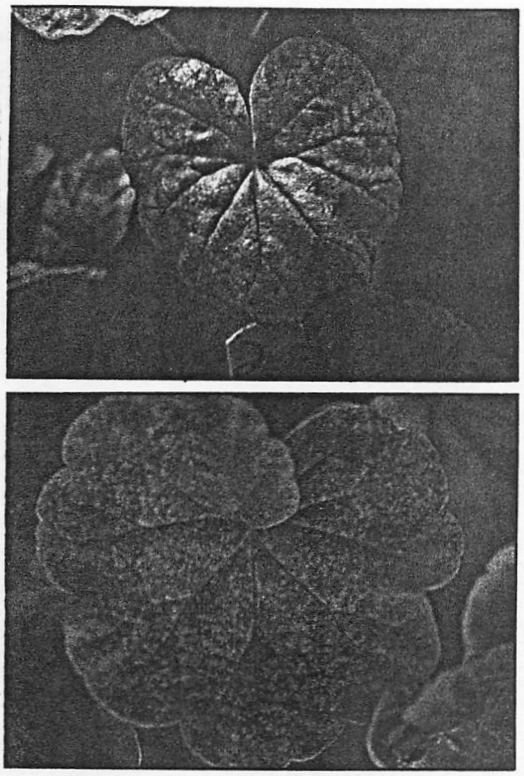


Figure 1: Moderate (top) and severe (bottom) foliar chlorosis of geraniums.

Figure 2: Bronzing (top) and chlorosis of marigolds.

Low pH Causes Iron

by JOHN BIERNBAUM, WILLIAM CARLSON,

A very serious nutritional problem has been observed in many locations in the U.S. and Canada in the last 4-5 years. The visual symptoms have puzzled many growers and have been attributed to many different factors. The losses in crop quality and production have been significant. A combination of grower experience, tissue analysis from service labs, and experimental evidence have helped to identify the primary cause of this problem and how it can be avoided.

The visual symptoms of this problem are most commonly found on geraniums and marigolds. On geraniums, the symptoms appear as an interveinal stippling or chlorosis on mature and expanding leaves (Figure 1). In some cases leaf necrosis may develop (Figure 1).

On marigolds, the symptoms include a leaf chlorosis and/or a bronze spotting of the leaf (Figure 2). In both species, the plants are stunted and flowering is delayed. The symptoms can begin to develop within 10-14 days from transplanted seedlings or plugs. Similar symptoms associated with this same problem have been identified on cabbage and tomato transplants, impatiens, and elatior begonias.

The cause of the symptoms described above is toxic levels of iron and/or manganese in the leaf tissue. Normal ranges for iron and manganese are 100-250 ppm in leaf tissue. Based on the results of several experiments and many tissue samples, the critical concentration for symptom expression and decreased growth in geraniums is 400-600 ppm iron and manganese. Plants with severe symptoms have levels from 1200 up to 2500 ppm. Even higher values have been reported.

Figure 3: Growth of 'Ringo Scarlet' geranium 9 weeks after transplanting at pH of 4.0 or 7.0.

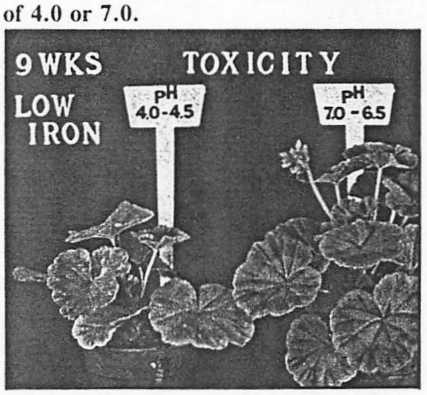
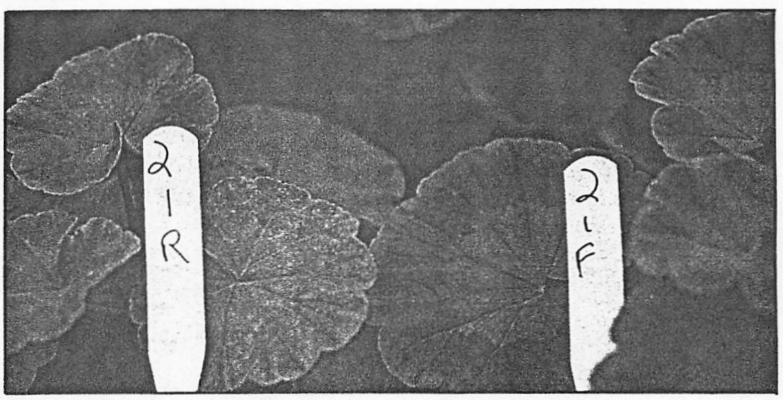


Figure 4: The effect of regular (R) and fast (F) lime reactions on 'Red Elite' geranium.



and Manganese Toxicity

CANDICE SHOEMAKER, and ROYAL HEINS

The Problem

The main factor leading to the accumulation of iron and manganese is low root media pH, which leads to increased availability of iron and manganese. The growth and development of 'Ringo Scarlet' geranium grown at a pH of 4.0-4.5 or 6.5-7.0 is shown in Figure 3. Four weeks after transplanting, the concentration of manganese and iron in plants grown at pH 4.0-4.5 was 900-1200 ppm while the concentration in plants grown at pH 6.5-7.0 was 70-90 ppm.

Over the last 5 years growers have been starting crops with a lower pH in soilless media because nutrient availability is increased in soilless media at pH 5.5 compared to pH 6.5. The optimum pH for crop growth depends on several factors in addition to nutrient availability, including the crop being produced and fertilization practices. For many crops such as geraniums and marigolds, a pH of 5.5-5.8 is too low. The optimum is closer to pH 6.0-6.3.

In some cases, the problem may also be caused by low pH from slow reacting, coarse liming materials or from intentionally anticipating the effect of alkaline water sources. Crops such as geraniums and marigolds can accumulate large quantities of iron and manganese following transplanting if the pH is below 5.8. Waiting 2-3 weeks for the pH to raise to 5.6-5.8 is not acceptable. The pH must be at least 5.8 at transplanting or soon after and quickly raise to 6.0-6.2.

Other Factors

An important factor affecting this accumulation of iron and manganese is the plant species and cultivar. We have already noted that this problem has been most prevalent on geraniums and marigolds. Some cultivars of geraniums and marigolds are more efficient at accumulating iron and manganese. This is fine when these elements are not readily available. But when they are, the plants con-

tinue to be very efficient and accumulate toxic quantities of these nutrients. This may be true for other greenhouse crops besides geraniums and marigolds.

While pH and plant species are probably the most important factors influencing iron and manganese accumulation, trace element fertilization practices can also be important. Trace elements can be incorporated into the soilless medium prior to planting, applied as a concentrated drench after planting, or applied as part of a liquid fertilization program — but not all 3 methods.

If the growth medium you are using already has a slow release trace element charge, you probably do not need a soluble fertilizer formulated with higher trace element levels for soilless mixes. Remember that trace elements are only needed in trace amounts and more is not better. Keep track of what has been applied.

The peat used in the soilless mix may also affect the rate of change of the pH for the mix. Peats differ in buffering capacity or the rate at which pH will change. Just as 2 water sources at the same pH may require different amounts of acid to lower the pH, 2 peat samples at the same pH may require different amounts of lime or alkaline water to raise the pH. Some hypnum peats, for example, are highly buffered and more resistant to changes in pH.

Prevention Strategies

The primary recommendation to avoid iron and manganese toxicity of sensitive crops such as geranium and marigold is to keep the pH at 5.8-6.2. To reach this pH at transplant or a few days after, only the finest ground dolomitic limestone should be used. With highly buffered peat, a small part of the lime (1-2 pounds per cubic yard) may need to be added as hydrated lime to raise the pH rapidly.

The effect of a rapid lime reaction is illustrated in Figure 4. Leaf chlorosis of geranium and iron levels in geranium, marigold, cabbage, and tomato tissue were decreased when 2 media samples were limed to the same final pH but with different liming materials, one to raise the pH traditionally, one to raise it rapidly.

Remember, a high pH above 6.5 is not recommended. High pH reduces trace element availability and will lead to nutrient deficiencies. If you have an alkaline water source, use acid injection to keep the pH down.

Treatment Strategies

If you recognize foliar symptoms in a crop or you suspect this problem, check the media pH immediately. In fact, if you don't already know the pH of your mix there is a good chance you are in trouble. Remember that what the pH has been the past several weeks is more important than what the pH is at the time symptoms become visible. Also have a tissue sample analyzed to confirm the presence of excess iron and manganese in the tissue.

If the pH is 5.6-5.8, a heavy leach-

ing with a high nitrate nitrogen source such as 200 ppm nitrogen from KNO_3 and $Ca(NO_3)2$ will help to remove soluble iron and raise the pH. If you catch the problem early enough, you may solve it by continued use of nitrate nitrogen sources and reduced application of iron and manganese.

If the pH is still at pH 5.4 or below, an application of liming material will probably be necessary. Finely ground dolomitic lime at the rate of 1 pound per 100 gallons can be applied to plants in containers. Hydrated lime mixed at the rate of 1 pound per 100 gallons is an alternative if it is used carefully. The lime should be mixed with water and allowed to settle overnight. Only the clear solution should be applied followed by clear water to rinse the foliage.

Increase the pH gradually. Wait 24 hours and test the pH again before making any additional applications. If you raise the pH too quickly with a large amount of ammoniacal nitrogen present in the medium, some ammonia may be released, which is toxic to plants.

Even though this problem could be anticipated based on existing knowledge of plant nutrition, it has caused significant crop losses. This is just one more illustration of the fact that there is no substitute for careful attention to detail where media and fertility programs are concerned. Proper pH is extremely important in container plant production. Know what the pH is prior to planting, track it over time, and keep it between 6.0 and 6.3. If you don't, you will see this problem. **GG**

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