e-GRO Alert




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Iron Chlorosis:
Exploring the Possibilities

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There are many potential causes of iron chlorosis. This Alert will assist you in rooting out the reason why it is occurring.

In greenhouse production, upper leaf interveinal chlorosis (yellowing; Fig. 1) occurs quite often. While these symptoms may be unsightly, they are easily remedied. Initial symptoms appear as a light green to yellow coloration of the new upper leaves (Fig. 2a), progress to a more pronounced interveinal chlorosis (Fig. 2b), and finally, in severe cases, total yellowing and bleaching (whitening) of the foliage with stark green veins (Fig. 2c).

One readily observes the signs of interveinal chlorosis, but the underlying cause of the disorder requires additional investigation to diagnosis and correct the problem. There are a number of abiotic and biotic factors that can result in interveinal chlorosis of the upper foliage. Table 1 lists the most common causal factors and provides a checklist to confirm your diagnosis along with corrective actions to remedy the symptoms.

Figure 1. Interveinal chlorosis (yellowing) occurs when iron (Fe) uptake is inadequate for the plant's needs. There are a multitude of reasons why this can occur, and determining the reason is key to managing the situation. Photo by: Brian Whipker.

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To best utilize this table, first identify which ***Possible Cause*** is resulting in the interveinal chlorosis. To do this, simply read through the ***Confirmation Steps*** and use the process of elimination. Once the cause has been identified, the ***Corrective Procedures*** should be taken. By using this table as a diagnostic guide, symptoms of interveinal chlorosis can be quickly remedied, and plant vigor and growth re-established.

Summary

Interveinal chlorosis of the upper foliage is detrimental to overall plant growth and impacts the photosynthate production of the plant resulting in stunted and sub-optimal plants. There are numerous possible causes as to why the plant(s) could be exhibiting these symptoms. In order to correct the problem, first, proper diagnosis is needed.

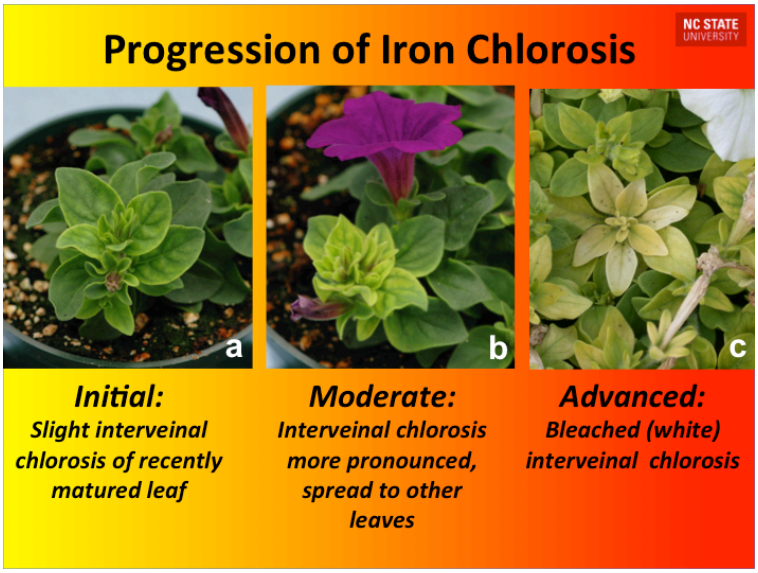

Figure 2. The progression of insufficient levels of iron (Fe)-induced interveinal chlorosis (yellowing) on petunia plants. Photo by: Brian Whipker.

Figure 3. Elevated substrate pH >6.5 will result in iron (Fe) being less available to plants. Photo by: Brian Whipker.

Figure 4. Inadequate iron (Fe) levels being supplied to plants can result in Fe deficiency. A tissue test will help diagnose this situation. Photo by: Brian Whipker.

Figure 5. Excessive phosphorus (P) applications result in a tie up of iron (Fe) in plants. Iron chlorosis develops readily in Fe sensitive species such as scaevola. Photo by: Brian Whipker.

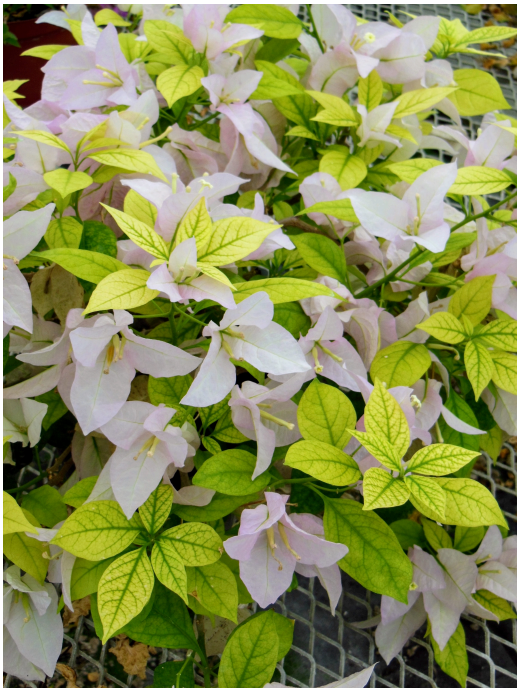

Figure 6. Cold growing temperatures slow down a plant's ability to uptake iron (Fe) and deficiency symptoms can develop. Tropical species such as bougainvillea typically develop Fe chlorosis (yellowing) during the winter when growing temperatures are cool. Photo by: Garrett Owen.

Figure 7. Excessive irrigation can inhibit iron (Fe) uptake by the plant and result in the development of interveinal chlorosis (yellowing) on the younger leaves. These veronica plants were excessively misted during propagation. Photo by: Brian Whipker.

Table 1. Possible abiotic and biotic causes, confirmation steps, and corrective procedures of interveinal chlorosis.

Possible Cause	Confirmation Step(s)	Corrective Procedure(s)
Elevated Substrate pH: (See Figure 3) *Substrate pH >6.5 results in tie up of iron so that plants cannot utilize it.*	Conduct a substrate test to confirm the pH. (See fertdirtandsquirt.com for more details.) Typically, signs of interveinal chlorosis appear at around pH 6.5, but can vary with plant species.	A number of options exist for managing excessively high substrate pH levels: *a) Acid-based Fertilizer* If the substrate pH is just beginning to increase, then first consider switching to an acidic-based fertilizer. These ammoniacal-nitrogen (N) based fertilizers are naturally acidic and plant nitrogen uptake will help moderate the substrate pH over a week or two. *b) Acid Water Drench* Some growers use this intermediate correction if pH levels are not excessively high and a quick reduction of the substrate pH is desired. Use sulfuric acid to acidify your irrigation water to a pH 4.0 to 4.5. Apply this acid water as a substrate drench providing 5 to 10% excess leaching of the substrate. Rinse the foliage to avoid phytotoxicity. Results should be visible within 5 days. Retest the substrate pH and repeat if needed. *c) Iron Drench* If the pH is excessively high, an iron chelate application can be applied to the substrate. Below are the options. Iron Drench (options) 1) Iron-EDDHA: mix 5 ounces in 100 gallons of water 2) Iron-DTPA: mix 5 ounces in 100 gallons of water 3) Iron sulfate: mix 4-8 ounces in 100 gallons of water Apply as a substrate drench with sufficient volume to leach the pot. Rinse foliage immediately. Avoid use on iron efficient plants (geraniums).

Table 1. Possible abiotic and biotic causes, confirmation steps, and corrective procedures of interveinal chlorosis, *continued*.

Possible Cause	Confirmation Step(s)	Corrective Procedure(s)
Inadequate Iron (Fe) Supplied: (See Figure 4) *The quantity of iron supplied to the plant is inadequate.*	To aid in confirming this diagnosis requires eliminating other possibilities first. First determine if the pH is not too high (>6.5), inspect the root system, and confirming that the other possibilities listed in this table are not the cause. If none of the other possibilities seem feasible, determine if adequate Fe is being provided to the plants by submitting fertilizer, substrate, and tissue samples to a commercial lab.	Historically the micronutrient blend added to a complete water-soluble fertilizer was based on a fertilization rate of 200 to 300 ppm N. With the current practice of applying lower levels of fertilization of 100 to 150 ppm N, this can lead to inadequate levels of iron and micronutrients being applied. Possible steps: a) Consider utilizing a fertilizer with added iron to provide adequate levels. b) Consider providing additional micronutrients in your fertilizer program based on your lab test results.
Nutritional Antagonisms [Excessive Phosphorus (P)]: (See Figure 5) *Excessive P levels can tie up Fe and make it unavailable to the plant.*	Excessive levels of some nutrients, most notably P, can have an antagonistic effect on micronutrient uptake, especially of iron. Problems may start to appear at >15 ppm P (elemental P; not P_2O_5) for phosphorus-sensitive Australian species or >30 ppm for other plants. Submit fertilizer, substrate and tissue samples to a commercial lab to help determine.	Apply lower levels of P at <15 ppm for phosphorus-sensitive Australian species or <30 ppm for other plants. Supply supplemental Fe: a) From a higher Fe containing fertilizer b) Supplemental Fe applications if the lab tests confirm the need.
Low Growing Temperatures: (See Figure 6) *Roots are less efficient at Fe uptake under low substrate temperatures.*	Cool or cold growing conditions [<55°F (13°C)] reduce metabolic activities of plant roots. Determine the root-zone temperature to help diagnose the situation.	Multiple options can help improve Fe uptake by the plant: a) Increase the growing temperatures. b) Grow plants on benches to improve air movement. c) Manage the irrigation so that the substrate does not remain wet for prolonged periods of time.

Table 1. Possible abiotic and biotic causes, confirmation steps, and corrective procedures of interveinal chlorosis, *continued*.

Possible Cause	Confirmation Step(s)	Corrective Procedure(s)
Over Irrigation: (See Figure 7) *Roots are less efficient at Fe uptake when the substrate is irrigated too often.*	Evaluate the wetness and dry down periods of the plants to determine if the substrate is staying saturated for extended periods of time.	Multiple options are possible to help improve Fe uptake by the plant: a) Manage the irrigation so that the substrate does not remain wet for prolonged periods of time. b) Increase the growing temperatures to increase water use by the plant.
Waterlogged Substrate: (See Figure 8) *Roots are less efficient at Fe uptake when the substrate is kept continually wet or saturated.*	Waterlogging typically occurs on scattered plants in pockets when the irrigation volume is not consistent from pot to pot, there is a low spot on the growing surface, or a water leak.	Correct or manage underlying reason that results in excessive water pooling at one point.
Root Rot: (See Figure 9) *Without a healthy root system, plants cannot take up Fe from the substrate.*	Inspect the root system for discoloration. For biotic disorders such as root rot, typically scattered plants are affected and not the entire crop (which is a stronger indication that the problem is abiotic). Submit a sample to a diagnostic clinic to confirm.	Discard affected plants if problem is isolated. Apply suitable fungicide application based on lab confirmation.
Insect Feeding: (See Figure 10) *Fungus gnat larvae feeding can result in compromised root and stem tissues, which limits the plant's ability to translocate Fe from the roots to the leaves.*	Inspect the stem and roots for the presence of insects. Fungus gnat larvae have 0.25 cm long clear bodies with a distinctive black head.	Typically stem girdling caused by fungus gnat larva feeding cannot be reversed. Discard affected plants if problem is isolated. Apply suitable insecticide application based on lab confirmation.
Chemical Phytotoxicity: (See Figure 11) *Some applications can result in leaf symptomology.*	Determine substrate pH, growing temperatures, and irrigation frequency or duration for the likelihood of overirrigating and waterlogging the substrate. Inspect the stem and roots for the presence of insects or diseases to discount those options. Review pesticide application records.	Plants may recover given enough time. Discard affected plants if problem is severe.

Figure 8. Low spots or drips from the roof can cause waterlogged conditions for a plant, which inhibits iron (Fe) uptake. Photo by: Brian Whipker.

Figure 9. Biotic factors such as root rots diminish the plant's ability to uptake iron (Fe). Therefore, it is always a good idea to inspect the root system when diagnosing problems. Scattered plants are typically affected and this pattern will aid in diagnosing the situation. Photo by: Brian Whipker.

Figure 10. Feeding by fungus gnat larvae can result in girdling of the stem. Inspect the plants for signs of insects. Photo by: Brian Whipker.

Figure 11. Phytotoxicity from a chemical application can also lead to interveinal symptoms. Photo by: Garrett Owen.

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