COLORADO FLOWER GROWERS ASSOCIATION, INC.

IN COOPERATION WITH COLORADO STATE UNIVERSITY
Dorothy Conroy, Executive Secretary
901 Sherman Street, Denver, Colorado 80203

Bulletin 221

September, October 1968

Carnation Nutrition

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The current experiment was designed to learn the importance of ionic balance in a nutrient solution on the growth of carnation (Dianthus caryophyllus L.) under greenhouse conditions in two media: soil and perlite. Five questions were to be answered: How do carnations respond to low, medium, and high levels of potassium: What level of magnesium do carnations require? What are the differences in growth when chloride is absent and when it is added to the nutrient solution? How do varying levels of nitrate and ammonium as sources of nitrogen affect carnation growth? How is growth affected by different levels of phosphate? Finally, are the answers to the above questions different for soil or for an inert medium such as perlite?

Methods and Materials

The plants were grown in a fiberglass covered greenhouse. Temperatures were controlled at 52-53^{o}F night and during the day heated to 60^{o}F, cooled to 65^{o}F. CO_2 was not added to the atmosphere. There were fifteen nutrient solutions (Table 1). Each solution was used to water four pots of soil and four pots of perlite, two plants per pot.

On February 8, rooted cuttings of CSU White Sim were planted in 8-inch plastic pots containing either soil or perlite. The plants were pinched to five leaf pairs March 2. The perlite pots were watered daily until established and then watered every other day. Starting May 7, the plants in perlite were watered daily due to increased water loss. The soil pots were watered on demand but kept on the moist side to minimize water stress. The plants were harvested on June 24. Fresh and dry weights were taken and tissue analysis made.

Table 1. Nutrient Solution Composition.

(NUTRIENT SOLUTIONS (Milligram equivalents/liter)

	K	Ca	MG	Na	NH_4	NO_3	SO_4	H_2PO_4	Cl
1.	9.5	2.5	1.0	0.5	0.0	12.0	1.0	0.5	0.0
2.	6.0	6.0	1.0	0.5	0.0	12.0	1.0	0.5	0.0
3.	2.5	9.5	1.0	0.5	0.0	12.0	1.0	0.5	0.0
4.	6.0	5.0	2.0	0.5	0.0	12.0	1.0	0.5	0.0
5.	6.0	3.5	3.5	0.5	0.0	12.0	1.0	0.5	0.0
6.	6.0	2.0	5.0	0.5	0.0	12.0	1.0	0.5	0.0
7.	6.0	6.0	1.0	0.5	0.0	10.0	3.0	0.5	0.0
8.	6.0	6.0	1.0	0.5	0.0	10.0	2.0	0.5	1.0
9.	6.0	6.0	1.0	0.5	0.0	10.0	0.0	0.5	3.0
10.	2.5	2.5	.4	3.0	5.0	7.0	6.0	0.5	0.0
11.	2.5	2.5	.4	2.0	6.0	6.0	7.0	0.5	0.0
12.	2.5	2.5	.4	1.0	7.0	5.0	8.0	0.5	0.0
13.	6.0	6.0	1.0	0.5	0.0	10.0	3.25	0.25	0.0
14.	6.0	6.0	1.0	0.5	0.0	10.0	2.50	1.00	0.0
15.	6.0	6.0	1.0	0.5	0.0	10.0	1.50	2.00	0.0

In all nutrient solutions pH and total ion concentration were held constant. Thus, the primary variable studied was that of ion balance. The solutions are replacement series, varying only in the ions studied while maintaining a constant ionic concentration.

Green (1) found the level of total nitrogen in the nutrient solutions to be critical. Total nitrogen cannot be varied in the nutrient solution without drastically varying plant growth and the organic anion (C-A) content. In solutions 1-6 and 10-12, total nitrogen was maintained at 12 me/l. In solutions 7-9 and 13-15, the level of total nitrogen was decreased 2 me/l to allow testing of chloride concentrations as high as 3 me/l (7-9) and phosphate concentrations as high as 2 me/l (13-15), while maintaining constant total ion concentrations.

Solutions 1-9 and 13-15 were single replacement series, and 10-12 were double replacement series. The double replacement series was necessary to study the replacement of an anion (NO_3^-) with a cation (NH_4^+). To replace an anion with a cation, another anion and cation had to be varied to maintain total ion concentration. Therefore in the double replacement series (solutions 10-12), sodium was replaced by ammonium and sulfate was replaced by nitrate. The primary interest in this series was to study the ratio of nitrate to ammonium. Green (1) found that sodium and sulfate are accumulated in the plant tissue at relatively constant concentrations, regardless of their concentration in the applied nutrient solution.

To maintain the total nitrogen supplied at 12 me, it was necessary to keep the total $Na^+ + NH_4^+ = 8$ me and the total $NO_3^- + SO_4^= = 13$ me. This caused little disturbance of the anion ratios, as phosphate was kept at a standard 0.5 me. The total concentration of potassium, calcium and magnesium was reduced from the standard 13.0 me to 5.5 me. However, the ratio of K^+:Ca^{++}:Mg^{++} was maintained the same as that in the reference solutions.

Solution 2 is the reference solution for those solutions containing 12 me of total nitrogen (1-6, 10-12). Solution 7 is the reference solution for those solutions containing 10 me of total nitrogen (7-9, 13-15). Solution 7 can be compared to solution 2 to compare the result of decreasing the total nitrogen. Solution 7 contains the same ionic ratios as 2 except for lower total nitrogen and increased sulfate.

Potassium-Calcium Balance

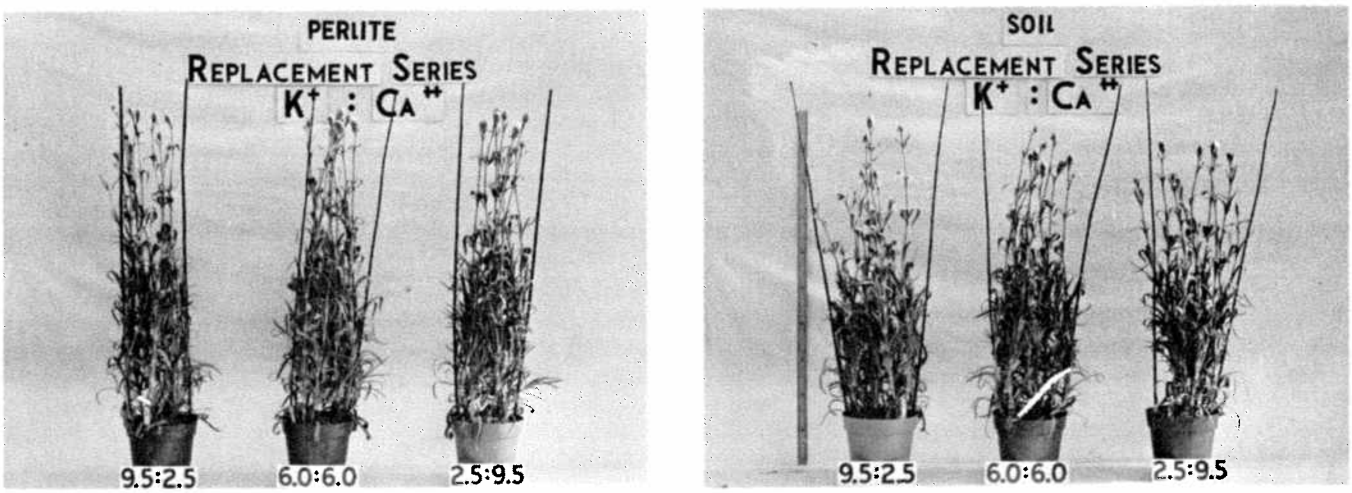


Fig. 1. Typical plants grown with 3 nutrient solutions for 5 months.

The replacement series of nutrient solutions to find near optimum balance between K and Ca omitted the two extremes. Concentration of K+Ca was held constant and the ratios varied as shown in Table 1 and Fig. 1. All ions except K and Ca were identical in each of the three solutions and were supplied at near optimum levels. Differences in growth between solutions were small (Table 2). Best growth in perlite was from Solutions 2 and 3 while best growth from soil resulted when Solution 1 was used. Yield in fresh weight averaged 17% higher from perlite than from soil. This difference was due to taller and heavier plants in perlite that matured buds slightly earlier (Fig. 1).

Results of tissue analysis made at the end of the experiment are shown in Table 3. The uptake of most of the nutrients was not affected by the K:Ca balance. Low K in the nutrient solution (No. 3) was reflected in low tissue K. Plants grown in perlite showed this to a greater degree since there was some potassium in the soil at the start of the experiment. Plants grown with Solution 1 (low Ca) showed low tissue Ca. Again soil containing some calcium produced a higher, though probably inadequate tissue calcium level than perlite.

Table 2. Effects of K:Ca balance on yield in grams of fresh weight[a] of carnations in two media.

K:Ca	Soln. no.	Soil	Perlite
9.5:2.5	1	339	382
6.0:6.0	2	323	398
2.5:9.5	3	311	395
Total		973	1175

[a]Average yield of 8 plants.

Table 3. Effects of K:Ca balance on tissue analyses[a] of carnations after 5 months of growth.

Medium and solution	K	Ca	Mg	Na	NO_3	SO_4	H_2PO_4	Cl
	Percent of dry matter							
Perlite								
1	4.8	0.7	.23	.11	.52	.16	.29	.12
2	4.3	1.4	.20	.11	.66	.19	.29	.12
3	2.8	1.9	.28	.29	.43	.14	.30	.12
Soil								
1	4.8	1.0	.25	.08	.61	.12	.28	.12
2	4.4	1.4	.27	.08	.69	.17	.28	.12
3	3.3	1.7	.29	.11	.53	.14	.28	.12

[a]Composite of 8 plants per treatment.

A balanced supply of K:Ca (Solution 2) maintained tissue levels of these ions in both soil and perlite. Nitrate nitrogen (usable reserve) was highest in the tissue of plants from both media when fed with Solution 2. As long as the total concentration of K + Ca was equal in this experiment growth varied within a narrow range in soil or perlite.

Conclusions

Optimum tissue K or Ca was not maintained in either perlite or soil with a nutrient solution containing 2.5 me/l of the respective cations. Equal amounts of K and Ca are indicated as near optimum with suggested concentrations of 6 me/l of each.

Explanation of the term "milliequivalent"

We are using the term milliequivalent because it has more meaning in terms of plant growth and metabolism than do the terms percent (%) and parts per million (ppm). Percent and ppm are expressions of the weight of the ion present in the plant tissue, whereas milliequivalent is the expression of the number of units of ion present. An analogy would be saying you have so many pounds of brick in a building (% or ppm) compared to saying how many bricks you actually have (milliequivalents). A milliequivalent of a chemical is one unit of that chemical. The plant takes up chemicals by units, not by the pounds.

A milliequivalent weight of an ion =

$$\frac{\text{atomic weight of the element (mg).}}{\text{VALENCE OF THE ELEMENT}}$$

Each element has its own characteristic atomic weight and consequently also has its own characteristic milliequivalent weight. For example, a milliequivalent of potassium $\frac{39.1}{1}$ 39.1 milligrams.

A milliequivalent of calcium $= \frac{40.08}{2} = 20.04$ mg.

To convert ppm to milliequivalents per liter, divide the ppm by the milliequivalent weight of the ion in question:

$$\frac{\text{ppm of the element}}{\text{milliequivalent wt of the element}} = \text{milliequivalents of the element}$$

To convert ppm to %, point off 4 places to the left.
100 ppm = .01%
To convert % to ppm, point off 4 places to the right.
.03% = 300 ppm

Calcium-Magnesium Balance

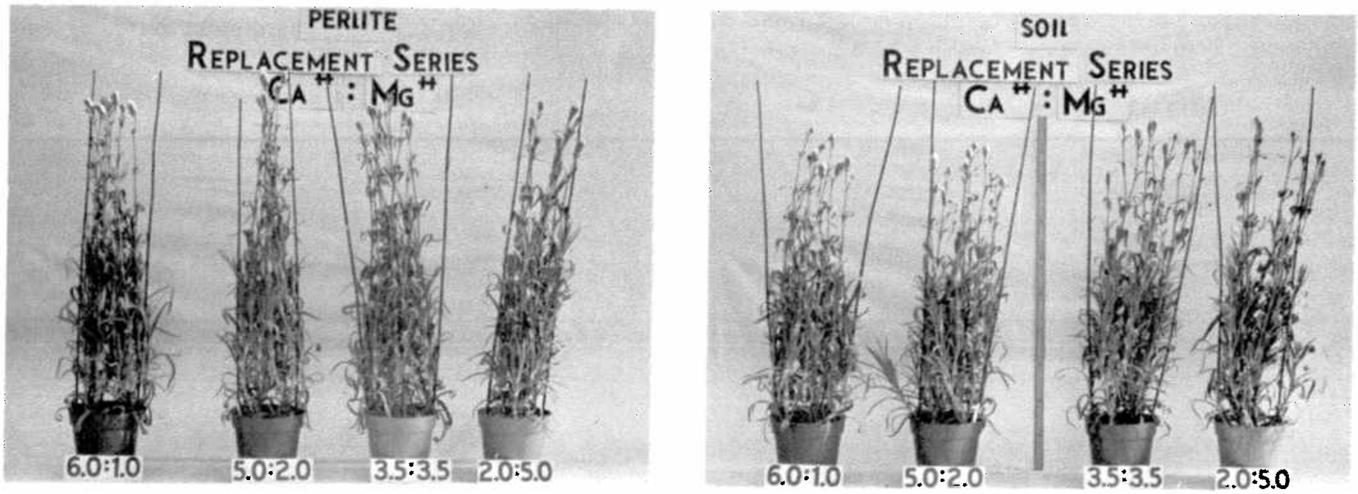


Fig. 2

The solutions used in the Calcium-Magnesium replacement series are indicated in Table 1. The differences in growth were greater than those in the K:Ca series. Solutions 5 and 6 gave best growth in perlite while 5 gave the best in soil (Table 4). Yield in fresh weight averaged 18% higher from perlite than from soil. This difference was due to taller and heavier plants (Fig. 2).

Results of the tissue analysis are given in Table 5. Uptake of the ions other than Ca and Mg were not significantly affected by the Ca:Mg balance. Low Ca in the solution (No. 6) is reflected by low concentration in the tissue. The same is true for Mg with plants from Solution 2. Again those plants grown in soil showed an increase due to the ions contained initially in the soil.

Table 4. Effects of Ca:Mg balance on yield in grams of fresh weights[a] of carnation in two media.

Ca:Mg	Soln. no.	Soil	Perlite	
6.0:1.0	2	323	398	
5.0:2.0	4	324	367	
3.5:3.5	5	398	429	
2.0:5.0	6	315	412	
Total		1360	1660	18%

[a]Average yield of 8 plants.

The results, growth and tissue analysis, from this series indicate that carnations require a higher Mg level than is in the check solution (1 me/1). While the Mg concentration in the tissue continued to increase with Solution 6, the yield did not increase. Optimum growth was obtained from 3.5 me/l Mg. Magnesium tissue levels of 0.40% in soil and 0.54% in perlite gave maximum growth in this experiment. This is a higher level than that reported in CFGA Bulletin 220.

Table 5. Effects of Ca:Mg balance on tissue analyses[a] of carnation after 5 months of growth.

Medium and solution	Percent of dry matter K	Ca	Mg	Na	NO_3	SO_4	H_2PO_4	Cl
Perlite								
2	4.3	1.4	.20	.11	.66	.19	.29	.13
4	4.3	1.2	.35	.10	.63	.14	.33	.13
5	4.3	1.8	.54	.11	.50	.19	.28	.13
6	4.3	0.7	.74	.11	.49	.14	.30	.13
Soil								
2	4.4	1.4	.27	.08	.69	.17	.28	.13
4	4.3	1.3	.31	.08	.70	.15	.29	.13
5	4.3	1.1	.40	.08	.66	.16	.30	.06
6	4.1	1.2	.47	.09	.75	.14	.28	.13

[a]Composite of 8 plants per treatment.

Sulfate-Chloride Balance

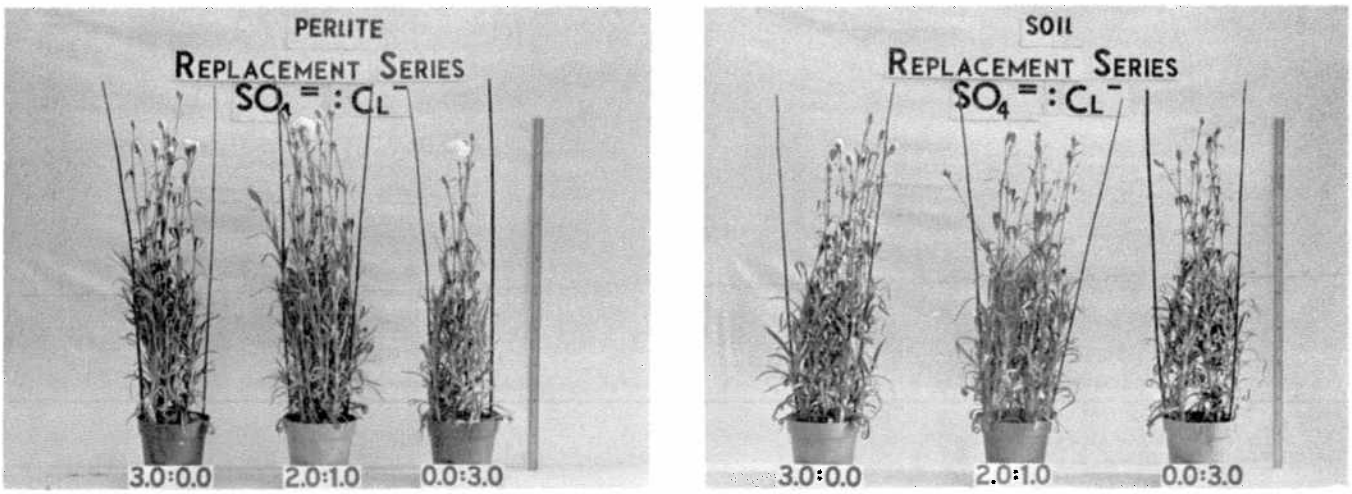


Fig. 3

Results of the sulfate-chloride replacement series on carnation growth are shown in Table 6. Only these two ions were varied in solutions 7-9. Sulfate decreased as chloride was increased and the total ionic concentration of the three solutions was the same. Best growth in perlite was from Solution 8 while Solution 7 produced best growth from soil (Fig. 3). Perlite produced an average of 18% more growth than soil with these solutions.

Tissue analyses for this experiment are shown in Table 7. No real differences were found in tissue levels of K, Ca, Mg, and Na. Tissue phosphate increased as sulfate decreased in the nutrient solution. Sulfate was low in tissue only when it was not added to the nutrient solution. Relatively high sulfate in the nutrient solution (No. 7) did not cause high tissue sulfate. As chloride increased in the nutrient solution tissue Cl increased. This was reported also by Green (1).

Table 6. Effects of SO_4:Cl balance on yield in grams of fresh weight[a] of carnations in two media.

SO_4:Cl	Soln. no.	Soil	Perlite
3.0:0.0	7	314	360
2.0:1.0	8	287	385
0.0:3.0	9	253	276
Total		854	1012

[a] Average of 8 plants.

Conclusions

Sulfur is essential for plant growth. Some tissue analyses have indicated that this nutrient may be limiting growth for Colorado growers using city water supplies and adding no sulfate forms of fertilizers. While carnations are tolerant to the sulfate ion and apparently do not take excess amounts, 1 me/1 in the nutrient solution is probably adequate for carnation growth. A tissue level of 0.10% should be adequate for healthy growth. When no sulfate was added in this experiment, tissue levels decreased to as low as 0.03% in plants growing in soil. The reduced growth at this level may have been caused by low sulfates, or more probably by high chlorides.

Table 7. Effects of SO_4:Cl balance on tissue analyses[a] after 5 months of growth.

Medium and solution	Percent of dry matter K	Ca	Mg	Na	NO_3	SO_4	H_2PO_4	Cl
Perlite								
7	4.2	1.3	.27	.09	.64	.10	.30	.19
8	4.3	1.3	.24	.11	.51	.11	.30	.63
9	4.4	1.2	.22	.05	.50	.08	.45	.63
Soil								
7	4.1	1.3	.26	.09	.51	.14	.27	.06
8	4.4	1.4	.27	.08	.58	.16	.30	.50
9	4.5	1.6	.27	.06	.63	.03	.39	.50

[a] Composite of 8 plants per treatment.

Chloride is probably assimilated according to its availability in the nutrient solution. Chloride reduced growth in this experiment when supplied in the nutrient solution to soil at concentrations of 1 and 3 me/1 (35 and 106 ppm). A concentration of 3 me/1 of Cl when applied to perlite reduced growth 30% compared to the growth produced by 1 me/1 of Cl. When chloride was increased from 0 to 3 me/1, growth in soil was reduced 20%.

Sulfate-Phosphate Balance

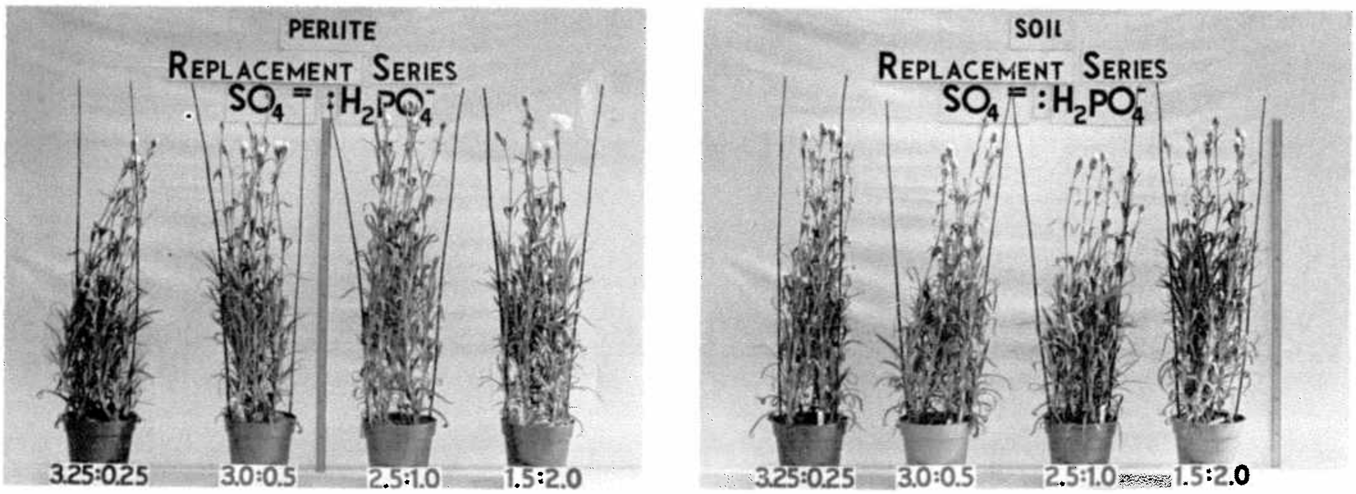


Fig. 4

Table 8 gives the sulfate-phosphate series with average yields for each solution. Typical plants from this series are illustrated in Fig. 4. Differences in growth were small for plants in soil. However H_2PO_4 levels in the tissue increased with applied phosphate both in soil and perlite (Table 9). Perlite produced 20% more than soil (Table 8).

Best growth in soil was from Solutions 7 and 14 containing 0.5 and 1.0 me/1 H_2PO_4. Tissue phosphate levels from plants grown with these solutions were 0.27 and 0.38%. Best growth from perlite (Table 8) was from Solution 14. Tissue phosphate level produced by this solution was 0.42%.

Poorest growth resulted from lowest phosphate (Solution 13) in both soil and perlite. Tissue phosphate levels were 0.21 and 0.25% in this reduced growth. Tissue levels around 0.44 to 0.46% produced by Solution 15 are considered to be near the upper limit of desirability for phosphate in carnation. Yields decreased slightly in soil and perlite when 2 me/1 of H_2PO_4 was used in the nutrient solution.

Sulfate exerted little or no influence on growth in this experiment. Even though sulfate varied widely in the applied nutrient solutions, intake of SO_4 was not related to concentration in the nutrient solution. Tissue sulfate levels were higher from plants grown in soil than from those grown in perlite (Table 9).

Table 8. Effects of SO_4:H_2PO_4 balance on yield in grams of fresh weight[a] of carnations in two media.

SO_4:H_2PO_4	Soln. no.	Soil	Perlite
3.25:0.25	13	289	305
3.0:0.5	7	314	360
2.5:1.0	14	304	395
1.5:2.0	15	284	371
Total		1191	1431

[a] Average yield of 8 plants.

Table 9. Effects of SO_4:H_2PO_4 balance on tissue analyses[a] of carnations after 5 months of growth.

Medium and solution	Percent of dry matter K	Ca	Mg	Na	NO_3	SO_4	H_2PO_4	Cl
Perlite								
13	4.7	1.2	.24	.08	.32	.08	.25	.13
7	4.2	1.3	.27	.09	.64	.10	.30	.19
14	4.5	1.3	.24	.11	.56	.10	.42	.13
15	4.1	1.2	.23	.10	.38	.10	.46	.13
Soil								
13	4.3	1.3	.27	.08	.55	.17	.21	.13
7	4.1	1.3	.26	.09	.51	.14	.27	.06
14	4.3	1.3	.27	.18	.51	.13	.38	.13
15	4.1	1.4	.26	.11	.46	.17	.44	.13

[a] Composite of 8 plants.

Conclusion

Where all phosphate is to be supplied by the nutrient solution, 1 me/1 of H_2PO_4 should be used. This can be supplied by 1.0 lb. crude phosphoric acid or 1.4 lbs. of 11-37-0 per 1000 gallons of irrigation water. In soil where some phosphate is available, 1/2 me/1 should be adequate. The lowest sulfate level (1.5 me/1) was probably more than adequate to maintain tissue levels.

NH_4 : NO_3 Balance

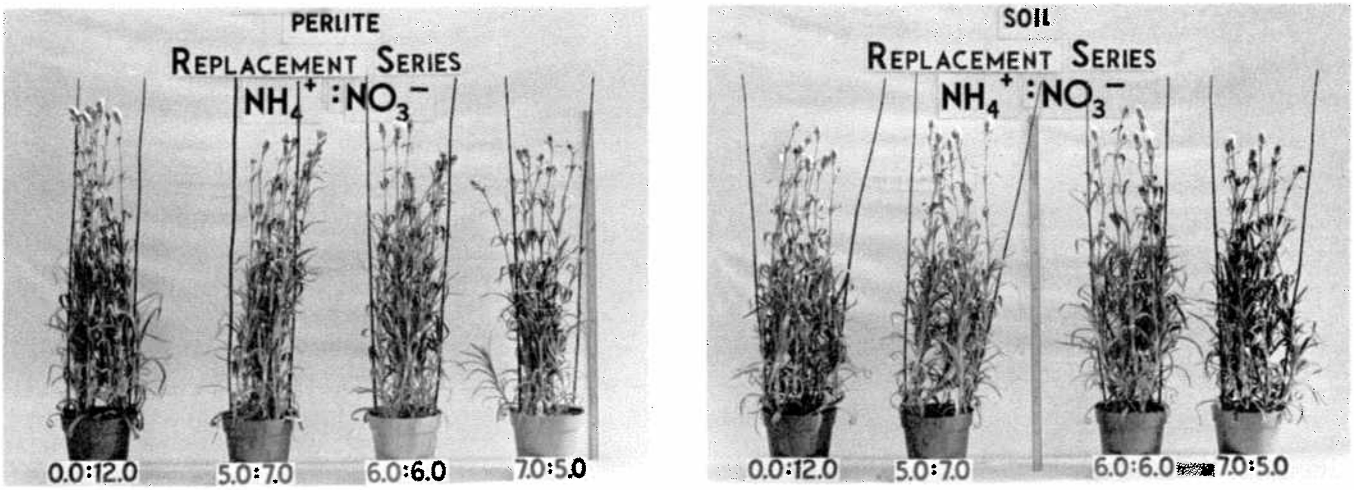


Fig. 5

Yield (fresh wt.) of the plants in soil was not greatly affected compared to the check solution (No. 2), Table 10 and Fig. 5. However, yield of those plants in perlite was greatly reduced compared to the check treatment. There are two possible explanations for the decreased yield from perlite. First, as was stated earlier this series was a double replacement series, ammonium replacing sodium and sulfate replacing nitrate. In order to do this the concentration of the other cations (K, Ca, and Mg) had to be lowered. Green (1) found that lowering the concentration of potassium in the nutrient solution increased the uptake of sodium. This can also be seen in Table 11. When the concentration of sodium increased in the tissue the concentration of the other cations (Ca, Mg, and K) decreased by 50%. This in turn decreased the sum of the cations while the sum of the anions (SO_4, H_2PO_4, Cl and NO_3) remained nearly constant, resulting in a low organic salt (C-A) content. Reduction of (C-A) in turn, reduces growth and yield.

Second, the ammonium ion could have had various physiological effects on the plants. NH_4^+ may compete with the other cations (Ca, Mg, K, and Na) for uptake. NH_4^+ is readily absorbed by the plant but before it is incorporated into the tissue, the positive charge is released as H^+. The NH_4^+ does not remain a cation in the tissue. Losing the positive charge it contributes nothing to the total cations. The combination of possible competition for uptake and the loss of charge could markedly reduce the total cations which in turn would reduce the organic salt (C-A) content of the plant.

The plants in the soil were not greatly affected by the composition of the solution (Fig. 5). This suggests that soil offers a certain buffering capacity for imbalances in nutrient solutions which inert media does not. Lack of a buffering capacity combined with an unbalanced nutrient solution illustrates the need for added precision with which a nutrient solution must be formulated for an inert medium.

It is felt that much more work must be done on the use of ammonium forms of nitrogen in both soil and inert media. This experiment produced much better growth in perlite when all nitrogen was supplied in the NO_3 form. However, due to the control of ionic concentration in a double replacement series it was not possible to look at effects of a low ammonium solution (say 3 me NH_4 and 9 me/1 NO_3). The next experiment will be set up as a grower would use it, without control of osmotic pressure. We must find out the percentage of total nitrogen that can be supplied as ammonium to 1) soil and 2) inert media without reducing growth.

The major conclusion that can be drawn from this experiment is that the NH_4 ion should be kept low in nutrient solutions for inert media. On the other hand, nutrient solutions for soil can contain half, or possibly more, of the N in the ammonium form.

Table 10. Effects of NH_4:NO_3 balance on yield in grams of fresh weight[a] of carnations in two media.

NH_4:NO_3	Soln. no.	Soil	Perlite
0:12	2	324	399
5.0:7.0	10	306	267
6.0:6.0	11	277	290
7.0:5.0	12	326	269
Total		1233	1225

[a]Average yield of 8 plants.

Table 11. Effects of NH_4:NO_3 balance on tissue analyses[a] of carnations after 5 months of growth.

Medium and solution	K	Ca	Mg	Na	NO_3	SO_4	H_2PO_4	Cl
Perlite								
2	4.3	1.4	.20	.11	.66	.19	.29	.13
10	2.5	.6	.14	.68	.48	.17	.39	.13
11	2.0	.5	.11	.31	.22	.46	.40	.13
12	2.2	.6	.12	.49	.46	.34	.39	.19
Soil								
2	4.4	1.4	.27	.08	.69	.17	.29	.13
10	3.0	1.3	.30	.33	.50	.17	.30	.06
11	3.0	1.5	.31	.32	.45	.15	.30	.06
12	2.7	1.4	.31	.25	.48	.19	.32	.13

[a]Composite of 8 plants.

Comparison of two nitrogen levels Discussion

Growth produced by the two balanced reference solutions are compared in Table 12. Solution 2 contained 12 me/l of N while Solution 7 contained 10 me/1. Solution 2 produced 6 and 11% more growth in soil and perlite respectively. The smaller difference for soil was probably caused by some nitrogen released by the soil during the course of the experiment. While these differences are small they confirm Green's findings (1) that 12 me/l of N is necessary in the nutrient solution for maximum growth of carnation.

Tissue analyses from the plants receiving the two levels of N are shown in Table 13. All nutrients were within the optimum range for healthy carnation growth. The tissue nitrogen level in plants grown in soil with Solution 7 was slightly low but the same was not true from plants grown in perlite with Solution 7. It is doubtful that reduced growth resulting from this slight reduction in applied N could be diagnosed by tissue analysis in most cases.

Table 12. Effects of two nitrogen levels on yield in grams of fresh weight[a] of carnation in two media.

Nitrogen in nutr. soln.	Soln. no.	Soil	Perlite
10 me/l	7	314	360
12 me/l	2	333	399
% increase		6	11

[a]Average of 8 plants

Table 13. Composite tissue analyses of plants grown in 2 media at 2 levels of applied nitrogen.

Medium and solution	K	Ca	Mg	Na	NO_3	SO_4	H_2PO_4	Cl
Perlite								
2	4.3	1.4	.20	.11	.66	.19	.29	.13
7	4.2	1.3	.27	.09	.64	.10	.30	.19
Soil								
2	4.4	1.4	.27	.18	.69	.17	.28	.13
7	4.1	1.3	.26	.09	.51	.14	.27	.06

Discussion

To put this series of experiments to maximum use while we are attempting to answer other questions raised by them, we recommend the following nutrient solution for irrigating carnations in Colorado. This solution results from some compromises but is developed for ionic balance and should result in optimum tissue levels of the major nutrients. We recommend the following weights of chemicals per 1000 gallons of irrigation water when used on a continuous basis:

5 lbs. Potassium nitrate
3 lbs. Calcium nitrate
1 lb. Ammonium nitrate
2 lbs. Magnesium sulfate
1 1/2 lbs. 11-37-0
1 ounce borax

Tissue levels that should result in carnations when watered continuously with the recommended solution are:

K	Ca	Mg	Na[a]	NO_3	SO_4	H_2PO_4	Cl[a]
4.0+	1.0+	.35+	--	.55+	.10+	.35+	--

[a]Levels depend upon Na and Cl in water supply as none is added to the nutrient solution.

Note that no muriate of potash is recommended. When chloride in excess of 1 me/l was used growth was greatly reduced (Fig. 3 and Table 6). Each pound of KCl (muriate of potash) per 1000 gallons supplies 1.6 me/l of K and 1.6 me/l of Cl. Two pounds per 1000 gallons would supply the 3 me/l of Cl that reduced growth in soil by 20% (Table 6).

The following substitutions may be made for soil culture. Phosphate and calcium may be applied to the soil as superphosphate and limestone. Ammonium nitrate should be increased by 1 1/2 pounds in the nutrient solution to replace the nitrogen not added in calcium nitrate.

The above recommendations are for Colorado mountain water that contains very little dissolved salts. Growers who use other water supplies should know what the water contains and make allowances for the dissolved salts. Calcium, magnesium and sulfates may be present in adequate to excess quantities. Unfortunately, sodium and chlorides are often present in undesirable levels also. Where calcium is present at 60 ppm or higher, substitute one pound of ammonium nitrate for each 2 pounds of calcium nitrate. If magnesium is present at 25 ppm or more, and sulfates in the water supply exceed 25 ppm, add no magnesium sulfate to the nutrient solution.

This recommended feeding rate is higher in K and Mg than we have previously considered necessary. Further experiments may indicate even higher Mg is needed. Both of these contribute to the cation pool within the plant and tend to increase (C-A) and growth.

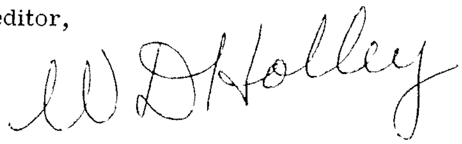
The addition of one pound per 1000 gallons of the following chemicals to the irrigation water adds in ppm or in me/l the following amounts:

Chemical	Analysis	ppm	me/l	also adds
Ammonium nitrate	33-0-0	40 N	1.4 NH_4	1.4 NO_3
Muriate of potash	0-0-60	60 K	1.6 K	1.6 Cl
Potassium nitrate	13-0-44	16 N + 44 K	1.2 K	1.2 NO_3
Calcium nitrate	16-0-0	19 N	1 NO_3	1 Ca
Diammonium phosphate	21-53-0	25 N + 28 P	1 H_2PO_4	1 NH_4
Polyphosphate liquid	11-37-0	13 N + 20 P	0.7 H_2PO_4	0.7 NH_4
Magnesium sulfate	-------	12 Mg	1 Mg	1 SO_4

Literature cited

1. Green, J. L. 1967. Ionic balance and growth of carnations. Colo. Flower Growers Assn., Inc. Bulls. 210, 211, and 212.

Your editor,



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