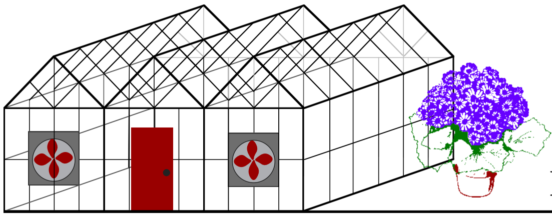
Department of Horticultural Science

Horticulture Information Leaflet 553
Revised 8/98



MANAGING MICRONUTRIENTS IN THE GREENHOUSE

Douglas A. Bailey, Professor and Paul V. Nelson, Professor

Proper plant nutrition is essential for successful greenhouse production of floricultural crops. As growers move towards substrates that do not contain mineral soil, micronutrient status of substrates and plants becomes more important. This bulletin outlines the major micronutrient problems that can be encountered in greenhouse production and outlines application treatments to correct micronutrient imbalances.

Micronutrient Excess

Excesses Can Cause Deficiencies. Excessive application of micronutrients probably accounts for more micronutrient disorders in the greenhouse than does insufficient application. Excessive application of micronutrients, in addition to toxicities, can lead to micronutrient deficiencies. Deficiencies in this case are due to antagonisms between micronutrients during plant uptake. When two nutrients are antagonistic, a super-optimal concentration of one in the substrate (soil) will suppress plant uptake of the other.

A high level of iron in the substrate commonly causes manganese deficiency and to a lesser extent can suppress zinc uptake (Table 1). Conversely, a high level of manganese in the substrate causes iron deficiency and also to a lesser extent, zinc deficiency. Super-optimal levels of copper cause zinc deficiency and conversely, high levels of zinc cause copper deficiency. Thus, it is possible to encounter deficiencies of iron, manganese, copper or zinc as a result of excess application of other micronutrients. These deficiencies can occur even when a normally sufficient concentration of the deficient micronutrient exists in the substrate.

What Causes Excesses? Many combinations of micronutrients are used in greenhouses. Each can be safe and effective when used in the role for which it was formulated. Excesses usually occur when multiple combinations of micronutrients are applied. This occasionally happens because some of the micronutrient sources are not obvious to the grower. Following are five sources or factors which provide or make micronutrients available:

❶ Most substrates, whether commercially or self-prepared, contain micronutrients.

❷ Most commercially formulated greenhouse fertilizers contain micronutrients. Fertilizers prepared by

Table 1. Common micronutrient antagonisms.

High soil level of:	Results in low plant level of:
iron	manganese, zinc
manganese	iron, zinc
copper	zinc
zinc	copper

Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Employment and program opportunities are offered to all people regardless of race, color, national origin, sex, age, or handicap. North Carolina State University, North Carolina A&T State University, U.S. Department of Agriculture, and local governments cooperating.

the greenhouse firm as an alternative to commercial products are often formulated with micronutrients. Generally, plants respond well to the combination of micronutrients in substrates and fertilizers.

❸ Specific fertilizers are commercially available for use in "soilless substrates" that have higher micronutrient concentrations than the standard greenhouse fertilizers. The differences in micronutrient content between the standard and the soilless substrate formulations of one given fertilizer analysis are given in Table 2. The increase of micronutrients in the soilless substrate formulation ranges from 100 percent for iron to over 1000 percent for molybdenum. This third source of micronutrients can be justified in a soilless substrate where the pH level is 6.0 or higher because the availability of micronutrients is strongly reduced in this situation.

❹ Research has indicated that, as is the case for organic field soils, the optimum pH level for organic (soilless) greenhouse substrates can be one pH unit lower than that desired for mineral-soil based substrates. The optimum pH range for soil-based substrates is 6.2 to 6.8 while for soilless substrates it is 5.6 to 6.2. When the pH of the substrate solution decreases, the availability of all micronutrients except molybdenum increases. Molybdenum availability decreases; however, deficiency of this nutrient is not known to be a problem in any floral crop except poinsettias. Thus, growing at a lower pH is equivalent to making an addition of micronutrients to the plant. Growers who maintain a pH level below 6.0 should consider using the standard fertilizer formulations rather than soilless substrate formulations that contain higher levels of micronutrients, unneeded in this situation.

Table 2. The content of individual micronutrients in a general and a soilless substrate commercial formulation of 20-10-20 and the micronutrient concentration increase in the soilless substrate formulation.

	Content (%)		
Nutrient	Standard	Soilless	Increase (%)
iron	0.05	0.10	100
manganese	0.025	0.056	124
zinc	0.0025	0.0162	548
copper	0.0036	0.01	178
boron	0.0068	0.02	194
molybdenum	0.0009	0.01	1011

❺ Often the four causes of increased micronutrient availability just discussed lead to excessive availability. Excess of one or more members of the micronutrient group can block uptake of another, bringing about a deficiency of the latter. It is then easy to mistakenly diagnose the total problem as a micronutrient deficiency. Without further information, correction is usually sought by applying a complete mixture of micronutrients. This makes the situation worse because the causal nutrients which are in excess become even higher in concentration. Even though the deficient nutrient is increased in the substrate, its uptake is not effectively increased.

<u>Toxicity Correction.</u> It is seldom possible to totally correct micronutrient toxicities. Vigilance should be exercised to prevent them. When toxicity does occur there are three steps which can be taken to reduce the problem:

❶ The first and most obvious step is to stop application of micronutrients. Some fertilizer companies offer fertilizers without micronutrients. Otherwise, growers can formulate their own fertilizer without micronutrients.

❷ The second step is to raise the pH of the substrate. The availability of all micronutrients except molybdenum decreases as the pH rises. Iron availability decreases tenfold when the pH level is raised one unit. Extreme shifts should be avoided. It is sufficient to move the pH level to the upper end of the acceptable pH range for the crop.

Three methods can be used for raising substrate pH: **(a).** A shift in the fertilization program from ammoniacal nitrogen (urea, ammonium nitrate, ammonium sulfate) to nitrate nitrogen (potassium nitrate, calcium nitrate) sources will bring about a gradual rise in pH. **(b).** Limestone may be applied to the substrate surface at a rate of approximately 1 lb/yd^3 per 0.1 unit rise in pH desired. This rate equals $^1/_8$ tsp per standard 6 inch pot per 0.1 unit increase in pH and 1 $^3/_8$ tsp per 6 inch pot for a 1.0 unit increase. These rates are for soilless substrates. Lower rates may suffice for soil-based substrates. Limestone reacts very slowly, thus two to six weeks may be required for a response. There are flowable suspensions of limestone that are more effective (faster reacting) than surface applications of ground limestone. Consult the label of commercial products for precise rates based on existing and desired pH. **(c).** For a rapid rise in pH, hydrated lime has been used. Caution should be taken to avoid contact with green tissues and neither limestone nor hydrated lime should be applied directly to substrates containing ammonium-containing fertilizers such as MagAmp or Osmocote. The high pH caused by these liming materials at the surfaces of such fertilizers can convert ammoniacal nitrogen to ammonia gas which is highly injurious to roots and foliage. To raise the substrate pH approximately 1 unit, one pound of hydrated lime should be mixed for five minutes in 5 gallons of water. Allow the mixture to settle overnight; and then apply *only* the liquid at the rate of one quart/ft^2 of bench area. This equates into 8 fl oz. per 6 inch pot. The substrate should be moist prior to applying the drench.

❸ The third measure which might be taken for alleviating a micronutrient toxicity involves manipulation of antagonistic pairs of nutrients. If the micronutrient present in excess is a member of an antagonistic pair (Table 1), make an application of the other member of the pair. For example, an excess of manganese, in addition to causing manganese toxicity, can result in iron deficiency. Application of iron alone will suppress manganese uptake and will increase iron uptake, thus alleviating both problems.

Diagnosing Micronutrient Status. It is important to diagnose the status of all micronutrients before undertaking corrective measures. As discussed, micronutrient disorders can involve one or more nutrients as well as combinations of toxicities and deficiencies. The presence of one micronutrient deficiency does not indicate that all other micronutrients are low. ***Application of a complete package of micronutrients in a situation where a deficiency/ toxicity situation exists will increase the problem!***

There are three systems for diagnosing nutrient status. The best diagnostic tool for micronutrients is foliar analysis. Visual observation of symptoms works but requires that damage be present. Most damage cannot be corrected. Commercial soil tests do not generally identify levels of all micronutrients. On the other hand, accurate tests and standards have been established for foliar analysis of all micronutrients. While the minimum and maximum critical foliar levels for micronutrients can vary for a few crops, these values do tend to be fairly standard for most crops. The general critical foliar levels for some floral crops are presented in Table 3. Plant foliar analysis is only $4.00 a sample, if submitted to the NCDA Plant, Soil and Solution laboratory, and is a wise investment for crop security. Contact your county agent for plant analysis sample sheets and sampling instructions.

Micronutrient Deficiency

Prior to adding micronutrients to correct a deficiency, check the substrate pH and make sure it is in the recommended range. If not, take steps to correct the pH before adding extra micronutrients. If there is still a problem then consider additions of the deficient micronutrient.

Table 3. Interpretative ranges for micronutrient values (reported in ppm) obtained from foliar analysis of selected floricultural crops.

Carnations

Nutrient	Deficient	Low	Sufficient	High	Excess
boron (B)	≤ 25	26–29	30–100	101–699	≥ 700
copper (Cu)	≤ 5	6–9	10–30	31–35	≥ 36
iron (Fe)	≤ 30	31–49	50–150	151–155	≥ 156
manganese (Mn)	≤ 30	31–99	100–300	301–799	≥ 800
molybdenum (Mo)	---	---	---	---	---
zinc (Zn)	≤ 15	16–24	25–75	76–80	≥ 81

Greenhouse Azaleas

Nutrient	Deficient	Low	Sufficient	High	Excess
boron (B)	≤ 20	21–30	31–100	101–200	≥ 201
copper (Cu)	≤ 5	6	7–15	16–20	≥ 21
iron (Fe)	≤ 50	51–59	60–150	151–175	≥ 176
manganese (Mn)	≤ 30	31–49	50–300	301–400	≥ 401
molybdenum (Mo)	---	---	---	---	---
zinc (Zn)	≤ 15	16–25	26–60	61–69	≥ 70

Chrysanthemums

Nutrient	Deficient	Low	Sufficient	High	Excess
boron (B)	≤ 20	21–49	50–100	101–124	≥ 125
copper (Cu)	≤ 5	6–24	25–75	76–80	≥ 81
iron (Fe)	≤ 50	51–59	60–500	501–525	≥ 526
manganese (Mn)	≤ 20	21–29	30–350	351–800	≥ 801
molybdenum (Mo)	---	---	---	---	---
zinc (Zn)	≤ 15	16–20	21–50	51–55	≥ 56

Poinsettias

Nutrient	Deficient	Low	Sufficient	High	Excess
boron (B)	≤ 20	21–29	30–100	101–200	≥ 201
copper (Cu)	≤ 2	3–5	6–10	11–15	≥ 16
iron (Fe)	≤ 50	51–99	100–300	301–500	≥ 501
manganese (Mn)	≤ 40	41–79	80–300	301–650	≥ 651
molybdenum (Mo)	0.50	0.51–1.00	1.01–5.00	5.01–806	≥ 806
zinc (Zn)	≤ 15	16–24	25–60	61–70	≥ 71

Foliage Plants (General)

Nutrient	Deficient	Low	Sufficient	High	Excess
boron (B)	≤ 25		26–100	101–124	≥ 125
copper (Cu)	≤ 5	6–24	25–75	76–80	≥ 81
iron (Fe)	≤ 50	51–59	60–500	501–525	≥ 526
manganese (Mn)	≤ 20	21–29	30–350	351–800	≥ 801
molybdenum (Mo)	---	---	---	---	---
zinc (Zn)	≤ 15	16–20	21–50	51–55	≥ 56

Roses

Nutrient	Deficient	Low	Sufficient	High	Excess
boron (B)	≤ 30	31–39	40–60	61–400	≥ 401
copper (Cu)	≤ 5	6–7	7–15	15–17	≥ 18
iron (Fe)	≤ 50	51–79	80–120	121–150	≥ 151
manganese (Mn)	≤ 30	31–69	70–120	121–250	≥ 251
molybdenum (Mo)	---	---	---	---	---
zinc (Zn)	≤ 15	16–19	20–40	41–50	≥ 51

Geraniums

Nutrient	Deficient	Low	Sufficient	High	Excess
boron (B)	≤ 18	19–29	30–280	281–290	≥ 291
copper (Cu)	≤ 5	6	7–16	17–700	≥ 701
iron (Fe)	≤ 60	61–69	70–268	269–280	≥ 281
manganese (Mn)	≤ 9	10–41	42–174	175–800	≥ 801
molybdenum (Mo)	---	---	---	---	---
zinc (Zn)	≤ 6	7	8–40	41–45	≥ 46

Other Crops (General)

Nutrient	Deficient	Low	Sufficient	High	Excess
boron (B)	≤ 25	26–30	31–100	101–200	≥ 201
copper (Cu)	≤ 5	6–10	11–20	21–24	≥ 25
iron (Fe)	≤ 50	51–60	61–150	151–350	≥ 351
manganese (Mn)	≤ 30	31–50	51–300	301–500	≥ 501
molybdenum (Mo)	---	---	---	---	---
zinc (Zn)	≤ 14	15–20	21–50	51–75	≥ 76

There are three alternative methods of application for micronutrients:

❶ Dilute concentrations may be applied in combination with macronutrients during each fertilizer application throughout the crop cycle. Sources, rates, and the final elemental concentration of each micronutrient are given in Table 4. This table will be helpful for those growers who formulate their own fertilizer and want to apply one or more but not all of the micronutrients. When all of the micronutrients are desired most commercially prepared fertilizers can be used since they contain all micronutrients. When fertilizers are self-formulated, commercial products containing all micronutrients can be added into the fertilizer. Some of these products include Peters STEM, Peters Compound 111, and Miller's Mitrel M.

❷ The second method of application calls for higher concentrations to be applied one time

Table 4. Sources, rates, and final concentrations of micronutrients for continuous soil application of one or more micronutrients with every liquid fertilization.

Micronutrient Source	Weight of source/100 gal oz	Weight of source/100 gal grams	Final conc. (ppm)
iron sulfate--20% iron OR	0.13	3.7	2.00 Fe
iron chelate (EDTA)--12% iron	0.22	6.2	
manganese sulfate--28% manganese	0.012	0.34	0.25 Mn
zinc sulfate--36% zinc	0.0018	0.051	0.05 Zn
copper sulfate--25% copper	0.0027	0.077	0.05 Cu
borax--11% boron OR	0.030	0.85	0.25 B
solubor--20% boron	0.017	0.48	
sodium molybdate--38% molybdenum OR	0.00035	0.010	0.01 Mo
ammonium molybdate--54% molybdenum	0.00025	0.007	

Table 5. Sources, rates, and final concentrations of micronutrients for a single corrective application of one or more micronutrients applied to the soil.*

Micronutrient Source	Weight of source/100 gal oz	Weight of source/100 gal grams	Final conc. (ppm)
iron sulfate—20% iron OR	4.0	113.4	62.0 Fe
iron chelate (EDTA)—12% iron	4.0	113.4	36.4 Fe
manganese sulfate—28% manganese	0.5	14.2	10.0 Mn
zinc sulfate—36% zinc	0.5	14.2	13.9 Zn
copper sulfate—25% copper	0.5	14.2	9.3 Cu
borax—11% boron OR	0.75	21.3	6.25 B
solubor—20% boron	0.43	12.2	
For soil-based substrates (>20% soil in substrate)			
sodium molybdate—38% molybdenum OR	0.027	0.77	0.77 Mo
ammonium molybdate—54% molybdenum	0.019	0.54	
For soilless substrates			
sodium molybdate—38% molybdenum OR	2.7	77	77 Mo
ammonium molybdate—54% molybdenum	1.9	54	

*Do not apply combinations without first testing on a small number of plants. Wash solution off foliage after application.

as a normal watering. See Table 5 for sources, rates, and final elemental concentrations to be applied in a single application.

❸ The third method involves a single foliar application of micronutrients. Sources, rates, and concentrations for foliar sprays are given in Table 6. Foliar sprays are very useful where root injury due to such factors as disease or a poorly drained substrate would reduce root uptake of nutrients. However, the greatest risk of plant injury exists with foliar application. Spraying should be avoided during the midday heat. Early morning, after sunrise, is an effective time for application. Plant uptake is enhanced by the increased drying time which occurs during the moist conditions in the morning. Nutrient uptake through the leaves is also greater in the light period than at night, thus making morning applications more desirable than evening sprays. Incorporate a recommended spreader/ sticker into micronutrient sprays for more effective coverage. Use rates similar to those employed when applying pesticides.

*Table 6. Sources, rates, and final concentration of the micronutrient for single foliar sprays for correcting micronutrient deficiencies.**

Micronutrient Source	Weight of source/100 gal oz	Weight of source/100 gal grams	Final conc. (ppm)
iron sulfate	4	113.4	62 Fe
manganese sulfate	2	56.7	40 Mn
zinc sulfate	2	56.7	56 Zn
tri basic copper sulfate (53% copper)	4	113.4	159 Cu
sodium molybdate OR	2	56.7	57 Mo
ammonium molybdate	2	56.7	81 Mo

*Do not apply combinations without first testing on a small number of plants. Use the same spreader-sticker product and rate with the above foliar sprays as used with insecticide and fungicide sprays.

Recommendations for the use of chemicals are included in this publication as a convenience to the reader. The use of brand names and any mention or listing of commercial products or services in this publication does not imply endorsement by the North Carolina Cooperative Extension Service nor discrimination against similar products or services not mentioned. Individuals who use chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Be sure to obtain current information about usage and examine a current product label before applying any chemical. For assistance, contact an agent of the North Carolina Cooperative Extension Service in your county.