e-GRO Alert
Volume 5, Number 3 January 2016


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Scaevola:
What Actually Causes Interveinal Chlorosis?

With scaevola, interveinal chlorosis of the younger leaves is a common problem. The most obvious cause is an iron deficiency as a result of elevated substrate pH. If the substrate pH is between 5.8 and 6.2, then the culprit may instead be your fertilizer formulation.

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Interveinal chlorosis (Fig. 1) and bleaching (Fig. 3) that develops on the younger leaves may be easy to identify, but the cause may not always be so apparent. When these symptoms are observed in a crop, it is easy to jump to one of two typical conclusions.

These symptoms are often caused when the iron (Fe) supply is sufficient in the root substrate (root medium, growing medium), but is unavailable for plant uptake due to elevated pH levels in the substrate. Lower substrate pH results in a greater availability of iron for plant uptake. The optimal substrate pH for iron availability is highly dependent on the specific crop being produced. Optimal pH values for scaevola are between 5.8 to 6.2 (Fig. 2).

In the case of high irrigation water pH, acidification may be all that is required to optimize conditions for iron uptake and allow the crop to obtain the iron it needs. On the other hand, iron deficiency symptoms may simply be caused by insufficient levels of iron in the root substrate. This issue may be easily remedied with additional applications of iron chelate in the form of a drench. So, what is occurring when iron levels are sufficient and the substrate pH is within the optimal

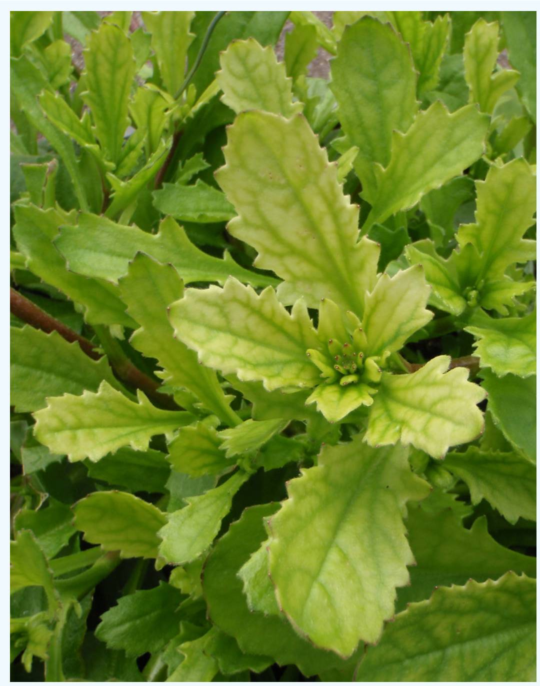

Figure 1. Interveinal chlorosis affecting scaevola.
Photo by Brian Whipker

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range? The answer may be an induced iron deficiency due to excessive levels of phosphorus (P).

Most greenhouse crops have a fairly wide range of luxury phosphorus consumption that will occur before excess or toxic levels become an issue. Interveinal chlorosis of the upper leaves induced by excessive phosphorus is especially prevalent on phosphorus sensitive crops, such as the Australian native *Scaevola aemula*. Plants that are sensitive to excess phosphorus will begin to develop symptoms of iron deficiency more readily due to the antagonistic relationship between iron and phosphorus. To put it simply, when phosphorus levels are high, it may

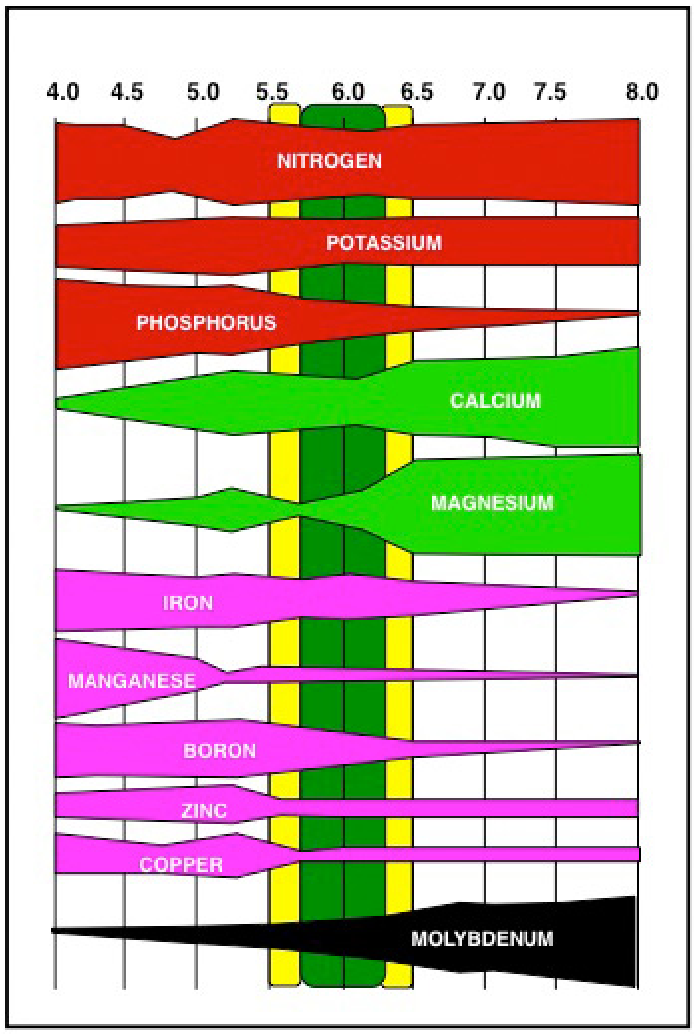

Figure 2. The optimal substrate pH range for scaevola is between 5.8 and 6.2. The dark green zone represents the pH range of 5.8 to 6.2. If the subsrate pH drifts lower or higher into the yellow zone, then corrective procedures should begin to prevent a problem from occurring.
Photo by Brian Whipker

inhibit a plants ability to acquire sufficient levels of iron, as well as zinc and copper, regardless of substrate pH or the actual supply of these nutrients in the substrate.

A series of studies conducted at the University of Maine took a closer look at this phosphorus antagonism issue and its effects on scaevola growth and nutrient uptake (Burnett et al., 2008; Zhang et al., 2004). In the initial study, Zhang et al. (2004) determined that when phosphorus was supplied at rates of 43.5 ppm or higher, poor shoot growth and development occurred. These higher levels of phosphorus supplied from an acidic-type fertilizer also caused the pH of the substrate to drop into the pH 4.3 to 5.0 range, leading to some uncertainty as to the actual cause of these symptoms.

Burnett's et al. (2008) conducted a follow up study to better determine the effects of phosphorus rates ranging from 0 to 80 ppm. It was found in this study that excessively high (80 ppm P) or low levels (0 ppm P) of P resulted in shorter branches and the formation of fewer flowers (Burnett et al., 2008). They determined that phosphorus rates greater than 20 ppm would lessen plant quality. Additionally, phosphorus rates of 20 ppm or more would result in toxic levels of phosphorus accumulating in the plant tissue. Phosphorus rates >60 ppm induced chlorosis, which became especially apparent at 80 ppm P. In this study, high rates of phosphorus were actually found to have a greater negative impact on the tissue levels of zinc and some other micronutrients and there was no significant impact on iron concentration.

[Note: many times when iron chlorosis symptoms are present in leaf tissue, a sufficient iron concentration can still be present in the leaf, but it is unavailable for incorporation into the chlorophyll molecule. Therefore what we observe on a plant is interveinal chlorosis. When the tissue is analyzed, the iron level many times may still be adequate and not be down into the deficient zone. This may be why the work by Burnett et al. (2008) did not find iron levels to

be lower.]

This study, along with other recent findings suggests that even 20 ppm is far more phosphorus than what is necessary, especially for a phosphorus sensitive species. Phosphorus rates for optimal iron uptake are within this 0 to 20 ppm range, and may very well be closer to only 5 to 10 ppm. Although the level of iron in the plant tissue was not significantly different among the various phosphorus rates, the chlorosis may be explained by a tie up within the plant cell. The plant may have sufficient levels of iron but the excess phosphorus can tie up the iron and prevent the plant from being able to use it where it is needed.

Excessive phosphorus levels are documented to limit the acquisition and translocation of iron as well as zinc and copper. It is possible that the symptoms of interveinal chlorosis of the upper leaves were indeed caused by deficient levels of iron within the plant tissue, but induced by toxic levels of phosphorus. The antagonistic relationship between these two elements indicate that even relatively low phosphorus rates (~20 ppm), may lead to a phosphorus induced antagonism that consequently leads to iron deficiency symptoms.

Recent studies conducted at North Carolina State University (Henry and Whipker, 2015) indicate that the optimal rates of phosphorus for most greenhouse crops may be as low as 5 to 10 ppm. When iron deficiency is becoming an issue, it is of course essential to first verify if the substrate pH is too high, and if sufficient iron is being supplied to the crop. In addition, it is important to consider the crop's phosphorus fertilization regiment and whether the crop is being supplied with

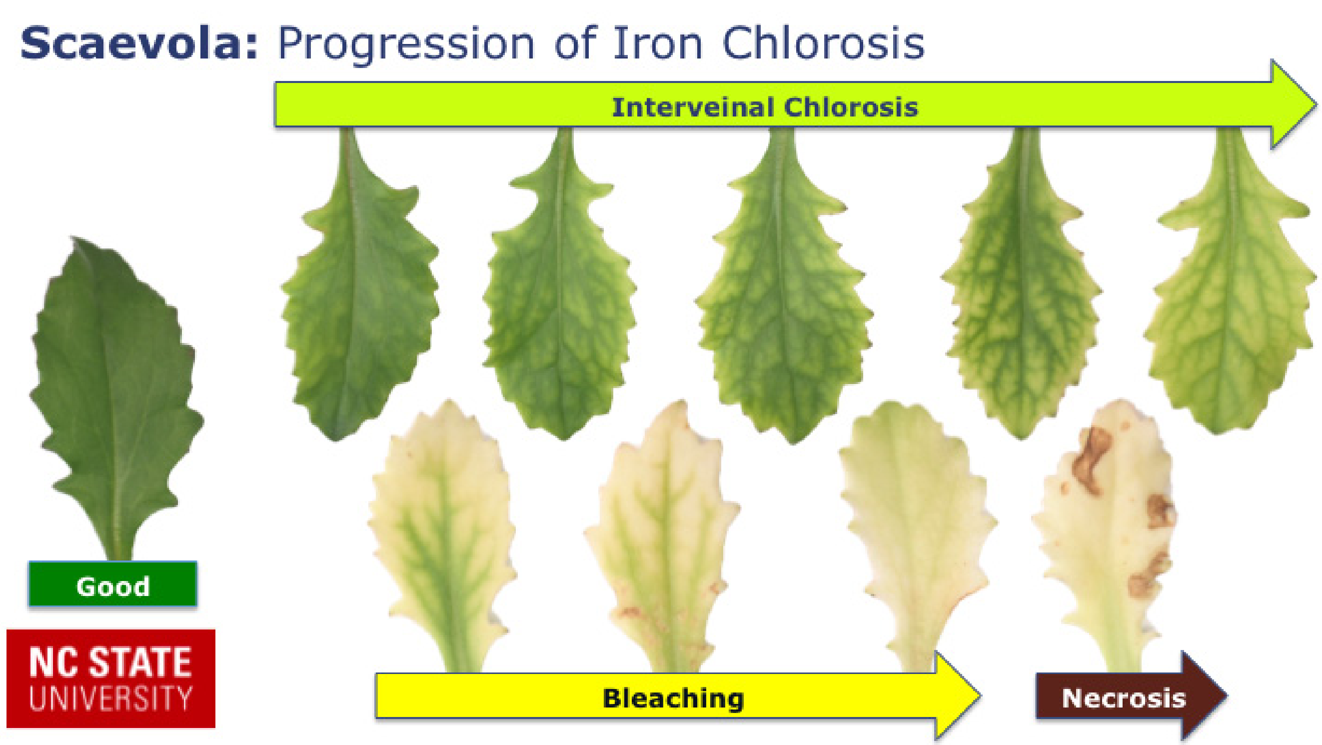

Figure 3. The progression of iron chlorosis symptoms of scaevola.
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too much phosphorus (>20 ppm P). If the phosphorus rates are greater than 5 to 10 ppm, it may be beneficial to begin using a fertilizer that is low in phosphorus, such as 13-2-13 Cal Mag. When you are diagnosing symptoms of iron deficiency, remember to consider the often forgotten culprit – excessive phosphorus levels being antagonistic for iron uptake.

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Iron Drench Rates
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 to 8 oz in 100 gallons of water
Notes: Apply as a substrate drench with sufficient volume to leach the pot. Rinse the foliage right after the application to avoid leaf phytotoxicity. Use with caution on iron efficient plants (ie: geraniums).