COLORADO FLOWER GROWERS ASSOCIATION, INC.

IN COOPERATION WITH COLORADO STATE UNIVERSITY
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Ion Balance in Carnation Nutrition

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Mineral nutrition is one environmental parameter determining the yield of carnation. Currently there is a shift from soil to inert substrates for growing media. Plant yield is now dependent upon the actual composition of the applied nutrient solution. Tissue analysis is becoming a valuable tool in assaying the degree of control achieved over the plant's nutrition. However, interpreting tissue analyses is complicated by interactions among the environmental parameters and mineral nutrition.

Seasonal variations of ionic concentrations within the plant have been reported. The ionic concentration of plant tissue is affected by CO_2 concentration, light (duration and intensity), temperature, and water stress, as well as by the composition of the nutrient solution.

Also, the concentration of specific ions within the plant tissue is dependent upon genetic differences among plants of the same species. Tissue from the same plant may have varying concentrations of specific ions depending upon the physiological age of the tissue sampled.

The primary interest in tissue analysis is to relate the observed analyses to yield and thus to improve yield by making recommendations for modification of the applied nutrient solution and/or other environmental factors. Interpretation of the tissue analyses requires a knowledge of the ionic balance as well as the absolute requirement for specific ions.

The ionic balance and specific ion requirements for carnation have been studied under limited environmental variation. Under the conditions of the past work (1), a 'normal' organic anion concentration (C-A), ranging from 1700 to 1900 meq/Kg dm, was established for carnation. The yield of carnation was found to be positively correlated with the organic anion concentration.

The first objective of this research was to study ionic balance in carnation tissue as regulated by the plant.

a) Previous work (1) has indicated that the higher the organic anion concentration the higher the yield. Can the organic anion concentration be increased above the previous high levels? If so, is yield increased as well?

b) Can the organic anion content of carnation be increased by supplying the plants a greater than normal concentration of: 1) cations which remain as cations in the plant, 2) an anion (NO_3) which is rapidly metabolized within the plant, and/or 3) an anion (SO_4) which is not rapidly metabolized, depending on the plant to absorb more cations and utilize the NO_3 present more efficiently.

Methods

Plants for this experiment were grown in a fiberglass covered greenhouse oriented east-west. Supplementary CO_2 was added to the greenhouse by a natural gas-fired generator. The generator

[1]This is one of a series of experiments done by Hartman while completing the requirements for the M.S. Degree at Colorado State University. The series will be presented in two parts.

supplied CO_2 only when the greenhouse was a closed system during the daylight hours. Temperatures were recorded by an aspirated bimetal recording thermometer. The night temperaure was nearly constant at 54°F. The greenhouse was heated to 60°F and cooling initiated at 65°F during the day. Day temperatures varied, according to the external environment, between 65 and 70° F. Cooling was accomplished by the conventional fan, pad, and plastic tube system. Outside daily solar radiation was measured with an Epply pyranometer.

The experiment was a randomized complete block design. There were 16 plants per treatment, two plants per pot. Two 3.5′ benches side by side were used. Each bench contained 4 complete blocks, 3.5′ by 8′ or 4 pots of each treatment. For statistical analysis of yield, the pots were considered replications and the plants observations. For analysis of tissue content, leaves from the 8 plants on each bench were composited to give 2 samples per treatment.

The nutrient solutions were formulated using reagent grade salts and tap water. For the duration of the experiment, the water was analyzed and had an average conductance of 84 micromhos and a range of 59-100 micromhos. The tap water inherently contained near constant concentrations of certain ions. Average concentration of these ions for the 26 week growing period were:

Fort Collins tap water in meq/l

Ca	Mg	Na	HCO_3	Cl	SO_4
0.4	0.45	0.2	0.5	0.3	0.3

The composition of the nutrient solutions for the organic anion series is presented in Table 1. This series was composed of 3 treatment groups. The first group (3,6,7,8) had KNO_3 added to the check solution (#3) in 2 meq/l increments. In the second group (3,9,10,11) K, Ca, Mg, plus NO_3 increased in 2 meq/l increments. The cation ratio remained constant but the sum of the cations increased. The third group (3,12,13,14) in this series was the same as the previous group except SO_4 was the increasing anion.

Carnation cuttings, cv. CSU White Sim, were rooted in a peat-perlite mixture under mist. Plants were transplanted into 8-inch pots of perlite on October 24, 2 plants per pot. The plants were watered with tap water 3 times daily the first 3 days. Starting the fourth day all plants were watered with the prescribed nutrient solution. Watering 3 times daily continued 3 more days and then was changed to once daily. On February 12, the frequency of watering was increased to 2 times daily.

The plants were irrigated automatically according to the desired frequency and duration. Nutrient solutions were made in 100 liter plastic containers. Each solution was pumped from a tank by an ITT Jabsco self-priming, positive pressure lab pump with a capacity of 4.3 GPM at O′ head. The pumps were controlled by an automatic irrigator (2) designed to control both irrigation frequency and duration.

One-half inch black polyethylene pipe conducted the solutions from the pumps to and along the benches. Polyethylene capillary tubes connected the header pipes with the pots. Double ring Chapin Water-Loops distributed the solutions about the surface of the growing medium.

An excess of nutrient solution was applied at each irrigation to leach the substrate. Periodic conductance and pH readings of the leachates were taken and indicated no build-up of salts.

The plants were harvested and fresh weights taken on April 25, 1970. Leaves for tissue analysis were sampled according to the method described by Nelson and Boodley (4). The leaves were washed, dried 48 hours in a forced draft oven at 70°C and ground in a Wiley mill to pass a 40-mesh screen. Analysis of the plant tissue was done by the CSU Soil Testing Laboratory.

Results

No significant differences between mean yields were found in the three series of treatments. As the total ionic concentration increased in the applied nutrient solutions, yields decreased slightly (Table 2).

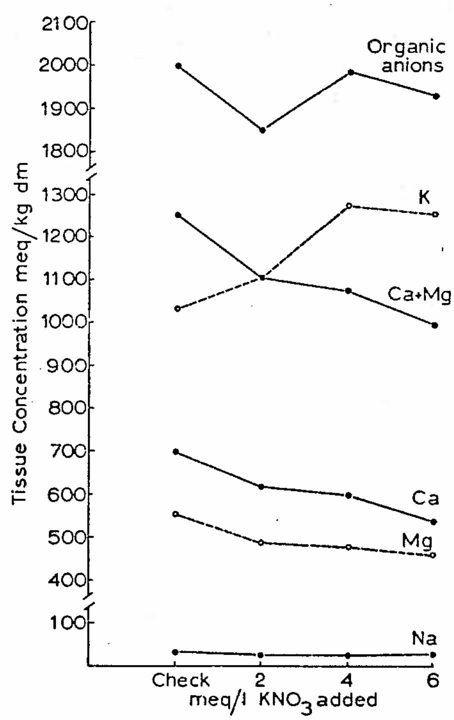

Fig. 1. Effects of addition of KNO_3 in 2 meq/l increments to the check treatment on carnation tissue concentrations of K, Ca, Mg, Na, Ca + Mg and organic anions.

In the series with KNO_3 increasing in 2 meq increments (Table 1), K increased in the tissue at the expense of Ca and Mg (Fig. 1). The sum of the cations remained nearly constant in the tissue, regardless of the changes of the individual cations (Table 2). Nitrate in the tissue increased slightly with the first additional increment but no further increase due to additional increments was observed. The sum of anions did increase slightly due to the increase in NO_3. However, organic anion concentration was not significantly changed.

The next series had the sum of K, Ca, and Mg plus NO_3 increased in 2 meq increments (Table 1). Even though the cation concentrations were increased in the same ratios as the check treatment, K concentration in the tissue increased and Ca and Mg decreased (Fig. 2). The sum of the cations remained constant. Again, the inorganic anion content of the tissue was slightly increased due to increased NO_3 but the sum of the anions was nearly constant. The organic anion content remained unchanged.

In the last series the sum of K, Ca, and Mg plus SO_4 as the anion were increased in 2 meq increments (Table 1). Potassium in the tissue did not change appreciably. The decrease in Ca and Mg was comparable to the preceding two series (Fig. 3). The sum of the cations decreased slightly while the total anions increased slightly resulting in a lower organic anion content. Sulfate in the tissue remained essentially constant.

Treatments within the organic anion study were developed to maximize cation accumulation and NO_3 absorption and reduction. The study was an effort to increase organic anion concentration above the level produced by the check treatment. A treatment similar to the check treatment (Soln. 3) by Hartman and Holley (3) produced an organic anion concentration within the range considered to be 'normal' for carnation, Green (1). However, the treatments in the present experiment did not produce increased accumulation of cations or NO_3. Consequently the organic anion concentration remained constant, even though the relative cation ratios in the tissue changed (Table 2). Mean yield was not significantly affected by treatments.

Failure to increase the organic anion concentration by modification of the nutrient solution composition in this study is in agreement with the findings of Wit et al. (5). Plants regulate their organic anion concentrations over a wide range of solution compositions.

Conclusions

The organic anion concentration of carnation tissue was not increased by adding successive increments of nutrient ions to a complete nutrient solution. The sum of the cations in the tissue remained nearly constant; however K increased at the expense of Ca and Mg when successive increments of all were added. Yield decreased slightly as solution concentration increased.

In commercial greenhouse culture, formulation of the nutrient solution is an important function of management. The cost of fertilizer is small relative to the total cost of production and marketing. However, mismanagement of feeding practices, leading to reduced production, soon makes the total feeding program quite costly. The results of the organic anion study point out one source of mismanagement of the total feeding program. Application of excess fertilizer salts to carnations in an inert substrate provides no benefit and may reduce yield.

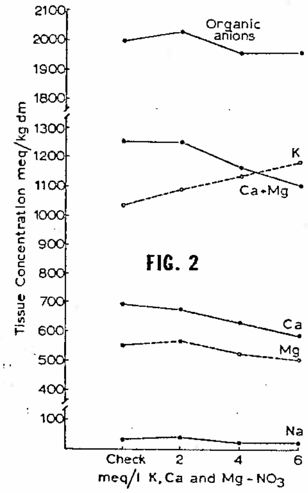

FIG. 2

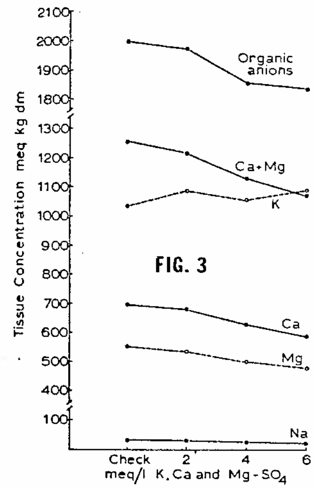

FIG. 3

Fig. 2. Effects of addition of K, Ca, and Mg plus NO_3 in 2 meq/l increments to the check treatment on carnation tissue concentrations of K, Ca, Mg, Na, Ca + Mg and organic anions.

Fig. 3. Effects of addition of K, Ca, and Mg plus SO_4 in 2 meq/l increments to the check treatment on carnation tissue concentrations of K, Ca, Mg, Na, Ca + Mg and organic anions.

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TABLE 1. Treatment nutrient solution composition in milligram equivalents per liter[a]

Treatment	K	Ca	Mg	Na	NH_4	NO_3	SO_4	H_2PO_4	Cl
	Milligram equivalents per liter								
Organic Anion Study									
Increasing KNO_3									
3.	6.00	3.50	3.50	0.5	0	12	0.5	1	0
6.	8.00	3.50	3.50	0.5	0	14	0.5	1	0
7.	10.00	3.50	3.50	0.5	0	16	0.5	1	0
8.	12.00	3.50	3.50	0.5	0	18	0.5	1	0
Increasing K, Ca, and Mg Nitrate									
3.	6.00	3.50	3.50	0.5	0	12	0.5	1	0
9.	6.90	4.05	4.05	0.5	0	14	0.5	1	0
10.	7.85	4.58	4.58	0.5	0	16	0.5	1	0
11.	8.77	5.12	5.12	0.5	0	18	0.5	1	0
Increasing K, Ca, and Mg Sulfate									
3.	6.00	3.50	3.50	0.5	0	12	0.5	1	0
12.	6.90	4.05	4.05	0.5	0	12	2.5	1	0
13.	7.85	4.58	4.58	0.5	0	12	4.5	1	0
14.	8.77	5.12	5.12	0.5	0	12	6.5	1	0

[a]All solutions contained trace elements as follows: B, 1ppm; Mn, .25ppm; Fe, .56ppm as Sequestrene 330; Zn, .05ppm; Cu, .02ppm; and Mo. .01ppm.

TABLE 2. The effects of nutrient solution treatment on carnation tissue composition and yield in the organic anion study[a]

Treatment	K	Ca	Mg	Na	C	NO_3	SO_4	H_2PO_4	Cl	A	Organic Anion[b]	Total N	Mean yield gms fr wt[c]
	Milligram equivalence/Kilogram dry matter												
Increasing KNO_3													
3.	1033.2	698.9	554.7	32	2318.8	104.9	31	144.3	42	322.2	1996.6	2445.0	440.4
6.	1102.0	617.6	488.9	27	2235.5	164.6	31	157.9	38	391.5	1844.0	2402.2	451.4
7.	1272.4	598.8	476.6	27	2374.8	147.9	36	167.6	40	391.5	1983.3	2487.9	424.9
8.	1254.5	536.4	460.2	28	2279.1	135.9	31	146.0	40	352.9	1926.2	2362.9	419.1
Increasing K, Ca, and Mg NO_3													
3.	1033.2	698.9	554.7	32	2318.8	104.9	31	144.3	42	322.2	1996.6	2445.0	440.4
9.	1086.9	679.9	571.1	32	2369.9	119.5	30	161.5	36	347.0	2022.9	2359.3	440.6
10.	1134.9	633.3	530.0	25	2323.2	138.4	35	158.6	33	365.0	1958.2	2423.6	420.4
11.	1184.2	592.6	509.5	26	2312.3	135.3	33	148.9	35	352.2	1960.1	2416.5	403.5
Increasing K, Ca, and Mg SO_4													
3.	1033.2	698.9	554.7	32	2318.8	104.9	31	144.3	42	322.2	1996.6	2445.0	440.4
12.	1086.9	679.6	533.6	30	2330.1	134.2	34	151.5	37	356.7	1973.4	2495.0	443.0
13.	1055.0	626.8	501.3	27	2210.1	98.6	37	162.0	59	356.6	1853.5	2348.7	417.7
14.	1086.9	589.3	480.7	24	2180.9	113.2	40	143.4	52	348.6	1832.3	2577.1	394.2

[a]Tissue analyses values are means of 2 individual analyses. Yield is the mean of 16 plants.
[b]no significant F
[c]no significant F

Your editor,

WD Holley

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