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Improving media-pH management by developing a model of the interacting factors in the pH system

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BACKGROUND

Many factors (lime, media components, water quality, fertilizer, plant species, plant growth rate, and leaching) contribute to the changes of media-pH. The best research approach to understand pH change is to develop an overall model using all interacting factors.

One key component of the pH system is un-reacted "residual" lime in the media. Residual lime buffers the growing media, by resisting a drop in pH over time. Soilless media are poorly buffered (lack resistance) to pH change. When no residual lime remains, media-pH could change very quickly, e.g., within a week causing crop losses. In this project, we developed a series of protocols to test limestone reactivity and measure residual lime in container media (Huang, et al. 2007a& 2007c). We developed a model to quantify how media-pH responds to reactive and residual portions of limestone (Fisher, et al. 2006). This report will focus on how limestone particle sizes and residual limestone concentration affect pH buffering capacity of the media.

MATERIALS AND METHODS

Nine research substrates were developed for the project. They varied in the type, rate, and particle size of limestone. The research substrates contained 70% peat and:30% perlite (by volume) with dolomitic hydrated lime at 2.1 $g \cdot L^{-1}$, followed by incorporation of dolomitic carbonate limestone with 10 to 20, 20 to 60, 60 to 100, or 100 to 200 US mesh particle sizes at 0, 1.5 or 3.0 $g \cdot L^{-1}$. In addition, 10 commercial container substrates were selected that represented a range of residual limestone concentrations typical for container plant production in North America. Substrate-pH buffering was quantified by measuring the pH change following either (a) mineral acid HCl drenches without plants (samples of each substrate were received one dose of 0, 20, 40, 60, 80, or 100 meq of 0.5 N $HCl \cdot L^{-1}$ of substrate and substrate-pH was measured 7 days after the drench); or (b) a greenhouse experiment where an ammonium-based (acidic) or nitrate-based (basic) fertilizer was applied to Impatiens for 6 weeks.

RESULTS

Increasing the residual lime concentration (as calcium carbonate equivalence: CCE) in substrates increased pH buffering to either a dose of acid drench or when Impatiens were grown with ammonium fertilizer.

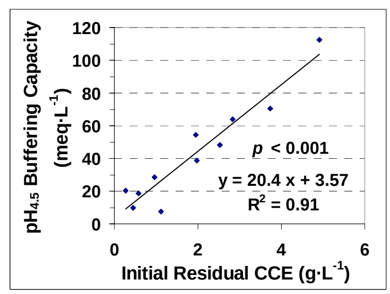

Figure 1.The relationship between initial residual CCE and $pH_{4.5}$ Buffering Capacity when substrates received a drench of HCl acid.

The $pH_{4.5}$ Buffering Capacity (meq acid per liter of substrate required to drop substrate-pH to 4.5) estimated for each commercial substrate using the acid HCl drenches is shown in Figure 1 and was positively correlated with the

initial residual lime concentration.
When Impatiens were grown in the research substrates for 6 weeks with the ammonium-based acid fertilizer, particle size significantly influenced substrate pH buffering. The coarsest particles (retained on a US 20 mesh screen) provided no pH buffering compared to only hydrated lime, and this coarse fraction has little reactivity in peat substrates over a period of weeks (Huang, et al. 2007b). Substrates amended with the lime particle fractions between 20 and 100 mesh had the greatest buffering. The finest particle fraction (passing a 100 US mesh but retained on a 200 mesh) was very reactive resulting in a high initial substrate-pH, but provided less pH buffering following 6 weeks of plant growth.

Substrate-pH increased following 6 weeks of fertigation with a nitrate basic-reaction fertilizer. The increase in substrate-pH was not affected by the initial residual limestone concentration.

CONCLUSION

Increasing residual lime concentration in substrates was correlated with greater pH buffering in both greenhouse plant experiments using a 100% ammonium-N, acid-reaction fertilizer, or when substrates were drenched with mineral HCl acid. A moderately coarse lime particle size (passed through a 20 US mesh but retained on a 100 US mesh) provided the most effective pH buffering. With a high nitrate-basic fertilizer application, residual lime concentration did not show significant effect on pH buffering. Therefore, providing residual lime did not have detrimental effects when plants were grown with a basic fertilization program.

IMPACT TO THE INDUSTRY

This project has provided lab protocols, information, and a decision-support tool to help growing media companies and growers select the best limestone types and rates not only to neutralize the initial acidity of peat or bark but also to provide a reasonably well-buffered medium during crop growth.
We showed that residual lime concentration in substrates plays a key role in pH buffering. The results emphasize the importance of residual limestone concentration and particle size selection in substrate formulation when developing growing substrates that resist a downward trend in pH over time. The lime and soil test protocols and tools developed will provide media, soil testing, and grower companies with new information to improve media-pH management.

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