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Calcium Tissue Levels in the Carnation

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Difficulties often arise in maintaining optimum calcium percentages in carnation tissue during the winter months. Reports have been made of growers applying as much as 1 pound of lime per square foot in order to raise Ca levels above the recommended 1.0% level. A study at Colorado State University attempted to determine Ca levels in carnation tissue at different times of the year and grown with different nutrient solutions. Results were not unusual, except to emphasize what has been learned in previous work (CFGA Bulletins 212, 221, 229, 249). That is, increasing nutrient solution concentrations will reduce Ca tissue levels. Excessive levels of potassium will reduce yield markedly. Calcium and magnesium levels will show a tendency to increase during low light periods. Increasing ammonium concentrations during the winter will tend to increase growth. During high light conditions, Ca tissue levels below 1.0% will result in typical calcium deficiency symptoms of leaf tip burning. This disappears during the winter even though Ca tissue levels may be less than 0.65%.

Methods

White 'Pikes Peak' were grown in gravel in the CSU Temperature House, two plants to an 8-inch pot. Every two months (Table 2) a new crop was started and grown until the first flower was visible, at which time it was harvested. The total fresh weight of plant material in each pot was determined. A tissue sample was taken at the same time. There were eight pots per treatment (Table 1), two in each compartment of the temperature house. There were ten nutrient solution treatments (Table 1) and six crops (Table 2). Solutions were suggested on the basis of Green and Hartman's work, indicating a possibility that changes in potassium and ammonium levels might help maintain Ca tissue levels. Calcium, magnesium, nitrate and phosphorous levels were held constant. No chloride or bicarbonate was added. No attempt was made to maintain a constant total solution concentration or constant pH. The nitrate and calcium levels were in excess of that recommended by Hartman and Holley (CFGA Bul. 221). Hartman suggested that 14 milliequivalents/liter NO_3 (868 ppm) would be luxurious. Levels suggested by Hartman and Holley and modified slightly by Schekel (CFGA Bul. 251) were:

	Hartman-Holley	Schekel
K	6 meq (235 ppm), 5 lbs KNO_3/1000 gal	6
Ca	3 meq (60 ppm), 3 lbs $Ca(NO_3)_2$/1000 gal	3
NO_3	10.4 meq (645 ppm)	12 (744)
Mg	2 meq (24 ppm), 2 lbs $MgSO_4$/1000 gal	2
H_3PO_4	1 (96 ppm), 1-1/2 lb 11-37-0/1000 gal	1
NH_4	1 (18 ppm), 1 lb NH_4NO_3/1000 gal	—
SO_4	2 (96 ppm)	2

The plants were watered two to five times daily, depending upon season. With exception of the first crop, one tissue sample was taken from each treatment of each crop.

Results

The effect of the solution on Ca concentrations in carnation tissue is summarized in Fig. 1. As the salinity of the solution increased, Ca in the tissue decreased. As light intensity decreased, Ca tended to increase. In fact, with the exception of Crop 4 (Table 2), average Ca levels for the crops were below the minimum for all treatments. The maximum Ca level during the experiment was treatment 3, during crop 4, with a concentration of 1.60%. Treatment 1 (check solution), however, was the only treatment usually to have Ca levels 1.0% or higher. For Crops 1, 2 and 6, any treatment that had a Ca level below 1% had typical necrosis of the leaf tips during high light periods. This

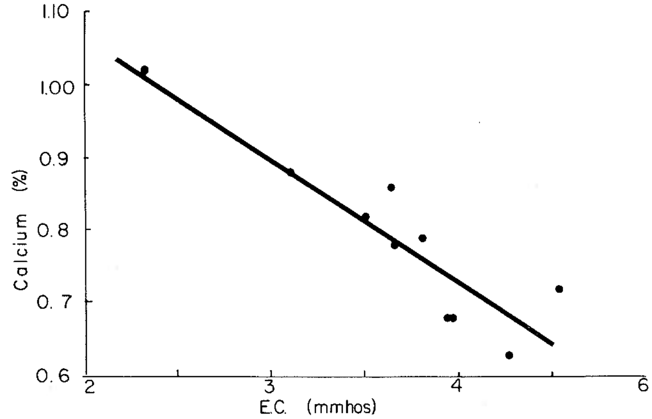

Fig. 1. Effect of total soluble salts on calcium levels in carnation tissue. Correlation between electrical conductivity (EC) of solution and percentage calcium was 0.86 where 1.00 is a perfect relationship. Points represent average tissue content for all crops, each treatment.

Table 1. Calcium nutrition study, Temperature House; 1974-75; concentrations in milliequivalents per liter. Trace elements added to each solution.

Solution No.	K	Mg	Ca	Na	NH_4	NO_3	SO_4	H_2PO_4	Cl	HCO_3
1	6.0	1.0	6.0	0	2.0	14.0	1.0	0.5	0	0
2	8.0	1.0	6.0	0	2.0	14.0	3.0	0.5	0	0
3	10.0	1.0	6.0	0	2.0	14.0	5.0	0.5	0	0
4	6.0	1.0	6.0	0	4.0	14.0	3.0	0.5	0	0
5	6.0	1.0	6.0	0	6.0	14.0	5.0	0.5	0	0
6	6.0	1.0	6.0	6.0	2.0	14.0	7.0	0.5	0	0
7	6.0	1.0	6.0	6.0	4.0	14.0	9.0	0.5	0	0
8	6.0	1.0	6.0	6.0	6.0	14.0	11.0	0.5	0	0
9	8.0	1.0	6.0	6.0	2.0	14.0	9.0	0.5	0	0
10	10.0	1.0	6.0	6.0	2.0	14.0	11.0	0.5	0	0

Table 2. Variation of element content of carnation tissue at different times of the year.

Crop No.	Planting date	Days in bench	Element analysis* (Average of all treatments)											
			Ca	Mg	K	NO_3	P	Na	SO_4	B	Cu	Zn	Mn	Fe
1	3/18/74	84	0.74	0.15	4.58	1.01	0.53	0.22	0.43	34	10	54	140	125
2	5/18/74	92	0.77	0.16	4.10	0.70	0.45	0.18	0.27	38	18	47	116	179
3	7/18/74	116	0.85	0.19	4.30	0.93	0.50	0.29	0.34	63	9	45	114	90
4	9/18/74	123	1.00	0.23	4.95	1.21	0.65	0.28	0.30	49	9	37	123	90
5	11/18/74	133	0.72	0.17	4.59	0.88	0.58	0.22	0.19	48	9	35	74	57
6	1/18/75	138	0.63	0.14	4.56	0.74	0.56	0.24	0.29	43	9	33	85	75
HSD**			0.13	0.08	0.43	0.13	0.08	0.19	0.13	12	—	—	35	60
Mean all crops			0.78	0.17	4.51	0.91	0.55	0.24	0.29	46	10	42	109	103

**Major element concentrations stated in percentage, trace elements in ppm.*
***HSD — The numerical value required for the values in the column above to be significantly different from one another. Two dashes indicate no significance.*

tip burning disappeared in Crops 3, 4 and 5. There were differences in tissue analysis among crops, but reasons why were not always clear (Table 2). The effect of the solutions on tissue analysis for all elements is given in Table 3. An effect similar to Ca of solution concentration on other ions could not be noted, although tissue Mg showed a tendency to increase during the winter season.

The effect of treatment on total fresh weight of the plants showed no marked correlation with Ca tissue level. Those solutions having 10 milliequivalents K (390 ppm) showed the least growth (Fig. 2). With high sodium (Na), growth was generally reduced with the exception of solutions 6 and 9, the former having 2 milliequivalents NH_4 (36 ppm) and 6 milliequivalents/liter K (234 ppm), and the latter with 2 milliequivalents/liter NH_4 and 8 milliequivalents/liter K (312 ppm). It appeared that increasing K up to 8 tended to offset the effect of high Na.

Although the treatments significantly affected Ca, P, Mg, K and Na levels (Table 3), the reasons were not always clear-cut. According to earlier work, Mg is usually decreased by increasing K, but this did not occur where 6 milliequivalents/liter Na had been added. Na uptake appeared to be in accordance with solution concentration, and SO_4 was unaffected. There was no apparent effect on trace elements, although there was a significant interaction between Cu and time, and Fe and time.

Conclusions

1. Any unnecessary increase in total solution concentration will decrease calcium tissue levels. Salty water will have the same effect.
2. Potassium levels of 10 milliequivalents/liter (390 ppm) will reduce total growth.
3. Calcium and magnesium levels will tend to rise under low light conditions.
4. Below calcium tissue levels of 1.0%, visible symptoms of calcium deficiency will be observed during high light seasons.

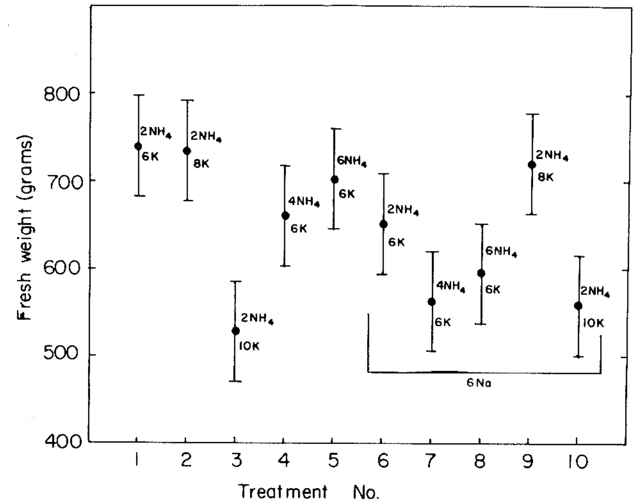

Fig. 2. Effect of nutrient solution treatment on total fresh weight of carnations grown until first flower in treatment was visible. The figures next to each bar show the concentrations of NH_4, Na, and K in the particular treatment, in milliequivalents/liter. Calcium in all treatments held at 6 milliequivalents/liter, phosphorous 0.5, nitrate 14.0, magnesium 1.0. The vertical lines show allowable variation. The bars of any two comparisons should not overlap if the means are truly different from each other.

Table 3. Effect of nutrient solution composition on concentrations of ions in carnation tissue.

Nutrient	Treatment number (See Table 1) 1	2	3	4	5	6	7	8	9	10	HSD*	Interaction of treatment and time
Ca	1.02	0.82	0.86	0.88	0.79	0.78	0.72	0.68	0.68	0.63	0.19	yes
P	0.56	0.60	0.54	0.51	0.56	0.58	0.54	0.55	0.48	0.55	0.09	yes
Mg	0.19	0.17	0.17	0.17	0.18	0.17	0.18	0.16	0.17	0.15	0.03	yes
K	4.57	4.77	4.30	4.63	4.37	4.62	4.33	4.72	4.02	4.82	0.61	no
NO_3	0.85	0.90	0.85	0.82	0.92	0.95	0.93	0.94	0.96	1.00	—	yes
Na	0.21	0.13	0.15	0.13	0.14	0.29	0.36	0.30	0.39	0.31	0.19	no
SO_4	0.31	0.25	0.30	0.28	0.23	0.30	0.32	0.24	0.33	0.30	—	no
B	46	38	45	46	43	57	50	49	43	42	—	no
Zn	40	40	34	38	64	38	32	53	36	41	—	no
Cu	9	11	8	9	8	8	9	10	9	10	—	yes
Mn	118	92	119	131	97	104	115	97	120	101	—	no
Fe	94	101	132	83	95	109	118	84	97	114	—	yes

**Difference required for significance among values in the table.*

Table 4. Summarization of recommended tissue levels for carnations.

Element	Range	Remarks
Calcium (Ca)	1.0-1.5%	(Deficiency symptoms visible under high light when below 1.0%)
Magnesium (Mg)	0.2-0.4%	
Potassium (K)	2.9-3.3%	(4.0% not unusual)
Phosphate (PO_4)	0.20-0.35%	
Nitrate (NO_3)	0.50-0.70%	(May run below 0.5 as long as plants do not appear "hungry")
Total N	3.20-3.60%	(Some suggest 2.0% to 4.0%)
Sodium (Na)	0.15+%	(Will vary with sodium in irrigation water)
Sulfate (SO_4)	0.10+%	(Should not vary with SO_4 in water supply)
Iron (Fe)	50-100 ppm	(Low considered to be 30 ppm, may exceed 200)
Manganese (Mn)	50-150 ppm	(Low 20 ppm, toxic 1500 ppm)
Zinc (Zn)	25-100 ppm	(Low 18, toxic 325 ppm)
Boron (B)	25-100 ppm	(Low 20, toxic possibly over 300)
Copper (Cu)	5-10 ppm	(Low 4 ppm, toxic 225 ppm)
Chlorine (Cl)	As low as possible.	(Excess Cl will reduce growth.)

Previous work by Hartman, Holley, Green and Schekel have shown that 3 milliequivalents/liter (60 ppm) calcium in good water should be adequate for carnations. Doubling calcium is no guarantee that plants will take up adequate amounts. At least two factors influence calcium availability: 1) total solution concentration, and 2) acidity of the soil solution. If water is hard, at least 2 milliequivalents/liter NH_4 are required. Release of hydrogen ion will tend to acidify the soil solution where it counts, and NH_4 exceeding 4 milliequivalents/liter (112 ppm) has been recommended (3 pounds NH_4NO_3 per 1000 gallons). Doubling the amount to 8 milliequivalents/liter may not provide commensurate return. We suspect that high pH of the soil is the major reason for low calcium tissue levels in the winter, and if calcium is applied dry, it should be applied as gypsum and not carbonate (lime). The water supply should be acidified to remove bicarbonates which will tend to raise pH. Applications of sulfur are another means to reduce pH, increasing calcium availability.

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