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Identifying Nutrient Deficiencies of Bedding Plants

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Why do nutrient deficiencies occur?

Bedding plants are profitable crops to grow because of their rapid growth rate and popularity among consumers. Unfortunately nutrient deficiencies can appear quickly within a crop and subsequently reduce profit by affecting marketability. There are several factors which can inhibit proper nutrition of bedding plant crops.

pH. One factor which can introduce nutrient deficiencies in bedding plants is the substrate pH. The general pH range for bedding plants is 5.4 to 6.8, but maintaining the pH between 5.6 to 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 (too much). 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 waterflow 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 is 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 bedding plants 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 (SME extraction).

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

Temperature (too cold). Temperature can also play a role in the introduction of nutrient deficiencies. One classic example is the effect of low temperature (<55°F) on the uptake of phosphorus in tomato. Purpling of the lower foliage is the common symptom. Geraniums also can express phosphorus deficiency when they are grown too cool in the spring.

Disease. Organisms like *Pythium* feed on the nutrients in roots causing 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: carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, zinc, molybdenum, and chlorine. 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.
- 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 (See Table 1). Plants obtain nutrients from the substrate solution via root systems. Nutrients are incorporated into tissues, are used for cellular growth, and utilized in photosynthesis or in the building blocks of plant tissue (See Table 1 for roles of the elements in plant growth).

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 that 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. Differences between mineral translocation will be demonstrated below in a comparison example between nitrogen and calcium.

Nitrogen Translocation

Nitrogen is incorporated into organic molecules and is involved in the structures of all amino acids, proteins, and many enzymes. As levels of nitrogen become less in the substrate, nitrogen is translocated from the lowest most leaves to the actively growing regions of the shoot tip. Deficiency symptoms appear on the older 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 is an important component in cell walls, structurally it acts as a 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 most 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 were present when calcium levels become devastatingly low in the substrate, bud abortion occurs.

Fertilization strategy

Bedding plant producers will normally apply a commercial fertilizer to the crop. Normal fertilization should provide adequate levels of micronutrients as well as the major macronutrients, as long as the pH is within the acceptable range. (The exception would be 20-10-20, which does not provide Ca or Mg. So it is always good to refer to the analysis on the back of the fertilizer bag to check the total elemental composition.)

Table 1. Essential nutrients which are important in bedding plant fertilization.
Nitrogen: N **Movement:** Mobile **Function:** Involved in the structure of amino acids, proteins, enzymes, and nucleic acids. **Deficiency Symptoms:** Stunted, pale green to yellow, weak stem, necrotic symptoms develop at a later stage. **Corrective Procedures:** Substrate applications include calcium nitrate ($Ca(NO_3)_2$) or potassium nitrate (KNO_3), or Excel 15-5-15 Cal-Mag at the rate of 300 to 400 ppm N. Do not overapply, a single application at 300 to 400 ppm N should return the lower leaves a normal green color within 1 to 2 weeks.
Phosphorus: P **Movement:** Mobile **Function:** Involved in energy transfer (ADP), nucleic acids, enzymes, and membrane structure. Plays an important role in root and floral development and stimulates rapid plant growth. **Deficiency Symptoms:** Slow and reduced growth, purple pigmentation of older leaves- accumulation of anthocyanin, foliage is a dark green, necrotic patches occur on the leaf margins at the advanced stage. **Corrective Procedures**: Substrate applications of 20-10-20 at the rate of 200 ppm will supply 44 ppm of P. Also avoid cool night temperatures which can cause inactivity of root systems.
Potassium: K **Movement:** Mobile **Function:** Maintains the ionic balance and water status in plants, opening and closing of stomata, photosynthesis, sugar translocation, enzyme activity. **Deficiency Symptoms:** Slow growth, marginal chlorosis on older leaves, burned or scorched appearance at the advanced stage. **Corrective Procedures:** Substrate applications include potassium nitrate (KNO_3) or 15-5-25 at the rate of 300 to 400 ppm K. One or two corrective K fertilizations will return the chlorotic tissue to the normal green color within 1 to 2 weeks.
Calcium: Ca **Movement:** Immobile **Function:** Constituent of cell walls, maintains cell wall integrity and membrane permeability, enhances pollen germination and growth, activates a number of enzymes for cell mitosis, division and elongation. **Deficiency Symptoms:** Curled and distorted leaves, strap-like leaves on top, tips turning brown to black, vascular breakdown at the base of the plant, short roots with comb-like or "herring bone effect". **Corrective Procedures:** Supplemental substrate applications of calcium nitrate ($Ca(NO_3)_2$) at 200 ppm Ca. Visible improvements should be evident on the new growth within 2 to 3 weeks. Do not overapply. Also allow the substrate to dry before irrigating to prevent poor uptake of calcium.
Magnesium: Mg **Movement:** Mobile **Function:** A component of the chlorophyll molecule and involved in enzyme activation. **Deficiency Symptoms:** Interveinal chlorosis on older leaves, defoliation of the lower leaves at the advanced stage. **Corrective Procedures:** Magnesium sulfate (Epsom Salts) application to the substrate at the rate of 1 pound per 100 gallons of water. Do not mix with other fertilizers. A corrective fertilization will return the chlorotic tissue to the normal green color within 1 to 2 weeks.
Sulfur: S **Movement:** Moderately mobile **Function:** Constituent of two amino acids, cystine and thiamine, contributes to odor and taste of some plants. **Deficiency Symptoms:** Slowed growth, general loss of green color, overall the plant appears to be a lighter green. **Corrective Procedures:** Magnesium sulfate (Epsom Salts) application to the substrate at the rate of 1 pound per 100 gallons of water. Do not mix with other fertilizers. A corrective fertilization will return the chlorotic tissue to the normal green color within 1 to 2 weeks.

Table 1. Continued.

Iron: Fe
Movement: Immobile
Function: Necessary for the synthesis of chlorophyll, component of many enzyme and electron transport systems, component of protein ferredoxin.
Deficiency Symptoms: Interveinal chlorosis of younger leaves, young leaves become a bleached yellow at the advanced stage leading to necrotic burn on the tips and margins.
Corrective Procedures: Supplemental applications of iron chelate to the root substrate at the rate of 1 ounce per 15 gallons of water. Rinse the foliage after the application. Visible improvements should be evident within 2 weeks. Do not overapply. Another corrective procedure is to apply a foliar spray of iron sulfate at a rate of 4 oz. per 100 gallons. This will provide 62 ppm of iron. Do not overapply. Also allow the substrate to dry before irrigating to prevent inactivity of the root system.

Manganese: Mn
Movement: Immobile
Function: Involved in pollen germination, respiration, photosynthesis, and nitrogen assimilation.
Deficiency Symptoms: Reduced and stunted growth with interveinal chlorosis on younger leaves.
Corrective Procedures: Add 0.5 oz. of manganese sulfate per 100 gallons of water. Apply to the substrate as a drench. Do not overapply. Another corrective procedure is to apply a foliar spray of manganese sulfate at a rate of 2 oz. per 100 gallons. This will provide 40 ppm of manganese. Do not overapply.

Zinc: Zn
Movement: Immobile
Function: Component and an activator of enzymes
Deficiency Symptoms: Upper new leaves will curl with rosette appearance, chlorosis in the interveinal areas, leaves will die off and flowers will abscise.
Corrective Procedures: Add 0.5 oz. of zinc sulfate per 100 gallons of water. Apply to the substrate as a drench. Do not overapply. Another corrective procedure is to apply a foliar spray of zinc sulfate at a rate of 2 oz. per 100 gallons. This will provide 56 ppm of zinc. Do not overapply.

Copper: Cu
Movement: Immobile
Function: Required for the activation of several enzymes, needed for photosynthesis, involved in the metabolism of carbohydrates and proteins.
Deficiency Symptoms: Reduced or stunted growth, distortion of the younger leaves and necrosis of the apical meristem.
Corrective Procedures: Add 0.5 oz. of copper sulfate per 100 gallons of water. Apply to the substrate as a drench. This will provide 9.3 ppm of copper. Do not overapply. Another corrective procedure is to apply a foliar spray of tri-basic copper sulfate at a rate of 4 oz. per 100 gallons. This will provide 159 ppm of copper. Do not overapply.

Boron: B
Movement: Immobile
Function: Associated with carbohydrate chemistry, pollen germination, and cellular activities (division, differentiation, maturation, respiration, and growth).
Deficiency Symptoms: Stunting, discoloration, possible death of the growing tips, bud abortion, lack of fruit set and development, roots are stunted with swollen stubby secondary roots.
Corrective Procedures: Add 0.75 oz. of Borax per 100 gallons of water or 0.43 oz. of Solubor per 100 gallons of water. Apply to the substrate as a drench. This will provide 6.25 ppm of boron.

The initial step to correct a micronutrient deficiency is to lower the pH below 6.2 for most bedding plant species. This can be accomplished by acid injection. Refer to NCSU HIL#558 for treating irrigation water with acid. Also refer to NCSU HIL#553 for more information on managing micronutrients. Documents can be found at http://www.ces.ncsu.edu/depts/hort/hil/flowers-index.html.