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197. Diagnosing Abiotic Disoders in the Greenhouse. Gibson, J., Whipker, B., and Nelson, P.V. American Nurseryman, 207(3): 12, 14, 16. 2008.

Diagnosing abiotic disorders in the greenhouse

Problems can arise in greenhouse production that may involve living (biotic) and nonliving (abiotic) factors. Oftentimes, biotic factors present themselves clearly, especially when the causal agent is an insect pest, but plant diseases are a little more difficult to identify. Abiotic factors pose difficulty in accurate diagnosis. Visual diagnosis is a popular monitoring tool; however, using a plant diagnostic lab to identify the source of nutritional problems is still the best way to ensure accurate diagnoses because many nutritional, physiological, insect and disease problems can mimic each other. This article features some of the common abiotic disorders along with a nutritional- disorder guide to assist plant producers.

When using visual diagnosis, one must first account for all other factors that could cause similar symptoms. A number of nutritional- disorder symptoms can also be the symptoms of other causal agents, such as air pollution, pesticide damage, herbicides in or near the crop area, plant growth regulators, pathogenic diseases (particularly viruses) and environmental extremes, such as frost, desiccation or temperature extremes.

A valuable asset for sorting out other causal agents is a crop-production record. Further help can be found in production and pest-control manuals for the crop at hand. Most abiotic disorders are associated with plant nutrition; however, listed in the chart on page 14 are other common abiotic disorders that occur in greenhouses with preventive activities or recommended solutions.

Leaf discoloration, which occurs days after a chemical application, is a key factor in identifying a phytotoxicity problem. Typical symptoms are more noticeable on the upper foliage, and within a week, the leaves, which developed after the chemical application, will not exhibit phytotoxicity.

A common nutritional problem of a high substrate pH is iron deficiency. The disorder is denoted by the interveinal chlorosis of the youngest leaves. Testing the substrate pH to determine if it is above 6.4 will aid in confirming the diagnosis.

Nutrient deficiencies. Nutrient deficiencies can appear quickly within a crop and subsequently reduce profit by affecting marketability. There are several factors that can inhibit proper nutrition of greenhouse crops.

pH: One factor that can introduce nutrient deficiencies in greenhouse crops is the substrate pH. The general pH range for greenhouse crops is 5.4 to 6.8, but maintaining the pH between 5.6 and 6.2 is recommended. Poor uptake of nutrients, particularly boron, copper, iron, manganese and zinc, can occur if the pH of a substrate is above 6.5. Certain macronutrients, like calcium and magnesium, can become less available at pH values below 5.4.

Improperly working equipment: An improperly working fertilizer proportioner can cause nutrients to be less than optimum in the substrate. Weekly calibration of the injector is required. The significant problem with equipment failure is the introduction of multiple nutrient deficiencies.

Water stress: Constant saturation of the substrate can lead to macro- and micronutrient deficiencies. As oxygen levels are inhibited by overwatering, root growth can be limited and water uptake slowed. Elements, such as calcium, are transported via water flow, and deficiency symptoms can develop rapidly on new growth. Also, the inactivity of root systems due to saturated conditions can lead to inefficient uptake of iron or phosphorus.

Low soluble salts: Soluble salts refer to the total dissolved salts in the root substrate at any given time and are measured in terms of electrical conductivity (EC). When the EC content of the root substrate is too low, plant growth is stunted and mineral deficiencies are observed. Low salts are usually due to too many clear water irrigations. Deficiencies among greenhouse crops, like lower-leaf yellowing (nitrogen), lower-leaf purpling (phosphorus) and lower-leaf interveinal chlorosis (magnesium), are common when values are below 0.75 mS/cm (millisiemens per centimeter).

Mineral antagonisms: When certain elements are provided in excess to plants, the uptake of other nutrients may be hindered. One example of a mineral antagonism is the nitrogen-potassium (N-K) interaction, where for most bedding plants a 1N:1K ratio is recommended. Another type of antagonism is the potassium-calcium-magnesium (K-Ca-Mg) interaction. Any one of these elements in excess can cause a decrease in the uptake of the other elements; therefore, a ratio of 4K:2Ca:1Mg should be adopted by bedding plant growers. Excess phosphorus can cause a decrease in the uptake of zinc, iron and copper.

Temperature: Temperature can also play a role in the introduction of nutrient deficiencies. One classic example is the effect of low temperature (less than 550)

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Common abiotic disorders of floral crops

Disorder	Symptoms	Preventive actions or corrective procedures
Air pollution	Yellow to bleach white shoot tips; wilting; flower drop	Plant-damaging levels of ethylene can be detected in greenhouses if flowers begin to drop quickly or do not bloom. Test heaters each year.
Edema or oedema	Corky growth or pimple-like bumps on leaf lamina	Increase airflow over plants with horizontal airflow fans. Reduce irrigation in cloudy weather or humid conditions. Supplemental applications of light can also increase transpiration.
Insufficient spacing	Excessive internode elongation	Use plant growth regulators before plants touch one another if pot-tight crop production is preferred. Space or pinch plants if the chemical approach is not preferred.
Mutation	Variegated patterns in plant tissue	Genetic mutations can occur with plants; therefore, growers should purchase stable cultivars or investigate possibilities of cultivar development (patenting or trademarking).
Photoperiod	Premature flowering or tuber formation; marginal necrosis; reduced growth; plant remains vegetative	Apply extended day- or night-break interruption for plants that need to remain vegetative. Provide black cloth to crops with a short day requirement for flowering.
Plant growth regulator overdose	Stunted and crinkled foliage	Check math or utilize a Web-based plant growth regulator (PGR) calculator, like the one found at www.ces.ncsu.edu/depts/hort/floriculture/software/index.htm. Growers may also want to check specific gibberellic acid containing PGRs to determine if a corrective spray is labeled to overcome plant stunting.
Sunscald	Marginal burn or papery burn on leaf lamina	Mist recently transplanted material to minimize the effects of light intensity.
Spray burn	Marginal burn or papery burn on leaf lamina	Spray pesticides during cooler periods of the day. Spray test plots (five to 10 plants) if crop has a flush of new growth.
Water stress	Marginal burn or papery burn on leaf lamina	Irrigate more frequently.

on the uptake of phosphorus in tomato. Purpling of the lower foliage is the common symptom. Geraniums can also express phosphorus deficiency when they are grown too cool in the spring.

Disease: Organisms, like *Pythium*, feed on the nutrients in roots, which causes an inefficient uptake of minerals. Iron deficiency (upper foliage interveinal chlorosis) can occur if root rot pathogens infect the root system. Foliar diseases — particularly fungal diseases — can cause chlorosis of leaf tissue, a direct reflection of harvesting nitrogen from plant cells.

Essential nutrients. Sixteen elements are considered to be essential elements for plant growth: boron, calcium, carbon, chlorine, copper, hydrogen, iron, magnesium, manganese, molybdenum, nitrogen, oxygen, phosphorus, potassium, sulfur and zinc. These elements have been determined to be essential because they have met these three criteria:

- the lack of the element makes it impossible for the plant to complete the vegetative or reproductive stage of life;
- the element cannot be replaced by supplying another element; and
- the element must exert its effect directly on growth or metabolism.

Macronutrient/micronutrient translocation. Knowing why the deficiency occurred is a crucial tool in the identification of a nutrient disorder. Another important aspect in diagnosis is the location on the plant where the symptom is expressed. Understanding the translocation principle in bedding plants will enable growers to diagnose more correctly and will, in most cases, pinpoint the macro- or micronutrient disorder.

Mobility of the nutrient or the ability of the element to translocate itself to another part of the plant has been determined for the essential elements (chart, page 16). Plants obtain nutrients from the substrate solution via root systems. Nutrients are incorporated into tissues, used for cellular growth and utilized in photosynthesis or in the building blocks of plant tissue.

Initially, nutrients are provided to plants from seed reserves, then as roots begin to develop, plants extract nutrients from the substrate. Once the nutrients become less available to the plant, the plant has to provide nutrients from older tissues so the actively growing regions (shoot tips and axillary shoots) can continue to develop. Basically, the plant is attempting to promote life by supplying nutrients to the upper growth, which harbors the reproductive structures, enabling the continuation of the species.

Some elements are unable to be translocated. In the following two sections, we have explained the differences in mineral translocation between nitrogen and calcium.

Nitrogen translocation. Nitrogen is incorporated into organic molecules, and it is involved in the structures of all amino acids, proteins and many enzymes. As levels of nitrogen decrease in the substrate, nitrogen is translocated from the lowest leaves to the actively growing regions of the shoot tip. Deficiency symptoms appear on the older

Essential elements and deficiency symptoms in greenhouse crop fertilization

Element*	Mobility	Symptoms
Nitrogen (N)	Mobile	Stunted growth; pale green to yellow color on older leaves; weak stems; necrotic symptoms develop at a later stage
Phosphorus (P)	Mobile	Slow and reduced growth; purple pigmentation of older leaves; accumulation of anthocyanin; foliage is dark green; necrotic patches occur on the leaf margins at the advanced stage
Potassium (K)	Mobile	Slow growth; marginal chlorosis on older leaves; burned or scorched appearance at the advanced stage
Calcium (Ca)	Immobile	Curled and distorted leaves; strap-like leaves on top; tips turn brown to black; vascular breakdown at the base of the plant; short roots with comb-like or "herringbone" effect
Magnesium (Mg)	Mobile	Interveinal chlorosis on older leaves; defoliation of the lower leaves at the advanced stage
Sulfur (S)	Immobile	Slow growth; general loss of green color; overall, plant appears to be a lighter green
Iron (Fe)	Immobile	Interveinal chlorosis of younger leaves; young leaves become a bleached yellow at the advanced stage leading to necrotic burn on the tips and margins
Manganese (Mn)	Immobile	Reduced and stunted growth with interveinal chlorosis on younger leaves
Zinc (Zn)	Immobile	Upper new leaves will curl with rosette appearance; chlorosis in the interveinal areas; leaves will die off and flowers will abscise
Copper (Cu)	Immobile	Reduced or stunted growth; distortion of the younger leaves and necrosis of the apical meristem
Boron (B)	Immobile	Stunted growth; discoloration; possible death of the growing tips; bud abortion; lack of fruit set and development; roots are stunted with swollen, stubby secondary roots

*Carbon (C), hydrogen (H), oxygen (O), chlorine (Cl) and molybdenum (Mo) are also essential elements; however, deficiency symptoms are rare on most annual floral crops.

leaves, and a lighter green color is observed. As symptoms progress, the stem becomes weak, the leaves become small, and the lower leaves drop. Necrosis of the older leaves is an advanced nitrogen-deficiency symptom.

Calcium translocation. Calcium plays a major role in cell elongation, and it is an important component in cell walls—it acts as cement between cells. Calcium is transported with water to plant tissues, but if levels in the substrate are too low, calcium deficiency can occur. Because calcium is immobile, it cannot be translocated to the region of active growth in the shoot tip; therefore, new growth is severely reduced.

Although calcium may be adequate in the lowest leaves, levels in the meristematic region can be too low, causing poor leaf expansion, followed by necrotic patches in the young leaves. Complete necrosis of the shoot is the advanced stage, causing the inability of the reproductive structures to form. If flowers are present when calcium levels become devastatingly low in the substrate, bud abortion occurs.

Abiotic disorders can at times be a challenge to properly identify. When problems occur, know the factors that lead to the specific disorder to assist you in asking the right questions. In addition, take full advantage of outside resources, such as company technical representatives and laboratories for diagnosis, to aid you in determining the possible cause of the disorder.

During periods of hot weather in the spring, water stress can occur. This 'New Guinea' impatiens was dried down on a sunny day. The browning from the leaf tip inward is a typical symptom of water stress.

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