Effect of Light Intensity and Nutrition Level on Growth and Flowering of *Adenium obesum* ‘Red’ and ‘Ice Pink’

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Additional index words. Apocynaceae, desert rose, flower number

Abstract. *Adenium obesum* (Forssk.), Roem. & Schult., commonly known as desert rose, is a high-value, container-grown ornamental plant produced worldwide for its bright floral display and striking sculptural caudex. Little scientific-based information exists regarding the effect of light intensity and nutritional levels on *Adenium* growth and flowering. In this study, *A. obesum* ‘Red’ and ‘Ice Pink’ were grown under full sun [with a measured maximum photosynthetically active radiation (PAR) of 1850 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$], 30% shade (1255 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$), or 50% shade (943 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) in 1.25-L pots top-dressed with controlled-release fertilizer Nutricote® Plus (18N–2.6P–6.6K) at rates to provide 0.4, 0.9, or 1.4 g of nitrogen (N) per pot. Canopy height and width, flower number, and visual quality ratings (based on plant size and form, foliage color, and flowering) were highest after 16 weeks of growth for both cultivars when fertilized with 1.4 g of N per pot. A 30% shade level resulted in plants with the highest flower numbers and quality ratings. Plants grown at 50% shade had the greatest canopy heights and widths, but flower numbers and quality ratings were low. In full sun, plants were smaller overall. In a second experiment, *A. obesum* ‘Red’ produced the highest shoot dry weight when grown 20 weeks at 30% or 50% shade with 1.4 g of N per pot. Root formation is an important measure of aesthetic value for this crop. As plants mature, roots enlarge dramatically and are often washed to expose sculptural forms. The highest root dry weights were measured at 1.4 g of N under both full sun and 30% shade.

The genus *Adenium* is a member of the family Apocynaceae and originates from Africa, south of the Sahara from Senegal to Sudan and Kenya, and through Saudi Arabia, Oman, and Yemen (Oyen, 2008; Plaizier, 1980). Commonly known as desert rose, the genus is prized for its attractive floral array atop a swollen, sculptural caudex (Rowley, 1987). As roots mature they swell and enlarge along with the caudex and add an important sculptural element that compliments the flowers; therefore, root formation is an important measure of aesthetic value for this crop (Dimmitt et al., 2009). *Adenium* plants in a wide range of architectural forms, growth habits, and flower colors are available for sale globally. However, there is no scientific literature regarding *Adenium* cultural requirements. Production of *Adenium* species under a minimum PAR of 1000 to 1600 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ and a temperature range of 30 to 35 °C (85 to 95 °F) with high humidity during the growing season has been suggested (Dimmitt, 1998). It also was reported that *Adenium* responded

well to a balanced fertilizer such as 20N–20P₂O₅–20 K₂O plus micronutrients at a concentration of 200 mg·L⁻¹ N (Dimmitt, 1998); however, no data were presented.

A limited number of nutritional studies on other herbaceous genera within the family Apocynaceae has been published. *Plumeria rubra* grown in pure silica sand in 4-L containers were treated with a low and high nutrient level (2.4 g and 24.0 g, respectively, of 14N–14P–14K of Osmocote®) in a glasshouse for 60 d during August and September (Huante et al., 1995). In that study, more biomass was produced under high nutrient supply, whereas more biomass was allocated to the roots in low nutrient supply.

Mandevilla Vogue varieties were shown to be moderate feeders, responding best to use of a balanced fertilizer at a rate of 100 to 200 mg·L⁻¹ and it was recommended that a low to medium rate of a standard slow-release fertilizer should be added at planting (Mart, 2012). In a study testing the effects of Sumagic® (uniconazole) on the growth and flowering of *Mandevilla* ‘Alice Du Pont’, Deneke et al. (1992) chose 8.3 kg of Osmocote® (18N–6P–12K) per cubic meter of potting medium. Plants were also liquid fertilized weekly with 300 mg·L⁻¹ N from 20N–4.3P–16.6K (20–10–20). In an experiment conducted with *Dipladenia sanderi* L. (Plaza et al., 2009), fertigation was applied in a nutrient solution containing with a pH of 7.2

and an electrical conductivity of 1.2 dS·m⁻¹. Established landscape plants of *Allamanda cathartica* ‘Hendersonii’ were used in an experiment testing four different fertilizers on growth and quality (Broschat et al., 2008). The authors concluded that *Allamanda* in the landscape may not benefit greatly from increasing fertilization.

Vinca (*Catharanthus roseus* L.) seedlings benefitted from high concentrations of N (up to 32 mM) in the fertilizer, whereas only low concentrations of phosphorus and potassium (0.25 mM) were needed (van Iersel et al., 1999). Kessler (1998) indicated that plug-grown *Vinca* seedlings should be fertilized once or twice a week with 50 to 75 mg·L⁻¹ N. Nitrogen levels could be increased to 100 to 150 mg·L⁻¹ once true leaves develop.

To determine the cultural requirements for producing good-quality desert rose plants in containers, the following study was conducted to determine effects of light and nutritional levels on growth and flowering of *Adenium obesum* ‘Red’ and ‘Ice Pink’, two cultivars that are in commercial production in Florida.

Materials and Methods

Expt. 1. Established liners from vegetative stem cuttings (10 to 15 cm in height) in 72-cell trays of *A. obesum* ‘Red’ and ‘Ice Pink’ were obtained from a commercial propagator (Oglesby Plants International, Inc., Altha, FL). Fifty-four plants of each cultivar were potted into green 1.25-L (15.2 cm diameter) azalea pots with Fafard 2 Mix substrate (65% peat, 20% perlite, 15% vermiculite; Conrad Fafard Inc., Agawam, MA). After potting, all plants were trimmed to 5.0 to 7.5 cm in height and Nutricote® Plus (18N–2.6P–6.6K; 140-d formulation) controlled-release fertilizer (Chisso-Asahi Fertilizer Co., Ltd., Tokyo, Japan) was applied to the substrate surface at 2.5, 5.0, or 7.5 g per pot (equivalent to 0.4, 0.9, and 1.4 g N per pot). One month after planting, flower buds were removed to promote shoot growth. Fertilizer treatments were reapplied 12 weeks after the initial potting.

Pots were placed onto groundcover beds outdoors under natural daylength and temperature conditions 22 Apr. 2010 at Mid-Florida Research and Education Center (MREC), Apopka, FL. Different light intensity treatments were obtained by attaching 1.5-m wide sections of black woven polypropylene shade cloth to a 1.2-m high steel pipe (1.4 cm diameter) structure spaced to cover individual growing areas 1.2 m wide × 1.5 m long (Fig. 1). There were 18 individual blocks that were 1.2 m high, 1.2 m wide, and 1.5 m long laid out in north-by-south orientation. Six blocks were covered with woven polypropylene shade cloth at 30% or 50% shade rating and six blocks were left unshaded. One plant of each cultivar received each fertilizer treatment under each light level for a total of 54 plants. The use of no shade cloth (i.e., full sun), 30% or 50% shade cloth resulted in maximum PAR levels

Received for publication 21 Nov. 2013. Accepted for publication 27 Jan. 2014.

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of ≈ 1850 , 1255, or 943 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, respectively, in individual growing areas. Light levels were measured biweekly with a LI-COR Quantum Radiometer Photometer (Model No. LI-185B; Lincoln, NE). In addition, total solar radiation ($\text{W}\cdot\text{m}^{-2}$) was measured throughout each experiment using a LI-COR Model LI-200 pyranometer (LI-COR® Biosciences, Lincoln, NE). Plants were hand-watered as needed for the first 4 weeks after which they received daily irrigation from overhead 20.3-cm spinner sprinklers for 15 min unless it rained. To prevent blowover or knocking over, potted plants in each block were placed in Dillen CTA66 pocket azalea trays (48 cm $\times$ 32 cm) (Myers Industries, Middlefield, OH).

Final plant canopy height and width, leaf length and width of the first fully expanded leaf on the dominate stem, and visual plant quality were recorded after 16 weeks of growth. The number of open flowers on each plant was recorded weekly. Visual quality rating was based on evaluations and rankings by four observers of overall plant form, foliage quality, and appearance and flower number on the following scale: 1 = poor; 2 = fair; 3 = saleable; 4 = good; 5 = excellent.

Expt. 2. Fifty-four liners of *A. obesum* 'Red' (7 to 9 cm in height) were potted from 72-cell trays into 1.25-L (15.2 cm diameter) containers filled with Fafard 2 Mix. To promote lateral branching, plants were trimmed to 5.0 to 7.5 cm in height. The same fertilizer and application rates as in Expt. 1 were used and pots were placed on groundcover beds outdoors on 25 July 2011 under natural day-length and temperature conditions at MREC, Apopka, FL, using the same growth structures and watering regime as in Expt. 1. Fertilizer treatments were reapplied 12 weeks after initial potting and light treatments consisted of the same 0%, 30%, or 50% shade as in Expt. 1. Twelve weeks after initiation of the experiment, open flowers were first observed and weekly flower counts began and ended 8 weeks later at which time final measurements of canopy height and width and flower counts were made and plants were rated for visual quality using the same scale as in the first experiment. Plants were then cut off at the soil line and the tops bagged in brown paper bags. Roots were removed from

pots and excess soil was washed away; roots were allowed to air-dry for 3 to 4 h and then were placed in paper bags. The bagged tops and roots were dried in a TD Vac Dryer (Heat Pipe Technology, Gainesville, FL) at 73 °C (165 °F) for 2 weeks. Dry weights were recorded using a Scout Pro scale (Model No. SPE2001; Ohaus Corporation, Pine Brook, NJ). Data were analyzed using analysis of variance procedures of the SAS program (SAS Institute Inc., Cary, NC).

Results

Expt. 1. Canopy height and width of *A. obesum* 'Red' increased at higher fertilizer and shade levels, whereas leaf length and width were larger as shade levels increased but did not respond to fertilizer level (Table 1). *Adenium* 'Red' produced the most flowers when grown at 30% shade and flower number was greater at the highest fertilizer rate (Fig. 2). Visual plant quality was scored greatest at the 1.4-g N rate and decreased with lower fertilizer levels. Overall, visual plant quality

ranked best for plants produced under 30% shade and 1.4 g of N.

A. obesum 'Ice Pink' canopy height and width increased as shade and fertilizer levels increased (Table 2). Leaf length and width were greater as shade increased but showed no difference in response to change in fertilizer levels. Flower number declined as shade levels increased, whereas higher fertilizer levels resulted in more flowers regardless of shade level. Similar to *A. obesum* 'Red', the best rankings for visual quality for 'Ice Pink' plants were produced at 30% shade at fertilizer rates of 0.9 or 1.4 g N per pot (Table 2).

Expt. 2. After 20 weeks of growth, canopy height and width of *A. obesum* 'Red' plants increased in response to higher fertilizer and shade levels (Table 3). The tallest plants were produced under 50% shade and 1.4 g of N, whereas the shortest canopy height occurred at 0.4 g N and 0% shade (full sun). Similarly, the greatest canopy width was produced with 1.4 g of N under 50% shade, whereas the smallest canopy width was grown at 0.4 g N under 0% shade (full sun). Like in Expt. 1,

Table 1. *Adenium obesum* 'Red' growth, average flower number, and visual quality as affected by fertilizer rates (Nutricote Plus 18N–2.6P–6.6K) and light levels after 16 weeks of growth (Apr. to Aug. 2010).

Shade (%)	Canopy ht (cm)	Canopy width (cm)	Leaf length (cm)	Leaf width (cm)	Total flower count	Visual quality (1–5) ^a
0	20.3 $\pm$ 0.7 ^y	22.8 $\pm$ 1.0	7.0 $\pm$ 0.1	1.6 $\pm$ 0.1	8.9 $\pm$ 1.5	2.9 $\pm$ 0.1
30	22.1 $\pm$ 0.5	27.4 $\pm$ 1.3	7.7 $\pm$ 0.1	1.8 $\pm$ 0.1	12.7 $\pm$ 2.2	3.2 $\pm$ 0.2
50	25.2 $\pm$ 1.1	34.4 $\pm$ 1.3	7.7 $\pm$ 0.1	1.8 $\pm$ 0.1	4.8 $\pm$ 0.7	2.4 $\pm$ 0.1
LSD _{0.05}	2.1	2.6	0.4	0.1	3.4	0.3
Fert. (g N/pot)						
2.5	20.4 $\pm$ 0.8	23.1 $\pm$ 1.2	7.4 $\pm$ 0.2	1.7 $\pm$ 0.1	2.6 $\pm$ 0.5	2.3 $\pm$ 0.1
5.0	23.0 $\pm$ 0.9	28.1 $\pm$ 1.2	7.4 $\pm$ 0.1	1.8 $\pm$ 0.1	9.1 $\pm$ 1.1	2.8 $\pm$ 0.1
7.5	24.1 $\pm$ 0.8	33.0 $\pm$ 1.4	7.6 $\pm$ 0.1	1.7 $\pm$ 0.1	15.3 $\pm$ 2.3	3.3 $\pm$ 0.2
LSD _{0.05}	2.1	2.6	0.4	0.1	3.4	0.3
Shade ^x	**	**	**	**	**	**
Fertilizer	**	**	NS	NS	**	**
Shade $\times$ fertilizer	NS	NS	NS	NS	**	**

^aVisual quality where 1 = unsaleable, 3 = saleable, 5 = excellent quality.

^yMean $\pm$ error mean square.

^xNS, **, nonsignificant or significance at $P \leq 0.01$, respectively.

LSD = least significant difference.

Fig. 1. A view of the shade structures used to grow *Adenium obesum* 'Red' and 'Ice Pink' at three different light levels.

Fig. 2. *Adenium obesum* 'Red' after 20 weeks of growth in 1.25-L pots with three different fertilizer rates (left to right: 2.5, 5.0, and 7.5 g Nutricote Plus (18N–2.6P–6.6K) under 30% shade from July to Dec. 2011.

Table 2. *Adenium obesum* 'Ice Pink' growth, average flower number, and visual quality as affected by light levels and fertilizer rates (Nutricote Plus 18N–2.6P–6.6K) after 16 weeks of growth (Apr. to Aug. 2010).

Shade (%)	Canopy ht (cm)	Canopy width (cm)	Leaf length (cm)	Leaf width (cm)	Total flower count	Visual quality (1–5) ^z
0	20.4 ± 0.8 ^y	18.0 ± 0.8	5.2 ± 0.1	1.8 ± 0.1	23.1 ± 2.0	2.7 ± 0.1
30	23.9 ± 0.7	21.0 ± 0.8	5.7 ± 0.1	2.0 ± 0.1	24.0 ± 1.8	3.3 ± 0.1
50	26.2 ± 0.8	24.5 ± 1.2	5.6 ± 0.1	2.3 ± 0.1	10.2 ± 1.0	2.1 ± 0.1
LSD _{0.05}	1.6	1.7	0.3	0.1	3.0	0.2
Fert. (g N/pot)						
2.5	19.2 ± 0.7	15.6 ± 0.6	5.5 ± 0.1	2.1 ± 0.1	11.8 v1.2	2.2 ± 0.1
5.0	24.2 ± 0.6	21.4 ± 0.7	5.4 ± 0.1	2.0 ± 0.1	19.1 ± 1.5	2.8 ± 0.1
7.5	26.6 ± 0.7	25.8 ± 0.9	5.7 ± 0.1	2.0 ± 0.1	27.3 ± 2.1	3.1 ± 0.2
LSD _{0.05}	1.6	1.7	0.3	0.1	3.0	0.2
Shade ^x	*	**	**	**	**	**
Fertilizer	**	**	NS	NS	**	**
Shade × fertilizer	NS	NS	NS	NS	**	**

^zVisual quality where 1 = unsaleable, 3 = saleable, 5 = excellent quality.

^yMean ± error mean square.

^xNS, **, *, nonsignificant or significance at the $P \leq 0.01$ or 0.05, respectively.

LSD = least significant difference.

Table 3. Effect of three light and fertilizer (Nutricote Plus 18N–2.6P–6.6K) levels on canopy height and width, top and root dry weight, flower number, and visual quality of *Adenium obesum* 'Red' after 20 weeks of growth (July to Dec. 2011).

Shade (%)	Canopy ht (cm)	Canopy width (cm)	Top dry wt (g)	Root dry wt (g)	Total flower count	Visual quality (1–5) ^z
0	18.1 ± 0.8 ^y	20.5 ± 1.1	15.0 ± 1.6	8.5 ± 0.7	22.7 ± 4.2	3.1 ± 0.2
30	20.8 ± 0.8	22.3 ± 1.1	17.2 ± 1.6	8.0 ± 0.5	21.2 ± 3.2	3.6 ± 0.2
50	24.3 ± 0.8	25.3 ± 1.2	17.9 ± 1.4	5.6 ± 0.5	8.3 ± 2.0	3.1 ± 0.2
LSD _{0.05}	1.7	1.7	1.9	1.2	8.4	0.3
Fertilizer (g N/pot)						
2.5	17.8 ± 0.9	17.7 ± 0.7	9.4 ± 0.6	5.5 ± 0.4	10.6 ± 3.0	2.4 ± 0.1
5.0	22.2 ± 0.8	23.1 ± 0.8	16.9 ± 0.8	7.2 ± 0.4	15.0 ± 2.5	3.2 ± 0.2
7.5	23.2 ± 0.9	27.2 ± 0.8	23.6 ± 0.8	9.3 ± 0.7	26.7 ± 4.0	4.0 ± 0.1
LSD _{0.05}	1.7	1.7	1.9	1.2	8.4	0.3
Shade ^x	*	**	*	**	**	**
Fertilizer	**	**	**	**	**	**
Shade × fertilizer	NS	NS	NS	NS	NS	NS

^zVisual quality rating where 1 = unsaleable, 3 = saleable, 5 = excellent quality.

^yMean ± error mean square.

^xNS, **, *, nonsignificant or significance at the $P \leq 0.01$ or 0.05, respectively.

LSD = least significant difference.

flower counts increased with higher fertilizer rates but decreased as shade level increased. The highest average weekly flower counts were produced with 1.4 g of N application and at 0% and 30% shade, respectively. In contrast, plants grown at the 0.4-g N rate produced the lowest total flower count at 50% shade, whereas the next lowest was at 0.9 g N at 50% shade.

Adenium 'Red' top dry weight exceeded root dry weight in all treatments. Both top and root weight increased at higher fertilizer rates with top dry weight more than doubling as the fertilizer rate increased from 0.4 to 1.4 g N per pot (Table 3). Root dry weight was greatest in full sun and at highest fertilizer treatments. This is in contrast to results with *Plumeria* that showed an increase in root biomass under low nutrient supply (Huante et al., 1995). *Adenium* 'Red' top dry weight increased as shade increased from 0% to 50%, whereas root dry weight decreased at higher shade levels. In a study of *Betula*

pendula, light regime had no effect on dry matter allocation except at very low photon flux densities (less than 6.5 mol·m⁻²·d⁻¹), in which a small decrease in the root fraction was observed (Ericsson, 1995). Overall, the shoot-to-root weight ratio was 1.8, 2.2, and 3.2 at 0%, 30%, and 50% shade levels. Shoot-to-root weight ratio was 1.7, 2.4, and 2.5 at the 2.5-, 5.0-, or 7.5-g fertilizer rates, respectively.

Discussion

Adenium obesum can be grown under full sun conditions in central Florida; however, when the plant is commercially produced as an ornamental flowering potted plant crop, this study indicates that best quality plants with the highest flower counts and best quality leaves were produced under 30% shade (maximum intensity of ≈1255 μmol·m⁻²·s⁻¹). This optimum PAR level supports Dimmitt (1998) and is in the middle of the light intensity

range (1000 to 1600 μmol·m⁻²·s⁻¹) that he recommended for *Adenium*. Our study showed significantly lower flower numbers and lower quality ratings for both *A. obesum* 'Red' and 'Ice Pink' grown at 50% shade (943 μmol·m⁻²·s⁻¹). The average daily solar radiation was 2334 and 1650 W·m⁻² during Expts. 1 and 2, respectively. Although the average total solar radiation was ≈30% less in the later summer/fall test, it did not affect flower number of *A. obesum* 'Red', which produced more flowers in the summer/fall experiment than in the spring/summer experiment.

A. obesum 'Red' and 'Ice Pink' growth was greater as rates of Nutricote® Plus (18N–2.6P–6.6K; 140-d formulation) increased from 0.4 to 1.4 g N per pot when applied at 12-week intervals. This agrees with results of a study with *Plumeria rubra* L., another member of the Apocynaceae family, in which greenhouse-grown plants produced a larger canopy biomass under higher nutrient supply, whereas more biomass was allocated to the roots at a low nutrient supply (Huante et al., 1995). *Adenium* 'Red' under low nutrient supply relocated more biomass into roots because shoot-to-root ratio of plants grown with 0.4 g of Nutricote® was 1.7 but increased to 2.5 when grown under 1.4 g per pot (Table 3). A study with *Tabernaemontana pachysiphon* Staph, another Apocynaceae member, treated with three levels of Osmocote®, two water regimes, and two light intensities indicated that increasing nutrient supply and higher light intensity had a positive effect on growth (Hoft et al., 1996).

Results of this study indicate that *A. obesum* 'Red' and 'Ice Pink' should be produced at 30% shade or a light intensity ≈1255 μmol·m⁻²·s⁻¹ to achieve best quality and highest flower production. If plants are produced in 1.25-L pots, a nutritional regimen that provides 0.9 or 1.4 g N per pot from a slow-release fertilizer source should be provided. Poorest plant quality ratings occurred at the lowest fertilizer level (0.4 g N per pot) regardless of shade level. Future research is needed to study the effects of higher light levels and fertilization levels on caudex and root development in relation to shoot growth because some markets prefer large caudices in addition to floral displays. The results from the experiments reported here give growers a basis to adapt *Adenium* for large-scale commercial potted plant crop production.

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