Identifying the Optimal Application Rate of Three Fertilizers Used to Grow New Guinea Impatiens[1]

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Abstract

This manuscript describes the effect of controlled-release, and water-soluble fertilizers on the growth and quality of New Guinea impatiens (NGI) (*Impatiens hawkeri* Bull.). Three different fertilizers were applied at three rates each in order to investigate their effect on growth and quality of 'Paradise New Red.' NGI. Fertilizer treatments included 1) a 20-4.4-16.6 water-soluble fertilizer (WSF), 2) a 10-1.8-2.5 soybean-based fertilizer (SBF), and 3) a 15-4-10, three-to four-month longevity controlled-release fertilizer (CRF). CRF was applied as a pre-plant at 1×, 0.75×, and 0.5× the label rate. WSF and SBF fertigation rates of 75, 150, and 250 mg·L^{-1} N (75, 150, and 250 ppm N), respectively, were used based on a common range of fertigation rates in a greenhouse setting from what is considered relatively low, moderate, and high for NGI production. Plants were irrigated or fertigated by hand every 1 to 5 days as needed, based on environmental conditions and plant size, with either approximately 300 mL (10.4 oz) of either tap water or a fertilizer solution. SPAD readings, above ground plant weight, consumer preference ratings, and cumulative flower number were measured and used to calculate a quality index (QI). Optimal fertilizer rates as determined by the QI were found to be 1) CRF at 7.11 kg·m^{-3} (11.8 lb·yd^{-3}), 2) SBF at 150 mg·L^{-1} (150 ppm) N, and 3) WSF at 75 mg·L^{-1} (75 ppm) N. With the application method used in this work, the WSF was more efficient than the SBF because it produced high quality plants with less fertilizer applied. While for the most part overall consumer preference ratings coincided with plant dry weight, there were some exceptions, indicating that consumers can prefer plants that are not necessary the largest as indicated by their dry weights. Consumer preferences may not coincide with typical plant parameters of plant growth all the time. Consumer preferences should be always considered in an industry that sell its products based mainly on their appearance.

Index words: consumer preferences, controlled-release fertilizer, fertigation, plant nutrition, plant quality, soybean-based fertilizer, water-soluble fertilizer.

Species used in this study: New Guinea impatiens (*Impatiens hawkeri* Bull. 'Paradise New Red').

Significance to the Horticulture Industry

For growers, it is important to use the minimum amount of fertilizer that produces the most attractive, highest quality ornamental crops because of economic and environmental reasons. Most consumers buy ornamental crops based on appearance. To the best of our knowledge, this manuscript is the first to incorporate consumer preferences based on plant characteristics such as the vegetative aspect of the plant, the number of flowers, and the uniformity of plants to determine optimal fertilizer application rates. The three fertilizers used were able to produce quality plants but their optimal rates differed on how much nitrogen was required.

Introduction

New Guinea Impatiens are an important crop for the floriculture industry. While New Guinea impatiens (NGI) may be a significant source of income to growers, the issue of fertility management presents challenges. During crop establishment, NGI have shown sensitivity to soluble salts (Judd and Cox 1992), highlighting the importance of maintaining constant control over the amount of nutrients applied and the monitoring of substrate electrical conductivity (EC). Substrate EC should not exceed 2.6 dS·m^{-1} during production, and EC above 1.5 dS·m^{-1} has been shown to inhibit growth (Cavins et al. 2001, Judd and Cox 1992). Thus, fertilization rates are dictated based on substrate EC during production and inorganic water-soluble fertilizers (WSF) are often used to meet NGI nutritional requirements. However, other fertilizer types and application methods, such as controlled-release fertilizers (CRF), have been demonstrated to be effective for NGI production (Richards and Reed 2004). The issue of concern is the current inability of CRFs to match nutritional demands for some crops. Although CRFs may release nutrients over a period of time (Simonne and Huchinson 2005, Guertal 2009), they tend to have a peak of nutrients release a few weeks after application (Merhaut et al. 2006, Adams et al. 2013, Andiru et al. 2015). Furthermore, nutrient release from the CRF prills is temperature dependent (Adams et al. 2013).

Another fertilizer of interest in bedding plant production is a soybean-based fertilizer (SBF). In contrast to WSF, SBF contains a biologically derived component from an oilseed extract, and has been demonstrated to benefit petunia, vinca, pansy, and cyclamen production (Nelson et al. 2010). This fertilizer requires additional research of its efficacy in floriculture production in general and NGI in particular.

Most studies dealing with bedding plants determine ideal fertilization rates based solely on aspects of growth, such as height, dry weight, or leaf area (James and van Iersel 2001, Kang and van Iersel 2009, Kent and Reed 1996, Richards and Reed 2004). While growth is an essential element of plant quality, no studies have determined ideal rates also based on consumer opinion, as the consumer's decision determines whether or not a plant is purchased (Conover 1986). There are many aspects of plant quality that are not related to plant size that may be more important factors when consumers decide to purchase a plant. Such aspects of quality include overall health, the presence of flowers, lack of insect and disease damage, and crop uniformity (Conover 1986).

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The objectives of this study were to determine the effect of various rates of three different fertilizers on growth of New Guinea impatiens and to identify their respective optimal rates based on three plant growth characteristics and consumer preference (CP).

Materials and Methods

Substrate preparation. The substrate consisted of a 7:3 ratio of peat (Sunshine Peat Moss, SunGro Horticulture, Bellevue, WA) to perlite (Thermo-Rock East, Inc., New Eagle, PA) mixture (by vol) with no pre-plant nutrient charge. Pulverized carbonated lime was added to the mix at a rate of 3 kg·m^{-3} (5.1 lb·yd^{-1}) to adjust pH to the target range of 5.8 to 6.4. The substrate was hydrated by adding a solution of 11.2 ml of surfactant (AquaGro, Scotts Co., Marysville, OH) per liter of water (1.5 fl oz per gal). This solution was added to the substrate at a rate of 10 L·m^{-3} (2 gal per yd^{-3}). The substrate was prepared and stored in sterile plastic bags and left to stabilize for 24 h before use.

Crop selection and fertilizer treatments. Rooted cuttings of 'Paradise New Red' New Guinea impatiens (Ecke Ranch, Encinitas, CA) were transplanted into 700 cm^3 (11.4 cm diam) plastic containers. Three fertilizers were selected for application at four rates each with seven replications. Fertilizer treatments included a 20-4.4-16.6 WSF (Peters Professional 20-10-20, Everris International, Geldermalsen, The Netherlands), a liquid 10-1.8-2.5 SBF (Daniels 10-4-3, DP Foods, Sherman, TX), and a 15-4-10, 3- to 4-month longevity CRF (Osmocote 15-9-12, Everris International, Geldermalsen, The Netherlands). CRF was applied at 1×, 0.75×, and 0.5× the label rate, which resulted in the following rates: 7.11, 5.33, and 3.56 kg·m^{-3} (11.98, 9.98, and 6.0 lb·yd^{-3}), respectively. These CRF rates of application are in line with previous experiments using this type of fertilizer on NGI (Richards and Reed 2004, Vendrame et al. 2004). WSF and SBF fertigation rates of 75, 150, and 250 mg·L^{-1} N (75, 150, and 250 ppm N), respectively, were used based on a common range of fertigation rates in a greenhouse setting from what is considered relatively low, moderate, and high during NGI production (Hamrick 2003, Hartley 1995). The CRF was evenly top dressed on the surface of the substrate following transplanting of rooted cuttings. Fertigated treatments (SBF and WSF) were prepared immediately preceding irrigation events. Control plants had no fertilizer applied. Containers with plants were labeled and placed on a bench as a completely randomized design with seven replications in a greenhouse with a double-layer acrylic roof at temperature settings of 22 C (71.6 F) day and 18 C (64.4 F) night.

Irrigation, substrate, and crop monitoring. Plants were irrigated or fertigated by hand every 1 to 5 days as needed, based on environmental conditions and plant size, with either approximately 300 mL (10.4 oz) tap water or approximately 300 mL prepared fertilizer solution to allow the substrate to reach a target leaching fraction (LF) range of 0.2 to 0.3. EC measurements were taken using the pour-through nutrient extraction procedure (Cavins et al. 2000) at 9, 31, and 71 days after planting (DAP). Leachate EC and pH were measured using an EC/pH meter (Accumet Model AP85 pH/Conductivity meter, Fisher Scientific, Pittsburgh, PA) within two hours following collection. Once flowering began, flower number was recorded at 56, 63, 65, 70, 72, 77, 79, and 84 DAP and added to obtain a cumulative flower number (CFN). Only fully open, non-senescent flowers were recorded.

Consumer preference survey. Chadwick Arboretum volunteers, students, and staff of the Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH, were asked to evaluate plants shortly before harvest. These evaluations occurred at 76, 77, and 78 DAP. Before consumer preference evaluations, plants were organized by treatment and then treatments were completely randomized on a greenhouse bench. Survey participants were asked to evaluate plants in each treatment group based on four criteria: vegetative (foliage/plant vigor), flower number, and uniformity (the level of variation between plants in a given treatment). Participants were given a rating scale of 1 to 5 with 1 = poor or unacceptable, 2 = fair, 3= good, 4 = very good, and 5 = excellent. A total of 22 individuals anonymously participated in the survey.

Plant measurements. At harvest (84 DAP), SPAD chlorophyll measurements were taken using a SPAD-502 meter (Konica Minolta Sensing, Tokyo, Japan) by taking an average reading from three fully expanded leaves at the upper-most point of the plant. After obtaining SPAD readings, plants were cut at the crown directly above the substrate surface, placed in paper bags and located in a forced air oven (GS, Blue M Electric, Williamsport, PA) for 48 hours at 57 C (134.6 F) to measure above-ground plant dry weight (DW).

Quality indices. In order to determine ideal rates of fertilization based on all data obtained from the experiment, growth characteristics were transformed to a scale of 0 to 5 in order to equally represent a total quality index (QI) for each of the fertilizer treatments at the various rates. Four plant growth characteristics were used for this analysis: DW, CFN, SPAD, and overall consumer preference (CP). Measurements of each characteristic were transformed by dividing the rating for each plot by the maximum observed value for that fertilizer treatment and multiplying this quotient by five. By transforming these measurements, each was equally weighed in the calculation of the total QI (QI = CP + SPAD + CFN + DW) of each replicate, thus allowing for a QI that represented all four growth characteristics. QI were calculated to compare the rate response for each fertilizer type rather than to compare the rate response among different fertilizers.

Data analysis. PROC GLM of SAS Version 9.4 (SAS Institute, Cary, NC) was used for statistical analysis of DW, CFN, SPAD, CP, EC and pH across rates of fertilization. One-way ANOVA with polynomial contrasts was used to compare application rates within each fertilizer. In addition, Tukey's Honest Significant Difference (HSD) multiple comparisons were used to compare the results across application rates within fertilizers and across all combinations of fertilizer and rates. The format used for presentation of data in tables analyzed using polynomial contrasts was modeled from Bi et al. (2010).

Results and Discussion

Substrate pH and electrical conductivity. Substrate pH did not vary significantly with increasing rates of fertilization at 9, 31, and 71 DAP (Table 1). The pH usually remained within

Table 1. **Average pH and EC (dS·m⁻¹) from three collection dates (7, 31, and 71 DAP) measured using the pour-through extraction method. Plants were treated with varying rates of soybean-based fertilizer (SBF), controlled-release fertilizer (CRF), and water-soluble fertilizer (WSF). DAP = days after planting. Fertilizer rate response identified using significant quadratic (Q) or linear (L) polynomial contrasts. Tukey's Studentized Range Test (HSD) between all treatment groups for each DAP was performed. Means with the same letter are not significantly different. All the tests have been performed at α = 0.05 level of significance.**

		Days after planting					
		9		31		71	
Fertilizer	Application rate	pH	EC	pH	EC	pH	EC
Control	No fertilizer	5.1a	0.9e	5.4a	0.7d	5.4ab	0.9c
CRF	3.56 $kg \cdot m^{-3}$	5.3a	0.9e	5.7a	0.7d	5.5ab	0.6c
CRF	5.33 $kg \cdot m^{-3}$	5.5a	0.9e	6.1a	0.9d	5.9a	0.6c
CRF	7.11 $kg \cdot m^{-3}$	5.4a	1.1de	6.3a	1.4c	5.6ab	1.1c
SBF	75 $mg \cdot L^{-1}$ N	5.1a	1.3cd	5.5a	1.0cd	5.5ab	0.7c
SBF	150 $mg \cdot L^{-1}$ N	4.8a	1.5bc	5.1a	1.4c	5.1ab	0.9c
SBF	250 $mg \cdot L^{-1}$ N	5.1a	2.0a	5.3a	2.1b	5.3ab	1.0c
WSF	75 $mg \cdot L^{-1}$ N	4.6a	1.0de	5.0a	1.1cd	5.3ab	0.9c
WSF	150 $mg \cdot L^{-1}$ N	5.2a	1.3cd	5.4a	2.1b	5.1ab	2.1c
WSF	250 $mg \cdot L^{-1}$ N	5.1a	1.7ab	5.3a	3.4a	4.8b	4.9c
				Fertilizer rate response[z]			
CRF		NS	L***Q*	NS	L***Q*	NS	L***Q*
SBF		NS	L**	NS	L***	NS	NS
WSF		NS	L**	NS	L***	NS	L***Q***

[z]NS, *, **, or ***: non-significant or significant at p≤0.05, 0.01, or 0.001 respectively

or slightly below the recommended pH range of 5.4 to 6.5 for bedding plant production (Nelson 2003), especially near harvest (71 DAP). Substrate EC was significantly affected by increasing fertilization rate of all treatments at 9, 31, and 71 DAP, with the exception of SBF-treated substrate at 71 DAP. EC responded linearly and quadratically to CRF-treated substrate at 9, 31, and 71 DAP, as well as WSF-treated substrate at 71 DAP. EC of all other treatments responded linearly to increasing fertilization rate. In general, suggested substrate EC during NGI production is 1.0 to 2.6 $dS \cdot m^{-1}$ (Hamrick 2003, Hartley 1995). The EC for WSF-treated substrate at 250 $mg \cdot L^{-1}$ (250 ppm) N on 31 and 71 DAP was above the recommended EC range. Substrate EC decreased over time for SBF-treated substrates but notably increased for WSF-treated substrate at the 250 $mg \cdot L^{-1}$ (250 ppm) N rate, possibly due to continuous additions of nutrients during fertigation.

Consumer preference ratings. Consumer ratings of plant foliage and vegetative growth (vigor), flower number, uniformity, and overall ratings were significant across increasing fertilizer rates with the exception of flower number for SBF-treated plants (Table 2). Vegetative ratings responded linearly and quadratically to fertilizer rate in all treatments. Flower number ratings responded linearly with increased fertilization rates of CRF and WSF although with CRF the slope was negative. Consumer ratings for flower number of SBF-treated plants did not differ across rates. SBF, and WSF-treated plant uniformity ratings responded linearly to increased fertilization rate, while CRF responded quadratically, indicating that uniformity for CRF-treated plants has an optimum rate of application beyond which uniformity decreases. Overall CP ratings responded linearly to increased fertilization rate for SBF, and WSF, and quadratically for CRF. Overall ratings increased with increasing fertilization rate for SBF. The highest consumer preference was for plants treated with CRF at 3.56 and 7.11 $kg \cdot m^{-3}$ (11.98 $lb \cdot yd^{-3}$), SBF at 250 $mg \cdot L^{-1}$ (250 ppm) N, and WSF at 75 $mg \cdot L^{-1}$ (75 ppm) N.

Plant growth and flowering. Increasing fertilization rates resulted in higher SPAD readings and DW for CRF and SBF-treated plants (Table 3). SBF and WSF-treated plants tended to have higher SPAD readings than CRF-treated plants. SPAD readings responded linearly to increasing rates of WSF. DW responded linearly to increasing fertilizer rates with the exception of WSF-treated plants, for which it only responded quadratically. The response of CFN to increasing fertilizer rates was significant for SBF-treated plants; while CFN responded linearly only to SBF (Table 3). There were no differences in flowering with increasing CRF and WSF rates.

Optimal fertility rates. When differences were significant, the optimal rate for each fertilizer was determined based on the highest QI. In the case of WSF, because quality indices were not significantly different, the lowest rate of application was selected as optimal. Therefore, optimal rates for each fertilizer were: 7.11 $kg \cdot m^{-3}$ (11.98 $lb \cdot yd^{-3}$) for CRF, 150 $mg \cdot L^{-1}$ (150 ppm) N for SBF, and 75 $mg \cdot L^{-1}$ (75 ppm) N for WSF. The three QI selected were not significantly different (Table 3). However, it can be concluded that WSF is more efficient in providing nutrients than SBF because WSF produced high quality plants with less N applied.

SPAD readings are a useful representation of overall plant health. SPAD readings have been highly correlated with chlorophyll content, and thus N and micronutrient status of bedding plants (Smith et al. 2004). Higher SPAD readings (Table 3) were probably the result of higher N application rates. Foliage and vegetative ratings (Table 2) and SPAD readings (Table 3) were lower at lower N application rates, indicating that consumers recognized lower quality plants.

EC was an effective tool to indicate whether growth inhibition occurred due to excessive soluble salts in the substrate. While many treatments exceeded 1.5 $dS \cdot m^{-1}$, WSF at 250 $mg \cdot L^{-1}$ (250 ppm) N was the only treatment exceeding the maximum EC recommendation of 2.6 $dS \cdot m^{-1}$ for bedding

Table 2. **Average consumer preference ratings. Survey conducted 76, 77, and 78 DAP. Ratings of vegetative growth, flower number, and uniformity are based on a scale of 1-5, with 1 representing poor and 5 representing excellent. Overall ratings are a mean of the three aforementioned ratings. Fertilizer-rate response identified using significant quadratic (Q) or linear (L) polynomial contrasts. Tukey's Studentized Range Test (HSD) between all treatment groups for each consumer preference rating was performed. Tukey groupings (indicated by letters) are reported below. Means with the same letter are not significantly different. All the tests have been performed at α = 0.05 level of significance.**

		Consumer preference rating (1–5)			
Fertilizer	**Application rate**	**Vegetative**	**Flower number**	**Uniformity**	**Overall**
Control	No fertilizer	1.1f	1.2f	2.5c	1.6d
CRF	3.56 kg·m^{-3}	3.8bcd	3.95a	4.1ab	3.9a
CRF	5.33 kg·m^{-3}	2.9e	3.55abc	3.1bc	3.2bc
CRF	7.11 kg·m^{-3}	4.3abc	3.4abcd	3.9ab	3.9a
SBF	75 mg·L^{-1} N	3.1de	2.6de	3.2bc	3.0c
SBF	150 mg·L^{-1} N	4.3abc	2.7cde	3.7ab	3.6abc
SBF	250 mg·L^{-1} N	4.5a	3.0bcde	3.8ab	3.8ab
WSF	75 mg·L^{-1} N	4.4ab	3.8ab	4.3a	4.1a
WSF	150 mg·L^{-1} N	4.7a	2.9cde	4.0ab	3.9a
WSF	250 mg·L^{-1} N	3.6cd	2.1e	3.3abc	3.0c
		Fertilizer rate response			
CRF		L*Q***	L*	Q***	Q***
SBF		L***Q*	NS	L*	L***
WSF		L***Q***	L***	L***	L***

NS, *, **, or *** non-significant, or significant at p ≤ 0.05, 0.01, or 0.001 respectively

plants classified as 'light feeders,' based on the pour-through method (Cavins et al. 2000). Applying WSF at 250 mg·L^{-1} (250 ppm) N produced average EC values of 3.42 and 4.97 dS·m^{-1} at 31 and 71 DAP, respectively, explaining the significant growth suppression in comparison to the 150 mg·L^{-1} (150 ppm) N WSF treatment, which remained below 2.1 dS·m^{-1} (Table 1). Substrate EC values from CRF treatments indicate that nutrient release may have been fairly constant and did not result in excessive soluble salt buildup at a 0.2 to 0.3 LF, even at the 7.11 kg·m^{-3} rate. It has been demonstrated that substrate for NGI production does not exceed recommended EC levels when a CRF fertilizer is used during sub-irrigation (Richards and Reed 2004). Since NGI are light feeders, growth is affected by high EC.

In this experiment, SBF-treated plants grew more than WSF-treated plants at a rate of 250 mg·L^{-1} (250 ppm) N (Table 3). This difference in DW may have been the result of substrate EC being too high for WSF-treated plants (Table 1), resulting in stunting of growth. Consumers recognized differences in the overall rating parameter in these plants, as SBF plants at 250 mg·L^{-1} (250 ppm) N were significantly preferred to WSF plants at the same rate (Table 2).

Table 3. **Average consumer preference overall rating (CP), SPAD readings, cumulative flower number (CFN), plant dry weight (DW) (g), and total-quality index (QI). Plants were treated with varying rates of controlled release fertilizer (CRF), soybean-based fertilizer (SBF), and water-soluble fertilizer (WSF). TV represents the transformed values to a scale of 1 to 5 of the preceding (left to right) growth variables. Total QI is the sum of the TV values for all variables measured. Total QI highlighted in bold represent the highest QI obtained at the lowest rate of each fertilizer. Values are the mean of seven replications. Fertilizer- rate response identified using significant quadratic (Q) or linear (L) polynomial contrasts. Tukey's Studentized Range Test (HSD) between all treatment groups for each quality aspect was performed. Means with the same letter are not significantly different. All the tests have been performed at α = 0.05 level of significance.**

Fertilizer	**Application rate**	**Overall CP**	**SPAD**	**TV**	**CFN**	**TV**	**DW**	**TV**	**Total QI**
Control	No fertilizer	1.6d	24.6d	—	0.3b	—	1.8e	—	—
CRF	3.56 kg·m^{-3}	3.9a	53.5c	3.7	23.6a	2.4	9.6d	3.4	13.5bc
CRF	5.33 kg·m^{-3}	3.2bc	56.5c	3.9	24.0a	2.4	10.0d	3.6	13.1dc
CRF	7.11 kg·m^{-3}	3.9a	67.9b	4.7	28.0a	2.9	12.6bc	4.5	**15.3**ab
SBF	75 mg·L^{-1} N	3.0c	56.7c	3.6	12.3ab	1.5	11.1dc	2.5	10.5d
SBF	150 mg·L^{-1} N	3.6abc	68.7b	4.3	24.1a	2.9	17.6a	4.0	**14.7**abc
SBF	250 mg·L^{-1} N	3.8ab	73.3ab	4.6	26.6a	3.2	19.0a	4.3	15.8abc
WSF	75 mg·L^{-1} N	4.1a	67.4b	4.1	22.1a	2.8	14.1b	3.7	**14.7**abc
WSF	150 mg·L^{-1} N	3.9a	73.1ab	4.5	29.1a	3.6	16.7a	4.3	16.3a
WSF	250 mg·L^{-1} N	3.0c	78.8a	4.8	24.0a	3.0	12.6bc	3.3	14.1abc
					Fertilizer rate response				
CRF		Q***	L***Q*		NS		L***		
SBF		L***	L***Q*		L*		L***Q***		
WSF		L***	L***		NS		Q**		

NS, *, **, or *** non-significant, or significant at p ≤ 0.05, 0.01, or 0.001 respectively

These findings may be explained by how the biologically derived component in SBF reacts when it is added to the substrate, possibly acting as a 'slow-release' fertilizer (Nelson, P.V., North Carolina State University, personal communication). This fertilizer contains nutrients that must undergo conversion to either a nitrate (organic N, 0.75%) or ammonium form (urea, 3.65%) to become available. As hypothesized in Nelson et al. (2010), the presence of a biologically derived component and urea-form N may explain the lower EC of SBF-treated substrate. Consequently, there may have been more N available in SBF-treated plants during the latter part of the experiment when plant uptake was the highest.

Optimal fertility rates for CRF and WSF determined in this research were generally within accepted ranges for NGI production using fertilizers currently on the market (Hamrick 2003, Hartley 1995). Previous research has identified CRF as producing quality NGI plants at or above our ideal rate of 7.11 $kg \cdot m^{-3}$ (11.98 $lb \cdot yd^{-3}$) (Richards and Reed 2004). The determined ideal rate of WSF, 75 $mg \cdot L^{-1}$ (75 ppm) N, was the result of no significant differences in overall quality between rates. SBF-treated plants at 75 $mg \cdot L^{-1}$ (75 ppm) N had noticeable symptoms of chlorosis, explaining why these rates resulted in significantly lower QI, due to a reduction in CP (Table 2), DW and SPAD (Table 3).

This study provides consumer preference data that, to the best of our knowledge, has not been previously used to evaluate the effects of different fertilizer types at varying rates on plant quality. While for the most part overall CP ratings coincided with DWs, there were some exceptions, indicating that consumers can prefer plants that are not necessary the largest as indicated by their DWs. For example, higher rates of CRF produced higher DWs but consumers gave the same CP rating to the plants grown at the lowest and the highest application rates (Table 3). Similarly, the highest CP rating given to plants grown with the lowest WSF application rate did not produce the plants with the highest DW. This is an indication that CP may or may not coincide with typical plant parameters of plant growth. In an industry where consumers buy products mainly on how they look, CP should be a factor in the decision process of cultural practices. It should be noted that while consumer preference ratings in this experiment are useful, they are not necessarily representative of the entire population of consumers due to the small sampling size, single geographical location, etc. This rating system could be further developed and used in the future with a larger population size to more precisely identify treatment differences among plants. In addition, future studies should be conducted in order to determine the minimum consumer preference ratings required to produce marketable plants for sale. While plant characteristics such as dry weight, SPAD readings, number of flowers, etc. are typically used to determine plant quality, ornamental plants are sold for their beauty as determined by consumers. Integrating measurable plant quality parameters with consumer preferences may be the way of the future.

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