Sudden Substrate pH Decline

Examining the three chief causes of sudden substrate pH decline (SPD) in geraniums.

By Matt Taylor, Paul Nelson and Jonathan Frantz

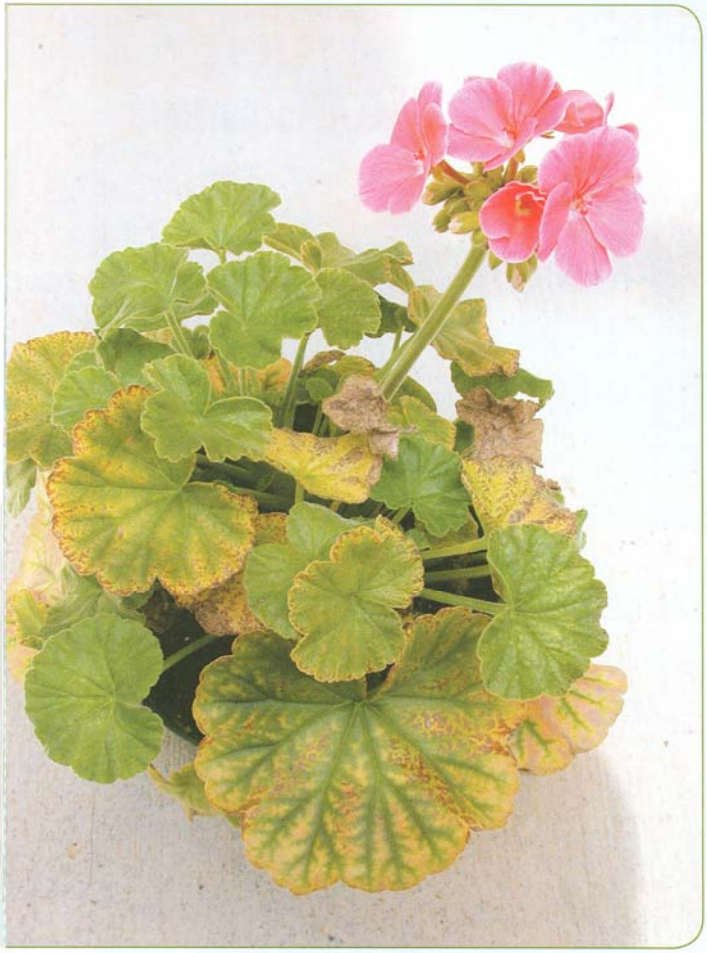

Figure 1. Chlorosis and necrosis on older leaves of zonal geranium caused by micronutrient toxicity because of low pH (Photo: Brian Whipker)

During the 1980s, geranium growers began reporting problems with sudden pH decline (SPD) associated with micronutrient toxicities. SPD describes a situation where plants growing at an appropriate pH rapidly (within one to two weeks) cause the substrate pH to shift downward 1 to 2 units. When substrate pH is low, the solubility of most micronutrients increases to a point where they can become toxic to the plant. Symptoms of micronutrient toxicity in geranium can include chlorosis and necrotic spotting along margins of older leaves (Figures 1 and 2), upward and/or downward cupping of the leaves, leaf distortion and large, purplish-black spots. Symptoms have been reported to be highly influenced by genetic variability among species.

A distinguishing feature of SPD is its sporadic occurrence: Within a greenhouse firm, one geranium crop might be affected while another is not. Within a geographic area, a crop in one firm is affected but not in a second firm, even though all crops appear to be similarly grown. In 2004, a project began at North Carolina State University to determine the factors that could trigger unpredictable SPD. Because this was relatively uncharted territory, the initial focus of this project tested an array of environmental and nutritional factors, singularly and in combination. There are three possible causes for SPD.

Phosphorus Deficiency

The first causal factor that became evident was phosphorus (P) deficiency. Phosphorus is a likely culprit because growers often rely on alkaline fertilizers to anticipate and offset pH declines, and P is low or absent in these formulations — for example, 13-2-13, 15-0-15, 14-0-14. Hydroponic studies showed that under a growth-limiting P supply, geraniums

can lower solution pH from 5.8 to below 4 in only three days. Additional work in hydroponics indicated that plants grown under P deficiency shift nitrogen (N) preference from nitrate (NO_3^-) to ammonium (NH_4^+). When this shift occurs, excess positive electrical charges from NH_4^+ enter the roots. The roots compensate for the excess charge by exudation of H^+, which acidifies the substrate. To verify the acidifying effect of P deficiency in a commercial substrate, experiments were also conducted in a 3:1 peat to perlite substrate mix. These experiments confirmed the P effect, and in most cases, when plants were experiencing P deficiency, substrate pH declined sharply over time.

The target range for tissue P concentration in geranium is 0.2 percent to 0.6 percent. If values are below 0.2 percent, plants are deficient (Figures 3 and 4), and P must be added. This can be accomplished with one to two applications of a high P fertilizer, such as 15-16-17. Using acidic fertilizers like this is not recommended for geraniums, but there are no basic fertilizers available with high P. Be sure to return to a basic fertilizer following this type of fertilizer application. An alternative option would be to top dress triple-super-phosphate, but this can be too labor intensive.

High Temperatures

The second factor shown to cause SPD is high temperature. In both hydroponics and peat-based substrate, higher temperatures caused plants to have increased substrate acidification. The results of a study that compared three temperatures and two preplant triple-super-phosphate rates are shown in Figure 5. Regardless of P rate, as temperature increased, substrate pH began to decrease midway through the crop. The recommended temperatures for the production of zonal geraniums ranges from 64-75° F for the day and 63-72° F for the night period. The temperatures used for the high-temperature treatment in this study (72° F night, 80° F day) were above these recommendations. It is highly likely, during normal geranium production, that temperatures will exceed these temperatures, especially in the late spring and in Southern regions.

The effect of low P is also apparent in Figure 2. At the end of the experiment, all plants grown with the lower P rate had tissue P concentrations below 0.10 percent (deficient) and plants with higher P were above 0.24 percent (sufficient). Although initial pH of plants fertilized with inadequate P was higher than plants with adequate P, at each individual temperature, pH values at the end of the crop were lower with inadequate P. This again indicates the acidifying effect of P deficiency, which in this study added to the acidifying effect of high temperature.

High Light Intensity

The third factor that can cause SPD is high light intensity. Preliminary results of a series of light studies indicated that high light intensity caused lower substrate pH. Tissue analysis later revealed that nearly all plants grown under high light intensity had P deficiency, even with high P fertilization rates. At that point in our study, it was impossible to ➧

Figure 2. *Micronutrient toxicity on an older zonal geranium leaf (Photo: Brian Whipker)*

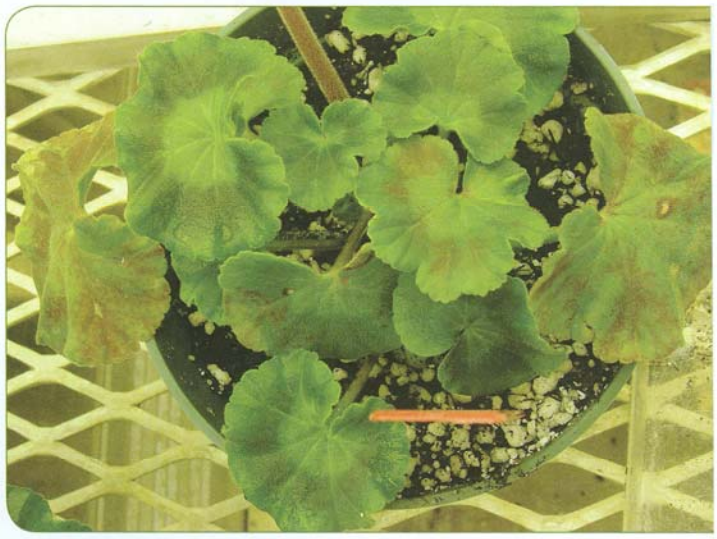

Figure 3. *Progression of P deficiency on the lower leaves of zonal geranium beginning as chlorosis along margins that spreads inward followed by necrosis from margins inward*

Figure 4. Young zonal geranium with small leaves and reddening of older leaves caused by phosphorus deficiency

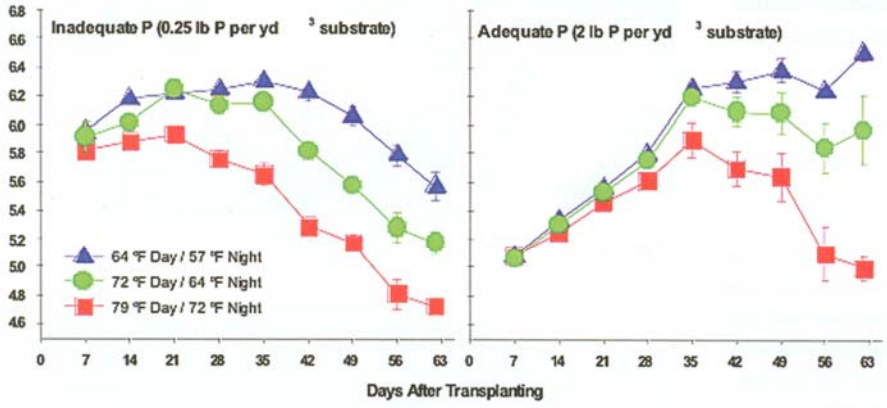

Figure 5. Effect of three temperatures and two preplant triple-super-phosphate rates on substrate pH of zonal geranium

determine whether low substrate pH was a direct effect of high light or P deficiency. Since low tissue P was consistently coupled with high light intensity, research was conducted to determine the effect of high light on P uptake. The results revealed that P uptake is reduced under high light intensity. This indicates that if plants are being grown with marginally adequate P and the light intensity is excessive, P deficiency can occur and cause SPD.

The recommended light intensity for the production of geraniums is 3,000-5,000 foot-candles, which is lower than the high light treatments used in these studies. During normal geranium production it is likely light will exceed recommendations, especially in the late spring and in Southern regions. To help prevent SPD, geranium growers should supply adequate P and avoid extended periods of high-intensity light. This can be accomplished by applying shade in late winter or early spring. This will also help reduce greenhouse temperatures.

The SPD project at N.C. State was successful in determining three potential causes of SPD. Phosphorus deficiency and high temperature can directly cause SPD, and high light can suppress P uptake and lead to SPD. It is not clear, however, whether high light intensity contributes to substrate acidification if P is adequate. Further investigation of this question is warranted.

Some Basic Solutions

Because other factors, such as genetic variability and potential cultural issues, may be involved with SPD, substrate pH of zonal geraniums must be regularly monitored and maintained between 6.0 and 6.6. If pH drops below this recommended range, corrective action must be taken to prevent micronutrient toxicity. Two recommended methods that can be used to increase substrate pH are flowable lime at 1-2 quarts per 100 gallons and potassium bicarbonate at 2 pounds per 100 gallons. Plants should be rinsed off after application of flowable lime or potassium bicarbonate to remove foliar residues and prevent burn. One day after applying potassium bicarbonate, the soil should be leached with water containing fertilizer to remove excess potassium and re-establish the proper nutrient balance. Allow three days reaction time, and recheck the substrate pH to determine whether a second application is necessary. ■

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