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Longevity of Potted Chrysanthemums at Various Nitrogen and Potassium Concentrations and NH_4 : NO_3 Ratios

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Abstract. **Plant height, flower diameter, days to flower, and longevity of 'Iridon' chrysanthemums *[Dendranthemum × grandiflorum* (Ramat.) Kitamura] were not affected by various N and K concentrations (112, 225, 337, and 450 mg·liter^{-1}) supplied during the last 5 weeks of production. However, increasing N concentration increased medium conductance, while varying K concentration had no effect on conductance. Visual grade of 'Iridon' after 3 weeks in a simulated interior environment showed an interaction between concentrations of N and K. In a second study, growth and longevity of 'Iridon' were affected by NH_4 : NO_3 ratios. Plants receiving a 0:1.0 ratio flowered 4 days later than plants receiving a 0.5:0.5 ratio and were taller than plants fertilized with a 1.0:0 ratio. Longevity was greater in plants receiving a 0:1.0 ratio than in those receiving 0.5:0.5 or 0.75:0.25 ratios. Also, longevity was similar in plants receiving NH_4 : NO_3 ratios of 0:1.0, 0.1:0.9, 0.2:0.8, and 0.3:0.7. Plants receiving 0:1.0 lasted 6 days longer than those receiving a 0.4:0.6 ratio.**

Successful chrysanthemum production is directly related to environmental conditions and proper nutrition. Lunt and Kofranek (1958) showed that high N concentrations during the first 7 weeks of cut chrysanthemum production improved flower quality and that N concentrations should be decreased during the final 3 to 4 weeks of production to avoid brittle leaves. Joiner and Smith (1962) theorized that the demand for K increased when N supply increased because K is needed in protein synthesis. Boodley and Meyer (1965) found that the total N in the leaf tissue of chrysanthemums grown in sand increased from juvenile growth to anthesis, with the greatest increase occurring during the first few weeks after planting. Percent N in the leaf tissue remained constant and the amount of K decreased once the flower showed color.

Ammonium-nitrate nitrogen ratio and N : K ratios have been shown to affect growth and longevity of cut chrysanthemums. Waters and Conover (1969) recommended a 1 N : 1 K ratio for the first half of production, but suggested a 1 N :2 K ratio for the last half. Tsujita et al. (1974) found that cut chrysanthemums had more flowers with greater stem strength and more vigorous root systems when NO_3-N was the major source of N during periods of high irradiance. Crater et al. (1973) found that cut chrysanthemums fertilized with NO_3-N lived 7 days longer than NH_4-N-fertilized plants.

Our research was conducted to determine the effects of N and K concentrations and NH_4 : NO_3 ratios on growth and longevity of potted 'Iridon' chrysanthemums.

Cultural procedures. Three experiments were conducted using rooted cuttings of 'Iridon' chrysanthemums planted one per 12.5-cm {1.17 liter) plastic container filled with Vergro Klay Mix (a commercially available mix consisting of vermiculite, Canadian sphagnum peat, and calcined clay) (Verlite Co., Tampa, Fla.). Plants were initially placed under a noninductive photoperiod (lighted from 2200 to 0200 HR using incandescent lamps) in a fiberglass, fan-and-pad-cooled greenhouse in Gainesville, Fla. Maximum light levels ranged from 500 to 600 μmol·s^{-1}·m^{-2} in winter to 800 to 900 μmol·s^{-1}·m^{-2} in summer. Night temperature varied from 16 to 18C in winter to ≈ 25C in summer. Plants were pinched and the photoinductive period was initiated 10 days after planting. Plants were treated with butanedioic acid mono(2,2-dimethylhydrazide) (daminozide) at 5000 mg·liter^{-1} as a foliar spray when lateral shoots were 4.5 cm long. An additional daminozide spray was applied 10 days later in the first experiment of NH_4 : NO_3 ratios.

General procedures. At" flowering, one plant per treatment and block was used to measure flower diameter, plant height, medium pH, conductance of the soil solution, and chlorophyll content (NH_4 : NO_3 ratio experiments). Conductance was determined using the 1:2 dry-weight procedure (Joiner et al., 1981), and chlorophyll content was analyzed according to Arnon (1949). The number of days to flower was designated when the first two rows of petals were perpendicular to the flower stem.

At flowering, one plant per treatment and block was placed in simulated interior rooms to determine longevity. Simulated interior rooms provided 12 μmol·s^{-1}·m^{-2} of irradiance for 12 h daily from cool-white fluorescent lamps. Temperature was maintained at 20 ± 1C with 50% ± 5% relative humidity (RH). Plants were watered as needed to maintain uniform soil moisture. Flowering plant longevity was recorded when the first two rows of petals or 50% of the leaves turned brown.

Plant quality was evaluated for plants fertilized with varying N and K concentrations at flowering and after 3 weeks in the simulated interior rooms, based on foliage color

Table 1. Effects of N and K on medium conductance and visual grade of 'Iridon' chrysanthemums at flowering and after 3 weeks in simulated interior rooms.

Fertilizer[z] N (mg·liter^{-1})	K	Conductance (dS·m^{-1})	Visual grade[y] Flowering	Interior
112	112	2.3	2.1	3.6
112	225	2.4	2.1	3.6
112	337	2.8	3.1	3.7
112	450	3.1	3.3	3.8
225	112	2.5	3.7	4.1
225	225	2.7	3.3	3.3
225	337	3.0	3.3	4.1
225	450	3.5	3.1	3.6
337	112	3.8	3.4	3.4
337	225	4.2	2.7	3.7
337	337	3.7	3.7	3.8
337	450	3.8	2.9	2.6
450	112	3.3	3.8	3.2
450	225	3.6	3.1	3.7
450	337	4.0	2.7	3.1
450	450	3.8	3.3	3.3
N		*	*	*
K		NS	NS	*
N × K		NS	*	*
$HSD_{0.05}$		1.6	1.6	0.7

[z]Fertilizer treatments initiated 6 weeks after planting.
[y]Visual grade was evaluated on a scale of 1 = poor to 5 = excellent. Plants were evaluated at flowering and after 3 weeks in simulated interior rooms maintained at 20C and 50% ± 5% RH with 12 μmol·s^{-1}·m^{-2} of light for 12 h daily.

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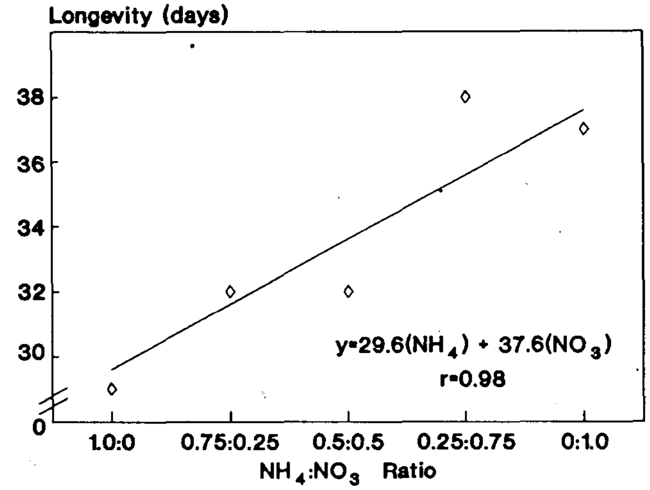

Fig. 1. Relationship between longevity of 'Iridon' chrysanthemum and $NH_4:NO_3$ ratios (Expt. 1). Plants were maintained in simulated interior rooms at 20C with 50% ± 5% RH and 12 $\mu mol\cdot s^{-1}\cdot m^{-2}$ of irradiance for 12 h daily.

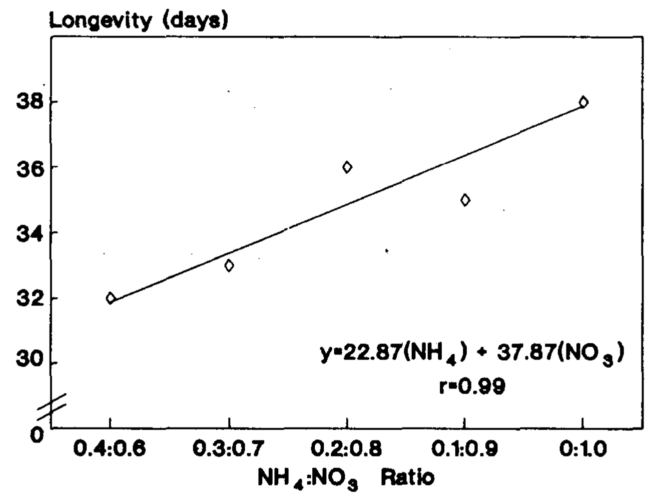

Fig. 2. Relationship between longevity of 'Iridon' chrysanthemum and $NH_4:NO_3$ ratios (Expt. 2). Plants were maintained in simulated interior rooms at 20C with 50% ± 5% RH and 12 $\mu mol\cdot s^{-1}\cdot m^{-2}$ of irradiance for 12 h daily.

and flower form and color using a scale of 1 = poor to 5 = excellent. A rating of 1 represented a plant with light-green to yellow foliage and distorted and/or faded flowers, a rating of 5 represented a plant with dark-green foliage, uniform flower display, and no flower-color fading. Root systems of plants fertilized at varying $NH_4:NO_3$ ratios were rated by removing plants from the pot and observing roots on the surface of the soil. A scale ranging from 1 (few poorly branched, dark-brown roots) to 5 (numerous well-branched, light-brown roots) was used.

Each experiment was arranged in a completely randomized block design with six replications and two plants per experimental unit. In the simulated interior rooms, plants were arranged in a completely randomized design. Data were subjected to analysis of variance, Tukey's honest significant difference (HSD) mean separations at $P = 0.05$, and regression analysis. In the experiments involving $NH_4:NO_3$ ratios, mixture analysis was used (Cornell, 1990).

Nitrogen and potassium concentrations. Cuttings were planted on 19 Feb. and fertilized at each irrigation with 337 mg each of N and K/liter from planting until 6 Apr., when treatments were initiated. A factorial experiment was established with four concentrations each of N and K: 112, 225, 337, and 450 $mg\cdot liter^{-1}$. All treatments had an $NH_4:NO_3$ ratio of 0.25:0.75 by using potassium nitrate, ammonium nitrate, and potassium sulfate to develop N and K concentrations. Each plant was fertilized with 300 ml of solution every other day from planting until 8 Apr., when plants received daily fertilization with 300 ml of solution until flowering.

High N concentrations increased conductance, but K concentrations had no effect (Table 1). Potassium and N concentrations during the final 5 weeks of production had no effect on height, flower diameter, days to flower, and longevity of 'Iridon' chrysanthemums (data not shown). Plant visual grade was affected at flowering and again after 3 weeks in simulated interior rooms (Table 1). At flowering, K concentration had no effect on visual grade. After 3 weeks in these rooms, increased concentrations of K at 112 mg N/liter had no effect on visual grade, but increasing K from 112 to 225 $mg\cdot liter^{-1}$ at 225 mg N/liter decreased the visual grade. The plant visual grade increased as concentrations of K increased from 225 to 337 $mg\cdot liter^{-1}$ at 225 mg N/liter. At 337 mg N/liter, increasing K concentrations from 337 to 450 $mg\cdot liter^{-1}$ resulted in a decrease in visual grade. The observation that N and K concentrations had no effect on longevity of potted chrysanthemums (data not shown) is in contrast to previous work conducted on cut chrysanthemums (Boodley and Meyer, 1965; Waters and Conover, 1969). Two explanations for these results are possible: 1) conductance, which would be affected by N concentration, may be a significant factor in longevity of a potted flowering crop or 2) modifying the N and K concentrations during the final 3 to 4 weeks of production does not affect longevity of potted chrysanthemums. The second explanation seems most plausible since work with cut chrysanthemums has shown that foliar N increases most during the first half of the crop cycle (Boodley and Meyer, 1965; Joiner and Smith, 1962).

Ammonium-nitrate nitrogen ratios (Expt 1). An experiment with $NH_4:NO_3$ ratios of 1.0:0, 0.75:0.25, 0.5:0.5, 0.25:0.75, and 0:1.0 was initiated on 15 May. Treatments were initiated at planting and each ratio included (in $mg\cdot liter^{-1}$): 300 N, 20 P, 180 K, 80 Ca, and 60 Mg. The chemicals used were magnesium sulfate, calcium sulfate, potassium sulfate, diammonium phosphate, phosphoric acid, ammonium sulfate, magnesium nitrate, potassium nitrate, ammonium nitrate, calcium nitrate, and sodium nitrate. Plants were fertilized every day with 300 ml of fertilizer solution, which provided a total of 5.76 g of N to each plant during the experiment.

Longevity ranged from 24 to 40 days and was greater in plants receiving a 0:1.0 ratio than 0.5:0.5 or 0.75:0.25 ratios (Fig. 1). These results are similar to those observed by Carter et al. (1973) with cut chrysanthemums. However, in our study, potted chrysanthemums fertilized with a 0:1.0 ratio were not marketable due to light-green foliage. Longevity was found to be positively correlated with $NH_4:NO_3$ ratios ($r = 0.98$), but no relationship was noted between longevity and conductance, medium pH, or chlorophyll content. Differences in longevity of plants fertilized with a 0:1.0 ratio might be related to the numerous well-branched, light-brown roots found in this treatment. Plants fertilized with a 1.0:0 ratio showed symptoms of' ammonium toxicity-reduced growth rate, dark-brown roots, and suppressed root development –as described by Nelson and Kuo-Hsien (1971). Root visual grade increased as NO_3-N increased (Table 2).

Days to flower, plant height, chlorophyll content, medium pH, and conductance were affected by $NH_4:NO_3$ ratio (Table 2); flower diameter was not affected (data not shown).

Table 2. Effect of NH_4 : NO_3 ratio on characteristics of 'Iridon' chrysanthemum plants and their growing medium.

	Plant				Medium	
NH_4 : NO_3 ratio	Root visual grade[z]	Days to flower	Plant ht (cm)	Chlorophyll ($mg \cdot liter^{-1}$)	pH	Conductance ($dS \cdot m^{-1}$)
1.0:0	1.4	72	22	8.5	3.6	3.9
0.75:0.25	2.4	72	24	7.5	4.3	2.7
0.5:0.5	3.1	71	24	7.7	4.1	3.4
0.25:0.75	4.6	72	27	7.7	5.6	2.8
0:1.0	4.7	75	29	6.5	7.1	2.2
$HSD_{0.05}$	1.0	3.6	2.0	0.7	0.4	0.9

[z]Root visual grade was evaluated by removing plants from the pot and observing roots on the surface of the soil (1 = few poorly branched, dark-brown roots; 5 = numerous well-branched, light-brown roots).

Table 3. Effect of NH_4 : NO_3 ratio on days to flowering of 'Iridon' chrysanthemum and medium pH.

NH_4 : NO_3 ratio	Days to flower	Medium pH
0.4:0.6	63	6.6
0.3:0.7	63	6.9
0.2:0.8	64	6.9
0.1:0.9	64	7.1
0:1.0	64	7.2
$HSD_{0.05}$	0.9	0.4

Plants receiving a 0:1.0 ratio flowered 4 days later than plants receiving a 0.5:0.5 ratio and were taller than plants fertilized with a 1.0:0 ratio. Medium pH decreased and chlorophyll content and conductance increased with increases in NH_4-N content.

Ammonium-nitrate nitrogen ratios (Expt. 2). Cuttings were planted on 8 Jan. The NH_4 : NO_3 ratios were: 0.4:0.6,0.3:0.7,0.2:0.8, 0.1:0.9, and 0:1.0. Chemicals used to achieve NH_4 : NO_3 ratios, as well as concentrations of P, K, Ca, and Mg, were the same as described for Expt 1. Plants were watered every other day with 300 ml of fertilizer solution. Each plant received a total of 3.06 g N during the experiment.

Longevity was greatest in plants fertilized with a 0:1.0 ratio and shortest in plants receiving a 0.4:0.6 ratio and showed a positive correlation to NH_4 : NO_3 ratio (Fig. 2). Days to flower and medium pH were also affected by NH, : NO_3 ratios (Table 3). Plants fertilized with a 0.4:0.6 or 0.3:0,7 ratio flowered 1 day earlier than plants receiving lower proportions of NH_4-N. Plants fertilized with a 0.4:0.6 ratio had a lower medium pH than plants fertilized with a 0.1:0.9 or 0:1.0 ratio. Flower diameter, plant height, and chlorophyll content were not affected by the NH_4 : NO_3 ratios used in this experiment (data not shown).

In our studies, N and K concentrations during the final 5 weeks of production had no effect, while NH_4 : NO_3 ratio did affect growth and longevity of 'Iridon' chrysanthemums. Proper nutrition of foliage and flowering plants is imperative if high-quality, long-lasting plants are to be produced. These results are similar to previous work on the effects of NH_4 : NO_3 fertilization on the growth of *Petunia hybrida* 'Candy Apple' and *Pelargonium hortorum* 'Sprinter Scarlet' (Tew Shrock and Goldsberry, 1982), 'Forever Yours' roses (Woodson and Boodley, 1983), and potted poinsettia (Nell and Barrett, 1985). However, to the best of our knowledge, this is the first research relating longevity of potted flowering plants to NH_4 : NO_3 ratios. Joiner et al. (1983) suggested that most plants do best with 50% to 60% of their total N supplied in the NO_3 form and 40% to 50% in the NH_4 form. Our results demonstrate that growth and longevity of potted chrysanthemums is optimum when 50% to 70% of the N is supplied in the NO_3 form and 30% to 50% is supplied in the NH_4 form.

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