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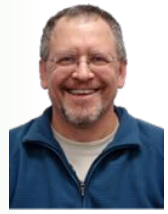

Brian E. Whipker[1]
bwhipker@ncsu.edu

Paul Cockson[1]

Volume 9 Number 8 February 2020

Nutrient Disorder Primer:

A quick guide to nutritional disorders

Nutrient deficiencies and toxicities can occur in greenhouse crops for numerous reasons other than simply a shortage or over application of nutrients. To prevent future issues and costly miscalculations, knowing how and when nutrient disorders can occur is highly beneficial. Unless you know why a nutrient disorder occurs, you will be unable to formulate a plan for preventing its reoccurrence in future crops. The following are some of the common reasons for nutrient deficiencies and toxicities.

Figure 1. Overwatering can result in limited uptake of iron (Fe) and the corresponding development of interveinal chlorosis of the upper foliage. (Photo: © Brian Whipker, 2020)

[1]NC State University, Dept. of Hort. Science
bwhipker@ncsu.edu

CAUSES OF NUTRIENT DISORDERS

pH

One factor that can introduce nutrient problems in floriculture crops is the substrate pH. The general pH range for greenhouse crops in a soilless substrate is 5.8 to 6.2, but a wider pH range of 5.5 to 6.4 is sometimes used with more pH tolerant species. Low uptake of nutrients due to nutrient tie-up can occur if the substrate pH is too high. The most common situation is the induction of an iron (Fe) deficiency, and to a lesser extent boron (B) deficiency. Deficiencies of copper (Cu), manganese (Mn) and zinc (Zn) resulting from an elevated substrate pH levels can also occur, but are rare.

When the substrate pH drops below 5.5, many nutrients become more available, particularly the micronutrients B, Cu, Fe, Mn, and Zn. Levels of these elements become readily available for plant uptake and can lead to toxicity conditions. Iron and Mn are the two main elements that commonly become toxic due to over accumulation (symptomology described below). When diagnosing plant problems, if the substrate pH is below 5.0, there is a high probability this is the primary cause.

Broken or un-calibrated equipment

An improperly working fertilizer injector (proportioner) can affect the nutrient delivery to the plants. Typically an injector fails to provide adequate levels of fertilizer and slow plant growth and deficiency symptoms occur. Weekly injector calibration will help detect problems before plants exhibit symptomology.

Overwatering

Constant saturation of the substrate can lead to both macro- and micronutrient deficiencies. Overwatering reduces the oxygen levels available to the plant, and root growth can be negatively affected. An inactive root system due to overly saturated conditions commonly results in limited Fe (upper leaf interveinal chlorosis, Fig. 1) and phosphorus (P) (lower leaf purpling) uptake by the plant. In addition, an overly saturated substrate can hinder the uptake of both calcium (Ca) and B, and result in leaf symptoms.

Low temperature

Growing and substrate temperatures can also play a major role in the induction of nutrient deficiencies. One classic example is how low temperatures (less than 55F [13C]) results in a phosphorus deficiency in tomato, pansies (Fig. 2) and geraniums. Uptake of Fe is also hindered and can result in the appearance of interveinal chlorosis on the upper leaves. The lower temperatures result in a slower movement and a slower rate of uptake by the plants.

Figure 2. Low substrate temperatures can slow uptake of phosphorus and result in the development of an overall reddish-purple leaf coloration of the lower leaves. (Photo: © Brian Whipker, 2020)

Disease

Diseases such as *Pythium*, *Phytophthora*, and *Rhizoctonia* impair the root system resulting in inducing nutrient deficiencies. The most common element deficiency that occurs is Fe (interveinal chlorosis on the upper leaves). Phosphorus (lower leaf purpling) is also common. Plant growth is also commonly stunted with disease pressure. As with most biotic disorders, the pattern of problematic plants most likely is scattered across the bench. Inspect the root system if disease problems are suspected, specifically looking for white healthy roots verses discolored, brown roots affected by a disease (Fig. 3).

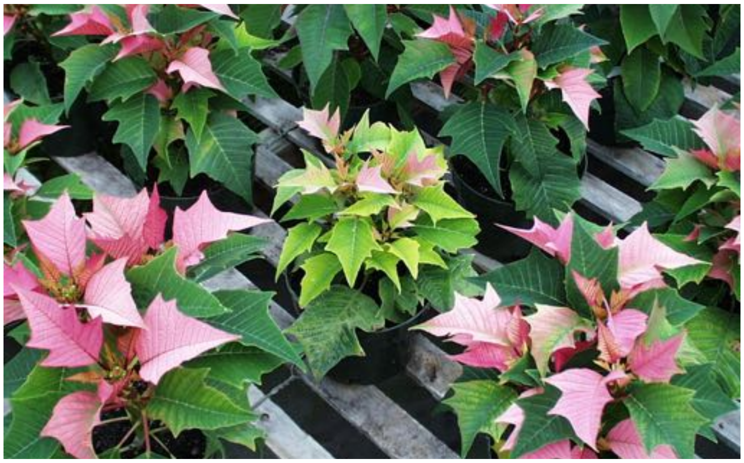

Figure 3. Discolored roots indicate a root disease problem and can hinder the uptake of nutrients by the plant. (Photo: © Brian Whipker, 2020)

Electrical conductivity (EC) [Soluble salts]

Soluble salts are the total dissolved salts in the substrate at any given time and can easily be measured by an EC meter. When the EC is too low, it can result in multiple deficiency symptoms. Lower leaf yellowing due to insufficient nitrogen levels is the most common problem observed (Fig. 4). EC levels below 0.75 mS/cm (PourThru extraction), 0.50 mS/cm (SME extraction), or 0.20 mS/cm (1:2 extraction) are threshold values to use when diagnosing low EC problems.

Figure 4. Insufficient nutrient levels will hinder plant growth and lead to the development of leaf symptomology. Lower leaf yellowing is occurring because of a nitrogen deficiency. (Photo: © Brian Whipker, 2020)

Excess substrate EC levels can result in stunted plant growth and elevated (luxurious) uptake by plants. Toxic levels of nutrients will result in marginal leaf necrosis of the lower leaves (Fig. 5). Elevated EC levels occur when the fertilizer concentration supplied to plants is in excess of the plant's needs. Root diseases also limit nutrient uptake and can result in the accumulation of elevated levels in the substrate. EC levels above 4.6 mS/cm (PourThru extraction), 3.5 mS/cm (SME extraction), or 1.26 mS/cm (1:2 extraction) are broad threshold values to use when diagnosing excessive EC problems.

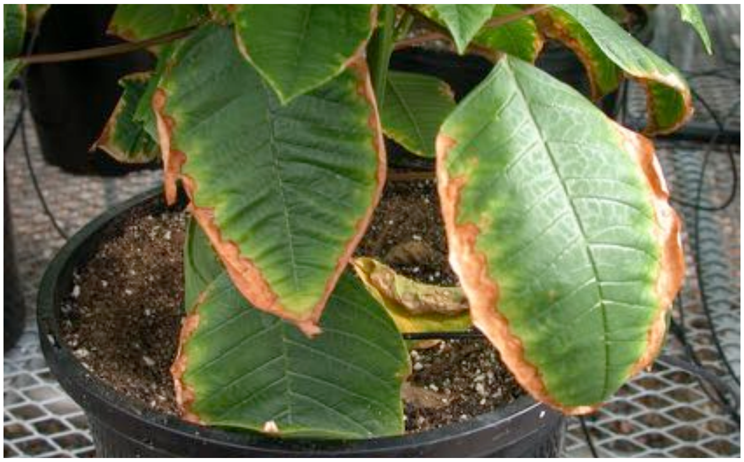

Figure 5. Excessively high levels of fertilizer can lead to lower leaf burn. (Photo: © Brian Whipker, 2020)

Monitoring the substrate EC levels over time will help detect a situation before problems occur. If substrate EC levels are high, a few irrigations with clear water will help moderate levels. Then decide if an overall lower fertilizer concentration should be used. If levels are excessively high, a clear water leach with 20% excessive volumes of water to flush the salts can be used. Avoiding the need to leach plants is preferred, for leaching is wasting your fertilizer investment and not environmentally sound.

Figure 6. Excessive levels of phosphorus can hinder the uptake of iron in scaevla. (Photo: © Brian Whipker, 2020)

Element antagonisms

A balance approach to fertilization practices result in optimal growth. If one element is provided in excess, it may not result in a toxicity, but instead can hinder the uptake of another element which becomes deficient. A classic example is excessive P can lead to a Fe deficiency in plants, especially for Australian natives such as scaevola (Fig. 6). Another situation is if any the cations potassium (K), Ca or magnesium (Mg) are provided in excess, it can result in inducing a deficiency of any of the other 2 elements. A balanced ratio of 4:2:1 for K:Ca:Mg will help avoid this situation. Excessive Ca can also hinder B uptake.

Figure 7. Lower leaf yellowing due to insufficient nitrogen being supplied to impatiens. (Photo: © Brian Whipker, 2020)

SYMPTOMS OF NUTRIENT DISORDERS

Being able to diagnose nutrient disorders requires knowledge of the factors that can lead to a disorder, as outlined above, and the common visual symptomology that occurs with each element. Due to mobility of elements in the plant, the use of

Figure 8. Slow growth and leaf discoloration occurs when plants are grown with ammonium-nitrogen and cool temperatures. (Photo: © Brian Whipker, 2020)

location of symptomology and the symptomology characteristics can help diagnose disorders. The following section discusses common symptoms that appear with nutritional disorders. Besides conducting in-house substrate pH and EC checks, until you become well versed in diagnosis, the submission of a substrate and/or tissue sample will help confirm the problem.

Nitrogen Deficiency

Nitrogen is mobile in the plant and deficiency symptoms appear on the oldest leaves as a uniform chlorosis over the entire leaf. As the deficiency progresses, chlorosis gradually progresses to the younger leaves, and the oldest leaves become necrotic and may abscise (Fig. 7). Purple to red discoloration may develop in older leaves as they turn chlorotic in plants such as *Begonia* spp., *Celosia* spp., marigold (*Tagetes* spp.), pansy (*Viola* spp.), kale (*Brassica* spp.) and tomato (*Solanum lycopersicum*).

Ammonium Toxicity

Symptoms of ammonium toxicity include marginal leaf necrosis in older leaves, and leaves may curl upward or downward, depending on the plant species (Fig. 8). Fewer roots form, and in advanced toxicities root tips become necrotic, often turning orange-brown.

Phosphorus Deficiency

Phosphorus is mobile in the plant; therefore, deficiency symptoms are expressed in the oldest leaves. Leaves become darker green and often turn purple, which extends into the stem (Fig. 9). Because of low phosphorus solubility in soil, environmental conditions that may stunt roots, such as cold soil, exacerbate phosphorus deficiency.

Figure 9. Purple discoloration on the lower leaves of gerbera due to inadequate phosphorus. (Photo: © Brian Whipker, 2020)

Figure 10. Ranunculus plants exhibiting lower leaf chlorotic margins due to low potassium levels. (Photo: © Brian Whipker, 2020)

Figure 11. Tip burn and distorted leaves occur if calcium uptake is limited during periods of rapid growth, as what occurs during the summer with zinnias. (Photo: © Brian Whipker, 2020)

Potassium Deficiency

Deficiency symptoms of potassium can vary by species. Lower leaf marginal chlorosis occurs on ranunculus (Fig. 10). Symptoms can also be expressed on the older leaves as a marginal necrosis (often without chlorosis preceding necrosis) and leaf curling. Similar necrotic spots may form across the blades of older leaves but are more numerous toward the margin. Soon the older leaves become completely necrotic. Symptoms are sometimes confused with deficiency of other macronutrients, especially magnesium.

Calcium Deficiency

Calcium deficiency symptoms are initially expressed at the top of the plant. Young leaves may develop variable patterns of chlorosis and if necrosis occurs due to cell death, then strap-like growth or crinkling develops (Fig. 11). Shoots stop growing and apical meristems die. Petals or flower stems may collapse. Roots are short, thickened, and fewer. Flower petals and bracts may be discolored or incompletely formed.

Magnesium Deficiency

Older leaves develop interveinal chlorosis (Fig. 12). In some plant species such as tomatoes, pink, red, or purple pigmentation may develop in the older leaves following the onset of chlorosis. Potassium deficiency can sometimes be confused with this disorder.

Sulfur Deficiency

Foliage over the entire plant becomes uniformly chlorotic (Fig. 13). The symptoms may tend to be more pronounced toward the top of the plant. While symptoms on the individual leaf look like those of nitrogen deficiency, sulfur deficiency can be distinguished from nitrogen deficiency because nitrogen deficiency begins in the lowest leaves.

Figure 12. Lower leaf interveinal chlorosis occurs with geraniums provided extra calcium to avoid low substrate pH issues. (Photo: © Brian Whipker, 2020)

Figure 13. Sulfur deficiencies are not common. The use of Cal-Mag fertilizers which do not include sulfur can result in deficiencies if supplemental S is not supplied. (Photo: © Brian Whipker, 2020)

Figure 14. Wax begonias exhibiting iron deficiency symptomology. (Photo: © Brian Whipker, 2020)

Iron Toxicity

Plants such as marigolds develop bronzing on recently fully expanded leaves. The bronzing consists of numerous pinpoint spots that start yellowing and quickly turn bronze. Affected leaves become necrotic. On other crops, the older leaves develop numerous pinpoint necrotic spots across the blade (Fig. 15). The entire leaf may die as the spots enlarge. This disorder mainly commonly occurs on African marigolds (*Tagetes erecta*) and seed geraniums (*Pelargonium* × *hortorum*).

Figure 15. Lower leaf bronzing occurs on geraniums when the substrate pH is too low. (Photo: © Brian Whipker, 2020)

Manganese Deficiency

Interveinal chlorosis of young leaves occurs, which is sometimes followed by tan spots or a brown spot flecking in the chlorotic areas between the veins.

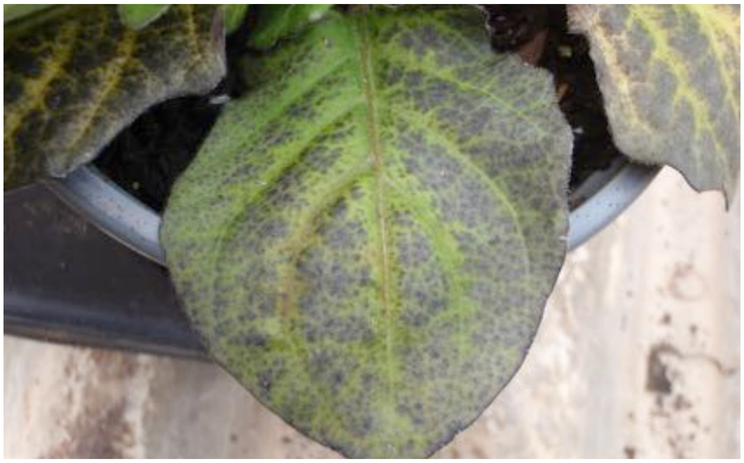

Figure 16. Lower leaf purplish-black spotting on gerbera due to a low substrate pH. (Photo: © Brian Whipker, 2020)

Manganese Toxicity

Toxicity often begins as blackish or purplish spotting of the lower leaves (Fig. 16&17). Spots become more numerous and eventually coalesce into patches. This disorder commonly occurs on basil (*Ocimum basilicum*), *Cosmos* spp., *Dahlia* spp. hybrids, pepper (*Capsicum* spp.), strawflower (*Helichrysum bacteatum*), and *Zinnia elegans*.

Figure 17. Lower leaf purplish-black spotting on pansy due to a low substrate pH. (Photo: © Brian Whipker, 2020)

Zinc Deficiency

Young leaves are moderately to severely stunted and internodes are short, giving the stem a rosette appearance. These leaves are also chlorotic in varying patterns but tend toward interveinal chlorosis. As the deficiency progresses, necrosis develops.

Copper Deficiency

Young leaves develop interveinal chlorosis; however, the tips and lobes of these leaves may remain green. Next, the youngest fully expanded leaves rapidly become necrotic. The sudden death of these leaves resembles desiccation. Flowers are small and deformed.

Boron Deficiency

Death of the apical meristem gives rise to branching followed by death of the new lateral buds, which eventually leads to a proliferation of shoots. Other symptoms include short internodes; crinkling of young leaves; corking of young leaves, stems, and buds; and thickening of young leaves (fig. 12.30). Chlorosis of young leaves may occur, but not in any definite pattern. Roots become short and thick with eventual death of root tips (Fig. 18). Incomplete development of flower parts such as fewer petals, small petals, sudden wilting or collapse of petals, and notches of tissue missing in flower stems, leaf petioles, or stems also may occur.

Figure 18. Growing conditions limited the uptake of boron by this gloxinia plant resulting in loss of the growing tip, flower bud, and the development of axillary shoots. (Photo: © Brian Whipker, 2020)

Boron Toxicity

The margins of older leaves become necrotic with a characteristic reddish brown color (Fig. 19). Necrotic spots may also develop across the leaf blade but tend to be concentrated at the margins.

Figure 19. Overdose applications of boron on pansies resulted in leaf necrosis. (Photo: © Brian Whipker, 2020)

Molybdenum Deficiency

The margins of leaves in the middle canopy become chlorotic, presenting a silhouette appearance and then quickly become necrotic (Fig. 20). Symptoms spread up and down the plant. These leaves may also become misshapen, resembling a half-moon pattern with some crinkling; the necrotic leaf margins also may curl upward and inward.

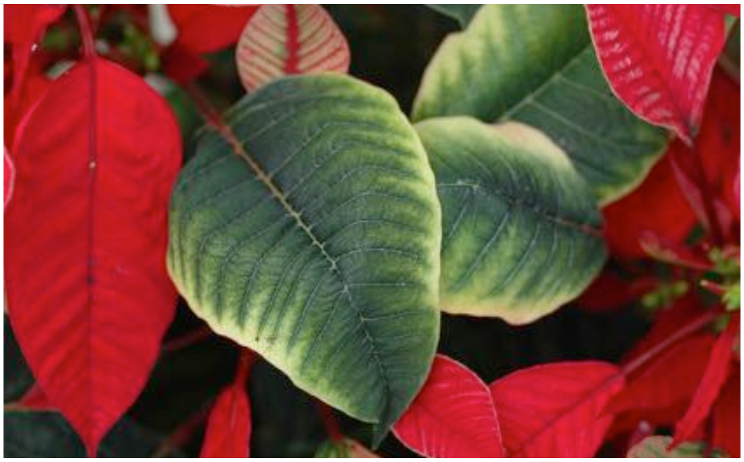

Figure 20. Poinsettias have a high demand for molybdenum and can develop deficiencies. (Photo: © Brian Whipker, 2020)

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CONTRIBUTORS

Dr. Nora Catlin
Floriculture Specialist
Cornell Cooperative Extension
Suffolk County
nora.catlin@cornell.edu

Dr. Chris Currey
Assistant Professor of Floriculture
Iowa State University
ccurrey@iastate.edu

Dr. Ryan Dickson
Greenhouse Horticulture and
Controlled-Environment Agriculture
University of Arkansas
ryand@uark.edu

Nick Flax
Commercial Horticulture Educator
Penn State Extension
nzf123@psu.edu

Thomas Ford
Commercial Horticulture Educator
Penn State Extension
tgf2@psu.edu

Dan Gilrein
Entomology Specialist
Cornell Cooperative Extension
Suffolk County
dog1@cornell.edu

Dr. Joyce Latimer
Floriculture Extension & Research
Virginia Tech
jlatime@vt.edu

Heidi Lindberg
Floriculture Extension Educator
Michigan State University
wolleage@anr.msu.edu

Dr. Roberto Lopez
Floriculture Extension & Research
Michigan State University
rglopez@msu.edu

Dr. Neil Mattson
Greenhouse Research & Extension
Cornell University
neil.mattson@cornell.edu

Dr. W. Garrett Owen
Floriculture Outreach Specialist
Michigan State University
wgowen@msu.edu

Dr. Rosa E. Raudales
Greenhouse Extension Specialist
University of Connecticut
rosa.raudales@uconn.edu

Dr. Beth Scheckelhoff
Extension Educator - Greenhouse Systems
The Ohio State University
scheckelhoff.11@osu.edu

Dr. Ariana Torres-Bravo
Horticulture/ Ag. Economics
Purdue University
torres2@purdue.edu

Dr. Brian Whipker
Floriculture Extension & Research
NC State University
bwhipker@ncsu.edu

Dr. Jean Williams-Woodward
Ornamental Extension Plant Pathologist
University of Georgia
jwoodwar@uga.edu

Cooperating Universities

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