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Diagnosing Signs of High and Low pH

While signs of high pH induced iron deficiency commonly occur, do you know what to look for when the substrate pH is too low?

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The Greenhouse production in the Southeastern U.S. offers a unique situation of experiencing both high and low pH induced plant disorders.

The coastal portion of North Carolina has high levels of alkalinity which can lead to iron deficiency induced by elevate substrate pHs. Production there necessitates acid injection similar to the Midwest and Great Plains.

When moving away from the coast, one enters new territory with drastically different management requirements. This area has pure irrigation water with low alkalinity levels and low content of mineral salts (low electrical conductivity). The water quality is excellent and many Midwestern greenhouses would love to have it! Low alkalinity water requires a change in management strategy. There is no buffering in the water because of the lack of

Figure 1. Initial signs of interveinal chlorosis of the upper leaves. This indicates that iron is limited, most likely due to elevated substrate pH levels above 6.5.

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alkalinity so fertilizer type can impact the substrate pH and cause it to quickly drift upward with basic types of fertilizer or downward with acidic fertilizer types.

Thus, symptoms of elevated substrate pH and excessively low substrate pH are frequently encountered. Recently an ornamental pepper sample was submitted to the clinic with low pH symptoms. The purpose of this e-GRO Alert is to familiarize you with the visual symptom when the substrate pH has gone adrift.

In greenhouse production we often rely upon reading the leaves for symptoms when diagnosing nutritional problems. We typically classify plants into one of three pH groups. The **Petunia Group** can experience high pH induced iron deficiency resulting in interveinal chlorosis (Fig. 1). It might actually be better to label these plants as being inefficient at iron uptake under elevated pH conditions. Besides petunias, calibrachoa, gerbera, hydrangea, pansy, snapdragon, and vinca all will quickly develop iron deficiency symptoms if the pH is elevated. Typically symptomology will begin when the pH increases above the 6.3 to 6.8 range.

To manage this situation, the substrate pH should be monitored to ensure that it is within the acceptable range. The corrective procedures below assume you are first working to manage excessive alkalinity with acid injection. If the substrate pH is just beginning to drift too high, switching to an acidic fertilizer may help (Table 1). If corrective procedures are required, applying a 10% excessive leaching irrigation of chelated iron (Table 1).

On the opposite end of the spectrum is the **Geranium Group** that experience lower leaf symptoms if the pH is too low. These plants can also be considered to be extra efficient at iron uptake. When the pH drops too low, the availability of micro-nutrients, especially iron and manganese, increase. If a plant is efficient at taking up these elements in excess, then the leaves develop

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symptoms that can vary from a bronzing with marigolds (Fig. 2) or geraniums to a blackish-purple spotting with cosmos, dahlia, fuchsia, gerbera (Fig. 3), pepper or tomatoes.

Prevention is the best course here. Monitoring the substrate pH will aid you in determining if the pH is drifting too low. Corrective procedures for low pH are listed in Table 2.

Switching to a basic fertilizer when the substrate pH is nearing the lower limit will help stabilize the pH. If the pH is below the recommended range, then corrective procedures will need to be implemented. Flowable lime is one option. Typically a rate of 2 quarts per 100 gallons of water will increase the substrate pH by roughly 0.5 pH units. Two quarts can be used through the injector. Additional applications can be made if needed. Potassium bicarbonate can also be applied. The rate of 2 pounds per 100 gallons of water will increase the substrate pH by roughly 0.8 pH units. This treatment will also provide exces-

Figure 2. Bronzing of the lower foliage caused by low substrate pH.

Table 1. Corrective procedures to lower the substrate pH.	
Option	**Rate / Notes**
Use an Acidic Fertilizer	-20-10-20, etc -Extremely acidic: 21-7-7 (avoid using this with cold growing because it can lead to NH_4-N toxicity) •Apply as a irrigation. •Best to use just when the substrate pH begins to increase near the upper pH limit.
Acid Water Drench	-Use sulfuric acid to acidify your irrigation water to pH 4.0 to 4.5. •Apply as a substrate drench •Rinse foliage ASAP
Iron Drench	-Iron-EDDHA: mix 5 oz in 100 gallons of water -or- -Iron-DTPA: mix 5 oz in 100 gallons of water -or- -Iron sulfate: mix 4-8 oz in 100 gallons of water •Apply as a substrate drench with sufficient volume to leach the pot. •Rinse foliage ASAP •Use with caution on iron efficient plants (geraniums)

sive potassium and cause a spike in the substrate electrical conductivity (EC). So the following day a leaching irrigation with clear water is required to restore the nutrient balance (the ratio of K:Ca:Mg) and lower the EC level. As always, remember to recheck your substrate pH to determine if reapplications are needed.

The final classification is the **General Group** which rarely exhibits pH induced symptoms and includes chrysanthemums and poinsettias. This leads to a story from a few years ago. A grower called who was trying to troubleshoot their garden mum crop. This was in June, and instead of the normal vigorous growth, the plants had stalled and were only about half their typical size for that time of year. No other leaf symptoms were present. The EC levels were within the acceptable range, but the pH was low at 4.5. We discussed options and a recommendation was made on how to increase the pH to the 5.8 to 6.2 range. Two weeks later he called back and expressed his amazement and reported how the plants had doubled in size by just getting the pH back to the acceptable range.

Table 2. Corrective procedures to increase the substrate pH.	
Option	**Rate / Notes**
Flowable Lime	-Use 1 to 2 quarts per 100 gallons of water. •Apply as a substrate drench with sufficient volume to leach the pot. •Rinse foliage. •Avoid damage to your injector by using rates of 2 quarts per 100 gallons of water, or less •Can split applications
Hydrated Lime	-Mix 1 pound in 3 to 5 gallons of WARM water. Mix twice. Let settle. Decant liquid and apply thru injector at 1:15. •Caustic (rinse foliage ASAP and avoid skin contact) •Apply as a substrate drench with sufficient volume to leach the pot. •Rinse foliage ASAP
Potassium Bicarbonate ($KHCO_3$)	-Use 2 pounds per 100 gallons of water •Apply as a substrate drench with sufficient volume to leach the pot. •Rinse foliage ASAP •Provides 933 ppm K •Leach heavily the following day with a complete fertilizer to reduce EC levels and restore nutrient balance. •Rates greater than 2 pounds per 100 gallons of water can cause phytotoxicity!

As a person who is called upon to troubleshoot production problems, this situation has always been intriguing. From the experience with the garden mum crop, we wanted to know if plants classified in the General Group were actually unaffected by low pH problems. To test this, we at North Carolina State University grew a petunia and poinsettia crop with three levels of lime, to provide a low, marginally low, and normal substrate pH conditions. In these two experiments, no lower leaf symptoms appeared. What did occur with the

low pH conditions was less growth (Fig. 4). With petunias, plant growth was 29% less when plants were grown at pH 4.8 instead of pH 5.1. At an extremely low pH of 3.3, plants were even more stunted.

The same thing occurred with poinsettias (Fig. 5). Growth was less and bract coloration was delayed at pH 2.8 when compared to either pH 4.7 or 6.0. For Viking Red poinsettias, they appear to be more adaptable to a lower pH of 4.7 than what we typically recommend between pH 5.8 and 6.3.

The take home message here is plants in the General Group are more adaptable to low pH conditions, but are not as immune as we thought. They may not develop leaf symptoms that alert you that there is a problem. Slowed or stunted growth is sometimes difficult to notice if it involves the entire crop. Because reading the leaves is not possible, growers will need to monitor their crop's pH to determine if the crop is within the acceptable range. This will ensure a normal rate of growth.

In summary, symptoms of sub-optimal pH will occur if the pH is too high or too low. A pH monitoring program will help ensure your crop's pH is on track. Hopefully this article will help improve your diagnostic skills if your pH drifts outside the optimal range.

Figure 3. Blackish-purple spotting on the lower leaves due to low substrate pH.

Figure 4. Stunted growth of petunias at low pH.

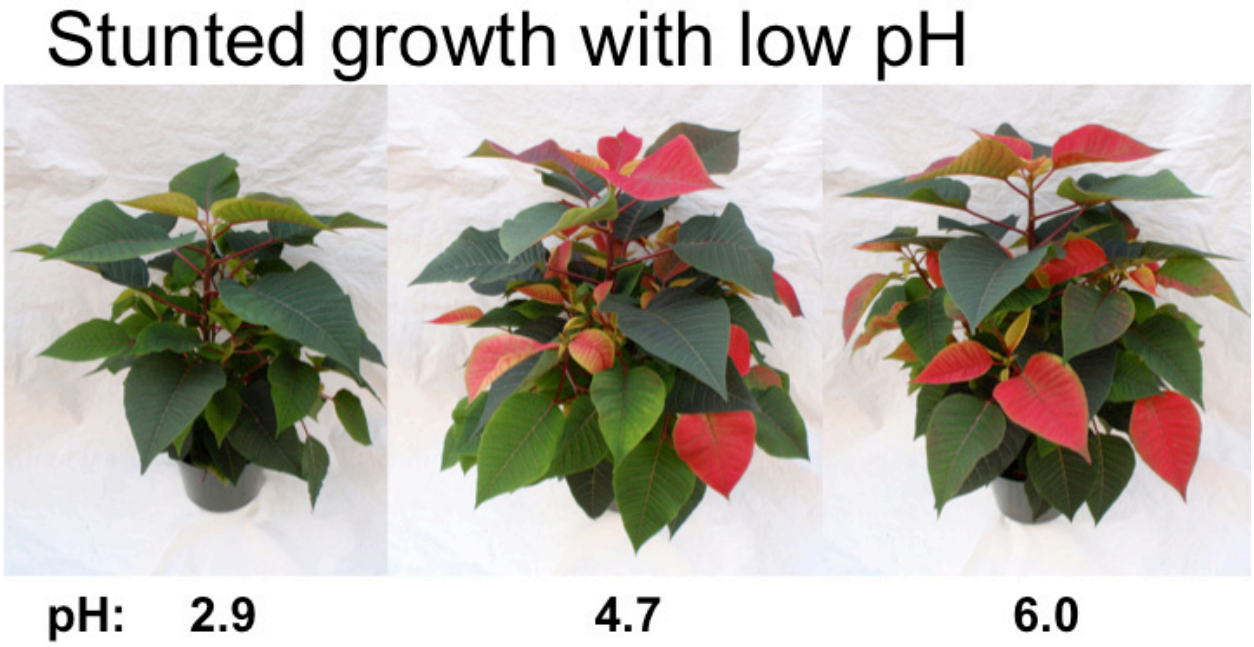

Figure 5. Viking Red poinsettias stunted at pH 2.9.