Preliminary and Regional Reports

Effects of Nitrogen Fertilization Rate on Aesthetic Quality of Landscape-grown Annuals and Perennials

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SUMMARY. Recent research suggested that the nitrogen (N) fertilizer rates needed to maintain high-quality landscape plants was lower than rates needed to grow the largest size plants. Our objective was to evaluate the effect of N fertilizer rate on the aesthetic quality of various landscape-grown annual and perennials species. Nineteen cool-season annuals, 20 warm-season annuals, and 4 perennials were planted into raised beds containing subsoil fill material in a completely randomized design in west-central Florida (U.S. Department of Agriculture hardiness zone 9b). Plants were fertilized every 12 weeks with polymer coated, slow-release N (42N-0P-0K) fertilizer at annual N rate of 3, 5, or 7 lb/1000 ft² (annuals) or 1, 3, or 5 lb/1000 ft² (perennials). Plants were rated for aesthetic quality every 6 weeks for a period of 18 weeks (annuals) or 54 weeks (perennials). For most species, quality ratings of plants fertilized with 3 lb/1000 ft² of N per year (annuals) or 1 lb/1000 ft² of N per year (perennials) were not significantly lower than plants receiving higher rates of N annually. Previously reported N fertilizer recommendations for central Florida of 2 to 4 lb/1000 ft² per year should be adequate for maintaining acceptable quality landscape-grown annual and herbaceous perennial plant species.

Between 40% and 60% of nitrogen that is applied to plants in fertilizers is actually taken up by plant roots; the remainder stays in the soil or moves offsite via leaching, runoff, or volatilization (Matson et al., 1997). Therefore, efficient application of fertilizers is necessary to prevent losses of N to the environment (Latimer et al., 1996). Careful management of fertilizer application rate, timing, and method of application is required to ensure that fertilizer application does not exceed the specific N requirements of growing plants (Line et al., 2002). Both homeowners and

landscape professionals can contribute to the improvement of water quality by fertilizing landscapes at the minimum required levels for healthy, attractive plants. However,

few studies evaluated how much fertilizer is needed to maintain aesthetically pleasing plants in the landscape (Shurberg et al., 2012a, b).

The University of Florida-Institute of Food and Agricultural Sciences (UF-IFAS) Florida Friendly Landscaping™ Program (FFL) provides general fertilizer recommendations for ornamental landscape plants ranging from 0 to 6 lb/1000 ft² of N (FFL, 2009). Shurberg et al. (2012a, b) evaluated the growth and quality of a limited number of annual and perennial species in central Florida with N applications of 0–12 lb/1000 ft². They suggested that attractive annual and perennial ornamental plant species could be maintained in the Florida landscape with relatively low N inputs (2 to 4 lb/1000 ft² for annuals and 4 to 6 lb/1000 ft² for perennials), provided the goal was to produce high-quality plants rather than plants of maximum size. However, the research was limited to the evaluation of the plant quality response to N fertilizer rate for only a few species of annual and perennial landscape plants. Screening of additional plants is necessary to determine if N fertilizer rates recommended by Shurberg et al. (2012a, b) can be applied broadly to other landscape-grown annual and perennial ornamental species in Florida. The objective of this study was to evaluate the quality response of a broad spectrum of landscape annuals and perennials to N fertilizer applied at three rates to confirm that high-quality plants can be produced at N rates recommended by Shurberg et al. (2012a, b).

Materials and methods

PLANT MATERIAL. A total of 35 annual (cool- and warm-season) annuals species were selected for validation of N recommendations over two growing seasons (Table 1). In addition, ‘Montego Yellow’ or ‘Montego Purple’ snapdragon (*Antirrhinum majus*)

Units			
To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.3048	ft	m	3.2808
3.7854	gal	L	0.2642
0.4075	gal/100 ft ²	L·m ⁻²	2.4542
2.54	inch(es)	cm	0.3937
48.8243	lb/1000 ft ²	kg·ha ⁻¹	0.0205
1	ppm	mg·L ⁻¹	1
(°F – 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32

and 'Profusion Cherry' zinnia (*Zinnia elegans* × *angustifolia*), which are cool- and warm-season annual species evaluated previously by Shurberg et al. (2012b), were planted as reference species in both years to ensure a consistent quality response to the N fertilizer rates across studies. Annual plant species were received as plugs from Knox Nursery (Winter Garden, FL), as seed from Park Seed (Greenwood, SC) or Harris Seed (Rochester, NY), or in 4-inch pots from American Farms (Naples, FL). Cool- and warm-season plugs and seeds were grown in 4-inch azalea pots (Reb Plastic Inc., Orlando, FL) for ≈6 (plugs) or 8 weeks (seed) before transplanting into raised beds, to ensure that all plants were of comparable size at transplanting. To maximize consistency in N contributions during rearing, annual species were fertilized with a liquid 21N–3.15P–5.8K acid special fertilizer (Peter's Professional®; Everris NA, Dublin, OH) at an N rate of 100 ppm twice per week for 1 week, then at an N rate of 200 ppm twice weekly until transplanting.

Three herbaceous perennials [blanket flower (*Gaillardia pulchella*), goldenrod (*Solidago chapmanii*), and mondo grass (*Ophiopogon japonicus*)] were also selected for validation of N rate recommendations. 'Mystic Spires' salvia (*Salvia*

longispicata × *farinacea*) was evaluated previously by Shurberg et al. (2012a) and was planted as a reference species to ensure a consistent quality response to the N fertilizer rates across studies. All perennial species were received in 1-gallon containers; blanket flower and goldenrod were received from Sweetbay Nursery (Parrish, FL); mondo grass and salvia were received from Landscape Flower Growers, Inc. (Riverview, FL).

EXPERIMENTAL DESIGN. Raised beds (10 × 50 × 0.5 ft) containing subsoil fill material (St. John's fine sand, Sandy, siliceous, hyperthermic Typic Alaquods) [U.S. Department of Agriculture (USDA), 2004] were constructed at the UF-IFAS Gulf Coast Research and Education Center in Wimauma, FL (USDA hardiness zone 9b). An initial sample of soil fill was analyzed for pH and soil nutrient content before transplanting as reported previously in our studies comparing annual and perennial growth to N fertilization under similar growing conditions in central Florida (Shurberg et al., 2012a, b). Sixteen annual plants of each species were planted in a square configuration (four plant species × four replicate plants spaced 1 ft apart) in a total of nine raised beds (plots). Cool-season annuals species were planted into raised beds on 29 Oct. 2010 (year 1) and 6 Dec. 2011 (year 2). Warm-season annual species were planted into raised beds on 25 May 2011 (year 1) and 3 May 2012 (year 2). Fifteen herbaceous perennial plants of each species were planted in a rectangle configuration (five plant species × three plant replicates spaced 1 ft apart) in the remaining area within the same nine plots on 4 Mar. 2011.

Irrigation was applied through nine drip lines (Jain Irrigation, Winter Haven, FL) installed on 1-ft spacing with 8-inch spacing between emitters and a flow rate of 0.65 gal/100 ft² per minute. Plants were irrigated for 25 min, three times per week starting at 0830 HR. Cumulative rainfall was 82.6 inches from May 2010 to Apr. 2012 with average temperatures ranging from 51 to 81 °F, maximum temperatures of 96 °F, and minimum temperatures of 22 °F (University of Florida, 2014). Weeds were manually removed or treated with

glyphosate (Round-Up®; Monsanto, Creve Coeur, MO) as needed. No mulch was added to beds to minimize outside N contributions. All plant species were fertilized at three different N rates, not to exceed current recommendations for landscape fertilization (Florida Department of Environmental Protection, 2002). Plants were fertilized every 12 weeks (based on the release rate of the fertilizer published by the manufacturer) with a 42N–0P–0K polymer-coated, controlled-release N source (Polyon; Harrell's, Lakeland, FL) at the following annual N rates: 3, 5, or 7 lb/1000 ft² (annuals) and 1, 3, or 5 lb/1000 ft² (perennials).

PLANT AESTHETIC QUALITY RATINGS. Aesthetic quality ratings (0–5), which considered canopy density, canopy dieback, flowers, and general form, were assigned every 6 weeks to the middle plants (four annuals and three perennials) from each planting to avoid potential edge effects. Quality ratings were applied on the following scale: 0 = dead, 1 = poor (low canopy density, few to no flowers, and/or substantial chlorosis), 2 = below average (significant dieback or chlorosis, lower density, and flowering), 3 = average or acceptable (moderate dieback, limited chlorosis, adequate form and flowering), 4 = above average (minimal dieback, healthy plant, above average density and form), and 5 = outstanding (dense leaf canopy, high-quality flowers, no nutrient deficiencies or dieback) (Shober et al., 2009). Annual species were evaluated for 18 weeks and perennial species were evaluated for 54 weeks.

STATISTICAL ANALYSIS. The experiments were designed as a completely randomized design, with N rates applied randomly over nine raised bed plots containing either four (annuals) or three (perennials) plants of each species per bed. Each plant type (cool-season annuals, warm-season annuals, herbaceous perennials) and species was evaluated separately. Plant aesthetic quality data for all plant species was analyzed using PROC GLIMMIX (SAS version 9.2; SAS Institute, Cary, NC) by species and weeks after planting (WAP), with N rate as a fixed effect. Plant cluster × treatment was included as a random effect using a normal distribution and an identity link function. No planting

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Table 1. Common name, scientific name, cultivar, and source of cool and warm-season annual plant materials used to evaluate aesthetic quality response to nitrogen (N) fertilizer rate for landscape-grown plants in west-central Florida (U.S. Department of Agriculture hardiness zone 9b).

Plant type and planting date	Common name	Scientific name	Cultivar	Source ^z
Cool-season annuals				
29 Oct. 2010				
	Alyssum	<i>Lobularia maritima</i>	N/A ^y	Knox nursery
	Dahlberg daisy	<i>Thymophylla tenuiloba</i>	N/A	Knox nursery
	Geranium	<i>Pelargonium ×hortorum</i>	Survivor Hot Pink	American Nursery
	Gomphrena	<i>Gomphrena globosa</i>	N/A	Knox nursery
	Impatiens	<i>Impatiens walleriana</i>	Super Elfin Bright Orange	American nursery
	Linaria	<i>Linaria</i> sp.	Enchantment	Knox nursery
	Petunia	<i>Petunia ×hybrida</i>	Plush Salmon	Knox nursery
	Phlox	<i>Phlox drummondii</i>	21st Century Scarlet	Knox nursery
	Wax begonia	<i>Begonia ×semperflorens-cultorum</i>	Bada Bing White	American nursery
6 Dec. 2011				
	Flowering cabbage	<i>Brassica oleracea</i>	Pigeon Purple	Harris seed
	Foxglove	<i>Digitalis purpurea</i>	Camelot Lavender	Park seed
	Gypsophila	<i>Gypsophila muralis</i>	Gypsy Deep Rose	Harris seed
	Ornamental kale	<i>Brassica oleracea</i>	Kamome White	American farms
	Nasturtium	<i>Tropaeolum nanum</i>	Princess of India	Harris seed
	Shasta daisy	<i>Leucanthemum ×superbum</i>	White Breeze	Park seed
	Statice	<i>Limonium sinuatum</i>	Fortress Dark Blue	Harris seed
	Viola	<i>Viola cornuta</i>	Penny Blue	Knox nursery
Reference species ^x	Snapdragon	<i>Antirrhinum majus</i>	Montego Yellow; Montego Purple	Knox nursery
Warm-season annuals				
25 May 2011				
	Ageratum	<i>Ageratum houstonianum</i>	Blue Puffs Improved (Blue Danube)	Knox nursery
	Cosmos	<i>Cosmos sulphureus</i>	Cosmic Mix; Cosmic Orange	Knox nursery
	Dusty miller	<i>Senecio cineraria</i>	Silverdust	Knox nursery
	Lobelia	<i>Lobelia erinus</i>	Riverine Sky Blue	Knox nursery
	Marigold	<i>Tagetes patula</i>	Bonanza Orange	Knox nursery
	Moss rose	<i>Portulaca grandiflora</i>	Sundial Yellow	Knox nursery
	Nicotiana	<i>Nicotiana alata</i>	Saratoga Red	Knox nursery
	Salvia	<i>Salvia splendens</i>	Vista Red	Knox nursery
	Torenia	<i>Torenia fournieri</i>	Crown Plum	Knox nursery
3 May 2012				
	African daisy	<i>Osteospermum asti</i>	Lavender Shades™	Park seed
	Angelonia	<i>Angelonia angustifolia serena</i>	Lavender Pink™	Park seed
	Balloon flower	<i>Platycodon grandiflorus</i>	Komachi	Park seed
	Celosia	<i>Celosia spicata</i>	Spiky Purple	Harris seed
	Gazania	<i>Gazania splendens</i>	Kiss Orange Flame	Harris seed
	Lavender	<i>Lavandula angustifolia</i>	Lavender Lady	Park seed
	Nierembergia	<i>Nierembergia hippomanica</i>	White Robe	Harris seed
	Ornamental basil	<i>Ocimum basilicum</i>	Cardinal Organic	Harris seed
	Ornamental pepper	<i>Capsicum annuum</i>	Medusa	Harris seed
Reference species	Zinnia	<i>Zinnia elegans ×angustifolia</i>	Profusion cherry	Knox nursery

^zReceived as plugs from Knox Nursery (Winter Garden, FL), as seeds from Park Seed (Greenwood, SC) or from Harris Seed (Rochester, NY), or in 4-inch (10.2 cm) pots from American Farms (Naples, FL).

^yN/A indicates no plant cultivar.

^xReference species indicates species that were also evaluated by Shurberg et al. (2012a, b).

year × N rate interaction was noted for annuals reference-species quality; therefore quality data from both years were combined for analysis.

Pairwise comparisons for aesthetic quality were conducted with the Tukey's honestly significant difference test at a significance level of

$\alpha = 0.05$. Data were checked for normality by examining histogram and normality plots of the conditional residuals.

Results and discussion

COOL-ANDWARM-SEASON ANNUALS.

Previous research at the central Florida experiment location evaluated the growth responses of cool and warm-season annuals to N fertilizer rate (Shurberg et al., 2012b). However, the goal of this research was to validate the suggested N fertilization rates to maintain acceptable quality cool and warm-season annuals. Aesthetic quality snapdragon, foxglove (*Digitalis purpurea*), and kale (*Brassica oleracea*) were affected by fertilizer rate (Table 2). Higher quality ratings were assigned to snapdragon receiving 7 lb/1000 ft² per year N compared with plants receiving 3 or 5 lb/1000 ft² N per year at 6 WAP and 3 lb/1000 ft² N per year 12 WAP. However, snapdragon consistently received quality ratings of 3 or greater (all weeks in both years) regardless of N fertilizer rate (Table 2). At 6 WAP, foxglove had higher quality when fertilized with N at the 7 lb/1000 ft² per year rate compared with plants that received N at an annual rate of 3 lb/1000 ft². However, no further fertilizer rate effects were noted for foxglove quality; all fertilizer rates produced foxglove plants with a quality rating of 3 or greater (Table 2). Aesthetic quality of kale was greater when plants were fertilized with N at an annual rate of 5 and 7 lb/1000 ft² at 12 WAP and 7 lb/1000 ft² at 18 WAP than when plants received only 3 lb/1000 ft² per year N (Table 2). There were no effects of N rate on aesthetic quality for any other cool-season annual species. Aesthetic quality ratings for cool-season annual receiving 3 lb/1000 ft² N per year ranged from 0.0 to 4.8 (Table 2). The quality of several cool-season annual species at 18 WAP [e.g., gypsophila (*Gypsophila muralis*), impatiens (*Impatiens wallerana*), ornamental kale, linaria (*Linaria* sp.), nasturtium (*Tropaeolum nanum*), and statice (*Limonium sinuatum*)] was below average, regardless of N fertilizer rates; all gomphrena (*Gomphrena globosa*) were dead by 12 WAP (Table 2). We suspect that environmental conditions, cultivar selection, or plant age may have impacted growth. Nitrogen fertilizer rate did not appear to be the major contributing factor to the low quality or death of these cool-season annual species.

Table 2. Plant quality response of selected landscape-grown cool season annual species to nitrogen (N) rate in 2 years in west-central Florida (U.S. Department of Agriculture hardiness zone 9b).

Species and fertilizer N rate (lb/1000 ft ²) ^z	Plant aesthetic quality (0–5 scale) ^y		
	6 WAP ^x	12 WAP	18 WAP
Alyssum			
3	2.9 a ^w	3.6 a	3.2 a
5	3.6 a	3.8 a	3.6 a
7	3.6 a	3.8 a	3.3 a
‘Bada Bing White’ begonia			
3	— ^v	2.9 a	3.4 a
5	—	3.5 a	3.8 a
7	—	3.4 a	4.3 a
Dahlberg daisy			
3	3.0 a	2.6 a	3.4 a
5	3.3 a	2.9 a	3.9 a
7	3.6 a	3.4 a	3.7 a
‘Camelot Lavender’ foxglove			
3	3.7 b	3.5 a	3.3 a
5	3.9 ab	3.8 a	3.8 a
7	4.0 a	4.1 a	4.2 a
‘Pigeon Purple’ flowering cabbage			
3	4.6 a	3.8 a	3.2 a
5	4.3 a	4.0 a	3.1 a
7	4.8 a	4.3 a	3.3 a
‘Survivor Hot Pink’ geranium			
3	1.9 a	3.1 a	2.8 a
5	1.9 a	3.3 a	3.2 a
7	2.3 a	3.7 a	3.5 a
Gomphrena			
3	3.8 a	0.0 a	0.0 a
5	3.9 a	0.0 a	0.0 a
7	3.9 a	0.0 a	0.0 a
‘Gypsy Deep Rose’ gypsophila			
3	4.8 a	4.1 a	2.6 a
5	4.9 a	4.5 a	2.2 a
7	4.8 a	4.3 a	2.2 a
‘Super Elfin Bright Orange’ impatiens			
3	—	2.5 a	2.5 a
5	—	3.2 a	2.5 a
7	—	2.2 a	2.1 a
‘Enchantment’ linaria			
3	3.5 a	3.7 a	2.6 a
5	3.8 a	3.8 a	2.8 a
7	4.0 a	3.9 a	2.6 a
‘Princess of India’ nasturtium			
3	3.5 a	2.6 a	1.6 a
5	3.7 a	3.1 a	2.0 a
7	4.1 a	2.8 a	1.6 a
‘Kamome White’ ornamental kale			
3	3.9 a	2.3 b	2.1 a
5	3.9 a	2.9 a	2.6 a
7	4.3 a	2.9 a	2.3 a
‘Plush Salmon’ petunia			
3	2.7 a	2.8 a	2.8 a
5	3.4 a	2.3 a	2.9 a
7	3.5 a	3.5 a	3.3 a
‘21st Century Scarlet’ phlox			
3	3.0 a	3.1 a	2.8 a
5	3.3 a	4.3 a	3.8 a
7	3.7 a	4.1 a	3.3 a

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Table 2. (Continued) Plant quality response of selected landscape-grown cool season annual species to nitrogen (N) rate in 2 years in west-central Florida (U.S. Department of Agriculture hardiness zone 9b).

Species and fertilizer N rate (lb/1000 ft ²) ^z	Plant aesthetic quality (0–5 scale) ^y		
	6 WAP ^x	12 WAP	18 WAP
‘White Breeze’ shasta daisy			
3	3.6 a	2.9 a	3.2 a
5	4.0 a	3.2 a	3.6 a
7	3.9 a	3.5 a	3.3 a
‘Montego Yellow’/‘Montego Purple’ snapdragon			
3	3.3 b	3.1 b	3.2 a
5	3.3 b	3.6 ab	3.8 a
7	4.1 a	3.8 a	3.9 a
‘Fortress Dark Blue’ statice			
3	3.0 a	2.5 a	2.1 a
5	3.0 a	2.6 a	2.3 a
7	3.0 a	2.3 a	1.7 a
‘Penny Blue’ viola			
3	3.5 a	3.1 a	2.6 a
5	3.7 a	3.6 a	3.6 a
7	3.6 a	3.6 a	2.7 a

^z1 lb/1000 ft² = 48.8243 kg·ha⁻¹.

^y0 = dead plant; 5 = outstanding plant quality (dense leaf canopy, high-quality flowers, and no nutrient deficiencies or dieback).

^xWeeks after planting.

^yMean separation for each species and WAP by Tukey’s honestly significant difference test at $P < 0.05$.

^zData not available.

Table 3. Plant quality response of selected landscape-grown warm-season annual species to nitrogen (N) rate in 2 years in west-central Florida (U.S. Department of Agriculture hardiness zone 9b).

Species and fertilizer N rate (lb/1000 ft ²) ^z	Plant aesthetic quality (0–5 scale) ^y		
	6 WAP ^x	12 WAP	18 WAP
‘Lavender Shades’ TM african daisy			
3	3.8 a	3.3 a	3.1 a
5	3.9 a	3.9 a	3.2 a
7	3.8 a	3.8 a	3.0 a
‘Blue Puffs Improved (Blue Danube)’ ageratum			
3	2.6 a ^w	1.4 a	1.5 a
5	3.1 a	1.2 a	1.8 a
7	2.8 a	2.3 a	2.3 a
‘Lavender Pink’ TM angelonia			
3	4.6 a	3.3 a	4.8 a
5	4.5 a	3.5 a	5.0 a
7	4.7 a	4.2 a	5.0 a
‘Komachi’ balloon flower			
3	3.8 a	3.2 a	2.1 a
5	3.9 a	2.9 a	2.2 a
7	4.2 a	2.9 a	2.0 a
‘Spiky Purple’ celosia			
3	2.9 a	0.0 a	0.0 a
5	3.0 a	0.0 a	0.0 a
7	2.8 a	0.0 a	0.0 a
‘Cosmic Mix’/‘Cosmic Orange’ cosmos			
3	1.7 a	0.0 a	0.0 a
5	1.7 a	0.0 a	0.0 a
7	1.2 a	0.0 a	0.0 a

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Nitrogen fertilizer rates did not affect the aesthetic quality of warm-season annual species, with the exception of ornamental basil (*Ocimum basilicum*) (Table 3). Ornamental basil produced higher quality plants when supplied with N at the annual rate of 5 lb/1000 ft² compared with plants receiving the 3 lb/1000 ft² annual N rate at 6 WAP or the 7 lb/1000 ft² annual N rate at 12 WAP. However, aesthetic quality of ornamental basil was unaffected by N rate at 18 WAP. Warm-season annual quality ratings ranged from 0.0 to 4.7 when plants were fertilized at the 3 lb/1000 ft² annual N rate. The quality of several species [e.g., celosia, (*Celosia spicata*), cosmos (*Cosmos sulphureus*), lavender (*Lavandula angustifolia*), nicotiana (*Nicotiana glauca*), nierembergia (*Nierembergia hippomanica*), and salvia (*Salvia splendens*)] was below average (or plants were dead) toward the end of the evaluation period, regardless of N fertilizer rates (Table 3). We suspect that other factors, such as species selection, growing environment, or plant age, contributed to the low quality or death of these warm-season annual species.

Wright et al. (2009) reported that growth and dry weight of four annual landscape plants [‘Cocktail Vodka’ begonia (*Begonia xsemperflorens-cultorum*), ‘Red Hot Sally’ salvia, ‘Bonanza Yellow’ marigold (*Tagetes erecta*), and ‘Cooler Pink’ vinca (*Catharanthus roseus*)] increased as N fertilizer rate increased from 0 to 2 lb/1000 ft² N per year; but, the authors reported no effect of N rate on aesthetic quality. However, their study was conducted in Virginia and may not be directly comparable to central Florida. Shurberg et al. (2012b) reported that the application of >8 lb/1000 ft² of N annually in central Florida was required to maximize size index and dry biomass of six species of annual landscape plants [‘Profusion Cherry’ zinnia, ‘Cora White’ vinca, ‘Golden Globe’ melampodium (*Melampodium divaricatum*), ‘Telstar Crimson’ dianthus (*Dianthus chinensis*), ‘Delta Pure Violet’ pansy (*Viola wittrockiana*), and ‘Montego Yellow’ snapdragon]; however, acceptable aesthetic quality was achieved with much lower N rates of (2 to 6 lb/1000 ft² N per year), depending on species.

PERENNIALS. As reported for the annual species, the aesthetic quality

Table 3. (*Continued*) Plant quality response of selected landscape-grown warm-season annual species to nitrogen (N) rate in 2 years in west-central Florida (U.S. Department of Agriculture hardiness zone 9b).

Species and fertilizer N rate (lb/1000 ft ²) ^z	Plant aesthetic quality (0–5 scale) ^y		
	6 WAP ^x	12 WAP	18 WAP
'Silverdust' dusty miller			
3	4.7 a	4.0 a	4.0 a
5	4.3 a	3.5 a	3.8 a
7	4.5 a	3.8 a	3.6 a
'Kiss Orange Flame' gazania			
3	3.1 a	2.4 a	1.9 a
5	4.0 a	3.1 a	1.9 a
7	3.8 a	2.7 a	2.3 a
'Lavender Lady' lavender			
3	3.3 a	1.2 a	0.0 a
5	3.8 a	1.6 a	0.9 a
7	3.6 a	2.1 a	1.2 a
'Riverine Sky Blue' lobelia			
3	2.6 a	1.2 a	0.0 a
5	2.8 a	1.5 a	0.0 a
7	2.6 a	0.8 a	0.0 a
'Bonanza Orange' marigold			
3	3.6 a	1.2 a	1.5 a
5	3.4 a	1.0 a	1.5 a
7	3.7 a	1.1 a	1.7 a
'Sundial Yellow' moss rose			
3	2.8 a	1.4 a	2.3 a
5	3.3 a	1.6 a	2.5 a
7	3.6 a	2.6 a	2.5 a
'Saratoga Red' nicotiana			
3	2.0 a	0.0 a	0.0 a
5	2.3 a	0.0 a	0.0 a
7	1.7 a	0.0 a	0.0 a
'White Robe' nierembergia			
3	3.3 a	2.1 a	1.5 a
5	3.4 a	1.8 a	0.6 a
7	3.5 a	2.3 a	1.3 a
'Cardinal Organic' ornamental basil			
3	3.3 b	2.9 ab	2.7 a
5	4.2 a	3.1 a	2.6 a
7	3.9 ab	2.8 b	2.6 a
'Medusa' ornamental pepper			
3	3.8 a	2.2 a	1.8 a
5	4.0 a	1.8 a	1.5 a
7	4.0 a	1.7 a	1.7 a
'Vista Red' salvia			
3	2.3 a	0.6 a	0.0 a
5	2.5 a	0.5 a	0.0 a
7	2. a	0.8 a	0.0 a
'Crown Plum' torenia			
3	3.2 a	2.5 a	2.3 a
5	3.2 a	2.7 a	2.8 a
7	3.0 a	2.3 a	1.8 a
'Profusion Cherry' zinnia			
3	3.8 a	2.2 a	2.3 a
5	3.8 a	2.1 a	2.7 a
7	3.8 a	2.2 a	2.6 a

^z1 lb/1000 ft² = 48.8243 kg·ha⁻¹.

^y0 = dead plant; 5 = outstanding plant quality (dense leaf canopy, high-quality flowers, and no nutrient deficiencies or dieback).

^xWeeks after planting.

^wMean separation for each species and WAP by Tukey's honestly significant difference test at $P < 0.05$.

ratings of few perennial species were affected by N rate (Table 4). Again the goal was to validate N fertilizer rates determined in previous work by Shurberg et al. (2012a) on perennial plant growth to N fertilization rate. Differences in the aesthetic quality of perennial species due to N rate treatments were limited to blanket flower (18 WAP) and salvia [54 WAP (Table 4)]. Higher quality blanket flower and salvia plants were produced when plants received 3 or 5 lb/1000 ft² N annually compared with plants fertilized with N at the 1 lb/1000 ft² per year rate (Table 4).

Chen et al. (2011) reported that application of N fertilizer improved both growth and visual quality of six perennial landscape species in Louisiana up to a rate of 2 lb/1000 ft² N per year. Nitrogen fertilizer supplied at the higher rate of 4 lb/1000 ft² N per year continued to push growth of cigar plant (*Cuphea ignea*), 'New Gold' lantana (*Lantana × hybrid*), and 'Goldsturm' rudbeckia (*Rudbeckia fulgida*), but did not affect visual quality. However, results might vary in central Florida. Shurberg et al. (2012a) found that higher rates of N fertilization in Florida (>8 lb/1000 ft² N per year) could increase growth of five perennial landscape species [bush daisy (*Gamolepis chrysanthemoides*), 'New Gold' lantana and 'Mystic Spires' salvia, 'Evergreen Giant' liriopse (*Liriope muscari*), and 'White Christmas' caladium (*Caladium bicolor*)], but that acceptable aesthetic quality was achieved at low rates of 0 to 4 lb/1000 ft² N per year, depending on species.

Conclusions

While the aesthetic quality of some evaluated landscape-grown annual and perennial species did respond to higher fertilizer rates, our results showed that application of a controlled-release fertilizer at an N rate of 1 lb/1000 ft² annually (perennials) to 3 lb/1000 ft² annually (annuals) was adequate to sustain acceptable quality for most species. Increasing N fertilizer rate did not improve plant quality for species with quality ratings that were less than acceptable (<3), suggesting that other factors (e.g., environment, species selection, or plant age) other than N fertilization might have affected plant quality. Based on these results, we suggest that an N

Table 4. Plant quality response of selected landscape-grown herbaceous perennial species planted 4 Mar. 2011 to nitrogen (N) rate in 2 years in west-central Florida (U.S. Department of Agriculture hardiness zone 9b).

WAP and fertilizer N rate (lb/1000 ft ²) ^z	Plant aesthetic quality (0–5 scale) ^y			
	Blanket flower	Goldenrod	Mondo grass	‘Mystic Spires’ Salvia
6 WAP				
1	3.6 a ^x	3.2 a	3.4 a	3.7 a
3	3.9 a	3.2 a	3.4 a	3.8 a
5	3.8 a	3.1 a	3.3 a	4.3 a
12 WAP				
1	2.9 a	2.9 a	3.2 a	2.6 a
3	3.2 a	3.1 a	3.2 a	2.9 a
5	3.0 a	3.3 a	2.9 a	3.1 a
18 WAP				
1	3.5 b	2.8 a	2.2 a	2.8 a
3	3.6 a	3.0 a	2.2 a	3.1 a
5	4.0 a	3.1 a	1.8 a	3.2 a
24 WAP				
1	— ^w	3.6 a	2.4 a	2.9 a
3	—	4.0 a	2.3 a	3.1 a
5	—	3.9 a	2.0 a	3.1 a
30 WAP				
1	2.5 a	2.7 a	2.3 a	1.9 a
3	2.9 a	2.6 a	2.4 a	2.2 a
5	2.8 a	2.7 a	2.2 a	2.4 a
36 WAP				
1	3.1 a	1.1 a	2.4 a	2.0 a
3	3.2 a	1.0 a	2.4 a	2.1 a
5	3.0 a	1.0 a	2.4 a	2.4 a
42 WAP				
1	1.1 a	1.1 a	2.1 a	2.6 a
3	1.1 a	1.3 a	2.3 a	2.7 a
5	1.0 a	1.2 a	2.1 a	2.8 a
48 WAP				
1	2.1 a	1.8 a	2.1 a	2.2 a
3	2.2 a	2.0 a	2.3 a	2.3 a
5	2.1 a	1.9 a	1.9 a	2.3 a
54 WAP				
1	2.5 a	2.7 a	1.9 a	1.6 b
3	2.6 a	2.6 a	1.9 a	2.2 a
5	2.8 a	2.7 a	1.8 a	2.6 a

^zWAP = week after planting; 1 lb/1000 ft² = 48.8243 kg·ha⁻¹.

^y0 = dead plant; 5 = outstanding plant quality (dense leaf canopy, high-quality flowers, and no nutrient deficiencies or dieback).

^xMean separation for each species and WAP by Tukey’s honestly significant difference test at $P < 0.05$.

^wData not available.

fertilizer recommendation of 2 to 4 lb/1000 ft² per year of controlled-release fertilizer, as reported by Shurberg et al. (2012a, b) should be adequate for maintaining acceptable quality annual and herbaceous perennial plant species when grown in the landscape in west-central Florida. However, quality response may vary with the location and soil type, type of species, year planted, and type of N fertilizer product. Future work should address the environmental benefits of lower N rates and changes in fertilizer application methods as well as the economic

benefit of using lower N rates. However, the purpose of this work was to provide science-based evidence for revising the FFL-IFAS N fertilizer recommendations for annual and perennial plants.

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