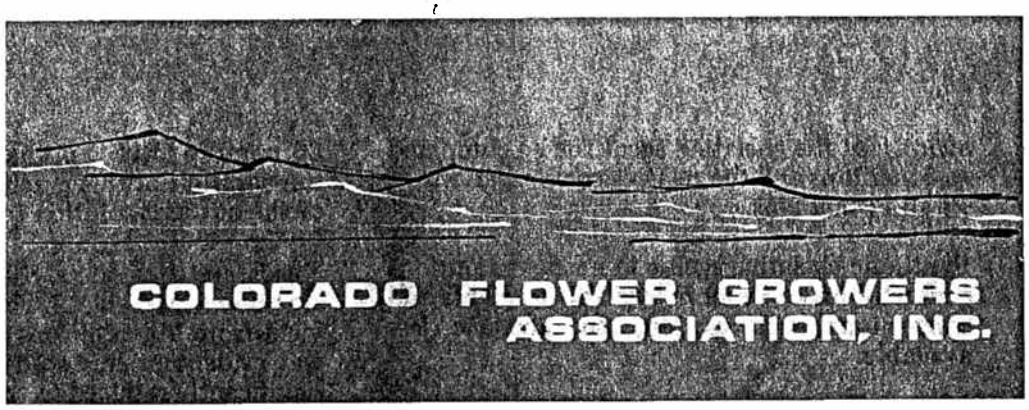

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CARNATION MICRONUTRITION

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During the past decade a more exact knowledge of all aspects of carnation nutrition has become increasingly important for the following reasons: 1) In standard soil culture the advent of steam sterilization has led to continuous use of soil. This fact, in addition to the use of highly pure fertilizers for liquid injection feeding and the shift from micronutrient-rich manures to peat moss as an organic amendment, has led to the possibility of soil media becoming devoid of certain micronutrients. At the other extreme many commercial fertilizers purposely contain micronutrient additives which may become excessive if not properly used. 2) At the present time there is a shift from soil to inert substrates as growing media for carnations. With inert growing media, the yield of carnation becomes dependent on the nutrients supplied in the applied nutrient solution. The absence of an organic soil buffer also leads to the increased possibility of toxicity resulting from high levels of applied nutrients.

Since very little knowledge of carnation's micronutrient requirements, other than boron, exists, this investigation was undertaken as an initial look at the micronutrient requirements of carnation. This study involved primarily high levels of the micronutrients Fe, Mn, Zn, and Cu since high levels of these elements would seem to be the most prevalent problem in commercial carnation culture. Very low levels and "normal" levels were also included to test for any advantage of adding small amounts of these elements to nutrient solutions used for growing carnations.

METHOD AND MATERIALS

The micronutrition experiment consisted of 20 micronutrient solution treatments divided into 4 subexperiments. Each subexperiment consisted of 5 treatments supplied with increasing amounts of one of the elements Fe, Mn, Zn, or Cu. All other nutrients except the one being varied were held constant. Treatment variable levels of the 4 micronutrients are shown in Tables 1-4. The experiment was initiated on November 9, 1970 and terminated May 1, 1971. Plants were grown in granitic gravel.

Since Fe was supplied as the DTPA chelate (Sequestrene 330) some of the results from this study are affected by the complex chemistry of metal chelation. No attempt is made here to explain this complex chemistry but in order to promote better understanding the following general considerations about metal chelation are made.

(1) Since Fe in its natural state is easily precipitated or fixed into highly insoluble forms, chelating agents complexed with Fe are used to slow or prevent the precipitation or fixation of Fe and therefore make it more available to plants.

(2) Ions other than Fe can compete for and displace Fe from the chelate. The degree of this displacement depends on the relative

[1]This is a part of the thesis completed by John Parker for the M.S. Degree at Colorado State University.

affinity of the chelating agent for Fe compared to other ions and the relative concentrations of Fe and other ions.

(3) Synthetic chelating agents in nutrient solutions generally make Fe more available to plants and other ions such as Mn, Zn, and Cu less available.

(4) Micronutrient uptake by plants seems to be a natural metal chelation process. Plant roots in taking up ions such as Fe, Mn, Zn, and Cu bind the ion to uptake sites located on the root in much the same manner as Fe or other ions are bound to synthetic chelating agents. Micronutrient cations generally compete with each other for these uptake sites. The degree of competition varies with plant species since the chelating sites of the root have different affinities for the various ions being taken up. There is some evidence that plants may have the ability to regulate the affinity for various ions depending on the plant's need for various micronutrients.

(5) Metal chelating agents compete with plant roots for Fe and other ions from solution. The degree of this competition depends on the stability of the metal chelate formed and also the affinity of the plant root for the ion being competed for. In some cases Fe and other ions may be held so tightly that plant roots are unable to successfully compete for the ion.

(6) Due to the competition effects discussed above, the major effect of micronutrient toxicities is generally considered to be an adverse effect on the uptake and utilization of Fe. Synthetic Fe chelates reduce the effect of metal toxicity by making Fe more available to plant roots and other ions less available.

RESULTS AND CONCLUSIONS

The effects of Fe treatments on carnation growth and tissue concentrations are shown in Table 1. No advantage of adding 3 ppm Fe over nonaddition of Fe is obvious. The reduction in yield evident with the 5 and 15 ppm Fe levels is attributed to excessive complexing of Zn by the DTPA chelate. DTPA is known to complex Zn very strongly, thereby making it less available to plants. The effect of DTPA on Zn is evident in the first 2 treatments of this study where the addition of 3 ppm Fe as the DTPA chelate greatly reduced the amount of Zn taken up. Since the difference between inadequate and adequate Zn is a very subtle one, tissue analysis does not appear sufficiently sensitive to point out these differences. The reduction in yield at the 50 ppm Fe level is primarily a low pH effect since the addition of this much FeDTPA reduced the pH of the nutrient solution to 4.1.

Yields and tissue analysis values for the Mn study are shown in Table 2. No significant difference in yield from Mn additions ranging from 0 to 25 ppm was evident in this study. Yield of carnation was significantly reduced at the 50 ppm Mn level.

The effect of various Zn levels on the yield and tissue concentration of carnation is shown in Table 3. Yield was significantly reduced in the treatment where no addition of Zn was made. The reduction in yield of this treatment is a result of Zn complexing by the DTPA chelate present in the nutrient solution to such an extent that the plants were unable to successfully compete for sufficient Zn. The 0.2 ppm Zn added to the second solution was sufficient to supply the small amount of Zn needed by carnation plants. Zn tissue concentration was slightly higher in the treatment receiving no Zn, but uptake values indicate that more Zn was taken up in the treatment receiving 0.2 ppm Zn. The higher concentration of tissue Zn in the first treatment can be explained as a dilution effect. High levels of Zn caused reduction in yield in the last two treatments of this study.

Yields and tissue analysis values for the Cu study are shown in Table 4. The only significant reduction in yield from various Cu levels was in the last treatment of this study receiving 7 ppm Cu. Coincident with this reduction in yield was a very substantial reduction in tissue concentrations of both Fe and P.

Conclusions of this carnation micronutrition study are presented below.

(1) Under normal circumstances, the addition of small amounts of Fe, Mn, Zn, and Cu to nutrient solutions used for growing carnations is unwarranted. One exception is Zn, although if Fe chelating agents are not used, addition of this element might also be unnecessary.

(2) If Fe chelating agents such as DTPA (Sequestrene 330) are used, care should be taken to provide a small amount of Zn.

(3) Carnation seems relatively tolerant of high levels of Fe, Mn, Zn, and Cu, but yields can be reduced if excessive levels are applied.

Using visual symptoms to ascertain micronutrient problems is completely unacceptable. Substantial reduction in yields may occur without any symptoms other than reduction in growth being evident. Periodic tissue analysis, although not a perfect tool, provides the best available method for determining micronutrient status of carnations.

Table 1. The effect of Fe treatments (as FeDTPA) on the yield and tissue concentration of carnations grown in gravel culture.

Applied Fe level ppm	Fresh weight yield g/pot[1]	Mn content ppm[2]	Mn uptake mg/pot	Fe content ppm	Fe uptake mg/pot	Cu content ppm	Cu uptake mg/pot	Zn content ppm	Zn uptake mg/pot	P content %
0	787.0ab*	98b	77b	49b	39b	7a	6a	27ab	21a	.39a
3	831.0a	94b	78b	54b	45b	6a	5a	17cd	14b	.38a
5	693.5bc	113b	78b	48b	34b	6a	4a	18bcd	12b	.42a
15	707.6bc	141b	99b	61b	43b	6a	4a	21bcd	15b	.36a
50	664.1c	529a	351a	170a	113a	8a	5a	31a	20ab	.36a

Values with the same letter are not significantly different at the 5% level.

[1]*Yield values are means of 8 pots or 16 plants.*

[2]*Tissue values are the average of 2 tissue samples.*

Table 2. The effect of Mn treatments on the yield and tissue concentrations of carnations grown in gravel culture.

Applied Mn level ppm	Fresh weight yield g/pot[1]	Mn content ppm[2]	Mn uptake mg/pot	Fe content ppm	Fe uptake mg/pot	Cu content ppm	Cu uptake mg/pot	Zn content ppm	Zn uptake mg/pot	P content %
0	863.7a*	63d	54d	50a	46a	5a	4a	20a	17a	.40a
0.5	844.3a	87d	73d	57a	48a	6a	5a	19a	16a	.40a
10	864.0a	342c	295c	63a	54a	6a	5a	19a	16a	.46a
25	799.1ab	1190b	951b	71a	56a	6a	4a	18a	14a	.46a
50	737.3b	1745a	1287a	75a	55a	9a	6a	18a	13a	.48a

Values with the same letter are not significantly different at the 5% level.

[1]*Yield values are means of 8 pots or 16 plants.*

[2]*Tissue values are the average of 2 tissue samples.*

Table 3. The effect of Zn treatments on the yield and tissue concentrations of carnations grown in gravel culture.

Applied Zn level ppm	Fresh weight yield g/pot[1]	Mn content ppm[2]	Mn uptake mg/pot	Fe content ppm	Fe uptake mg/pot	Cu content ppm	Cu uptake mg/pot	Zn content ppm	Zn uptake mg/pot	P content ppm
0	603.0b	121c	73c	64a	39a	6a	3a	26d	16d	.49a
0.2	834.3a	131c	109b	52a	43a	5a	4a	21d	17d	.38ab
10	811.1a	158a	128a	52a	42a	6a	5a	162c	81c	.43ab
25	586.6b	97d	57d	57a	33a	6a	4a	337b	196b	.33b
50	515.5b	144b	74c	50a	26a	8a	5a	1712a	882a	.41ab

Values with the same letter are not significantly different at the 5% level.

[1]*Yield values are means of 8 pots or 16 plants.*

[2]*Tissue values are the average of 2 tissue samples.*

Table 4. The effect of Cu treatments on the yield and tissue concentrations of carnations grown in gravel culture.

Applied Cu level ppm	Fresh weight yield g/pot[1]	Mn content ppm[2]	Mn uptake mg/pot	Fe content ppm	Fe uptake mg/pot	Cu content ppm	Cu uptake mg/pot	Zn content ppm	Zn uptake mg/pot	P content %
0	758.1a*	150a	113a	58ab	44a	6c	5c	17a	13a	.38a
0.05	785.7a	142a	112a	65a	51a	7c	5c	19a	15a	.39a
1	748.8a	140a	105a	56ab	42a	7c	5c	18a	13a	.37a
3	787.6a	156a	126a	63ab	50a	14b	11b	28a	22a	.41a
7	544.6b	141a	77b	28b	15b	50a	27a	26a	14a	.29b

Values with the same letter are not significantly different at the 5% level.

[1]*Yield values are means of 8 pots or 16 plants.*

[2]*Tissue values are the average of 2 tissue samples.*

Table 5. Proposed tissue analysis values in ppm for indicating micronutrient status of some elements in carnation.

Element	Possible deficiency	Low range	Adequate range	High range	Possible toxicity
Fe	30	30-50	50-100	150- 200	
Mn	20	20-50	50-150	1200-1500	1500
Zn	18	18-25	25-100	150- 300	325
Cu	4	4- 5	5- 10	10- 20	225

Tentative tissue level criteria for carnation in relation to the micronutrients Fe, Mn, Zn, and Cu are shown in Table 5. The criteria are based on the results of this study and previous investigations with carnation (White, 1967) and other crops (Chapman, 1966).

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FALL QUARTER GRADUATE

John Burl Parker is completing the requirements for the Master of Science degree this quarter. John completed high school in Greeley, Colorado and finished his undergraduate work in floriculture at CSU in 1967. He served 2 years with the Army Infantry and was discharged an Operations Sergeant. While in the Army he was successively Radio-Telephone Operator, Company Clerk, Mail Clerk, and Operations Sergeant. John is 26 and single.

John worked in greenhouses and garden centers while in high school and during summers while he

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While well qualified for employment in production management, John has interests in all aspects of the florist industry. He enjoys people and prefers a job that emphasizes contact with people.

Your editor, WD Holley

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