From Forest Nursery Notes, Winter 2010

49. The difference between nutrient solubility and mobility. Mattson, N. and Leatherwood, W. R. Greenhouse Management and Production 29(12):22-26. 2009.

By Neil Mattson and W. Roland Leatherwood

The difference between **nutrient solubility** and **mobility**

Understanding nutrient solubility and mobility can help you hone your fertilizer management practices and diagnostic skills.

Several complex processes occur when plants take up and use mineral nutrients. Two key factors that influence a plant's ability to use nutrients present in the root zone are nutrient solubility within the container growing medium and nutrient mobility once inside the plant. Knowing about these two properties can help you improve fertilizer management and diagnose plant nutrient disorders.

Solubility

Solubility refers to the ability of a fertilizer nutrient to dissolve into water. Water-soluble fertilizers usually list their maximum solubility on package labels. Solubility is the maximum pounds of fertilizer that can be dissolved in one gallon of water. The amount is simply a property of the various mineral salts that are combined to make up the fertilizer.

When mixing fertilizer into a stock tank, solubility is useful because it tells you the maximum fertilizer concentration or injector ratio. If a fertilizer's maximum solubility is exceeded, then some of the fertilizer being mixed will settle out in solid form at the bottom of the stock tank and will not be taken up by the injector line.

Water present in the growing medium also contains dissolved nutrients. For the rest of this article, solubility is referred to in terms of dissolved nutrients in the growing medium solution.

If a particular nutrient exhibits low solubility, then only a small amount is able to dissolve in solution. The rest of the nutrient in the growing medium is present in solid form. Solubility is important because roots can only take up nutrients that are dissolved in solution and cannot take up the solid nutrient form.

Table 1. Solubility of mineral nutrients in soilless container growing media as a function of pH.

NUTRIENT	pH 5.0	pH 6.0	pH 7.0
Nitrogen	high	high	high
Potassium	high	high	high
Phosphorus	high	medium	low
Calcium	low	medium	high
Magnesium	low to medium	medium	high
Iron (general response)	high	medium	low
Iron chelate EDDHA	high	high	high
Iron chelate EDTA	high	high	low
Iron sulfate	high	medium	low
Manganese	high	medium	low
Zinc	high	medium	medium
Boron	high	medium	low
Molybdenum	low	medium	high

Factors affecting solubility

Two primary factors that influence nutrient solubility are the growing medium pH and the chemical form of the nutrient. Nutrient solubility is significantly impacted by the medium pH (Table 1).

Growing medium pH

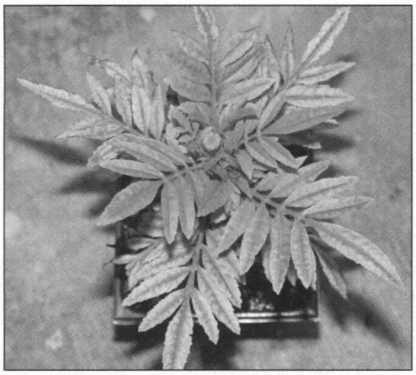
The micronutrients iron, manganese, zinc and boron are highly soluble at low pH (5.0-6.0). Therefore, at low pH these nutrients are available and readily taken up by the roots. If the pH is too low, typically below 5.0 for most plants, the nutrients become so soluble that they may be taken up at harmful or toxic concentrations.

Certain plants (seed and zonal geraniums and marigolds) that are especially efficient at taking up iron, can exhibit iron toxicity when the medium pH is below 6.0. At a high medium pH, the low solubility of iron, manganese, zinc and boron makes these nutrients less available to be taken up by roots and so deficiency symptoms can occur.

Chemical form of the nutrient

The chemical form of a nutrient that is applied to the growing medium also affects solubility. A classic example of

 29(12): 22-26



Symptoms of iron toxicity in marigold are leaf bronzing and chlorosis, which first appear on mature leaves.

Symptoms of iron deficiency in petunia are yellowing between the veins of young leaves.

this is the iron form. The solubility of iron sulfate decreases rapidly as the medium pH increases above 5.5. Chelated forms of iron are soluble over a higher pH range, but this also depends on the type of chelating agent. The chelating agent, EDDHA, is highly soluble at pH 7.0, whereas the chelating agent EDTA is poorly soluble at the same pH.

If iron deficiency is identified in a greenhouse crop, two questions should come to mind:

1. Is iron present at sufficient levels in the growing medium (was it added to the substrate or present in the fertilizer program)?
2. Is the iron available to be taken up by roots? Is the pH low enough for the iron form to be soluble? In many cases iron is included in the water soluble fertilizer program, but over time the medium pH becomes too high for the iron form to be soluble.

Solubility is also important because highly soluble nutrients readily leach out of the growing medium, whereas nutrients with low solubility are retained in the medium for a longer period. Nitrogen and potassium are soluble over a wide pH range. Therefore if excessive leaching fractions are used, these highly soluble nutrients are quickly washed away necessitating frequent reapplication.

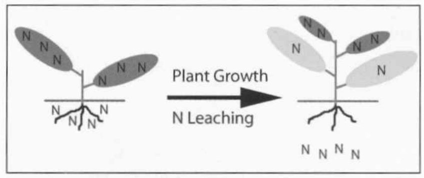
Nutrient mobility

Mobility refers to the ability of a nutrient to move around within a plant once it has been taken up by the roots. Transpiration is the primary force driving the initial movement of nutrients from the roots to the leaves and shoots via the xylem. The highly mobile nutrients nitrogen, phosphorus, potassium and magnesium can be remobilized and readily moved from older, mature leaves to new actively growing leaves (Table 2).

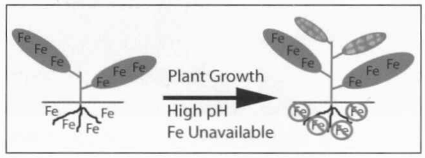
Nutrient mobility gives plants some flexibility in allocating nutritional resources. If the supply of a mobile nutrient has been cut off, new tissue growth can proceed since the nutrient in short supply can be scavenged from the older leaves that are not actively growing.

Table 2. Mobility of mineral nutrients within a plant.

LOW		LOW TO MODERATE	HIGH
Boron	Molybdenum	Sulfur (S)	Nitrogen
Calcium	Zinc		Phosphorus
Copper			Potassium
Iron			Magnesium
Manganese			Nickel



Nitrogen can be mobilized within a plant to support growth of new leaves.



Iron cannot be mobilized within a plant to support new growth. When iron becomes unavailable, new growth shows deficiency symptoms first.

Mobile nutrient deficiency symptoms are observed first on the older leaves. Consider an example where the nitrogen supply in the growing medium is suddenly cut off and there is no longer sufficient nitrogen for new growth. Because nitrogen can be mobilized from mature leaves to actively growing new leaves, deficiency symptoms (yellowing of the lower leaves) are exhibited first on the lower leaves. The young leaves can continue to grow with nitrogen scavenged from the older leaves.

Most micronutrients have low mobility within plant tissue. Unlike nitrogen, once iron, manganese and zinc have been initially taken up and used by plant tissue, they cannot be remobilized within the plant.

Iron has low mobility. When it becomes unavailable in the growing medium, it cannot be scavenged from older leaves to support newly growing tissue. Consequently, when the iron supply has been disrupted, deficiency symptoms occur on the newer leaves.

When excessive or toxic amounts of immobile nutrients are absorbed by a plant, the older leaves usually show symptoms first. This is a result of some of the absorbed nutrient being continually deposited in older leaves through the transpiration process. Symptoms of micronutrient toxicity are usually found first on older leaves as they have been transpiring longer and thus accumulating toxic amounts of nutrients longer than younger leaves.

Table 3. Growing medium pH guidelines for some common greenhouse plants.*

IRON INEFFICIENT PLANTS pH 5.4 to 6.2	GENERAL GROUP pH 5.8 to 6.4	IRON EFFICIENT PLANTS pH 6.0 to 6.6
Bacopa	Chrysanthemum	Geranium (seed and zonal)
Calibrachoa	Geranium (ivy)	Marigold
Nemesia	Impatiens	New Guinea impatiens
Pansy	Poinsettia	Lisianthus
Petunia		
Snapdragon		
Scaevola		

*Adapted from Managing pH for Container Media by Paul Fisher, Chapter 4 in Ball Redbook Crop Production, Volume 2, 17th Edition, Ball Publishing.

A balancing act

Fertilizing greenhouse crops is a balancing act. Many different types of nutrients must be supplied and the growing medium pH must be maintained within a range that maintains sufficient nutri-

Symptoms of nitrogen deficiency in impatiens are yellowing of lower leaves.

ent solubility and concentration. The optimal medium pH for many common crops is 5.8 to 6.4 (Table 3). For iron-efficient plants, the medium pH should be kept slightly higher (6.0 to 6.6) to limit solubility of micronutrients. Conversely, calibrachoa, petunia and other iron-inefficient plants are less capable of absorbing iron and manganese from the medium. The medium pH for these crops should be kept slightly lower (5.4 to 6.2) to increase solubility of micronutrients.

When nutrient disorders are discovered, informed decisions can be made as to the deficiency or toxicity problem based on whether old or young tissue is affected. As you act to correct nutrient disorders, keep in mind that nutrient availability is determined by both the nutrient supply and nutrient solubility in the medium. Symptoms of many nutrient disorders have a similar appearance, so be sure to check a pictorial guide and consult your own fertilizer program records before correcting a problem.

Regular monitoring of the medium pH, soluble salts and nutrient levels can help avoid nutrient disorders before they occur. For persistent problems, consult a nutrient analysis laboratory or extension specialist to precisely diagnose the disorder and recommend a corrective course of action.

Neil Mattson is assistant professor and floriculture extension specialist, and W. Roland Leatherwood is postdoctoral associate, Cornell University, Department of Horticulture, (607) 255-0621; nsm47@cornell.edu.