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Understanding Plant Nutrition: High pH Problems

In the third article of this 12-part series, Argo and Fisher pore over the details to systematically identify and correct common nutritional problems found in the greenhouse.

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HIGH media-pH (above 6.4) induced iron deficiency is the most common nutritional problem for certain iron-inefficient crops (**Figure 1**), including calibrachoa, diascia, nemesia, pansy, petunia, scaevola, snapdragon and vinca. Plants only take up dissolved nutrients through their roots. When the media-pH is too high, micronutrients (especially iron) are less soluble and unavailable for uptake by plant roots. High-pH induced iron deficiency can develop within one to two weeks, resulting in chlorosis of new growth and overall stunting. This problem is not occurring because plants need more "feed" or are "heavy feeders." Instead, it occurs because the iron supplied in fertilizer becomes insoluble due to the high media pH.

Getting Started

We have undertaken considerable research and worked closely with growers to develop strategies to rescue crops that are stressed from high media-pH. If you think there is a problem, the first thing to do is test the pH and electroconductivity (EC) of the growing medium (using a commercial or university lab, or your own recently calibrated meter). Checking the pH and EC will tell you whether the problem is nutritional, and also if it is caused by inadequate fertilizer concentration (EC) or a high media-pH.

Figure 2. The iron deficiency symptoms on this calibrachoa are the result of root damage, rather than high pH.

Photograph by Paul Fisher, University of Florida.

Don't forget to check roots. Root damage caused by overwatering, fungus gnats or root pathogens such as Pythium can give symptoms similar in appearance to high media-pH induced iron deficiency because the plant does not have healthy roots to take up nutrients from the growing medium (**Figure 2**). In that case, careful irrigation and a fungicide are required in order to grow a healthy root system.

When you've established that the media-pH is too high (above 6.4 for sensitive crops), consider the following steps.

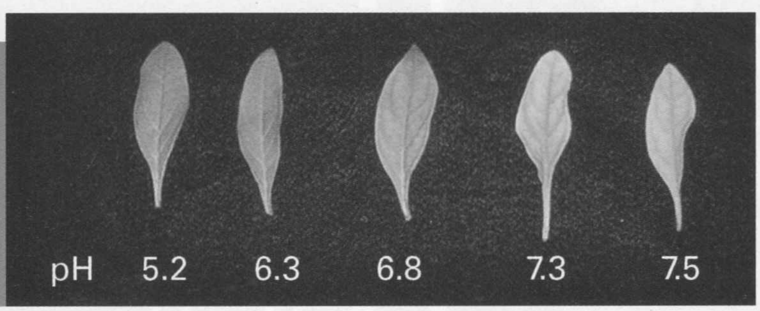

Figure 1. Effect of media-pH on growth of petunia plants, showing progression of iron deficiency symptoms at high pH.

Photograph by Linda Bilodeau, University of New Hampshire.

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The first three steps can be combined in one application (high ammonium fertilizer with iron supplement, and water acidification if alkalinity is high) to help turn a crop around quickly. All of these steps can result in phytotoxicity, so trial on a small group of plants before applying to the entire crop.

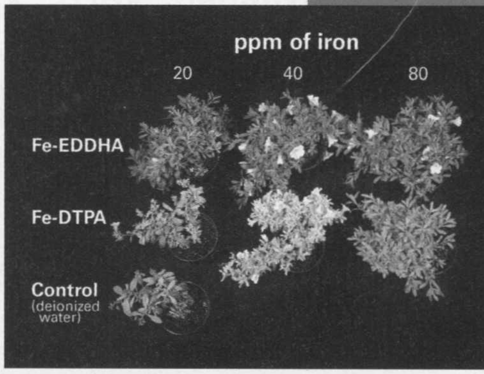


Figure 3. Effect of a single drench of either Iron-EDDHA or Iron-DTPA at 20, 40 or 80 ppm iron and 100 mL (3.4 ounces) per 4-inch-diameter pot, compared with control plants (which were drenched with deionized water). Drenches were applied 14 days after transplanting 'Million Bells Trailing White' rooted cuttings, grown in a peat/perlite medium at media-pH 7.0. The photograph was taken 22 days after the drench.

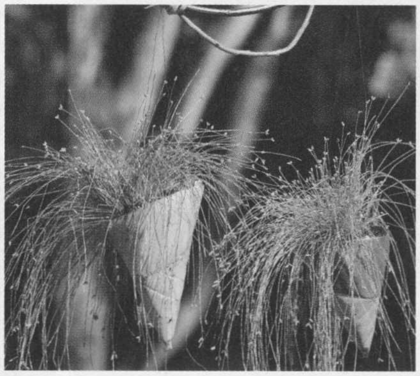
Photograph by Ron Wik, University of New Hampshire.

1. Use a high-ammonium fertilizer. Check with your fertilizer supplier to select a high-ammonium, acid-reaction fertilizer (such as 21-7-7). The effect on media-pH can sometimes be slow (less than one to two weeks), especially in cool, wet conditions, or with small plants growing in large containers. Repeated applications of ammonium in cool, dark conditions may also cause toxic levels of ammonium to accumulate in leaf tissue. You may also see increased shoot growth with the high ammonium fertilizer, requiring additional growth regulator applications.

Concentration of this corrective fertilizer is important. We suggest 200 to 250 ppm for plugs and liners, and 300 to 400 ppm for finished plants as one- or two-time applications. Make sure media-EC is not already high, or you can run into salt damage of roots at those fertilizer rates.

2. Correct micronutrient deficiencies. Masking the symptoms of high pH with supplemental iron applications can be very effective for keeping plants alive and healthy when grown under high media-pH conditions. Unless your customers continue the iron sprays or drenches, or transplant the plants soon after receiving them, quality will suffer. When plants show chlorosis, send in a tissue analysis to test which nutrient is deficient. Although iron deficiency is most common, if a different nutrient (e.g. manganese) is limiting, then application of iron may worsen the problem because of antagonistic effects. While waiting for the lab test results, you could try an iron drench on a small group of test plants to check the response.

The recommended application rate for an iron drench is 5 ounces per 100 gallons of either Iron-EDDHA (several brands including Sprint 138 are available from many nursery suppliers), which provides 22.5 ppm iron,

or Iron-DTPA (for example, Sprint 330), which provides 37.5 ppm iron). The letters EDDHA or DTPA are important because the iron form affects solubility at high pH (**Figure 3**). Iron forms decrease in solubility above pH 7 in the order from EDDHA (best) > DTPA > EDTA > sulfate (worst).

The solutions should be applied with generous leaching, followed immediately by washing of foliage to avoid leaf spotting. If there is no greening up of foliage after one week, these materials can be reapplied. All options are low cost, at less than 0.1 cents per 4-inch-diameter pot. We have found soil drenches are more effective than foliar sprays when iron deficiency is severe.

Do not apply iron chelate or iron sulfate drenches to iron-efficient plants, for example zonal and seed geranium, marigold or New Guinea impatiens. In addition, it is not recommended to drench iron into mixed containers that contain both iron-inefficient plants (i.e. petunias) and iron-efficient plants (i.e. geraniums) in the same basket.

3. Acidify your water to neutralize alkalinity. Alkalinity can be thought of as the "lime content" of the irrigation water and is different than the water pH. The alkalinity concentration can be determined by sending in a water sample to a laboratory. Low-cost alkalinity test kits are also available from laboratory suppliers such as Cole Palmer, Hach and Hanna.

If alkalinity in the irrigation water is above 80 ppm calcium carbonate ($CaCO_3$) equivalents and media-pH is high, consider injecting acid in the irrigation water to bring water-pH down

Photograph by Linda Bilodeau, University of New Hampshire

Petunia pH

- **Disorder:** Iron deficiency at high pH
- **Symptoms:** Pale or interveinal chlorosis on new leaves
- **Likely suspects:** Calibrachoa, diascia, nemesia, pansy, petunia, scaevola, snapdragon and vinca (iron-inefficient plants)
- **Less likely to show the disorder:** Geranium, marigold, New Guinea impatiens (iron-efficient plants)
- **Confirm with:** pH and EC test, tissue analysis, response to iron drench
- **Causes:** High media-pH (above 6.4) from either high water alkalinity combined with a nitrate (basic reaction) fertilizer, or excess lime in the growing medium. Low iron may have been supplied because of inadequate fertilizer.
- **Solutions:** Apply a high-ammonium (acid reaction) fertilizer, reduce water alkalinity with acid injection, supplement with iron-EDDHA chelate, and consider an iron sulfate drench in extreme cases.

Figure 4. Toxicity symptoms from a drench of iron-EDDHA – always test on a small group of plants first, and do not apply iron drenches to iron-efficient plants such as New Guinea impatiens.

Photograph by Ron Wik, University of New Hampshire.

to 4.5 to 5.0. You can calculate the appropriate acid rate for your water source from the North Carolina State University website: **www.ces.ncsu.edu/depts/hort/floriculture/software/alk.html**. For example, 2.8 fluid ounces of 35 percent sulfuric acid will neutralize 100 ppm $CaCO_3$ of alkalinity in 100 gallons of irrigation water. Ensure that you follow safe handling practices when working with acid, and that your injector equipment can handle corrosive chemicals.

4. Consider an iron sulfate drench if pH is not coming down below 6. If uptake of ammonium is not lowering media-pH quickly enough (a realistic target is 0.5 pH units within a week), a drench of iron sulfate (also called ferrous sulfate or $FeSO_4$) can be applied to lower media-pH within a day or two. Iron sulfate can be purchased from agricultural suppliers.

Iron sulfate is moderately acidic and has the benefit of adding iron (20.8 percent by weight). The material is highly soluble at water pH below 6.0, and it can be applied as a drench at 2 pounds/100 gallons (2.4 g/L). If iron sulfate is not washed off foliage immediately following a drench application, phytotoxicity is very likely. One week after the drench, leach the pot generously with clear water, followed by irrigation with a complete fertilizer solution to restore the nutrient balance. **GG**

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