COLORADO FLOWER GROWERS ASSOCIATION, INC.

IN COOPERATION WITH COLORADO STATE UNIVERSITY
Dorothy Conroy, Executive Secretary
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Ion Ratios and Competitive Uptake of Nutrients in Carnation

James L. Green

Pertinent literature on the effects of ionic balance on plant growth was presented in CFGA Bulletin 210. Results of an experiment to investigate these nutritional concepts on carnation growth were presented in Bulletin 211. The outline of experiment 1 was presented in Bulletin 211. This experiment was designed to study the effect of 3 variables on carnation growth: 1. nutrient solution treatment, 2. light level, and 3. CO_2 level.

A second experiment was designed strictly to evaluate the effect of the 8 nutrient solution treatment outlined by Homes (1), as follows:

- 4 replicates (chambers 1, 2, 3, and 4).
- 1 CO_2 level = 750 ppm CO_2.
- 8 nutrient treatments within each replicate.
- 5 plants/treatment/replicate.

The light gradient between chambers was removed from the analysis by considering each chamber as a complete block. Data from both experiments are used in the results that follow.

Maintenance of Specific Ion Ratios

The relation of ion concentration in the plant tissue (me/kgdm) to the total ion uptake per plant is illustrated in figures 2 and 3. The ion ratios within the plant tissue are stated in table 1.

The effect of the ratios among the ions in the applied nutrient solution on the uptake by the plant of each of the ions can be seen in figure 2b. The greatest effect was in the applied nutrient treatment having K:Ca = 12:0. Even though the potassium, magnesium, and sodium concentrations in the tissue were normal (Fig. 2a), the total uptake per plant (Fig. 2b) of all cations was greatly reduced due to the calcium imbalance in the applied solution. In this treatment there was a greatly reduced (C-A) content and yield (Fig. 1, point 5). In the applied nutrient treatment having K:Na = 0:10, the plants were potassium deficient and the growth rate was greatly reduced due to the ion-ratio imbalance. A "normal" (C-A) content was maintained by plants in this treatment at a greatly reduced growth rate (Fig. 1, point 6).

In the NO_3:Cl replacement series the H_2PO_4, SO_4, and NO_3 concentrations in the tissue remained relatively constant (Fig. 3a, b). The chloride content of the applied nutrient solution and the chloride concentration within the tissue had no apparent effect on the ratios of the other ions or upon uptake. Chloride was apparently taken up by the carnation plant independently of all other anions. The chloride uptake, did, however, greatly lower the (C-A) content by increasing the total anion content (A) of the plant tissue. The reduced (C-A) content was accompanied by a reduction in yield (Fig. 1, points 13, 14).

The K:NH_4 replacement series (Fig. 4 a, b) did not greatly change the ratios within the cation and anion groups (table 1). With increasing NH_4 there was a decrease in the (C-A) content and plant yield (Fig. 1, points 10, 11). The decrease in (C-A) was mainly due to an increase in inorganic anion concentration and a slight decrease in cation concentration.

There was a slight decrease in salt-cation content (C) when nitrate was supplied along with ammonium in the external nutrient solution (Fig. 7, points 10, 11). It appears that ammonium in the external nutrient solution increased the inorganic-salt content (A) at the expense of the organic salts. Ammonium in the absence of nitrate, experiment of Tuil (2), lowered the total salt content (C) at the expense of the organic salts with little or no effect on the inorganic-salt content (A).

TABLE 1. Experiment 1: relative ion concentrations in the plant tissue. Cation contents relative to K; anion contents relative to NO_3

Trt-mt	Relative Cations				Total cations to inorg. anions	Relative Anions			
	K	Ca	Mg	Na	C:A	NO_3	SO_4	H_2PO_4	Cl
K-Ca Replacement									
2	1.0	1.61	0.43	0.18	6.2:1	1.0	0.92	0.77	0.45
3	1.0	0.86	0.23	0.03	6.9:1	1.0	0.74	0.70	0.40
4	1.0	0.60	0.28	0.03	5.9:1	1.0	0.93	0.90	0.44
5	1.0	0.06	0.23	0.03	5.5:1	1.0	0.86	1.21	0.64
K-Na Replacement									
6	1.0	12.93	6.85	35.35	4.3:1	1.0	1.13	1.99	1.48
7	1.0	0.70	0.36	0.17	6.1:1	1.0	0.87	0.88	0.25
8	1.0	0.54	0.27	0.09	6.1:1	1.0	0.95	0.82	0.35
4	1.0	0.60	0.28	0.03	5.9:1	1.0	0.93	0.90	0.44
$K-NH_4$ Replacement									
10	1.0	0.39	0.19	0.02	4.8:1	1.0	1.10	0.86	0.68
11	1.0	0.41	0.21	0.03	4.3:1	1.0	1.03	1.03	0.65
NO_3-Cl Replacement									
11	1.0	0.41	0.21	0.03	4.3:1	1.0	1.03	1.03	0.65
13	1.0	0.47	0.22	0.03	2.6:1	1.0	1.50	1.50	3.92
14	1.0	0.44	0.21	0.03	2.7:1	1.0	1.18	1.36	7.63
Concentration Series									
12	1.0	1.78	0.53	0.13	6.5:1	1.0	38.70	11.70	35.30
1	1.0	0.47	0.23	0.04	6.4:1	1.0	0.92	0.78	0.36
4	1.0	0.60	0.28	0.04	5.9:1	1.0	0.93	0.90	0.44
9	1.0	0.39	0.20	0.03	5.8:1	1.0	0.86	0.79	0.45

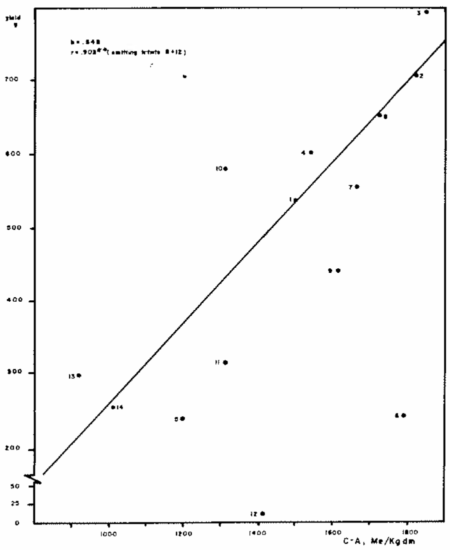

Fig. 1. The relation between yield and (C-A) content on the carnation plant tissue. Experiment 1.

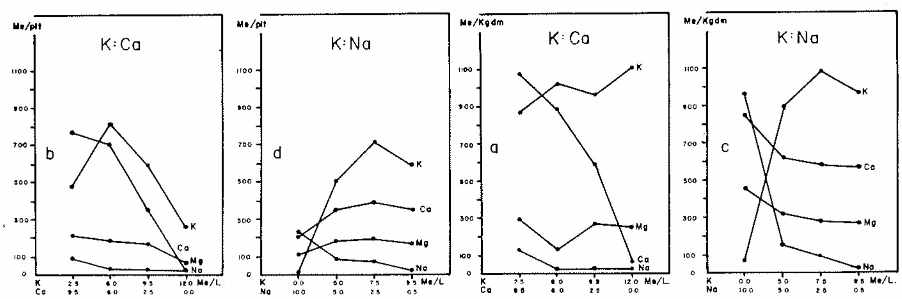

Fig. 2. Cation replacement diagrams for the leaf tissue of carnation showing effect of replacement in the external nutrient solution on the plant tissue ion concentration and on the total ion content per plant. a. Effect of potassium-calcium replacement on cation concentration. b. Effect of potassium-calcium replacement on total cation content. c. Effect of potassium-sodium replacement on cation concentration. d. Effect of potassium-sodium replacement on cation content.

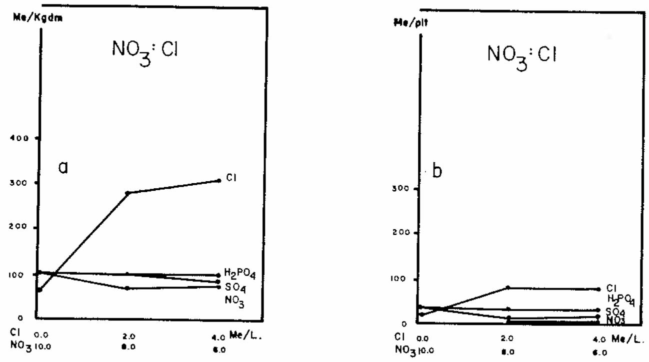

Fig. 3. Anion replacement diagrams for the leaf tissue of carnation. Initial composition of the solutions is given in Table 2, Bull. 211. a. Effect of nitrate-chloride replacement in the external nutrient solution on the Cl, H_2PO_4, SO_4, and NO_3 ion concentration in the plant tissue. (See figures 4a and 4b.) b. Effect of nitrate-chloride replacement on the total anion content per plant.

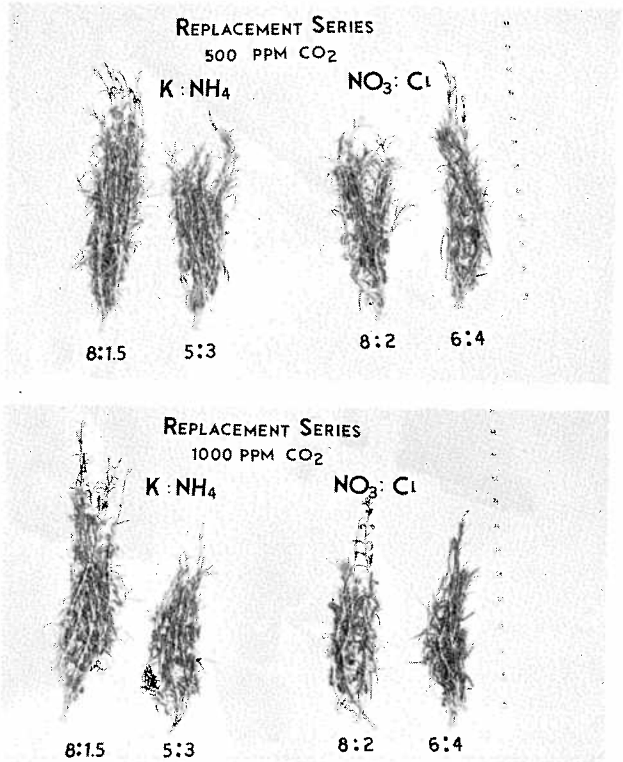

Fig. 4. Plants from the potassium-ammonium and the nitrate-chloride replacement series.

Competitive Uptake and Enhancement Effects

By replacing one ion with another while supplying all other ions at a constant level, the ability of one ion to be taken up to the same extent (replacement) as the other can be studied. Also, the effect of the concentration of one ion in the nutrient solution on the uptake of other ions in solution can be studied.

In the K:Ca replacement series (Figs. 2, 5a), even though the sodium and magnesium levels in the applied nutrient solution were held constant in all treatments, there was a decrease of sodium concentration in the plant tissue with each increase in potassium. This decrease in sodium with increase in potassium is also seen in figures 5c and 5d.

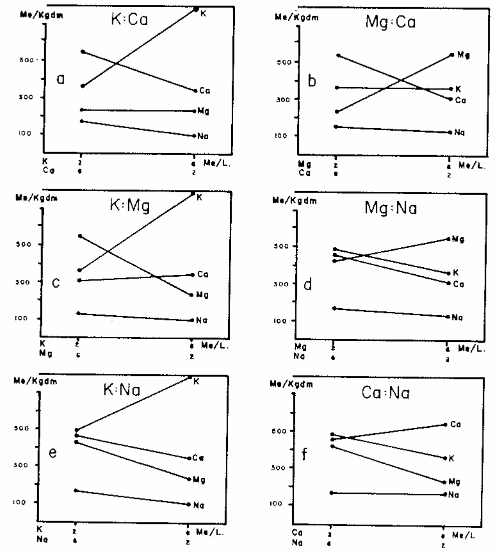

Fig. 5. Cation replacement diagrams for the leaf tissue of carnation plants of experiment 2. Effect of replacement in the nutrient solution on the concentration of K, Ca, Mg, and Na in the plant tissue. a. Effect of potassium-calcium replacement. b. Effect of magnesium-calcium replacement. c. Effect of potassium-magnesium replacement. d. Effect of magnesium-sodium replacement. e. Effect of potassium-sodium replacement. f. Effect of calcium-sodium replacement.

Calcium when supplied at the same level as potassium in the applied solution was taken up by the plant to nearly the same extent as was potassium. Potassium and calcium are probably taken up independently as indicated by the constant horizontal line for potassium concentration in figure 5b. The ability of carnation to absorb calcium as readily as potassium is different from the selectivity of the gramineous plants, but in agreement with that for tobacco, citrus, and other dicotyledonous plants studied by Tuil (2).

The enhancement effect of sodium on the uptake of potassium, calcium, and magnesium is illustrated in the K:Na replacement series (Figs. 2, 5c). A high ratio of sodium to the other cations compared to a low sodium ratio (Figs. 5d, 5e, 5f) increased the concentration of the other cations in the plant tissue when these cations were at a constant level in the applied nutrient solution. This apparent enhancement effect is also seen in figure 2. There was a progressive decrease in calcium and magnesium concentration in the plant tissue as the sodium level in the applied solution decreased. As the potassium content of the nutrient solution was increased with subsequent decrease of the sodium content, potassium concentration in the plant tissue increased to a point and then decreased as the sodium content of the applied solution decreased (Fig. 2).

Probably, there is a certain level at which sodium greatly enhances the uptake of other cations. Sodium can become a problem, however, when the potassium level in the applied nutrient solution is extremely low (Fig. 2c). The sodium content increases slightly with decreasing potassium in the applied solution until the potassium level becomes deficient, then sodium rapidly replaces potassium in the ratio of the ions in the plant tissue. The increasing sodium content with decreasing potassium content suggested that these two ions effected each other in a competitive fashion, independent of the other cations given.

There were probably three systems operating in cation uptake by the carnation plant. 1) When potassium was in good supply, the presence of potassium suppressed the uptake of sodium rather effectively. 2) When the potassium supply was deficient, the four ions K, Na, Ca, and Mg competed for uptake. 3) Magnesium and calcium may have been taken up by a separate system in which they competed equally for uptake. The last uptake system is postulated because even though the calcium level was held constant in the applied nutrient solution (Fig. 5c), there was an increase in calcium concentration in the plant tissue when the magnesium in the applied solution was decreased.

When magnesium and calcium were held constant at 2me/liter in the applied solution (Fig. 5e), the lines for their concentration in the tissue were approximately parallel, suggesting that they are taken up by the same system at approximately equal rates.

There was no apparent competitive system involved in the uptake of chloride. Chloride appeared to be taken up over and above the normal inorganic anion uptake.

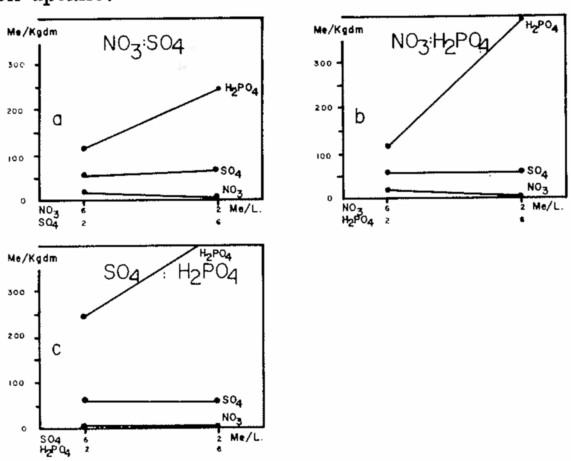

Fig. 6. Anion replacement diagrams for the leaf tissue of carnation plants in experiment 2. Effect of replacement in the nutrient solution on the concentration of H_2PO_4, SO_4, and NO_3 in the plant tissue. a. Effect of nitrate-sulfate replacement. b. Effect of nitrate-phosphate replacement. c. Effect of sulfate-phosphate replacement.

The sulfate concentration in the plant tissue remained constant regardless of the ratios and levels in the applied external solution. Phosphate concentration in the plant tissue increased linearly with increasing supply in the applied solution; phosphate uptake and concentration in the plant tissue was greatly increased at a high level of sulfate in the applied solution (Figs. 6a, b, c).

The nitrate level was low in all of the treatments of experiment 2 (Fig. 6) compared to experiment 1 (Fig. 3). The low nitrate level in experiment 2 resulted in a stress on the (C-A) content associated with a lower cation content. This was probably due to the lower transport of nitrates and organic anions to the top of the plant resulting in the (C-A) content not being maintained at its normal value.

Discussion and Conclusions

A 'normal' (C-A) content is only one of the prerequisites for optimal growth; the ion ratios affecting competitive ion uptake and the subsequent ion constituents of the (C-A) are critical.

The major fraction of the K was taken up through a system where the four cations K, Na, Mg, and Ca compete. Only a minor portion entered the plant through the system operative for the K and Na ions only. In the presence of ample potassium (the four-cation uptake system), sodium enhanced the uptake of the other cations in a noncompetitive way.

Potassium apparently had two functions in the plant. It was essential as such and it functioned as a positive charge in uptake accompanying organic anions. As an essential element potassium could not be replaced by any other ion. The cations K, Na, Mg, and Ca all functioned as positive charges. And in the absence of potassium, sodium was more readily taken up by the plant than were calcium or magnesium. When potassium was replaced by sodium, the (C-A) content of the plant was maintained at approximately the same level (Fig. 7c, points 6 and 8). The high cation content associated with point 6 (Fig. 7a) was accompanied by a high anion content (Fig. 7b, point 6). The high anion content was mainly the result of increased chloride and phosphate concentration in the plant tissue. In this treatment, there was a 'normal' (C-A) that was not associated with an optimum yield.

The mobility of sodium in the plant was less than that of potassium. Sodium moved readily upward, but was not able to move downward to the roots. This resulted in an accumulation of organic salts in the leaf tissue and a consequent reduction in cation uptake because of the immobility of the organic anions.

Other cations, even when absorbed in similar quantities, were unable to perform the specific functions of potassium because their rate of internal circulation was insufficient. Partial substitution of other salt cations for potassium did not affect the ionic balance and growth as long as potassium remained present in sufficient amounts to perform its specific function.

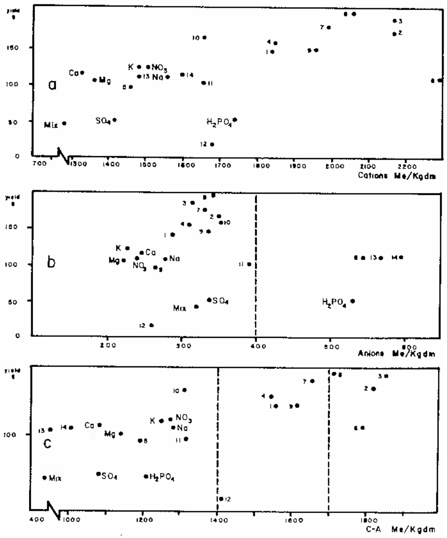

Fig. 7a. The relation between cation concentration in the tissue and yield. b. The relation between anion concentration in the plant tissue and yield. c. Relation between (C-A) content of the plant tissue and yield. Points numbered 1-14 are results from experiment 1; other points are from experiment 2. Tissue analyses from experiment 1 are plotted against their respective plant weights after 12-week growth period. Tissue analyses from experiment 2 are plotted against their respective plant weights after 14-week growth period.

Nitrate was readily absorbed and transformed to the reduction stage of ammonia before it was assimilated into organic compounds. Ammonium was also readily absorbed. Any difference in response to either form was therefore attributed to their different effects on the ionic balance of the plant. The ammonium ion probably competed with the potassium ion for uptake. When the ammonium ion was incorporated into the protein, its positive charge was released as H^+. The ammonium ion was of no use in maintaining the cation content of the plant tissue.

Phosphate was readily absorbed by the plant and caused a stress on the (C-A) content because of the increased anion content of the tissue. Phosphate was probably taken up in luxury quantities.

LITERATURE CITED

1. Homes, M. V. 1963. The method of systematic variations. Soil Sci. 96 (6):380-386.
2. Tuil, H. D. W. van. 1965. Organic salts in plants in relation to nutrition and growth. Versl. Landbouwk. Onderz 657, Wageningen, 83p.

Pentac Dusting

A number of progressive rose growers have been dusting instead of spraying with wettable Pentac. It's not known where the idea originated but J. H. Thompson, Inc. of Kennett Square, Pa., has been dusting with Pentac for two years, and they find the dust is much easier to apply and that one dusting usually gives control for 2 to 3 months. Residue is less visible.

The regular wettable Pentac is used and applied with the small model 2 1/2 HP Solo Mistblower. The dusting is usually done with the vents closed, but if the weather is hot they can be cracked. Where there are overhead fans in the house, or Fan Jets, these are turned on during the dusting to insure better distribution. However, good results have been obtained by a careful operator under all conditions. An extra shot is given to hot spots where spiders are established. The aim is to apply as much Pentac as a dust as would be applied to the same house if it were applied as a spray, or about one pound per 8,000 sq. ft. of ground area. A gas mask is worn during the dusting to protect the eyes, nose and mouth. The small Mistblower is more easily handled in aisles than larger models.

Wettable powders have an advantage over regular dust formulations as there is not as much residue. Also, dusts are usually less stable. Ordinary dusters may not give the results with wettable powders that a power mistblower gives, because they cannot produce the air blast, turn the leaves, and give the uniform distribution.—from Geiger News Vol. 3 No. 6. WDH.

German Flower Imports--1966

West Germany imported approximately 55 million dollars worth of cut flowers in 1966. Flower imports have climbed steadily from a total of $32 million in 1962. The 1966 imports included $26 million worth of carnations principally from Italy and Holland and $10 million worth of roses mainly from Holland. Substantial imports of cut flowers also came from Spain, France, Denmark.—from zb, July 20, 1967. WDH.

20 Years of Joy With Migros Flowers

Migros department stores in Switzerland sold approximately 11 million dollars worth of flowers in 1967. Among the flowers sold were 21 million carnations, 5.2 million tulips, 5 million roses and 2.2 million pot plants.

This all started in a very small way 20 years ago with an idea to stock a few flowers late each week to bring joy to their customers over weekends. They realized a genuine need and were attempting to make modest homes more cheerful. Mostly outdoor flowers were sold at first but soon it was evident that higher quality was wanted.

Glasshouse grown carnations were soon their major item, supplemented with carnations imported from Spain when available in good quality. With all flowers and pot plants quality eventually became the Migros guideline in procurement. The growth of their sales over 20 years shows how much they have done to popularize flowers.

Migros is satisfied with a small profit margin, hence they pay high prices for quality flowers to protect their sources of supply. A low markup allows serving the customer with quality flowers at lowest prices.

Migros Stores are expanding to new flower shop-garden center operations in their larger Kombi-Stores. Flower corners have been established where flower arrangers and trained sales personnel serve the public. There is an element of contagion in the whole scheme for today in every room of Migros Stores are found flowering or green plants.—from ZB (Zierpflanzenbau Gartenbautechnick) Nov. 9, 1967. Transl. by Johanna Klausner.

Research Note

Stevenson, D. S., 1967. Effective soil volume and its importance to root and top growth of plants. Can. J. Soil Sci. 47:163-174. The author investigated root and top growth of clover, wheat, and sunflower in varying soil volumes. The soil depth in all cases was 6 inches, but total volume varied from 831 cm^3 to 6,670 cm^3 per plant. Sufficient water was added at each irrigation to return the soil to a tensiometer reading of approximately 20.

In general, the top growth of clover and wheat increased steadily with increasing soil volume. Sunflower approached a direct proportionality between growth and soil volume. The ratio of root growth to top growth decreased with increasing soil volume, i.e. the growth of tops exceeded the growth of roots. The different watering treatments employed had no effect on top or root growth or the root-top ratio.

Stevenson defines effective soil volume and concludes that above a certain root density, individual roots may interfere with the daily water supply of nearby roots and hence restrict plant growth.

In CFGA Bulletin 213 (now in press), Hanan and Kowalczyk report on growth of carnations in 4- and 8-inch deep soils. Undoubtedly, the difference in soil volume affected growth, as well as differences in moisture content. Where carnations are grown for periods of a year or longer, soil depth less than 6 inches should probably be avoided.—JJH.

Your editor,

W D Holley

COLORADO FLOWER GROWERS ASSOCIATION, INC.
OFFICE OF EDITOR
W. D. Holley
Colorado State University
Fort Collins, Colorado 80521

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