ± 5.7	1413 ± 94.5	154 ± 10.8
9.9	Low	834 ± 30.9	97 ± 5.0	866 ± 78.0	116 ± 12.3

^zMean ± standard error.

Plants were equally split between the two irradiance level treatments. Leaching irrigation for 26 d was applied by lead weighted drip lines (3 mL·s⁻¹ flow rate) controlled by an automatic timer. An irrigation frequency of 2 min·d⁻¹ was chosen based on the amount of time to fill the pot to the top with water, a common practice in the retail nursery environment.

Plants were maintained under postproduction conditions for 26 d. At final harvest the following data were collected: shoot dry mass, number of leaves, leaf area, and medium EC in the upper and lower halves of the medium.

Experimental design. In the production phase, each cultivar was arranged separately as a completely randomized block design consisting of 24 blocks. Separation of the two cultivars was necessary due to cultivar growth differences and space limitations relating to the irrigation control system. Therefore, no statistical comparison between cultivars is possible. Each block contained one pot for each of the six treatment combinations (three fertilizer levels × two moisture levels). Data were collected from eight randomly chosen blocks per cultivar. The postproduction phase consisted of eight blocks per irradiance level with one pot for each of the six production treatment combinations (three fertilizer levels × two production moisture levels). Each cultivar was arranged separately as a randomized complete block. Individual variables were analyzed with analysis of variance and selected single degree of freedom contrasts. Stepwise regression was used to correlate medium EC to shoot and/or root dry mass (SAS Institute, Cary, N.C.).

Results

Production

Plant biomass, leaf nutrient levels, and medium ECs of both cultivars were influenced by fertilizer and moisture interactions (Tables 2 and 3; Figs. 2 and 4). Exceptions to this response occurred in 'Blazon', where root dry mass and B levels responded only to moisture level, and in 'Illusion', where Mn levels in leaf tissue depended on CRF rate alone (data not shown). Manganese levels in 'Illusion' decreased linearly from 4.6 to 1.8 mmol·kg⁻¹ dry mass as CRF rates increased, and B levels in 'Blazon' decreased from 36.6 mmol·kg⁻¹ dry mass at high moisture to 23.3 mmol·kg⁻¹ dry mass under low moisture.

Shoot and root dry mass corresponded significantly to medium ECs in 'Illusion', and shoot dry mass alone responded to medium ECs in 'Blazon' (Fig. 3). Increasing the EC in the lower half of the pot resulted in a larger decrease in biomass than increasing the EC in the upper half of the pot. For example, in 'Illusion', an increase in EC from 2.0 to 3.0 dS·m⁻¹ in the lower half of the pot caused a 21% decrease in shoot dry mass; whereas, the same increase in medium EC in the upper half of the pot resulted only in a 7.4% decrease in shoot dry mass. Root biomass of 'Illusion' declined with increasing medium ECs, whereas root dry mass of 'Blazon' was not related to medium EC. In 'Blazon', shoot dry mass decreased 5% to 8% per unit increase in lower or upper medium EC.

A comparison of the leaf tissue mineral levels from plants in this

Table 3. Electrical conductivity (EC) of the upper and lower halves of the growing medium of two New Guinea impatiens cultivars grown at three controlled-release fertilizer (CRF) and two moisture levels for the last 42 d of a 70-d production period. Tension setpoints were 4 to 6 kPa for the low moisture level and 1 to 3 kPa for the high moisture level. Means are based on eight plants.

Treatment		Illusion		Blazon	
CRF	Moisture	EC (dS·m ⁻¹)			
(g/pot)	level	Upper	Lower	Upper	Lower
3.3	High	5.2 ± 0.18 ^z	3.3 ± 0.24	4.5 ± 0.31	2.7 ± 0.18
3.3	Low	5.3 ± 0.65	3.1 ± 0.35	4.7 ± 0.36	3.3 ± 0.31
6.6	High	3.9 ± 0.33	2.5 ± 0.48	3.2 ± 0.37	1.8 ± 0.10
6.6	Low	6.3 ± 0.59	3.6 ± 0.26	7.1 ± 0.74	4.5 ± 0.47
9.9	High	4.6 ± 0.42	2.9 ± 0.15	5.9 ± 0.53	4.1 ± 0.24
9.9	Low	7.3 ± 0.53	5.3 ± 0.39	7.0 ± 0.41	5.2 ± 0.32

^zMean ± standard error.

Fig. 2. Effect of fertilizer rate and medium moisture level applied the last 42 d of a 70-d production period on root and shoot dry mass of two New Guinea impatiens cultivars. Means are based on eight plants. Low represents the low medium moisture level consisting of tension setpoints of 4 to 6 kPa and high represents the high moisture level consisting of tension setpoints of 1 to 3 kPa. Each pot was amended with 3.3, 6.6, or 9.9 g controlled-release fertilizer (CRF).

study with published normal levels revealed that leaf N, P, K, and B in both cultivars in all treatments were within the acceptable range (Banner and Klopmeier, 1995). In general, Ca and Mg levels were high in both cultivars, while Mn levels were slightly lower than normal.

Response to CRF rates under low medium moisture. Under low medium moisture, medium ECs increased as CRF rates increased (Table 3). A CRF rate of 9.9 g/pot applied to 'Illusion' resulted in the highest ECs in the medium and produced the lowest shoot and root dry masses (Table 3, Fig. 2). Leaf area and leaf number were significantly higher at 3.3 than at 6.6 or 9.9 g/pot (Table 2). Shoot dry mass and leaf area in 'Blazon' decreased when plants were amended with 6.6 or 9.9 versus 3.3 g/pot. (Table 2, Fig. 2). Medium ECs were similar at 6.6 and 9.9 g/pot (Table 3). Root dry mass, however, remained unchanged with increasing CRF rates (Fig. 2).

In 'Blazon', leaf P, K, Mg, Mn (data not shown), and N concentrations (Fig. 4) were similar at all three CRF rates. Levels of P ranged from 0.7 to 0.8 mol·kg⁻¹ dry mass, K from 1.9 to 2.5 mol·kg⁻¹ dry mass, Mg from 1.9 to 2.4 mol·kg⁻¹ dry mass, and Mn from 6.0 to 6.5 mmol·kg⁻¹ dry mass. Calcium levels responded quadratically to increasing CRF rates with levels of 3.5, 2.7, and 3.2 mol·kg⁻¹ dry mass at 3.3, 6.6, and 9.9 g CRF/pot, respectively. Molybdenum levels decreased linearly from 1.1 to 0.5 mmol·kg⁻¹ dry mass with increasing CRF rates.

In 'Illusion', leaf N concentrations decreased linearly with levels significantly higher at 3.3 than at 6.6 or 9.9 g/pot (Fig. 4). Similar linear trends were found for P, K, Ca, Mg, Mo, and B. Phosphorus decreased from 0.6 to 0.4 mol·kg⁻¹ dry mass, K decreased from 1.8 to 0.8 mol·kg⁻¹ dry mass, Ca decreased from 2.6 to 1.4 mol·kg⁻¹ dry mass, Mg decreased from 2.0 to 1.0 mol·kg⁻¹ dry mass, Mo decreased from 0.2 to 0.1 mmol·kg⁻¹ dry mass, and B decreased from 24.9 to 16.4 mmol·kg⁻¹ dry mass as CRF rates increased.

Besides reduced biomass, no other symptoms of salt sensitivity were detected throughout the production phase, except for leaf curling and cupping of new leaves on plants grown with 9.9 g CRF/pot. Generally, these symptoms are associated with overfertilization (Erwin et al., 1992).

Response to CRF rates under high medium moisture. Leaf area, leaf number, and biomass of 'Illusion' under high medium moisture responded positively to an increase in CRF rate from 3.3 to 6.6

g/pot (Table 2, Fig. 2). However, at 9.9 g/pot, leaf area, leaf number, and biomass decreased and were similar to plants amended with 3.3 g/pot. The most dramatic decrease, a 64% reduction in root biomass, occurred when plants were amended with 9.9 versus 6.6 g/pot (Fig. 2). No significant differences in medium ECs were detected, but levels at the optimum CRF rate were as high as 3.9 dS·m⁻¹ in the upper half of the medium at the end of production (Table 3).

'Blazon' leaf area, leaf number, and biomass increased as CRF rates increased above 3.3 g/pot and produced similar biomass at 6.6 and 9.9 g/pot (Table 2, Fig. 2). Medium ECs in the lower and upper halves of the pot responded quadratically to increasing fertilizer rates with the lowest ECs at 6.6 g/pot (Table 3). Although the highest medium ECs at the end of the 70-d production phase were measured at 9.9 g/pot, plant quality was not adversely affected except for some leaf curling and crinkling on new growth.

Nitrogen content in the leaves of 'Illusion' were higher at 6.6 than at 3.3 or 9.9 g/pot (Fig. 4). All other nutrients analyzed responded with a similar quadratic trend, except Mn. The highest nutrient levels, except Mn, were found in plants grown at the high medium moisture level and 6.6 g CRF/pot. Under this treatment, the macronutrients P, K, Ca, and Mg were 0.9, 2.1, 3.2, and 2.0 mol·kg⁻¹ dry mass, respectively. The micronutrients B and Mo were 27.3 and 0.3 mmol·kg⁻¹ dry mass, respectively.

Leaf N in 'Blazon' increased linearly with increasing CRF rates and reached a maximum of 13.8 mol·kg⁻¹ dry mass at 9.9 g/pot (Fig. 4). Phosphorus, K, Ca, and Mg increased as CRF increased from 3.3 to 6.6 g/pot. Levels of these nutrients at 9.9 g/pot were not significantly different from those at 6.6 g/pot (data not shown). Both Mn and Mo responded quadratically to increasing CRF rates, with the highest levels at 6.6 g/pot of 11.0 and 1.1 mmol·kg⁻¹ dry mass, respectively.

Postproduction

Medium ECs, determined at the end of the 70-d production phase and the result of fertilizer rate and moisture level, considerably affected the growth of 'Illusion' during the production phase resulting in large differences between the treatments (Fig. 2). The interaction of fertilizer and moisture level continued to be significant for shoot dry mass, leaf number, and leaf area, even under a new postproduction irrigation regime and past the 100-d release period of the CRF. Leaf area, leaf number, and biomass trends were similar to those described for the production phase. Upper and lower medium ECs after 26 d of postproduction decreased to levels below 1.5 dS·m⁻¹ with no differences between treatments (data not presented). Light level acted independently of the production variables. Shoot dry mass, leaf number, and leaf area were highest under the 50% shade cloth (light levels similar to production).

Fig. 3. Relationship between shoot and root dry mass in 'Illusion' and shoot dry mass of 'Blazon' to medium ECs in the upper and lower halves of the medium. Best fit regressions were (A) $y = 8.240 - 0.533 EC$, $R^2 = 0.25$; (B) $y = 10.525 - 1.790 EC + 0.0164 EC^3$, $R^2 = 0.49$; (C) $y = 2.650 - 0.409 EC + 0.00199 EC^3$, $R^2 = 0.40$; (D) $y = 3.008 - 1.0189 EC + 0.0994 EC^2$, $R^2 = 0.46$; (E) $y = 7.763 - 0.333 EC$, $R^2 = 0.15$; (F) $y = 7.953 - 0.553 EC$, $R^2 = 0.23$.

However, 'Blazon' shoot dry mass and leaf number during postproduction were only significantly affected by the production period moisture level. 'Blazon' plants that were grown at the higher moisture level in production had more biomass than plants grown at the low moisture level, regardless of the applied CRF rate. Again, the upper and lower medium ECs after 26 d of postproduction decreased to levels below $1.5 \text{ dS} \cdot \text{m}^{-1}$ with no differences between treatments (data not presented). Leaf area and leaf dry mass were significantly affected by the interaction of postproduction light levels and production moisture levels. Plants grown at the high moisture level in production had higher leaf area and leaf dry mass

when grown under the 50% postproduction light level than plants grown at the low moisture level. The reverse occurred for plants grown under the high postproduction light level. 'Blazon' plants grown under the low light level similar to that of production had significantly fewer leaves than plants grown at the higher light level.

Discussion

'Illusion' plants grown with 6.6 g of CRF/pot at the high moisture level for the last 42 d of the production period produced the highest-quality plants based on biomass after 70 d of production. During the application of the high moisture treatment, 7.4 L of water per pot was applied, the highest water use among the treatments (Table 1). Growers commonly irrigate with an automatic timer that is programmed to water at a specific frequency and duration. For example, an irrigation of $3 \text{ min} \cdot \text{d}^{-1}$ with the same system used in this study would result in 11.2 L of water applied to each pot over a 42-d period—34% more water than we used for the best treatment. Additionally, this type of frequent irrigation, regardless of plant water demand, results in high LFs and wasted nutrients.

'Illusion' plants grown with 3.3 and 9.9 g/pot were of marketable quality, but lacked the stature and fullness of plants grown at 6.6 g/pot. The high moisture level and 6.6 g/pot also produced the highest-quality plants for 'Blazon'. This treatment also demanded the highest water use (Table 1). Although 'Blazon' plants grown at 9.9 g/pot had biomass similar to that of plants grown at 6.6 g/pot, the higher fertilizer rate did not improve the overall quality of the plants and, therefore, would not be beneficial.

Tensiometers measure the total water potential of the medium by measuring the matric potential and assuming the osmotic potential to be negligible. High CRF rates and no leaching facilitate an increase of the measurable osmotic potential. Therefore, tensiometer setpoints become unrepresentative of the total water potential of the medium over time and water may become limiting for the plants if setpoints are near the lower threshold of available water (Kramer, 1983). We are suggesting that at the lower moisture level (tension setpoints of 4 to 6 kPa) high medium ECs at 6.6 and 9.9 g/pot (a composite of moisture level and fertilizer rate) increased the osmotic potential of the medium enough to render the setpoints too high to supply available water constantly throughout production. The inability of young expanding leaf tissue to maintain turgor under water deficits results in reduced cell elongation and in turn reduced growth (Greenway and Munns, 1980). This problem can be overcome by lowering the setpoints to provide water at lower tensions such as in this study with the higher moisture level (tension setpoints of 1 to 3 kPa). At high CRF rates, medium ECs during production can reach levels high enough to limit water supply even at low tensions, which may in part explain the decrease in biomass of 'Illusion'

Fig. 4. Effect of fertilizer rate and medium moisture level applied the last 42 d of a 70-d production period on leaf N content of two New Guinea impatiens cultivars. Means are based on eight plants. Low represents the low medium moisture level consisting of tension setpoints of 4 to 6 kPa and high represents the high moisture level consisting of tension setpoints of 1 to 3 kPa. Each pot was amended with 3.3, 6.6, or 9.9 g controlled-release fertilizer (CRF).

plants grown with 9.9 versus 6.6 g/pot. Interestingly, medium ECs after production in all treatments, including those treatments that resulted in the highest biomass, were considerably higher than the previously recommended threshold of 1.5 dS·m⁻¹ (Judd and Cox, 1992). Irrigation methods differed significantly between the two studies resulting in different fluctuations in media moisture content and therefore may explain the variability in medium ECs at the end of production.

The high and the low moisture levels resulted in similar biomass production and medium ECs at harvest when plants were grown at the low CRF rates. Remarkably, about 34% less water produced marketable yet smaller plants at 3.3 than at 6.6 g/pot. Although medium ECs after production suggest high levels of soluble salts in the medium, we propose that 3.3 g of CRF/pot did not provide adequate nutrient levels during the most active growth phase, resulting in reduced biomass and less demand for water. Plants grown with inadequate nutrients tend to mature earlier than those plants with an adequate or excessive supply of nutrients (Mengel and Kirkby, 1982). One indicator that these plants were mature before the end of the production phase is that plants grown at the low CRF rates flowered 50 d into production, as much as 10 d earlier than plants supplied with 6.6 or 9.9 g CRF/pot. Although growth of the plants stagnated, CRF still released nutrients into the medium and, assuming a lower demand of the plant for nutrients, ECs may have built up.

'Blazon' seemed more tolerant of higher medium ECs, most likely due to the root dry mass being unaffected by changing ECs. 'Blazon' may have the ability to osmotically adjust to high ECs that developed in the medium over the 70-d production phase. Although ECs were only measured at the end of production, gradual salinization of the medium has been demonstrated in poinsettia under various LFs, including a LF of 0 (Yelanich and Biernbaum, 1993). Osmotic adjustment seems to occur most often in plants that are slowly subjected to stresses such as a gradual salinization (Kramer, 1983). Whole-plant leaf tissue analysis revealed that in 'Blazon' leaf N continued to increase at 9.9 g/pot over levels at 6.6 g/pot even though biomass production remained the same (Figs. 2 and 4). This suggests that N could have been incorporated into osmoticum or sequestered in vacuoles allowing 'Blazon' to osmotically adjust to the high medium ECs.

'Illusion' plants exposed to the higher light levels in postproduction responded with a reduced biomass compared to plants maintained at the light level similar to production. Severe leaf drop at the higher light level most likely accounts for the lower biomass. New leaves that adapted to the higher light level may have eventually developed during a longer postproduction phase. In contrast, 'Blazon' performed similar under both light levels. The ability of 'Blazon' to tolerate the higher light levels could be related to its green and yellow variegated leaves. A high number of energy quenching carotenoids would enable the leaves to maintain photosynthetic levels by avoiding photoinhibition (Lawlor, 1993).

In summary, New Guinea impatiens can be grown successfully using CRFs and constant media moisture as long as the moisture content of the medium remains high enough to keep soluble salts from contributing significantly to the total water potential of the medium. Weekly monitoring of medium ECs would provide a useful tool for improving this production method. Moisture setpoints can easily be altered if ECs are too high instead of the usual practice of heavy leaching to remove the salts.

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