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SUN GRO HORTICULTURE

THE SUN GRO'er

Inside this issue:

Welcome!

Welcome to another edition of the Sun Gro'er. In past issues, we have covered various topics that dealt either directly or indirectly with Sun Gro products. In this edition, we will deal with an issue that is basic to any mix and a major concern throughout the industry. As the crops we grow continue to change, the nutritional needs also change. The pH of a mix has a major impact on nutrition of the crop. Therefore, we will focus solely on pH in this edition of the Sun Gro'er. Shiv Reddy has put together an article describing the research that has been done looking at how lime affects medium pH. We also are publishing the Technical Team's position paper on pH.

~Dan Jacques

Harmonizing Peat and Lime

Current research on pH in search of a 'bloody' mix

Growing media pH is a perennial subject of interest in our industry. One reason is that unlike mineral soils where plants grow naturally, peat mixes are not well buffered against pH changes. Another reason is that, again, unlike in natural conditions where plants can grow more roots in favorable pH zones, the limited volume of mix in containers exacerbates pH effects. Drastic pH changes upset plant quality (see an example in figure 1).

Figure 1: Calibrachoa in high pH mix (photo courtesy of Dr. Paul Fisher, University of New Hampshire)

Though grower's water, the fertilizer regime the grower is practicing and even the plant species being grown also affect pH, the growing medium is the first thing questioned when pH problems occur, because pH changes occur right in the medium.

Here, I present the latest research in the area of growing media pH. The information may fulfill your curiosity, your practical needs or just give you talking points about how industry is striving to manage materials to produce a better growing media.

Truck-wide variation

Peat is acidic and lime is added to neutralize some of that acidity and raise its pH. However, even when the same amount of lime is added to the same amount of peat every time, the resulting mix pH is not the same every time. The pH variation can be, as the famous remark goes— wide enough for the truck carrying the mix to go thro— from 5.0 to 7.0. Remember that pH scale is logarithmic: a pH of 5 is *10 times* more acidic than pH of 6 and *100 times* more acidic than 7. Therefore, the variation is wide. If your blood pH varies by just 0.2, problems occur in your body. Don't worry, your body is so efficient, its buffer system kicks in and brings blood pH back to the original value in less than a minute. Don't you wish your mix maintained pH like blood in your body? To build such a buffer system into a mix, first we should know what causes pH variation in mixes. So, we wanted to explore this further in a quantitative manner.

In 2001, we initiated and partially supported a research study at North Carolina State University. Soon Martin Marietta Technologies joined the study. This company is a derivative of the aerospace company but they are on the ground in the limestone business and probably produce most of the limestone in the world. Our idea was whether, with their resources, a horticultural lime could be devised. Though, like peat, transport is a major factor in lime business, a lime produced differently for horticulture could have a good market.

Peat dimensions

At first, when you joined the industry, you thought all peats looked the same, didn't you? But you soon realized all peats are not the same all the time. Though it is called *Sphagnum*, there are various species that make up this genus. Further, within each species, peat can be at a different decomposition stage. Still more— one would expect that the water

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peat has been in contact with during its formation would influence its pH. The water could be groundwater or rain water. All these differences can affect peat's inherent acidity that has to be neutralized. The question is which of these characters predict a peat's requirement of how much lime?

During late 2002, nearly 500 peat samples were collected from different fields in Alberta bogs. In each sample, species were tediously separated and their percentages estimated. Their decomposition rate was also rated. The species content of Alberta peat varied. Why?

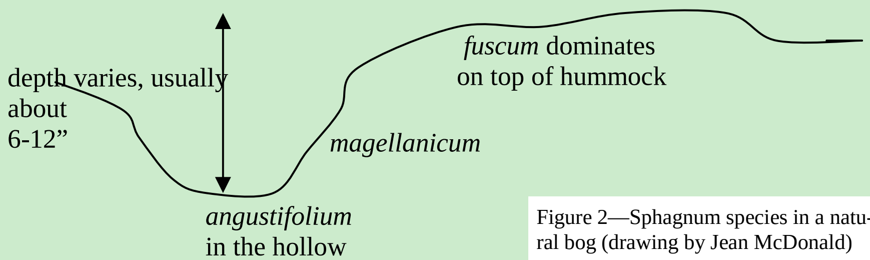

Figure 2—Sphagnum species in a natural bog (drawing by Jean McDonald)

A natural bog is not flat. For example, Alberta bogs naturally have hummock-hollow type topography and have major species occurring as shown in figure 2.

The differences in species correlate to differences in pH. *Sphagnum fuscum* on top of the hummock generally has a pH of 3.5. *Sphagnum fuscum* is horticulturally a best peat, because it has high water absorption capacity and decays slowly. *Sphagnum megellanicum* also absorbs water fast and retains it well, but decomposes quickly. *Sphagnum angustifolium* that is in the hollow has a pH of 4 to 5. There are also non-*Sphagnums* like sedges or debris, which not only have a higher pH, but also increase pH variability.

Why are there pH differences between *Sphagnum* species? All *Sphagnum* species have sites loaded with exchangeable hydrogen (acid) ions but the *number* of sites and the *percent* that are already saturated with bases vary. The saturation is influenced by how the species existed with respect to the water table. *Sphagnum angustifolium*, which is in the hollows, derives its moisture from water that is in contact with mineral soil. Such water has bases like calcium, magnesium, sodium, etc., which exchange places with hydrogen on peat. Therefore, *angustifolium* has a higher percent of its sites saturated with bases— so, less hydrogen or acid ions and higher pH. *Sphagnum fuscum*, which is on top of the hummock derives its moisture from precipitation only and there are few bases in rain water. Therefore, *fuscum* still has more hydrogen or acid ions, or lower pH.

What happens to pH as peat decomposes? Peats that are highly decomposed have high pH.

When the naturally undulating bog surface is made flat to allow for harvesting, each pass of harvester picks up variation in the species and decomposition, resulting in variation in peat pH (see figures 3a and 3b).

Figure 3a: Flattening of bog (photo from Sun Gro archives)

Further variation occurs over time as well. Because a field that has been harvested for a long time would have a different mix of species and different decomposition stages than a newly opened field. As an example, species content in different fields in a sample location are shown in figure 4. Such diagrams drawn for different fields can be used to know the homogeneity of peat and therefore predictability of pH variation.

Figure 3b: Harvesting flattened peat (photo from Sun Gro archives)

You might expect a peat starting at a pH of 4.5 to reach a target of 5.8 with less lime than a peat starting at a pH of 3.5. You would think in the peat with pH 4.5, some acidity is already reduced by bases, so further neutralization requirement should be lower. There is some such relation between higher starting pH and lower lime requirement but the relation is not strong (just 20%). Why? A peat with a pH of 4.5 can still have a lot *more number* of sites available for bases than a peat with pH of 3.5. Confusing? Let us take an analogy of hotel vs. small motel. Info like 25 rooms occupied in each lodging (like pH value of each peat) gives you little information about how many rooms are still vacant— till you know the total capacity of each lodging. Even when bases like calcium and

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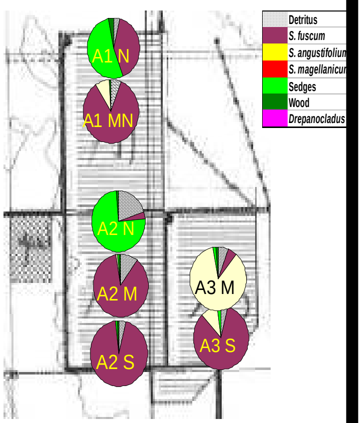
magnesium are extracted, a peat sample can yield greater quantity of bases (= *more number* of guests) and still have a lower pH (= *lower percent* occupancy).

Figure 4: Species and decomposition differences in fields (drawing by Jean McDonald)



Field Sample	A1MN	A1N	A2M	A2N	A2S	A3M	A3S
Decomposition	2	2	3	3.5	2	3	2
Detritus	6	4	10	20	4	6	4
S. fuscum	85	40	87	4	94	5	84
S. angustifolium	8		1			86	10
S. magellanicum						+	
Sedges	+	53	1	75	1	2	2
Wood	1	3	1	1	1	1	+
Polytrichum							
Tomenthypnum							

To predict the lime requirement of a peat, one should determine the total capacity for base saturation and the percent of that capacity already saturated with bases. The correlation between increasing percent of base saturation and decreasing lime requirement is stronger (40%). The total capacity of a peat to hold bases is based on its cation exchange capacity, where cations (positively charged ions like hydrogen, calcium, magnesium) are swapped for one another.

A high cation exchange capacity generally imparts a high buffer capacity. During growing, a peat with high buffer capacity will have great ability to trade other cations for hydrogen ions that are coming from plants, fertilizers, microbial action, etc. Thus, that kind of peat resists pH drifts, which is a property we desire in a mix. *Sphagnum fuscum* seems to be a species with high buffer capacity.

Finally, we generally think hydrogen is the source of acidity in peat. But interestingly iron is found in Alberta peat. Iron bonds with hydroxide in water leaving acidic hydrogen ions in the solution. Variations in peat pH could be due to differing amounts of iron as well.

Lime dimensions

Lime costs <1% of the mix price. But the value and the headaches it brings are well known. Most lime companies primarily serve the construction market and to them agricultural lime is a by-product. Consequently lime companies don't have technical people knowledgeable of our industry. The burden is on us to decide whether their lime serves our purpose or not.

Lime has to dissolve to act and neutralize peat acidity. We generally agree that the size of a lime particle affects its solubility: smaller particles dissolve faster. That's how agriculture lime is characterized now. Unfortunately, this is yet another time of getting into trouble when agriculture perceptions are transferred to horticulture. In agronomy, they have time. A slow rise in soil pH in 3-4 months and a residual lime effect that lasts for 3 years is ok in field crops. In greenhouse growing, we want rapid rise— in days if not hours and the residual effect for just 3-4 months. Our industry experience has been that the same amount of lime with the same sieve analysis (= particle size) doesn't always give same pH in mixes. This result makes one suspect that particle size alone may not characterize horticultural lime sufficiently.

Nine lime samples from our production plants (some shown in figure 5) and 40 from Martin Marietta quarries were gathered. Among these limes, there were dolomites (contain calcium and magnesium carbonates) and calcites (contain just calcium carbonate). These samples were tested.

When these limes were reacted to find out how fast they react and neutralize acid, there were tremendous variations in dolomites coming from different sources. But there was very little or no variation between calcitic limes (thus indicating it is difficult to change dolomite sources and easier to change calcite sources). Smaller lime particles did react faster than larger particles. But the tremendous variations in reaction rates were not fully related to particle size alone. Particle size accounted for only half of the reaction rate of lime. This finding gives an explanation of how mix pH can vary despite using limes having the same sieve analysis if these limes are coming from different sources.

Same sized lime particles taken from different sources were reacted. Dolomites took longer time to react than calcites— 4 times longer on average. So, is reaction slower because of the presence of magnesium carbonate in dolomite? When limes were listed in the order of increasing magnesium carbonate content (which is the same as decreasing calcium carbonate content), magnesium carbonate content showed an influence on slowing the reaction rate but again the reaction rate was not fully related to magnesium/calcium content.

Figure 5: Limes from different sources (photo courtesy of Dr. Rick Vetanovetz, Sun Gro)

What other character of lime is influencing its neutralization capacity? Surface area of lime particles was measured. Same size lime particles from different sources had different surface areas— up to 5-fold difference. This tells that the exposed area on some lime particles is not just on the geometric surface and there is considerable internal surface.

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When viewed using a microscope (see the images in figure 6), lime particles that have low surface area appear smooth. But same sized particles from different sources that have high surface area have many ridges and valleys, which increase surface area. Since all the exposed area reacts with water, this means same sized lime particles from different sources can react differently.

So far, particle size, content, surface area account for 80% of the neutralization capacity of lime. These findings tell us that in addition to the sieve analysis and of course reaction rate, content and surface area should be included in the specs to further reduce the variability of lime.

More data on other lime characters is being analyzed to account for 100% of the neutralization capacity.

Matching peat-lime

The goal of the research is to find out which characters determine neutralization capacity of lime and which characters determine neutralization requirement of peat and then match them suitably. Like what the eHarmony guy says on the radio about profiling different dimensions of men and women before matching soul mates!

Continuing on the matchmaking analogy, you might be wondering: What about the chemistry after marriage—pH drift during growing? The properties mentioned above give information to predict pH changes during growing as well. For example, different reaction rates of limes give information on balancing initial pH of the mix with pH maintenance during its use. For simplicity, I presented here the effect of one factor at a time, as if other factors remain the same. In the real world, as you can imagine, the peat-lime reactions occur in multifaceted dimensions in space and time. But since the whole effect is a sum of its parts, depending on the situation, we can select and add or subtract relevant factors and evaluate the effect.

Dolomite Calcite

Low surface area

High surface area

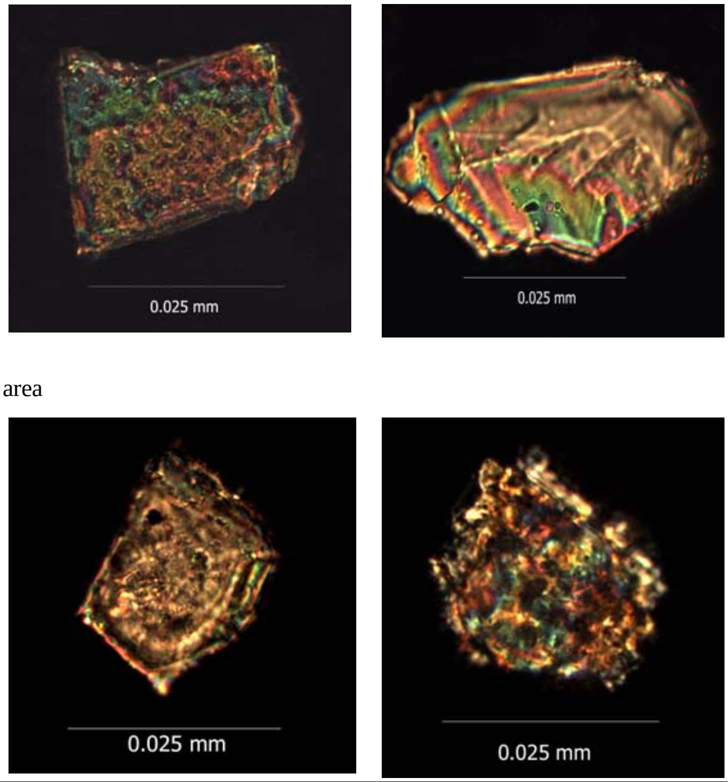

Figure 6: Microscopic digital images of same sized lime particles from different sources (courtesy of Dr. Janet Rippy)

Research & further research

People in the industry should understand that large randomized, controlled research trials like this one are slow and frustrating at times. This study began in 2001, and conclusions after going through the vigilance of peer review, are just coming out. But imagine 500 peat samples, 50 lime samples sieved into 8 fractions, each sample studied in replications for many different characters. Just devising a test on how to measure a character took time. For example, how to measure the surface area of lime particle (dinitrogen gas was used as absorbate because the gas accesses the same areas of the particle as water does), what type of base to use to disassociate hydrogen ions from peat, etc.

Still, we should support research. Just on the subject of pH, we know pH brought on contentions, disputes and even litigations between people and between companies. During some of those times, following the explanations and remedies suggested by well meaning participants was like following the moves of mouse in a maze, due to lack of good information. Working in the field we especially know how lack of good information adds uncertainty to our interpretation of a situation. New insights from research will reduce the uncertainty.

The research initiated by Sun Gro, NC State University and Martin Marietta branched into different angles. In 2004, Dr. Paul Fisher of the University of New Hampshire, got the remains of the large collection of Alberta peat samples to find out whether plants can mine the iron in some of those peats (like people do in Caribou Mountains in Alberta). His research is supported by a consortium of grower organizations and

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companies.

USDA funded Professor Paul Nelson to find out why some crops like geraniums push the mix pH down. Apparently, the protein that transports nitrate in geranium roots is somehow inhibited which leads to geranium taking up nitrogen in the form of ammonium, which causes low pH in the mix.

All these studies will let us position the pieces properly in the pH jigsaw puzzle and ultimately result in great looking plants like the one in figure 7 all the time.

Listed below are 4 research papers from this study that have been published so far and more are forthcoming. The papers have detailed work for interested people:

1) "Specific surface versus particle diameter of limestones" by Janet Rippy et al. Presented at the American Society of Horticultural Science Conference in Austin, Texas on 19 July 2004.
2) "Soilless root substrate pH measurement technique for titration" by Janet Rippy and Paul Nelson, published in *HortScience*, February 2005.

Figure 7: Calibrachoa (copyright Proven Winners)

3) "Lime specific surface versus particle size & Reaction times of twenty limestones" by Janet Rippy et al., to be published in *Communications in Soil Science and Plant Analysis.*
4) "Evaluation of limestone physical and chemical properties on neutralization capacity" by J. Rippy et al., presented at the International Symposium on Growing Media in Angers, France on 6 September 2005.

Janet Rippy and Professor Paul Nelson were the chief researchers. Former resident peat expert at Seba Beach, Tony Cable and botanist from Alberta, Jean McDonald helped in peat sampling and identification. Bryology Professor Dale Vitt from Southern Illinois University Carbondale participated in the peat background discussions. David Jahn from Martin Marietta helped in lime sampling, analyses and discussions. Tech specialists from all the regions helped in getting lime samples. Mark Spong supported the study.

~Shiv Reddy

Technical Position on pH of Unused Media

Maintaining a proper growing medium pH is important in achieving a high quality crop and has received a tremendous amount of attention in the horticultural press. Much of the information suggests maintaining a narrow growing medium pH range. Consequently, we often receive requests from customers requiring or "guaranteeing" growing media with a narrow pH range or specific pH when it arrives at their greenhouse/production facilities. Acceptance or rejection of a shipment is often contingent on meeting this guaranteed pH or narrow pH range.

The use of limestone is the principle means of adjusting initial medium pH. While initial medium pH is an important aspect for the addition of lime there are also other important aspects for the addition of lime. All these factors are considered in the development of the lime source and rate used. It is very important that we help our customers understand the many purposes of adding limestone to potting media.

- Initial pH adjustment—To bring the pH of the finished product within a more suitable range for growing crops in a soilless media, most experts suggest maintaining a medium pH within 5.6—6.2 for optimal nutrient availability. Although specific recommendations vary, a pH of 5.5 to 6.5 would be considered acceptable. Dolomitic limestone is more "forgiving" in hitting a specific pH target.
- Buffering effect—The addition of lime helps to buffer the medium pH, or reduce drastic changes (rises or falls) that would occur otherwise due to the limited buffering capability of most growing media. Dolomitic limestone has been found to offer a better 'residual" influence on buffering medium pH—a consideration often forgotten. Generally speaking, the acidic reactions of fertilization will tend to decrease the pH of a growing medium over time and the use of dolomitic limestone resists that change.
- To supply additional Calcium AND Magnesium for the duration of the crop cycle (2-3 months) time. As we all know, Mg is often lacking in a nutritional program. Dolomitic limestone contains both Calcium and Magnesium.

For the above reasons, Sun Gro has adopted the use of dolomitic limestone. Dolomitic limestone is the liming agent of choice. We have found that the use of a dolomitic limestone at a consistent rate targeting a pH range (rather than a specific pH) is the best all-around means of getting a crop started on the right track.

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Sun Gro formulates growing media products to fall within a targeted pH range after being "wet out", which means the mix has been moistened sufficiently to assure that the lime reaction will proceed efficiently. Even after "wet out" the medium pH typically takes at least two days to stabilize from the limestone addition alone and may take up to 2 weeks to be fully reacted. But why is that?

For dolomitic limestone to "react" and adjust growing medium pH, three criteria need to be met: proper moisture, time and temperature.

- Moisture content—Mixes are produced at 35-50% moisture-moisture does affect solubility of lime. Limestone must be solubilized in order to "react". The moisture content of unused growing media is usually not high enough for the liming reaction to come to full stabilization.
- Time of delivery—It takes a period of 2-3 weeks after production for pH to completely *stabilize under typical greenhouse growing conditions*. Delivery of products in relation to time of production vary, therefore it is difficult to predict pH levels at time of delivery.
- Temperature—Product may be exposed to freezing temperatures in transit which will affect the lime reactivity and it's ability to increase pH.

This means that growers who make decisions on the pH of unused growing medium are making decisions on media where the liming reaction in many cases has not come to "reasonable completion".

There are many points that need to be considered when attempting to assure a proper medium pH range—Considerations that Sun Gro employs and monitors during formulating and producing our growing medium products…

- We have conducted extensive research to determine the best rate and particle size of dolomitic limestone to adjust pH over time, while providing adequate Ca and Mg and buffering capacity for the duration of the crop cycle.
- Lime is routinely inspected when it is received and before use in growing media.
- We have several checks and balances in our production facilities to ensure that the quantity of lime added to the media is accurate and consistent.
- Dosage and run rates are recorded for each product run and kept on file for review by the quality control coordinator, production manager and technical specialists.

There are two more things that need to be considered. Firstly, how you measure pH. The method of pH measurement has a profound effect on the pH reading of a mix. This is a well-known and documented fact. Sun Gro employs the 2:1 distilled water to soil method of preparing mixes for pH measurement using state-of-the-art and well accepted pH measuring equipment. Deviating from this method invariable causes differing pH readings which then may lead to the incorrect disposition on the suitability of a mix. Secondly, and almost as significant, the irrigation solution applied to the crop affects the medium pH and often has the primary effect on medium pH. Growers need to be aware of the influence their fertilization program has on the medium pH before arbitrarily judging where the pH of an unused medium needs to be.

Logically, the most reasonable way to assess the suitability of a growing medium is to wet out the mix with the irrigation solution to be used and measure medium pH using a standard method after 2 to 3 days.

The question asked in many cases is if the lime source or rate can be tailored to their particular situation. Sun Gro can offer the customer reduced or increased lime mixes: however, the grower should understand that there will not likely be a great rise or fall in pH with increased lime addition and a lower buffering effect on pH with a decrease in lime addition.

It is our general recommendation that growers adjust their fertility regime (including water quality control) rather than the lime rate in the mix. Only when the grower is unable to adjust their fertility regime to control pH should there be a change in the lime rate.

~Prepared by the Sun Gro Technical Team (Zoel Gautreau, Dan Jacques, Kathryn Louis, Nancy Morgan, Connie Proceviat, Shiv Reddy, Mark Thomas, Rick Vetanovetz, Ron Walden

Impress Your Friends

Here is a technical quip to help you feel smug at those open house cocktail parties.

If you hear of any plant growing problem, say: 'I bet it is pH.' Odds favor you, as in university and industry circles, the general consensus is that 3 out of 4 growing problems are pH related.

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