COLORADO FLOWER GROWERS ASSOCIATION

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POTASSIUM FERTILIZER SOURCES FOR CARNATIONS

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Two potassium fertilizers, potassium nitrate (KNO_3) and potassium chloride (KCl) were used to test for possible chloride toxicities resulting from fertilizing standard carnations with KCl. In summarizing nutrition studies conducted on carnations, W. D. Holley recommended using no chloride forms of fertilizer unless plant hardening is desired (2). In a study with L. D. Hartman, (6) Holley found that when chloride levels in nutrient solution were increased from 0 to 3 milliequivalents per liter (me/l), growth in soil was reduced 20%. In studying ion ratios and competitive uptake of nutrients in carnations, Green (3) noted that chloride uptake by carnations greatly lowered the cation/anion ratio (difference between total positively charged cation (NH_4^+, Ca^{++}, Mg^{++}, K^+) and negatively charged inorganic anion ($HPO_4^=$, Cl^-, NO_3^-, $SO_4^=$) (content of tissue) by increasing the total anion content of the plant tissue. This reduced cation/anion ratio was accompanied by reduced yield.

At present, many Colorado carnation growers are using KCl fertilizer because it is a less expensive source of potassium than KNO_3 and readily available. Gravel medium is being used as well as soil. The effect these practices have on the growth and production of carnations was the focus of this experiment. Objectives were to answer the following questions: (1) Does fertilizing carnations with KCl affect plant growth? (2) Does fertilizing carnations with KCl affect the yield of flowers? (3) Does KCl fertilizer affect the quality of flowers produced? (4) Is there a difference between plants grown in soil and those grown in gravel when they are fertilized with KCl?

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Materials and Methods

From June 1977 to May 1978, standard carnations, 'Scania', 'Crowley Pink', and 'Elliott White' were grown in a fiberglass greenhouse. Temperatures of 50°-55°F. nights, and 60°-65°F. days were maintained without the addition of carbon dioxide. Carnations were planted in two east-west oriented raised benches, one with gravel medium and the other with soil. Each bench was divided into four plots consisting of four rows each (seven plants per row) of the three varieties, and treatments were replicated in each bench. Four additional rows of plants at both ends of the two benches served as buffer plants.

Two different nutrient solutions supplied fertilizer to the plants: one containing KCl as a potassium source, the other containing KNO_3. (Table 1) Chloride level was six me/l; other nutrient levels were relatively equal. The solution with KCl was fed to plots 2 and 4 in the gravel bench and plots 1 and 3 in the soil bench. The other plots received solution containing KNO_3. Twin-wall drip irrigation tubes supplied the benches with water. A time clock regulated automatic watering of the gravel bench two to three times daily, and the soil bench was watered when needed. Fertilizer injector systems pumped fertilizer and water to the benches.

Flowers were cut every two days and data was taken on number and grade of flowers from each plot. The Society of American Florists', grading standards were followed, grades being broken down into design, short, standard, and fancy flowers. (Table II)

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Table 1: Amount of Fertilizer in Nutrient Solutions

#Fertilizer/50 gal. stock soln. 1:200 injector		Nutrients Supplied to Plants (ppm)[a]	
A. POTASSIUM NITRATE SOLUTION			
KNO_3	50#	K	235 ppm
NH_4NO_3	10#	Cl	- - -
$Ca(NO_3)_2$	50#	NO_3-N	182 ppm
$MgSO_4$	20#	NH_4-N	14 ppm
Phosphoric Acid (75%)	800 ml	P	31 ppm
Borax	212 gms	Ca	240 ppm
$ZnSO_4$	24.4 gms	Mg	73 ppm
B. POTASSIUM CHLORIDE SOLUTION			
KCl	33#	K	235 ppm
NH_4NO_3	30#	Cl	213 ppm
$Ca(NO_3)_2$	50#	NO_3-N[b]	154 ppm
$MgSO_4$	20#	NH_4-N[b]	56 ppm
$NH_4H_2PO_3$	7#	P	31 ppm
$Mg(NO_3)_2$	17.5#	Ca	240 ppm
Borox	212 gms	Mg	121 ppm
$ZnSO_4$	24.4 gms		

[a]PPM = parts per million, an expression of the weight of an ion present in nutrient solution or plant tissue.

[b]More NH_4NO_3 was fed to the chloride plots than to the nitrate plots to assure adequate NO_3 uptake in spite of its competition which the chloride ion. Borax and $ZnSO_4$ in such small amounts were not critical to the chloride solutions.

Table II: Standard Carnation Grades

Grade	Minimum Flower Diam.	Minimum Length	Stem Strength
Design	none	none	no requirement
Short	none	12″	no requirement
Standard	tight 1¾″ open 2¾″	17″	when holding stem horizontally 1″ above minimum length for grade, head cannot be more than 30° below horizontal.
Fancy	tight-2″ open-3″	22″	same as above

Photographs recorded any differences in growth habit and any evidence of toxicity in flowers and foliage. Two tissue samples taken during the course of the experiment revealed nutrient levels in plant tissue. In sampling the plants, 60 full-grown leaves per treatment were randomly removed from vegetative shoots without visible buds. After drying, tissue was ground and tested. This procedure followed recommendations in Bulletin 267 of the Colorado Flowers Growers' Association, Inc. (August 1972)

Results and Discussion

Shortened internodes and brittle stems characterized the plants fertilized with KCl. This effect was more pronounced in the gravel bench. Numerous aborted buds occurred only on chloride plots in the gravel bench. (Figure 1) These buds failed to develop, turned brown, and terminated stem growth.

Gravel plots receiving KCl produced fewer standard and fancy grade flowers and many more design grade flowers than plots receiving KNO_3. The soil plots did not show the same differences. (Table III)

According to computer analysis of the data, only the differences in the number of design grade flowers between the four treatments were statistically significant (Figure 2). The gravel plots receiving KCl yielded a higher percentage of design grade flowers and a lower percentage of standard and fancy grade flowers. The differences were not as great in the soil bench.

Figure 1. An aborted bud from the gravel treatments fertilized with KCl.

Aborted buds fail to develop, turn brown, and terminate stem growth. Thus, they reduce production of flowers.

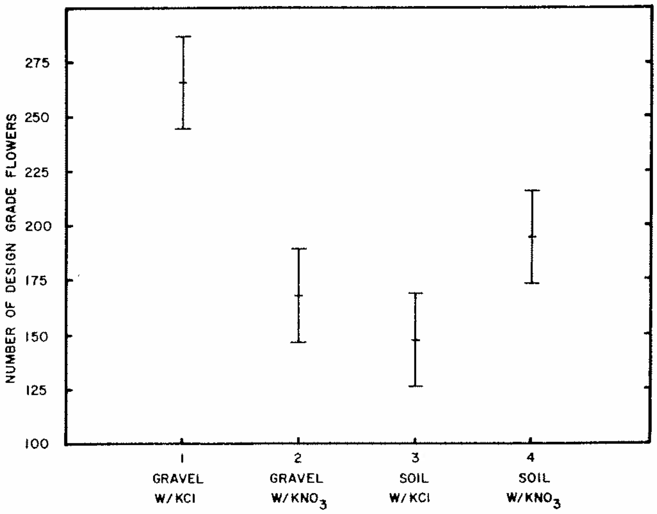

Figure 2. Comparison of Production of Design grade Flowers Among Treatments. Differences between treatments are significant if bars do not overlap. Thus, treatment 1 is different from all others and treatment 4 is different from treatment 3.

Table III: Flower production for 42 square feet of bench area.

Plot	# Design	# Short	# Standard	# Fancy
Gravel w/KCl	532 (29%)	527 (30%)	523 (29%)	238 (13%)
Gravel w/KNO_3	336 (17%)	591 (31%)	647 (34%)	330 (17%)
Soil w/KCl	295 (15%)	703 (35%)	665 (33%)	331 (17%)
Soil w/KNO_3	389 (19%)	624 (31%)	718 (35%)	302 (15%)

Table IV: Nutrient Levels of Carnation Leaf Tissue Fertilized with KCl and KNO_3

Element	Treatments							
	Gravel w/KCl		Gravel w/KNO_3		Soil w/CKl		Soil w/KNO_3	
	Jan.	April	Jan.	April	Jan.	April	Jan.	April
Nitrogen (NO_3-N)%	1.24	.60	1.39	.75	.99	.23	.75	.53
Phosphorus (P)%	.51	.37	.47	.38	.53	.49	.55	.38
Potassium (K)%	4.6	3.3	4.7	3.3	5.1	4.8	4.2	4.0
Calcium (Ca)%	1.4	1.5	1.3	1.3	1.6	1.9	1.8	2.0
Magnesium (Mg)%	.28	.27	.36	.28	.34	.35	.34	.36
Chloride (Cl)%	—	1.1	—	0.5	—	3.0	—	0.5
Sodium (Na)%	.09	.07	.07	.06	.06	.06	.12	.08
Sulfur (SO_4-S)%	.27	.23	.46	.26	.23	.27	.36	.22
Iron (ppm[a])	91.0	698.0	92.0	108.0	83.0	90.0	96.0	138.0
Manganese (ppm)	172.0	145.0	217.0	138.0	532.0	655.0	387.0	409.0
Zinc (ppm)	74.0	54.0	98.0	96.0	81.0	118.0	72.0	98.0
Copper (ppm)	16.0	8.0	9.0	8.0	19.0	8.0	23.0	16.0
Boron (ppm)	40.0	40.0	95.0	75.0	75.0	65.0	80.0	70.0

[a]ppm = parts per million, an expression of the weight of an ion present in nutrient solution or plant tissue.

Reason for the high iron level in the gravel treatment with KCl is not known, but level is not high enough to cause toxicity. All other nutrient levels are relatively equal, except for the chloride levels. Tissue from the soil treatment with KCl contained three times as much chloride as tissue from the gravel treatment with KCl.

In observing tissue test results, no great differences in nutrient levels occurred other than chloride which varied greatly. The gravel-grown plants fertilized with KCl contained twice as much chloride as the plants in gravel that received KNO_3. Yet, when KCl was applied to soil, plants receiving chloride contained six times as much as the plants fertilized with KNO_3. When administered the same amount of chloride in nutrient solution, the plants in soil apparently adsorbed much more of the ion than plants in gravel. (Table IV) Abnormal growth and reduced production were dramatic in the gravel plots with chloride, although tissue of these plants contained less chloride than that of plants in soil receiving the same element.

The effects of chloride fertilization were striking in the gravel bench. With inert media, the nutrients supplied in the fertilizer solution are critical. Without the added nutrients of soil or its buffering capacity, toxicities and deficiencies are more likely. The increase in design grade flowers and reduction in number of standard and fancy grade flowers were greater in the gravel plots fertilized with KCl than in the soil plots. Also, no buds aborted in the soil bench.

Conclusions and Recommendations

The observed differences in number and quality of flowers and growth habit of plants cannot be attributed to chloride toxicity in itself. The low chloride level of the plants grown in gravel does not correlate with the reduced production and abnormal growth of these plants. Similarly, the high chloride level in the plants grown in soil does not correlate with the good growth and production of these plants. An interaction of the chloride ion (anion) with other ions must have occurred to create a nutrient deficiency or imbalance in the plots receiving KCl. Competition between positively charged (cation) and negatively-charged (anion) ions does occur in many plant species (9). As Green reported (3), the response of plants to a given nutrient depends upon the level of the other nutrients, and, in this experiment, a clear-cut relationship between the two cannot be established. The chloride ion does compete with the nitrate ion during uptake by grasses, and carnations may demonstrate the same kind of ion competition.

The differences observed between plants grown in soil and those in gravel are partially due to the buffering capacity of soil, i.e., its ability to hold ions on the surface of soil particles so that they are not directly taken up by the plant or leached out in irrigation water. Because of this soil characteristic defining the nutrient levels and competitive uptake of ions is somewhat difficult. The question that remains is, "What kind of ion interaction was occurring that did not show up in the tissue test results?"

Further studies are needed to clarify how chloride interacts with other nutrients to cause reduced production and abnormal plant growth. Evidently, fertilizing soil-grown carnations with KCl does not carry the same risks as with gravel-grown plants. Thus, if KCl is to be used, soil media is recommended. Conversely, if gravel culture is desired, KCl fertilizer should be avoided.

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