Actual pH and Potential Acidity of Fertilizer Solutions Determine the pH of Soilless Mixes

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Index Words: EC, pH, ebb and flow, subirrigation, lime

Nature of work: The pH of the growing medium used in greenhouse production has important effects on the nutrient uptake and growth of plants (Argo and Biernbaum, 2002). Medium pH is governed by the composition of the growing medium (lime content in particular) and on the type of fertilizer being used. The way different fertilizers supposedly influence the pH of the growing medium is expressed as the calculated quantity 'potential acidity'. The potential acidity of a fertilizer is the estimated amount of $CaCO_3$ needed to negate the fertilizer's effect on the pH of the growing medium. High potential acidity implies that the fertilizer decreases the pH of the growing medium. This concept is widely used to make recommendations concerning the use of different fertilizers, but there seems to be no research that has looked specifically at how fertilizers with different potential acidity affect the pH of soilless growing media. Thus, the objective of this research was to determine how the pH of the growing medium is affected by lime content and fertilizers with different potential acidity. A secondary objective was to determine how these factors affected plant growth and chlorophyll content. Chlorophyll content is important because it is an indirect indicator of nutrient uptake by plants, with low chlorophyll content indicating that a plant does not take up enough of a certain nutrient.

Plug seedlings of marigold 'Bonanza Mix', begonia 'Ambassador White', and impatiens 'Cajun Red' were obtained from a commercial plug producer. Plug seedlings were transplanted into 10 cm (4”) square pots filled with soilless growing medium. The growing medium consisted of 2:1:1 sphagnum peat: perlite:vermiculite (V/V) with dolomitic limestone (50% Ca, 0.4% Mg) added at 0, 2, 4, 6, or 8 $kg•m^{-3}$. The different lime levels resulted in growing media with an initial pH of 3.7, 6.1, 8.1, 8.5, and 9.1 and an initial electrical conductivity (EC) of 0.11, 0.19, 0.45, 0.53, and 0.54 $dS•m^{-1}$, respectively (determined using the saturated medium extract method). Plants were placed on ebb and flow benches (0.9 × 1.5 m^2; 3 x 5 ft^2) and subirrigated daily with a fertilizer solution containing N at 175 ppm. The fertilizer solutions were made with one of three water-soluble fertilizers: 20-10-20 Peat-Lite Special, 15-16-17 Peat-Lite Special, or 15-5-15 Cal-Mag (all from The Scotts Co., Marysville, Ohio), which were selected because of their differences in potential acidity and actual pH. These fertilizer solutions had an EC of 1.07, 1.20, and 1.23 $dS•m^{-1}$, a pH of 6.2, 5.9, and 3.6, and a potential acidity of 203, 98, and -70 $g•kg^{-1}$ $CaCO_3$, respectively. Electrical conductivity and pH of the medium leachate were (determined with the pour through method), and chlorophyll content of the leaves were measured on 13, 20, 27, and 34 days after transplanting (begonias only). Leachate pH and EC of the impatiens and marigold were determined once, at harvest. Shoot dry mass of the plants was collected at the end of the experiment (29, 34, and 42 days after transplanting for impatiens, begonia, and marigold, respectively). After dry mass determination, tissue nutrient levels of the entire shoots were determined.

The experimental design was a randomized complete block with a split-split plot with five replications. The three different fertilizers were used as the main blocking factor, plant species as the first split, and growing medium as the second split. Data were analyzed with ANOVA and non-linear regression.

Results and Discussion: There was an interactive effect of lime level and fertilizer type on the pH of the leachate. Leachate pH increased with increasing lime content of the growing medium. Differences in leachate pH due to fertilizer type decreased with increasing lime level. Apparently, the buffering effect of the lime negated the effects of fertilizer type when the lime level was 4 to 8 kg•m^{-3}. At lower lime levels, there was a significant effect of fertilizer type on leachate pH. 15-5-15 fertilizer resulted in the lowest leachate pH, while 15-16-17 resulted in the highest pH (Fig. 1). These results are not as would be expected from the potential acidity of the fertilizers, since 15-5-15 had the lowest potential acidity, and thus would be expected to result in the highest leachate pH. Instead, this fertilizer resulted in lower leachate pH than the 20-10-20 and 15-16-17 fertilizers. Thus, there must have been factors other than potential acidity that affected leachate pH. One variable likely to affect leachate pH is the actual pH of the fertilizer solution. However, fertilizer pH could not explain the observed results either. 20-10-20 fertilizer solution had the highest pH, but resulted in lower leachate pH than 15-16-17 fertilizer. Leachate pH could be predicted accurately with an exponential equation, taking into account both the potential acidity (PA), actual pH of the fertilizer (pH_{fert}), and lime content of the growing medium (lime): $pH = 7.8 + (-11.9 - 0.0157xPA + 2.08xpH_{fert}) \text{ x } exp^{-(0.325xlime)}$ (R^2 = 0.95). This equation indicates that leachate pH decreases with increasing potential acidity, increases with increasing fertilizer pH, and increases asymptotically with increasing lime content of the medium.

Lime content of the growing medium affected shoot dry mass (Fig. 2) and chlorophyll content (not shown) of the plants. A lime level of 2 kg•m^{-3} in the soilless medium resulted in maximal growth of all three species, independent of fertilizer type. This is surprising because the different fertilizers resulted in different leachate pH. For example, the 15-16-17 fertilizer without any lime in the growing medium resulted in the same leachate pH as the 15-5-15 fertilizer with 2 kg m^{-3} lime, yet in both cases 2 kg m-3 lime resulted in maximum dry mass. Leaf chlorophyll content of the leaves of begonia and impatiens generally decreased with increasing lime content of the growing medium, while fertilizer type had little or no effect on the chlorophyll content. In general, the effects of the lime content of the growing medium on plant growth were much larger than the effects of fertilizer type.

As expected, lime level of the growing medium also affected nutrient uptake. N, P, K, B, Mg, Mn, and Zn concentrations all decreased with increasing lime level, while Ca and Mo increased with increasing lime levels in the growing medium. The effects of fertilizer type on nutrient uptake were much smaller than the effects of lime content of the growing medium (results not shown).

Significance to Industry: The results of this study indicate that fertilizer effects on the pH of the growing medium cannot be predicted solely from the potential acidity of the fertilizer. Instead, both potential acidity and the actual pH of fertilizer solutions should be taken into account when predicting fertilizer effects on the pH of the growing medium. Despite differences in pH of the growing medium among the fertilizer treatments, plants of all three species grew best when the growing medium contained 2 kg•m^{-3} (3.2 lbs/yard^3) of dolomitic lime.

Literature Cited:

1. Argo, W.R. and P.R. Fisher. 2002. Understanding pH management for container-grown crops. Meister Publ. Willoughby, Ohio.

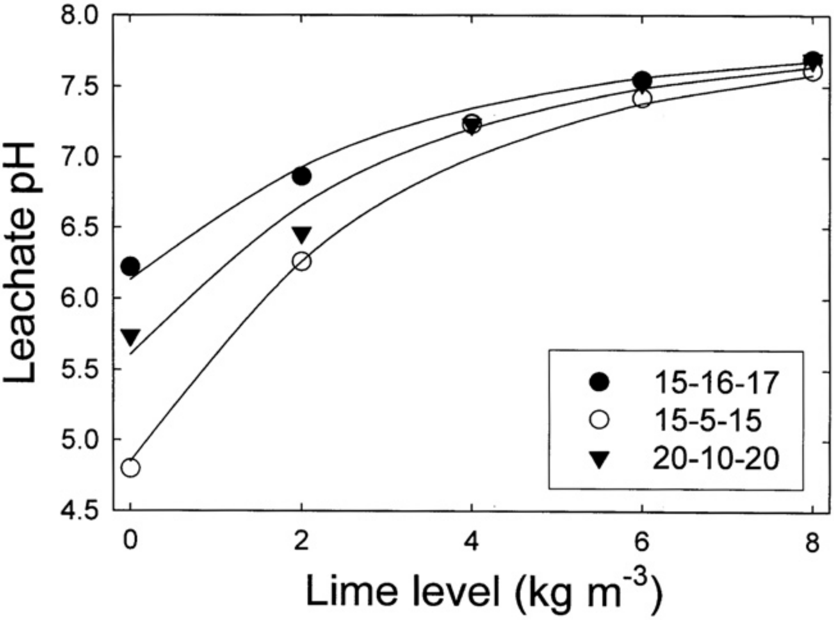

Figure 1. The effect of lime level and fertilizer type on the pH of the leachate of the growing medium of begonia (averaged over the duration of the experiment). Leachate pH could be described as a function of the lime level in the growing medium, and potential acidity and actual pH of the fertilizer solution. Lines show the predicted leachate using the equation in the results and discussion.

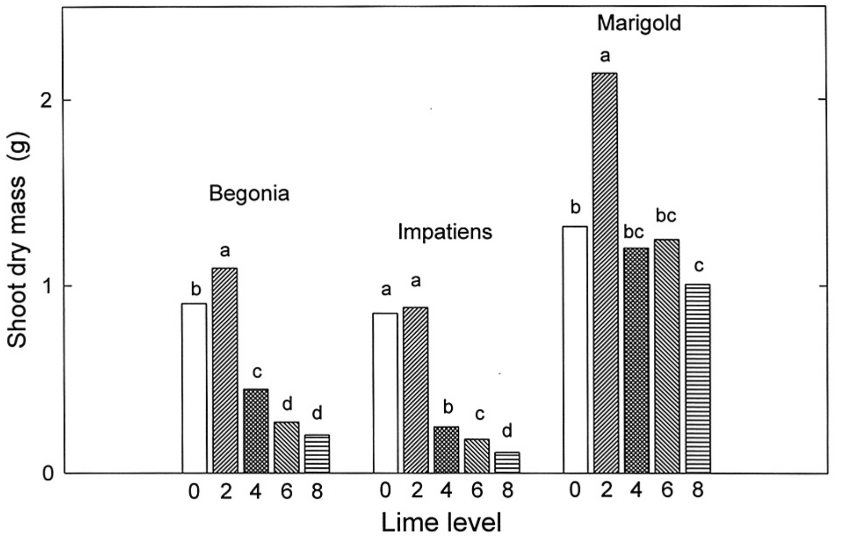

Figure 2. The effect of lime level in the growing medium of three bedding plant species. Data shown are averaged over the three fertilizer types, because fertilizer type had little or no effect on plant growth.