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Nitrate Distribution in Mature Citrus Trees

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Abstract. **NO_3-N concentrations in 35-year-old 'Hamlin' orange (*Citrus sinensis* L. Osbeck) and 'Marsh' grapefruit (*C. paradisi* Macf.) trees on rough lemon (*C. limon* Burm. f.) rootstock were highest in the feeder roots (212–962 ppm), followed by the leaves (160–300 ppm) and trunk wood (0–304 ppm). Only in 3 of 10 orange trees and in 1 of 10 grapefruit trees was NO_3-N detected in the bark. Nitrate-N concentration in the leaves and the wood and the percentage of NO_3-N in total N in the wood were higher in orange than in grapefruit trees.**

The presence of nitrate-N in the tops of citrus trees, as in other woody plants, had long been considered negligible because most or all of the NO_3 absorbed was thought to have been reduced in the roots and translocated as amino acids (12). Only in the last 20 years, as improved analytical methods became available, has NO_3-N in citrus received much attention (1, 2, 3, 6, 8, 9, 10), but most of the work done was with NO_3-N in the leaves and the xylem sap. Little is known about the NO_3-N distribution in other parts of citrus trees.

Leaves, bark, wood, and feeder roots of 10, healthy 'Hamlin' orange and 10 'Marsh' grapefruit trees were sampled in Jan. 1983 in the same block of a 35-year-old commercial grove in the Ridge area of central Florida. The trees were on rough lemon rootstock, planted 6 × 9 m on Astatula fine sand soil (hyperthermic, uncoated typic quartzipsamment). The 'Hamlin' trees had been fertilized with NH_4NO_3 at the rate of 98 kg N/ha in Oct. 1982 and with granular KCl (132 kg K/ha) in Jan. 1983; the 'Marsh' grapefruit trees received 112 kg N/ha and 186 kg K/ha. The grove was not irrigated.

Thirty summer-flush leaves from nonfruiting terminals, about 6 months old, were collected around the outside of the canopies: 2- to 5-cm diameter bark disks were removed from each trunk after making circular incisions with a hole saw. Wood samples were extracted on 2 sides of the trunk with an electric drill to a depth of 3 cm. Feeder roots were collected with a spade under the canopies. The samples were put immediately into an ice chest. The leaf and bark samples were washed in detergent solution, and rinsed with tap water and distilled water 4 times. The root samples were cleaned with a stream of tap water and then immersed in distilled water for 5 min to saturate the free space.

The washed samples were dried at 65°C and ground to 20-mesh size. Four hundred-mg aliquots were extracted with 40 ml of 0.025 M $Al_2(SO_4)_3$ for 30 min and the extract analyzed for NO_3-N by spectrophotometry using Heanes' method (7).

Feeder roots had the highest NO_3 concentrations (Table 1), but there was considerable variation ('Hamlin', 212–962 ppm; 'Marsh', 352–945 ppm NO_3-N). The orange leaves had higher total N and higher NO_3-N (P = 5%) levels than the grapefruit leaves. There was less variation in the leaves than in the feeder roots ('Hamlin', 190–300 ppm; 'Marsh', 160–290 ppm NO_3N). Third in NO_3-N concentration was the trunk wood ('Hamlin', 21–121 ppm; 'Marsh', 0–62 ppm); the mean concentration of NO_3-N was higher and the NO_3-N fraction of total N was larger (P = 1%) in orange wood than in grapefruit wood.

Nitrate was found in the bark in 3 of 10 orange trees and in 1 of 10 grapefruit trees. Total N was higher (P = 1%) in orange bark. Because the analytical method (7) is very sensitive, it is apparent that minimal NO_3-N is present in citrus bark. If the leaves made up 6% of the total dry weight of a grapefruit tree (4), the woody tissues 76%, and the feeder roots 15%, then 80% of the NO_3-N content of the tree was concentrated in the feeder roots, and the rest about equally divided between the wood and the leaves.

The relatively high level of NO_3-N in the wood supports Kato's (9) contention that NO_3-N is one of the principal forms in which nitrogen is translocated in citrus, especially when N is supplied in nitrate form. The almost total lack of NO_3-N in the bark suggests, but does not prove, that most of the NO_3 reduction takes place in the leaves.

The total N levels in the various tissues (Table 1) are comparable to those reported for 'Valencia' orange (5). No correlation existed (r^2 = 0.02–0.06) between total N and NO_3-N in the leaves, the wood, and the feeder roots. Total N does not always reflect the true N needs of citrus trees (12). The nitrate levels (1, 2) and the nitrate reductase activity (3, 11) in citrus leaves have been proposed as better indicators of N requirements. Total N includes metabolically inactive N, but only large-scale testing over long periods of time can prove that the nitrate level, governed by nitrate reductase activity, is superior to total N in assessing N-requirement. The much greater variability of NO_3-N than of total N (Table 1) in citrus leaves casts some doubt on the feasibility of judging the N status of citrus trees by the NO_3-N concentration.

Table 1. Total N, NO_3-N, and percentage of NO_3-N in total N in 4 tissues of 35-year-old 'Hamlin' orange and 'Marsh' grapefruit trees.

Source	Total N (%)	NO_3-N (ppm)	NO_3-N in total N (%)
Hamlin			
Leaves	2.88[z] ± 0.07[y]	233 ± 43	0.81 ± 0.14
Trunk bark	1.37 ± 0.10	6 ± 11	0.04 ± 0.07
Trunk wood	0.51 ± 0.04	71 ± 38	1.43 ± 0.77
Feeder roots	2.17 ± 0.17	529 ± 254	2.47 ± 1.29
Marsh			
Leaves	2.77 ± 0.13	190 ± 38	0.69 ± 0.13
Trunk bark	0.85 ± 0.02	2 ± 5	0.02 ± 0.05
Trunk wood	0.49 ± 0.04	18 ± 27	0.38 ± 0.57
Feeder roots	2.21 ± 0.14	592 ± 164	2.68 ± 0.71

[z]Mean of 10 determinations.
[y]SD.

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Peduncle Elongation of Pompon Chrysanthemums with Substituted Phthalimides

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Abstract. **Substituted phthalimides [1-(3-chlorophthalimido)-cyclohexanecarboximide (AC 94,377) and a related tetrahydrophthalimide (AC 99,524)] and gibberellic acid (GA_3) were applied to shoots of *Chrysanthemum* X*morifolium* Ramat. 'Starburst' on the fourth week of short daylength. Phthalimide rates of 250–1000 mg/liter caused elongated peduncles, higher peduncle dry weights, and greater internodal elongation than on untreated plants. These results with phthalimides compared favorably with GA_3 at rates of 10–50 mg/liter. Phthalimide AC 94,377 produced greater peduncle dry weights than did GA_3 on the first 4, most-terminal peduncles.**

Short peduncle lengths on pompon chrysanthemums are difficult to use in floral arrangements and are of lower quality than those having a fuller crown development. Causes for short peduncles of lateral flowers have been attributed to reduced solar radiation and improper pinching schedules (4). Several methods that have been found useful for elongating the lateral peduncles of cut spray mums include the use of interrupted photoperiod scheduling (9), foliarly applied GA_3 (3, 4), and temperature manipulation (2).

GA_3 elongates stem growth and reduces the long-day lighting period needed for standard cut-flower chrysanthemums (1, 3, 5). When applied to pompon cultivars at 10–20 mg/liter during the 4th week after the start of short days, peduncle length was increased (4, 11). The peak sensitivity to GA_3 for peduncle elongation was found to be during the 4th week of short days and high concentrations or applications later than this could result in weakened inflorescences (3, 11).

A new group of compounds, commonly called phthalimides (American Cyanimid Co., Princeton, N.J.), having pronounced plant growth regulating activities similar to GA_3 has been described (6). In a study designed to test the mode of action of phthalimides on nondwarf peas (*Pisum sativum* L.), Nuschke (7) found that these compounds do not solely elicit a gibberellin response. The activity of phthalimides was found to enhance gibberellin precursors which elevate endogenous gibberellin levels.

Phthalimides have been found to improve the flower formation in F_1 hybrids of *Cyclamen persicum* Mill (8, 10). Cyclamen, treated at flower bud set with a single application of 10–1000 mg/liter phthalimide, matured 2–5 weeks earlier than those given a single GA_3 treatment (10). Peduncles were stronger and fewer starshaped flowers were observed with phthalimides than compared with GA_3-treated plants. Phthalimides also have been found to modify sex expression of cucumber (*Cucumus sativus* L.). Single foliar applications of 1000–2000 mg/liter AC 99,524 or 94,377 delayed the appearance of the 1st pistillate flowers, while inducing staminate flower formation during winter (12).

The purpose of this study was to compare the activity of GA_3 with 2, substituted phthalimides for increasing the terminal floral peduncle lengths of a pompon chrysanthemum cultivar.

Rooted cuttings of 'Starburst' chrysanthemum were planted in beds on 16 Oct. 1981. Plants were spaced on 20-cm centers in each of 4 ground benches that were 1.32 (wide) × 3.35 m (length) and 30 cm deep. Soil medium consisted of 2 soil : 1 peat : 1 perlite (by volume) to which was added 953 g/m^3 0N–8.3P–0K, 50 g/m^3 of fritted trace elements, and sufficient dolomitic limestone to provide a pH of 6.5. Benches were lighted nightly from 2200–0200 HR for 4 weeks with incandescent lamps (about 4 μmol s^{-1} m^{-2}). Short-day treatment then was provided by dark cloth shading applied nightly (1630–0830 HR) from 13 Nov. until terminal florets were fully expanded. All water and fertilizer were applied twice/week using an injector that delivered 300 mg/liter of 20N–8.7P–16.16K until disbudding and 15N–4.4P–24.9K thereafter. Greenhouse temperatures were maintained at 16° to 18°C at night.

Chemical spray treatments were made on the 4th week following the start of short-day photoperiods. Treatments consisted of a single application of GA_3 (10, 25, 50 mg/liter), AC 94,377 (250, 500, 1000 mg/liter), AC 99,524 (250, 500, 1000 mg/liter), or control treatment of water plus surfactant. Chemicals were dissolved in water with 0.1% Tween 20 (polyoxyethylene sorbitan monolaurate) as a surfactant. Foliar applications were made to individual plants by directing the spray to the terminal region to runoff. Single-plant treatments were replicated 10 times in the 4 benches using a randomized block design, with perimeter plants providing guard rows. The terminal flower bud on each plant was removed on 22 Dec. 1981 to allow maximum lateral peduncle development.

Measurements were made when the most mature flowers were fully expanded. These included the lateral flower peduncle lengths, peduncle dry weights, and internodal lengths between peduncles. Measurements were determined for each of the 4, most-terminal peduncles, numbered consecutively from the top. Peduncle lengths were determined by measuring the distance between the stem juncture with the peduncle and the floral calyx. Internodal lengths were determined by measuring the main stem length between adjacent lateral peduncles. Dry weight was determined by harvesting individual peduncles without flowers and drying at 70°C for 48 hr.

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