# Still Keeping Shamrocks Green

Is yellowing a micronutrient problem? Researchers at Cornell University update their 2009 article and examine the various causes of leaf chlorosis in oxalis.

*Figure 1. The effect of iron (Fe) chelate drenches 5 days after application on iron deficient* O. regnellii. *Representative plants selected for Fe-chelate applications are shown in the top row. Oxalis plants five days after drenching are shown in the bottom row.*

**By Chad T. Miller and William B. Miller**

In the December 2009 issue of *GPN*, we published an article discussing the perplexing chlorosis problem in *Oxalis regnellii*, better known as the shamrock plant. The common suggested reasons for the chlorosis have been micronutrient deficiencies (iron and/or manganese) and virus. In the previous article, we reported evidence about a virus found in oxalis and that growers need to be aware of this, as the virus produces chlorosis symptoms that could easily be confused as a nutrient (iron) deficiency (Figure 2). Careful observation and rouging of virused plants can help eliminate the problem, from a rhizome producer perspective.

However, assuming the purchase of virus-free oxalis rhizomes, we were curious about the role of iron and manganese in this crop. Because iron deficiency and manganese deficiency show similar symptoms, namely interveinal chlorosis on newly-developed leaves, we conducted experiments to get to the bottom of that nagging question many growers have: Is the chlorosis a micronutrient problem?

*Figure 2. Shamrock plant with chlorotic ringspots due to a virus, possibly shamrock chlorotic ringspot virus.*

## Examining Nutrient Deficiencies

We set up a hydroponic system to control different nutrient inputs. We eliminated iron from one set of hydroponic plants and manganese from another set, while growing a third group with a full nutrient solution. As we expected, the iron-deficient group showed characteristic interveinal chlorosis (Figure 4) symptoms on newly developed tissues, within two weeks of removing iron from nutrient solutions. By the end of the seven weeks, some of the newest leaves were considerably smaller and severely chlorotic, with signs of bleaching. Conversely, plants growing in the manganese-free solutions were slightly less green than control plants but showed no visible signs of (interveinal) chlorosis, even though leaf tissue tests revealed significantly less manganese concentrations than control or plants grown without iron. It seems that 27-ppm manganese is sufficient for growing oxalis.

We then decided to look at iron deficiency in a more practical sense, not in a hydroponic solution. We designed an experiment to alter pH levels using different dolomitic lime rates (0, 2.5, 5 and 25 pounds per cubic yard) in a peat:perlite media. The objective was to create a high enough pH to induce iron deficiency, because as pH increases, iron and other micronutrients become available. Rhizomes were planted in 4-inch pots and fertigated with 21-5-20. We were able to achieve four different pH levels (Table 1) and over time, pH decreased due to the acidic nature of the fertilizer we used. We successfully induced iron deficiency at the high lime rate, where we observed the greatest incidence of interveinal chlorosis (Figure 3). Tissue analysis confirmed lower levels of iron in the high pH treatments (Table 2), while manganese levels were sufficient and did not vary between the lime treatments.

Moreover, pH had a significant effect on the growth and development, as plants were less vigorous, had smaller leaves and were much less green due to high pH induced iron deficiency.

So, what does all this mean? We successfully characterized iron deficiency in *Oxalis regnellii*. No surprise, the symptoms are just like any other iron-deficient crop — a distinct gradual yellowing followed by interveinal chlorosis in the center of the plant (youngest leaves). Plants growing in media pH greater than 7.0 were severely chlorotic and had stunted growth. We also observed what could be manganese toxicity in the plants grown at the lowest pH (~4.0). Thus, the current media pH growing recommendations of 6.0-7.0 are acceptable.

## Looking at Chelate Applications

So, one might ask, "What happens if I have anemic shamrocks? How can I make them green again?"

Well, first of all, we would highly recommend growers to carefully monitor their media pH, and know the water quality and the effects it will have on growing different crops. In addition, using the appropriate fertilizer based on that information will help to prevent the situation. But we all know that we cannot control everything all the time, especially in hectic production times. So, if you still run into a problem with yellow oxalis, there are other options. Many crops respond to micronutrient chelate applications as a 'quick fix' to a nutritional disorder. We conducted a couple of studies looking at iron chelate applications, both foliar and media drenches. We hand painted (with a small paintbrush) iron chelates (EDTA and EDDHA formulations) and a manganese EDTA chelate formulation, along with a spreader/sticker (CapSil) at three different rates (60-, 120- and 240-ppm iron or manganese) to chlorotic oxalis leaves. We hoped to see at least some effectiveness with the highest chelate concentrations; however we didn't observe any significant re-greening in any of the treatments after nine days. We think this may have been due to the leaves having moderate to severe leaf chlorosis. They were very pale; that perhaps was irreversible. Frankly, the corrective treatments would have been done earlier, before the leaves reached that stage of chlorosis. This is not to say foliar applications should not be considered — more research is needed.

We had better success with media chelate drenches. Chlorotic oxalis plants grown at high pH levels were treated with a 22.5-ppm iron media drench of iron EDDHA. We drenched each 4-inch pot with 4 ounces (~125 ml) of chelate solution, which was enough to produce a leachate. After five days, chlorotic plants were significantly greener (Figure 1). These are preliminary studies and further investigations on foliar applications (earlier chelate application), along with different chelate formulations and concentrations would be beneficial. This information provides growers with a starting point to correct iron chlorosis in oxalis. As with any type of treatment, we would recommend growers to test a small portion of the crop with any specific treatment.

## Additional Considerations

If that wasn't enough information for you on growing this crop, there's still more to consider. And this piece of information might be the most insightful: The shamrock plant is unique, in that, the leaves are nyctanastic. This basically means the trifoliate leaves fold down at night (Figure 5) and open up in the morning. Not only do they open and close with daylight, but they also close with high light intensities. This phenomenon looks very similar to plants that are too dry and thirsty!

So, you might ask, "What does that have to do with chlorosis"? It is actually quite important, from our experience. For example, an oxalis grower

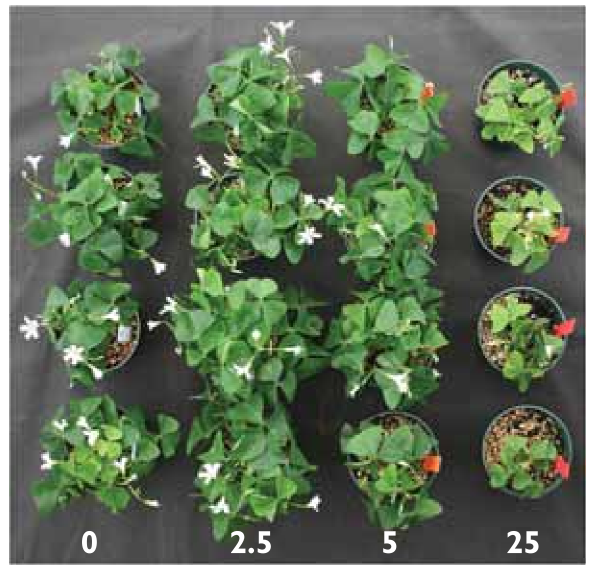



*Figure 3.* Oxalis regnellii *plants grown for seven weeks in a peat:perlite (3:1 v/v) potting media with different rates of dolomitic limestone. Application rates were (left to right) 0, 2, 5 and 25 lbs·yd3.*

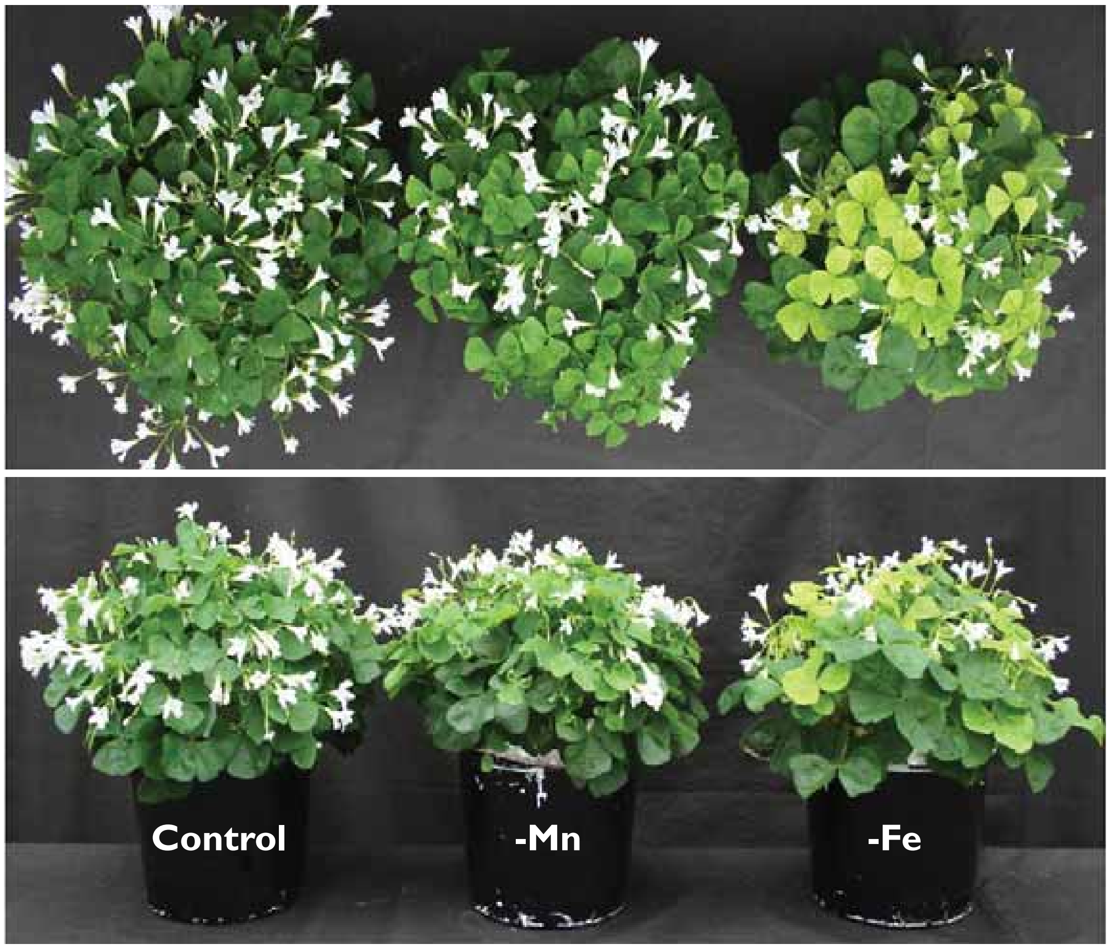
**Table 1:**
**pH values obtained using the pour through method for a peat:perlite (3:1 v/v) potting media with different incorporated rates of dolomitic limestone method.**

| | pH$^{Z}$ (days after planting) | | | |
|---|---|---|---|---|
| Lime Rate (lbs•yd$^{-3}$) | 7 | 14 | 21 | 49 |
| 0 | 4.18 | 4.05 | 3.83 | 4.25 |
| 2.5 | 6.34 | 6.25 | 5.2 | 4.32 |
| 5 | 7.07 | 7.02 | 6.52 | 5.73 |
| 25 | 7.61 | 7.49 | 6.83 | 6.09 |

**Table 2:**
**pH and iron concentrations of Oxalis regnellii grown in a peat:perlite (3:1 v/v) potting media with different incorporated rates of dolomitic limestone. pH was determined using the pour through method.**

| | pH$^{Z}$ (days after planting) | | Fe Concentration |
|---|---|---|---|
| Lime Rate (lbs•yd$^{-3}$) | 7 | 49 | (ppm) |
| 0 | 4.18 | 4.25 | 112 |
| 2.5 | 6.34 | 4.32 | 96 |
| 5 | 7.07 | 5.73 | 85 |
| 25 | 7.61 | 6.09 | 74 |

*Figure 4.* *Hydroponically grown* Oxalis regnellii *plants two weeks after treatment initiation. Treatments (left to right) are Control (complete nutrient solution); -Mn (Mn removed from nutrient solution); -Fe (Fe removed from nutrient solution). Iron-deficient treatments exhibit characteristic interveinal chlorosis in young foliage at the apical regions; whereas no interveinal chlorosis was observed in -Mn treatments. Note: the -Mn and -Fe plants are smaller than the controls.*




walks into the greenhouse early in the morning and the oxalis haven't fully awakened and opened their leaves. Well, the grower may interpret this to mean they need water and proceed to water them, when the media may already be moist. Or perhaps a grower checks on an oxalis crop in the middle of a bright, sunny day (no shade curtain has pulled, along with no shading compound on the glass) in the middle of winter. The leaves may have closed to protect the plant from the high winter light (the plant is a native shade plant, after all), but again, the grower perceives this as a water stress and proceeds to water. Oxalis have a fine root system and appear to be sensitive to over watering. Couple this with a peat-based media, and this can spell disaster, leading to root decline and subsequent induced nutrient deficiencies, which can lead to… leaf chlorosis!

Thus, we would recommend that growers carefully monitor the water status of oxalis, primarily by lifting the pots and assessing soil moisture. It is better with the shamrock plant to err by growing them on the dry side than potentially water logging them and ending up with yellow shamrocks. And nobody wants yellow shamrocks on St. Patty's Day!

## Acknowledgements

We gratefully acknowledge the Fred C. Gloeckner Foundation and Anthos (Dutch Royal Trade Association for Flowerbulb and Nursery Stock), and the Post-Schenkel Memorial Council for financial support of this project.

*Figure 5.* Oxalis regnellii *plant with 'closed' leaves. Also note the lack of roots due to over-watering.*

*Editor's Note: You can find the authors' first article, "Keeping Shamrocks Green," that appeared in the December 2009 issue of* GPN *on our website at http://www.gpnmag.com/Keeping-Shamrocks-Green-article11313.*

***Chad Miller is a Ph.D. student and William B. Miller is a professor in the department of horticulture at Cornell University. Chad Miller can be reached at ctm25@cornell.edu.***