

Soilless Media: Practices Make Profit

This is the first installment of a series on the best management practices for soilless media. The authors are technical specialists from major media manufacturers and suppliers or consultants in the industry. Although in competition for business, the authors are united in their knowledge that profit-making plants are produced each year through careful media management. Part I looks at the five major media components and their properties, as well as buying manufactured media versus mixing your own.



Coir (right) has a slightly lower nutrient-holding capacity than Canadian sphagnum peat moss (left). It also has high water-holding capacity and excellent aeration.

Photo courtesy of The Scotts Co.

by SHANNEN FERRY, RON ADAMS,
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PAUL SCHILL, and BOB STEINKAMP

THE primary purpose of a soilless mix is to provide a lightweight substrate that holds water and nutrients, permits gas exchange to and from the roots, as well as mechanical support. Many different components can be used to formulate soilless mixes, and historically, we tend to define a mix by the type of components used rather than the physical and chemical environments created by the mix when used by the grower.

It is a common misconception that desired characteristics of the mix can be obtained solely by the appropriate blending of mix components. Blending mix components is only one of many

factors that ultimately affect the container environment. Growers should focus on media properties that provide for the plants' needs (water retention, air space, pH, fertility) rather than the components themselves.

Methods of pot or flat filling, pot size, initial watering practices, and quantity and type of media amendments play significant roles in determining the plants' ultimate physical and chemical environment.

Soilless mix manufacturers have the responsibility to provide growers with a predictable starting point, but 75% of the responsibility for establishing the physical environment and 90% of the responsibility for establishing the chemical environment of a container on a greenhouse bench is determined by the grower's management practices.

Media Components And Their Properties

There are five major components used by professional mix companies for greenhouses in the U.S. and Canada today. These are peat (mostly Canadian sphagnum peat moss), bark (aged or composted), coir, perlite, and vermiculite. Other components also are used, but mainly in more regional mixes.

Additionally, lime, a wetting agent, and a nutrient charge (in most, but not all mixes) are commonly added to professional greenhouse mixes.

1) Peat. Canadian sphagnum peat moss (CSP) is the most commonly used peat in greenhouse media, and it will be the one discussed here. CSP is harvested from bogs across Canada. It generally has a pH range of 3.0-6.0, with most of it on the lower end of that range. Generally, soluble salts are

below 0.1 mmhos/cm³.

The organic content of CSP is from 90%-99%, with high nutrient- and water-holding capacities, along with a relatively low bulk density. Moist CSP will readily absorb water, but as it dries, it will tend to repel water. That is why mix companies use wetting agents, which help the mixes take up and evenly distribute water.

Because CSP is harvested in various bogs across Canada, there will be some variability in the CSP from one location to the next. Mix companies will test and adjust for some of these differences. That is also why mixes made by the same company, but from different locations (East versus West, for example) will sometimes have slightly different physical and chemical properties.

2) Bark. The most common bark source for greenhouse mixes is softwood barks (i.e., Southern pine bark and Northern softwoods). Bark tends to increase bulk density, along with slightly increasing air space and decreasing water holding of a mix. Many studies have shown that properly composted bark has a potential for imparting some disease resistance.

Bark used in greenhouse mixes is generally either aged or composted. This can be confusing at times as, in reality, both types of bark do compost.

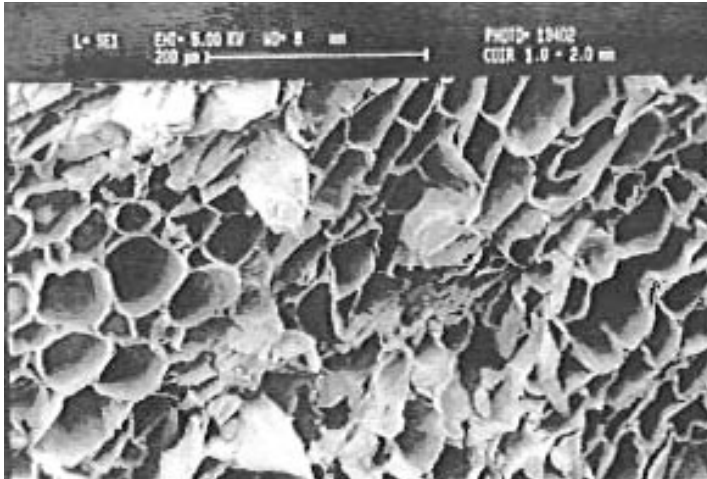
However, in the mix industry, the "composted" bark is composted in a more controlled process than "aged" bark. Generally this is done by adding some type of nitrogen source and then turning the pile frequently to enable aerobic conditions to continue, which allows for more even and quick composting. This type of bark has been shown to impart some disease resistance for plants grown in mixes made with it.

Aged bark is turned less often and is usually piled in higher and larger piles. This tends to cause more anaerobic conditions. However, all companies will test their bark, whether aged or composted, to be certain the bark has composted adequately to prevent overheating or excessive nitrogen draw.

Bark generally will have a pH in the range of 5.0-6.5, with a relatively low soluble salts level, similar to that of CSP. Mixes made with either type of bark will be suitable for plant growth because the mix companies have tested the barks prior to incorporation into the mix.

All bark mixes will tend to require a higher level of fertilizer in comparison to a similar CSP mix due to nitrogen draw by the bark. Many companies will add a nitrogen source (usually urea formaldehyde) to help decrease the level of nitrogen draw by the bark mix.

3) Coir. Coir is a by-product of the coconut fiber industry and is produced primarily in Sri Lanka, the Philippines, Indonesia, Mexico, and parts of the Caribbean and South America. The coir used in



Spongy texture of coir granule as photographed under an electron microscope. Photo of ScottsCoir® courtesy of the The Scotts Co.

greenhouse mixes is produced from the "dust" that is left after the fiber is processed for products such as mats, furnace filters, and rope. It has a pH range of 5.5-6.5 and a soluble salts level that is somewhat higher than CSP and bark.

Coir has a slightly lower nutrient-holding capacity than CSP, but it contains higher levels of sodium, chloride, phos-

phorus, and potassium than CSP. Some sources of coir can have high levels of chloride (up to 700 ppm), but the coir used by mix companies generally has much lower levels. The higher chloride level in coir as compared to CSP has not posed a problem.

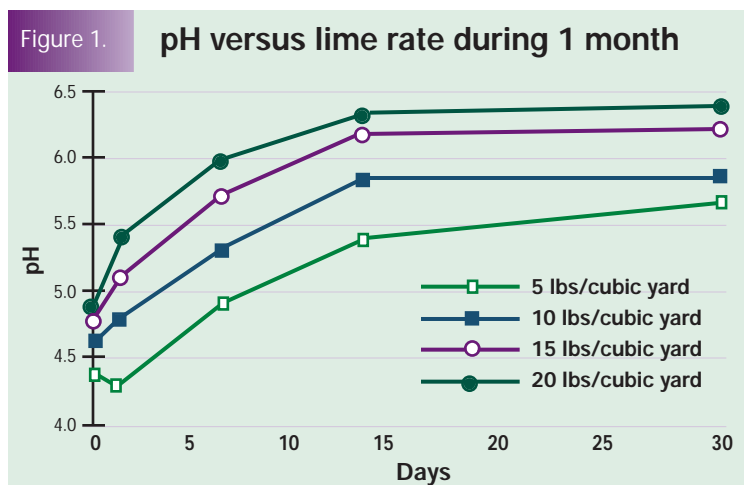
Coir has very high air- and water-holding capacities and readily absorbs water. Trials done with coir-based media show growth similar to CSP and bark-based products. Because of coir's lower nutrient-holding and higher water-holding properties, some adjustments in watering and fertilization regimes may be needed.

4) Vermiculite. Vermiculite is a micaceous mineral that is expanded in a furnace, forming a lightweight aggregate. It has a good nutrient-holding capacity and provides both air space and water-holding capacity to the mix, along with additional potassium, calcium, and magnesium. Vermiculite tends to be slightly basic. It is a fragile material and can tend to break down with improper or excessive handling. It also can break down over time because of the effect of watering on the media.

5) Perlite. Perlite is a mineral that is also heat expanded. The resulting product is a white, lightweight aggregate. Perlite is used to increase air space and will not hold water like vermiculite. It has little effect on pH or fertility, other than the dilution effect for fertility of a mix.

A Guaranteed pH?

Manufacturers often receive calls from frustrated growers who wonder why the pH of their medium is too high or



low. The grower often believes the manufacturer used the wrong amount of lime. During the conversation it is often discovered that the water source and fertilizer program contributed to the problem. Too many people still believe the manufacturer controls the pH of the medium. The fact is that the amount of lime added has only a small effect on the pH of media in use.

An experiment was conducted to determine the effect of various lime rates on a peat-lite mix for a month. Lime rates were 5, 10, 15, and 20 pounds per cubic yard of mix. The mix was thoroughly wetted. Results are shown in Figure 1. There was only a $\frac{1}{2}$ -pH unit difference immediately after mixing and about the same variance a month later.

Lime is added to soilless mixes to neutralize some of the acid from peat or bark and to buffer the pH. Other ingredients, such as vermiculite and coir also affect the starting pH and add some buffering. People often talk about the buffering capacities of particular media. However, the truth is that soilless mixes are not well buffered against pH change. So who or what does control the pH?

pH is a dynamic system, which means that it is a moving target. There is no way to set it and forget it. Soilless mixes should be thought of as hydroponic systems. Everything that is added to the system before and after planting can affect the pH – including the plant itself. One of the biggest factors is the alkalinity of the water used for growing. The effects of alkalinity will be discussed in detail in another part of the series.

Soilless mixes are not inert. From the day of manufacture, there are changes occurring in the mix. Moisture in the mix causes the lime to start dissolving slowly; pH starts to rise. Microbial activity in the media consumes the nutrients, which can

also affect the pH. Heat and age have their effects as well.

Within 6 months to a year after production, the pH of the mix might rise from 5.3 to 6.5 or higher. The electrical conductivity (EC) level can decrease from 1.6 to 0.4. Wetting agents also deteriorate with time. There is little the producer can do to prevent these changes.

Taking Control Of The Crop

What can the grower do to ensure consistency in the crop?

- 1) Water in newly planted crops with an appropriate fertilizer.
- 2) Do not buy mix too far in advance of expected use.
- 3) Test the pH and EC of each batch before use and respond accordingly. This test is best followed up by testing with a professional lab after 2 weeks in use to determine the effect of current practice.

- 4) Monitor pH and EC regularly throughout the crop. Conduct appropriate testing through a professional lab.

It is said that knowledge is power. By knowing the limitations of growing mixes, growers truly can take control of the crop.

Manufactured Media Versus Mixing Your Own

Most growers have struggled with the decision to buy a ready-to-use mix rather than mixing their own. They follow the old adage “If you want something done right, do it yourself.” Yet, how many growers make their own fertilizer or build their own greenhouses?

Blending numerous ingredients of various volumes and textures into a homogeneous mix is a highly technical process. Some growers have spent a lot of money on sophisticated equipment and do a pretty good job of it. Others have looked only at the cost of ingredients before deciding that it's cheaper to make their own mix. Let's look at some of the considerations.

Equipment, if adequate for the job, is expensive and requires regular maintenance. Some growers blend

their mix with a tractor and bucket. Others use old cement mixers. Studies have shown that these techniques do not blend media uniformly enough for use in small pots and packs. Small volume ingredients, in particular, will not be evenly distributed. These methods are more likely to damage the components. Batch mixers made for soil mixing do an adequate job, if properly used. But overmixing or adding too much water can adversely affect the properties of the medium.

Personnel who can be trusted to follow the recipe and understand the importance of the task are also expensive and hard to find. Many growers prefer to do it themselves. Couldn't the time of a valuable employee or owner be put to better use in the growing and management process? Who is watering or supervising the crew while the boss is making soil?

Ingredients are only part of the total cost of a mix. Many growers look at only the bulk ingredients when figuring the cost of homemade media. Nutrient and wetting agent costs can be significant, not to mention labor, overhead, and equipment. Inside storage of the dry ingredients also can be an issue.

Hidden costs are rarely considered. If the mix is inconsistent, uneven quality will reduce the value of the crop. When a mistake is made in a batch, crop loss might cost more than the grower saved on the mix. Very few growers, if any, perform the quality control that media manufacturers do.

Plugging all these factors into the equation might make a grower wonder how much money is saved by mixing at the nursery instead of buying a quality manufactured medium. Then there's the peace of mind that comes from knowing that a professional team stands behind the mix in the bale or bag. GG

About the authors: Shannen Ferry is a technical manager, The Scotts Co.; Ron Adams is the technical manager, Ball Horticultural Co.; Dan Jacques is the grower specialist, Eastern region, Sungro Horticulture; Bill McElhannon is a consultant, MMI Laboratory; Paul Schill is the grower services director, Premier Horticulture; and Bob Steinkamp is the technical services manager, Fafard.

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by SHANNEN FERRY, RON ADAMS, DAN JACQUES,
BILL McELHANNON, PAUL SCHILL, and BOB STEINKAMP

WHEN it comes to today's soilless mixes, industry people have come to realize one size does not fit all. Indeed, growers have to make a conscious media formulation choice based on crop need and the smartest management practices.

Once a particular product is chosen, there are chemical and size options to consider. Research shows crops such as pansies or pentas need different growing pH levels. Zonal geraniums have higher pH requirements than petunias. Plug seedling mixes require a finer media texture to manage the moisture level. Too fine a mix in a tub will increase the chance of root rot when grown outdoors during a wet period. Watering methods also will help determine mix texture.

Table 1.

Soilless Media Usage Options



	Plug trays	Cell packs	Pots 4"-8"	Hanging baskets & large pots	Tubs & planters
Fine texture	✓				
Medium texture		✓	✓		
Coarse texture			✓	✓	✓
Extra coarse texture			✓	✓	✓
Low pH	✓	✓	✓	✓	✓
High pH		✓	✓	✓	✓
Low charge	✓	✓	✓	✓	✓
Slow- or controlled-release fertilizers		✓	✓	✓	✓
Chemicals*		✓	✓	✓	✓

*Fungicides, insecticides, or hydrophilic polymers

Media requirements for ebb and flood irrigation are different from overhead irrigation or tube watering. Listed in the tables are options to show the complexity of the task.

Trialing New Media

Before changing growing mix, test the new product to determine its suitability. The mix sample size is an important consideration. If too small a sample is trialed, the benefits might not be apparent.

If the texture is different, then watering is compromised with small sample populations. Any mix test should be large enough to water and feed the sample by itself. Ideally, a whole bench of product would make a good sample size.

Cost is always a consideration when comparing mixes, but finished plant quality and the number of finished plants are even bigger considerations. Just because a particular mix works in one operation does not mean it is a perfect fit for another operation. It should only be considered after adequate testing.

Manufacturers' Lot Numbers

Should a grower be concerned with manufacturers' lot numbers? The answer is yes *and* no.

Yes, growers need to know that specific lots of production can be identified if necessary. But in most situations, growers never need to look up a lot number for a mix.

Lot numbers are developed by producers to track production. If a complaint is filed against a particular product, then the producer can verify when the mix was produced. Each company develops a code that uniquely indicates production information.

Media Storage

Most producers would prefer to use the mix within 3 months of production. Follow a mix manufacturer's recommendations when slow- or controlled-release fertilizers are incorporated to prevent soluble salt buildup.

There are several elements of a mix that can change during storage. Longer time spent in storage means the mix will have a greater chance of drying out. And when the mix is dried

Table 2.

Size Options

Mix companies have many different packaging options available to suit growers' needs. Check with your supplier to see which are available in your area.

- 2 cubic foot loose
- 3 cubic foot loose
- 4 cubic foot loose
- Bulk bags
- Bulk trucks
- 3.8 cubic foot compressed bale
- 6 cubic foot compressed bale
- Super bale

out, it's more difficult to wet after filling containers.

Storing bulk mix requires greater protection than packaged product to prevent contamination from weed seeds, insects, and diseases. Ideally, a packaged mix should be stored on pallets off the ground. There should be good air circulation around and through the bags or bales.

Product stored in direct sun can develop a slime mold in the area between the mix and the bag where condensate forms. Molds that are brown, yellow, red, or white can develop in the product during storage. These molds are saprophytic and are not plant pathogenic. The saprophytic molds normally disappear within a couple weeks after planting.

Storage also can cause chemical changes, such as a pH increase along with a decrease in soluble salt and nitrogen levels. It is advisable to test any product that has been stored for 6 months or longer to determine what changes have occurred and compensate for any change.

Avoid Overhandling

Commercially prepared growing media are formulated with certain built-in aeration and water-retention properties. After repeated use, growers develop a watering rhythm that allows the anticipation of watering needs. But it is important to know that handling mixes with potting machines, flat fillers, or other handling

systems can alter aeration and water retention.

Growing media's various components are somewhat fragile. During handling, media are subject to a grinding effect caused by stirring and agitation. This grinding effect causes particles to break up into smaller pieces, which brings increased water retention and decreased aeration. Perlite and vermiculite are most affected by this grinding effect. Peat moss and bark also are affected.

Often, when mixes are handled frequently, damage occurs. Wet or otherwise heavy mixes are subject to particle breakdown. The most damaging equipment are mixers and screw conveyors.

Some growers add granular fertilizers or other additives to the mix using a drum mixer or ribbon blender. Tumbling action in these mixers causes a severe grinding effect. The mixer should be run only long enough to stir the additive. Any additional run time unduly damages the mix.

Screw conveyors can be very damaging to wet mixes. Even belt conveyors can cause damage to a heavy or wet mix. Overloading pot or flat fillers, or bale busters can be damaging to mixes containing vermiculite or perlite.

Mixes that have been damaged by overhandling can feel greasy or appear to be coated in vermiculite dust. Often, the damage is not uniform. Overhandling can cause uneven drying that is particularly noticeable in cell packs and smaller pot sizes. While all mixes can be damaged by excessive handling, those containing higher per-

Volume Considerations

When determining growing medium usage needs, growers should think in terms of the number of bags needed to do the job. Most mix companies provide charts that show the pot count per cubic foot or per cubic yard for various container sizes. These charts only provide a rough estimate because many factors affect the number of containers that can be filled with a given amount of mix.

centages of vermiculite or perlite are most susceptible.

Avoiding Weed Problems

Greenhouse weed infestations can develop quickly. Common greenhouse weeds like oxalis and bittercress grow quickly and each plant produces hundreds of seeds that can spread many feet from the parent plant.

Aside from obvious sources like weeds under a bench, the source of weed seeds can be hard to pin down. Weed seed can blow in through vents or come in with liners. Seeds can blow onto and stick to empty pots. Growers who irrigate with pond water can have weed problems caused by seeds blowing into the pond. But whatever the seed source, remember only a few weeds allowed to go to seed can result in a major infestation.

Volume Considerations

When determining their usage needs, growers should think about the number of bags or cubic yards needed to do the job. Most mix companies provide charts that show the pot count per bag or per cubic yard for various container sizes. At best, these charts provide a rough estimate.

Several factors affect the number of containers that can be filled with a given amount of mix. The most important factor affecting the pot count is the actual amount of mix that goes into each pot.

Because of its spongy texture, mix is easily compressed. During potting, mix can either be loose filled into the container or packed with varying degrees.

Compared to loose filled, even light to moderate packing can reduce the pot count by 10%-25%. The amount of packing that occurs varies by pot-filling method. Probably the most variation happens from hand potting by workers whose techniques vary. Potting machines pack consistently if the adjustments are not changed be-

Weed Control Strategies

1 Store bagged growing mix and pots inside to minimize contamination. Weed seed can stick to pots or to the outside surface of a mix bag. Weed seed also can get into unopened mixes through the bag's small vent holes. Keep bulk mixes covered. All it takes is one gust of wind for weed seed contamination to occur.

2 Control weeds around the outside of the greenhouse, particularly near doors, fans, and other openings. Weed seed can stick to shoes and clothing and can be tracked inside.

3 Control weeds under benches and in hanging baskets.

4 Constantly scout crops for weeds and never pass a weed without pulling it. A few weeds allowed to go to seed in the greenhouse cause the majority of infestations. Common greenhouse weeds can go from seed to seed in 3 weeks, and each parent plant can produce hundreds of fresh seeds.

tween runs. But several other factors affect the pot count even if a potting machine is used.

The mix's degree of moisture can affect the pot count. Some growers moisten a mix before use. When a somewhat dry mix is moistened, the particles absorb water and plump up, increasing the mix's volume. The pot count from moistened mix can be somewhat higher than the dry mix's. But if too much water is added and excessive stirring occurs, the peat fibers collapse and the mix loses some of its premoistened volume. This reduces the pot count compared to the drier mix.

Most bagged and bulk mixes contain about 50% moisture when manufactured. Baled mixes and peat moss

are somewhat drier but still contain moisture. As the material sits in storage, it can dry out. As the mix dries, particles shrink a little and the mix loses some of its original volume, reducing the pot count compared to a fresh mix.

Baled mixes and peat moss are compressed 2:1 when packaged, and the pot count can be affected by how the material is loosened. While it takes a lot of work to fully decompress bales that are fluffed out by hand on a potting bench, mechanical bale busters will fully decompress bales of peat or mix.

A higher pot count may be obtained by using a bale buster. But an overloaded bale buster can pound the mix or peat into dust and actually reduce the pot count and alter the material's physical properties.

Mixes that contain a high percentage of bark do not compress as easily as mixes with a high peat moss percentage. On average, a higher pot count can be achieved with bark mixes rather than peat mixes.

When figuring mix usage requirements, do not rely on pot fill charts to determine the amount needed. Instead, take a measured volume of mix and fill pots as usual. The pot count from this measured volume will give a much closer estimate of actual mix usage. GG

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Correction

A photo on page 28 in Part I of this series on soilless media (July) was incorrectly identified. The coir is on the left side, and the Canadian sphagnum peat moss is on the right.

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Meters like the Myron L Ag-5 are used to measure the electrical conductivity (EC) of media extracts and water and fertilizer solutions.

by SHANNEN FERRY, RON ADAMS,
DAN JACQUES, BILL McELHANNON,
PAUL SCHILL, and BOB STEINKAMP

SALTS are chemical compounds consisting of positively and negatively charged particles called cations and anions. These ions can be strongly or weakly held together, which is what determines salt solubility. Common examples of salts are sodium chloride (table salt), magnesium sulfate (epsom salt), and potassium nitrate (saltpeter).

Soluble salts in horticulture are usually measured by their electrical conductivity (EC). The values are expressed as millimhos per centimeter (mmhos/cm), deciSiemens per meter (dS/m), or milliSiemens per centimeter (mS/cm). They are equivalent units of measure.

The EC measurement alone does not indicate the types of salt in irriga-

tion water. But this measurement can provide a good indication of the total amount of fertilizer being applied.

Testing The Waters

Water used for crop production is the first place to look for salts. There is tremendous variability in North American water quality – from very alkaline water with high mineral content to water that is almost as pure as rain. The first example might have an EC of 1.2 mS/cm, while the latter might be less than 0.2 mS/cm.

Water from different sources on the same property can be just as different. In general, surface water – a pond, river, or shallow well – will have lower salt content unless it contains runoff salts from agricultural fields or greenhouses. Deep well water quality depends on the aquifer or water source. Shallow wells and rivers near the coast might have high levels of

sodium, chloride, and alkalinity. The only way to know is to test the water regularly.

Testing the water more than once is important because water quality can change often. Check any of these variables that apply:

- wet season vs. dry season;
- high vs. low usage periods;
- unusual droughts; and
- city water that comes from various sources.

Ask the water authority to provide notification of changes and analysis.

Also, be sure to consider the water's EC when interpreting EC values for crops. If the salts in the water are unacceptably high for the crops grown, there are several possible remedies. Find another water source, such as city water. Install a reverse osmosis system to purify the water, or use a more open media and leach more thoroughly.

Growing Media Matters

Whether commercially manufactured or homemade, growing media usually contains relatively low levels of most nutrients. Typically, the EC is 0.75-2.0 mS/cm. Growing media also contains small amounts of nonnutrient minerals, such as sodium and chloride. And there are a few elements – calcium, magnesium, and sulfur – which could be fairly abundant.

Calcium comes from lime or dolomitic lime in most media. While it is the carbonate portion of this salt that provides pH buffering to the mix, calcium is a major nutrient that is often lacking in growers' water and fertilization programs.

Lime dissolves slowly, so calcium might not be readily available to the plant. Since solubility is low, conductivity due to lime will be low.

Dolomitic lime also will release magnesium.

Gypsum, another source of calcium, is much more soluble than lime, and it provides a more readily available source of calcium. It is also a good source of sulfur. Because of its solubility and the conductivity of sulfate, gypsum contributes more to the EC of the mix.

Dissecting Fertilizer

Fertilizer is one of the most significant sources of salts. Ideally, fertilizer should add only the nutrients the plant needs and in the exact propor-

tions required. Unfortunately, this is seldom the case.

Many formulations contain excess amounts of phosphorus. Also, some fertilizers contain salts like potassium chloride or sodium nitrate, which supply undesirable elements along with the nutrients. Plants use very little sodium or chloride.

All the salts from water, fertilizer, or media that are not used by the plant will be left in the soil solution. If they are not leached out regularly, they will accumulate.

Accumulated salts pose several problems. They make interpretations of EC values unreliable. The grower doesn't know whether the salts present are useful nutrients or undesirable elements. Also, high amounts of sodium and chloride contribute to plant stress and disease susceptibility.

The key to managing salts in media is choosing fertilizers that complement the water supply and provide the right balance of nutrients. Then feed constantly at a low to moderate rate to minimize the amount of fertilizer that might be leached into the environment.

If high salts in the water are a problem, more leaching will be required. In that case, choose a medium that leaches easily, and do not allow it to dry excessively.

Interpreting ECs

There are several methods common-

ly used to measure soluble salts, each with advantages and disadvantages. All require using distilled water to prepare the sample.

Most university and commercial horticulture laboratories use the Saturated Media Extract method (SME). One clear advantage of SME is that direct comparisons can be made to the results of a professional lab. This has been the standard for peat-lite media for many years, and it works equally well for bark-based and other soilless mixes. It is sometimes thought of as a 1:1 ratio of water to media, but this may not always be correct.

The method most widely used by growers is the 2:1 extract. In this technique, 2 parts of water are added to 1 part dried media. Since there is nearly twice as much water added to the media, the EC for the 2:1 sample will be roughly half that of the SME sample.

The 5:1 sample preparation is not widely used, but it reduces the need for a totally dry sample due to greater dilutions.

ECs for samples prepared using different methods must be interpreted using different standards. Since there is a difference in conductivity meters and preparation methods, correlation of on-site tests with those from commercial or university laboratories is necessary for best interpretation.

Table 1, prepared from various sources, presents comparisons between SME, 2:1, and 5:1 dilutions. Results may vary because of human error, so the comparisons are approximate. Make allowances according to the plant grown, the irrigation water EC, and the sampling interval following fertigation.

Certainly, watering in with a dilute, soluble fertilizer gets plants off to a faster start and evens out some of the media fertility differences.

Watering Frequency Versus Volume

Overwatering media causes oxygen depletion to the root zone. Overwatering occurs when water is applied too frequently. It should not be confused with thorough watering.

Thorough watering dissolves excess soluble salts and flushes them

Table 1.

Comparisons between Saturated Media Extract (SME), 2:1 extract, and 5:1 extract methods.

<i>Dilution Method</i>			<i>Interpretation</i> Depends on plant growth, water quality, and interval following fertigation.
SME	2 Water: 1 Media	5 Water: 1 Media	
Values given in mS/cm, mmhos/cm and dS/m			
0.74 mS/cm	0.24 mS/cm	0.11 mS/cm	Low.
0.75 - 2.00	0.25 - 0.75	0.12 - 0.35	Generally good for seedlings and salt-sensitive plants.
2.00 - 3.50	0.75 - 1.75	0.35 - 0.65	Good for established plants. Upper ranges may reduce growth of sensitive varieties.
3.50 - 5.00	1.75 - 2.25	0.9 - 1.1	Somewhat high, upper ranges might result in marginal burn. Do not allow to dry out.
Higher than 5.0	Higher than 2.25	Higher than 1.1	Very high potential for burn, root damage, and stunting. Wilt is likely.

SOILLESS MEDIA

MANAGEMENT PRACTICES

out while drawing air into the media from the top. Sometimes referred to as leaching, thorough watering establishes a healthy root environment. Depending on media EC, leaching can be done with or without fertilizer.

While growers in pure water areas may be able to practice “no leach” fertigation techniques, most growers who irrigate from the top of the container need to leach periodically to prevent soluble salt buildup. In particular, chloride and sodium salts may accumulate to damaging levels if thorough watering is not done.

Typically, 10%-15% of the volume applied should leach through the bottom of the container. In reality, growers may actually be leaching by 30% or more. Try not to waste water and fertilizer during this process.

Subirrigation via ebb and flood systems should typically use lower concentrations of fertilizer since the media is not often leached. The salts accumulate at a slower rate if water quality is good. If water quality is marginal, try periodic top watering on long-term crops to leach out accumulated salts.

Crop, season, media type, and greenhouse environment affect water and fertilizer solution application. Avoid watering during late afternoon unless the plants can dry off before nightfall. This helps discourage diseases.

Avoid severe wet/dry cycles. Disease expression and micronutrient toxicities are greater when plants are stressed in this manner.

Also, avoid withholding water for height control. Use total environmental control to accomplish this task. And check the weather forecast before watering during dark or cloudy weather. If media is not dry enough, overwatering may occur.

Examining pH

Media pH management is fundamental in greenhouse fertility programs. Container mixes have very limited buffering, and media pH values can change rapidly.

Solubility of mineral nutrients, particularly micronutrients, is dramatically affected by media pH. Iron, manganese, boron, copper, and zinc are

most soluble below pH 5.5 and may be available at toxic levels if the pH is below 5.0. For example, bronzing and chlorosis of geraniums and marigolds are closely correlated with the high levels of iron and manganese that occur with low pH values.

Molybdenum’s solubility is different from other micronutrients. Molybdenum availability decreases at low pH and increases at higher pH values. In fact, molybdenum deficiencies are more frequently observed at low pH values.

Even though optimum solubility of most micronutrients occurs at low pH, micronutrient deficiencies can also

grown across a pH range of 5.0-7.0, but optimum nutrient availability is achieved by maintaining media pH between 5.6 and 6.3.

Assessing Alkalinity

The alkalinity of irrigation water greatly influences media pH in greenhouse environments. Alkalinity makes irrigation water resist changes in pH. Irrigation waters with medium to high alkalinity may cause the media pH to increase over time.

But how much alkalinity is too much? Unfortunately, there is no consistent answer for this question.

Table 2. Values for common greenhouse fertilizers with potential acidity or basicity

<i>Formulation</i>	<i>Potential Acidity or Basicity</i>	<i>Formulation</i>	<i>Potential Acidity or Basicity</i>
21-7-7 Acid Special	1556 acidic	15-5-25	37 acidic
9-45-15	977 acidic	15-5-15	141 basic
20-20-20	547 acidic	13-2-13	220 basic
20-9-20	510 acidic	14-0-14	220 basic
20-10-20	394 acidic	15-0-15	380 basic
21-5-20	389 acidic	15.5-0-0	400 basic
15-16-17	196 acidic	13-0-44	460 basic
17-5-24	125 acidic		

occur. Conditions that promote optimum solubility are also conditions that promote rapid nutrient leaching from the container. At low pH, hydrogen ions saturate media exchange sites and increase the potential for leaching losses of nutrient cations such as calcium, magnesium, potassium, and ammonium.

As pH values increase, the availability of iron, manganese, boron, copper, and zinc decrease, and micronutrient deficiency symptoms may occur. There is a great deal of variation in plant response to high pH, but a number of plant species will begin to exhibit high pH-induced micronutrient deficiencies when media pH is above 6.5. Chlorosis (yellowing) of the upper portion of the plant is often caused by high media pH.

Simply lowering the media pH, rather than adding supplemental micronutrients, is often sufficient to alleviate this problem. Many plants can be

Acceptable alkalinity limits vary with plant species, media, irrigation methods, and fertilization programs.

If growers have difficulty preventing media pH from increasing to problem levels, then the alkalinity is probably too high for the species, media, and fertility program used. If media pH is consistently too low for the crops grown, alkalinity may be too low for the media and fertilizers used.

Acid injection is the only economical method of controlling high water alkalinity. An excellent computer program for calculating the appropriate amount and type of acid to use is available through Allen Hammer, of Purdue University’s Department of Horticulture, or Douglas Bailey, of North Carolina State University’s Department of Horticulture.

Managing Media pH

Frequently, growers effectively man-

age media pH values with their fertility programs. Fertilizers can have either an acidic or basic residual effect.

The acidifying effect of ammonium- or urea-containing fertilizers can be used to lower media pH. Nitrification of ammonium and urea to nitrate nitrogen releases hydrogen ions that can reduce media pH.

Additionally, when plants absorb ammonium, a surplus of hydrogen ions is generated inside the plant and released into the media solution. This causes media pH to decrease.

Basic fertilizers, which contain high levels of nitrate nitrogen, calcium, and/or magnesium, can be used to increase media pH. But some fertilizers, like poinsettia finishers, may have a neutral reaction. The potential acidity or basicity is stated on the fertilizer label. Values for some common greenhouse fertilizers are listed in Table 2.

Other variables affecting media pH are mix components and the amount and particle size of limestone amendments. Most professional mix companies have determined the amount of lime required to get target pH ranges with the components used. National mix producers, though, must target pH ranges that are acceptable for *most* crops in *most* locations.

But limestone amendments may be too much or too little when growers have very high or very low water alkalinity or grow crops that require pH

Postplant Management Of Media pH

To Lower pH

1. Use more acidifying fertilizers.
2. Acidify irrigation water to pH 5.8-6.2 using acid injection.
3. **Iron Sulfate:** 4-6 pounds per 100 gallons of water. Apply 1 quart per square foot or 8 fluid ounces per 6-inch pot. *Be careful not to use this on crops subject to iron toxicity.*
4. **Elemental Sulfur:** 0.75 pounds per cubic yard or $\frac{1}{3}$ teaspoon per 6-inch pot. Use media biological activity to make this solution work.

To Raise pH

1. Discontinue acid injection and allow water alkalinity to increase media pH.
2. Use fertilizers with lower potential acidity or higher potential basicity.
3. **Flowable limestone drench:** (a) calculate the number of flats or pots filled per cubic yard and drench with 2-3 pounds. Works best with a 1:15 proportioner; or (b) mix the container of flowable limestone with water in equal parts and apply using a 1:100 injector ratio. This should cover 135 square foot to a 4-inch depth.
4. **Potassium bicarbonate drench:** 1-1.5 pounds per 100 gallons of water.
5. Top dress with a fine grind of dolomitic limestone.
6. Calcium hydroxide drench.

values differing from typical plants. Particle size and solubility of added lime have a significant effect on the rate of reaction once the mix is wet.

Some limestone sources are very insoluble. Generally, the finer the lime, the faster pH adjusts. Very fine limestone works well with most short-term greenhouse crops. Many growers who want to make long-term improvements use blends of fine and coarser limestone to maintain desired pH levels with long-term crops.

Some pH problems can be avoided by choosing the appropriate preplant mix amendments. Limestone is added to soilless media to raise the pH and add calcium and magnesium. Growers with very high water alkalinity may benefit from the addition of no or low levels of limestone.

Gypsum can be used to add calcium with no effect on media pH. Magnesium can be incorporated in the fertility program. Stock plants or other long-term crops may require more limestone than is necessary for production of the same plants with a shorter production cycle. GG

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Soilless Media: Practices Make Profit

This is the last article in a series on the best management practices for soilless media. The authors are technical specialists from major media manufacturers and suppliers or consultants in the industry. Although they compete for business, they are united in the knowledge that profit-making plants are produced each year through careful media management. Part IV looks at media testing.

by SHANNEN FERRY, RON ADAMS,
DAN JACQUES, BILL McELHANNON,
PAUL SCHILL, and BOB STEINKAMP

SAMPLING your soil means knowing where your crop has gone and where it is heading. It certainly is an investment. But to maximize this investment, you should get acquainted with how to do sampling in-house or through laboratories and learn how to interpret your results.

Most soil mix companies have their own laboratories, or they contract out with professional laboratories that specialize in soilless media testing. Professional labs' testing procedures are designed for media containing less than 30% field soil and are conducted using the saturant media extract method (SME).

The SME is a water extraction, while field soil analyses are primarily done by grinding the media and using an acid extraction technique. The results are quite different and are not interchangeable with the SME. And pH readings taken on a slurry are typically lower than those taken in the extract.

In addition, it's vital for growers to choose a laboratory and stick with it. Because of differences in procedures and equipment, results may differ. Professional mix companies may offer technical support to help you interpret your lab analyses.

When you ship out your samples, make sure to include all pertinent information, including your fax number. The biggest delay in receiving complete

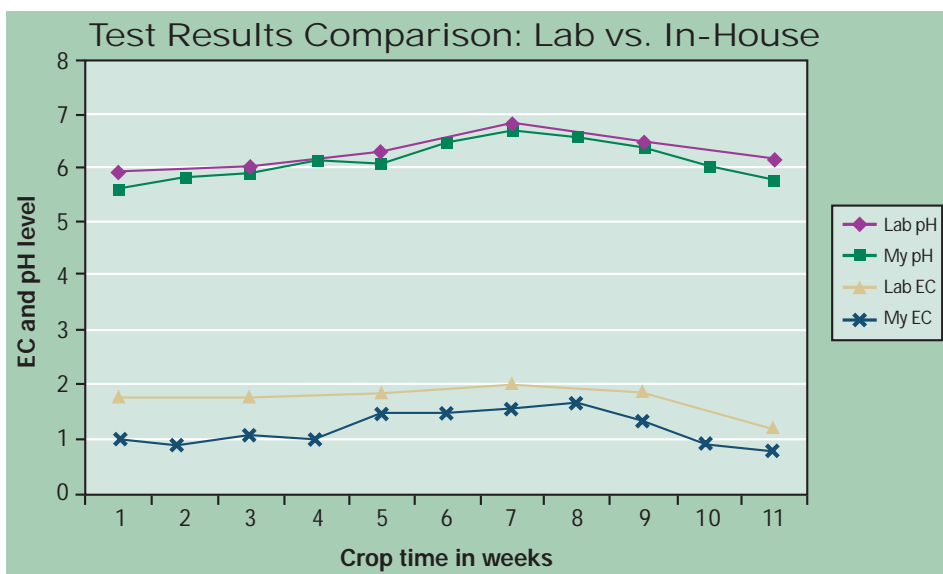


Figure 1. Grower's own weekly EC and pH test results (My pH, My EC) plotted along with bi-weekly lab test results should show similar results from each source.

analyses occurs in getting the sample to the lab. Ground transport via the postal service or UPS may take as much as 1 week for delivery. Overnight or expedited services are fastest.

Once samples arrive at the lab, testing is usually done quickly and results are faxed. If you do not have a fax, get one or access a local service. First-class mail may take 1 week to get a sample to the lab and 1 week to deliver the results. There's no question that 2 weeks could make a difference in your crop's success.

Sampling Methods

Media analyses are snapshots of a particular media at a particular time. A single analysis is not enough for making sound decisions.

It's important to follow the sampling procedures outlined by your lab. For most container media, sample 8-10 pots of the same plant type. Take a top-to-bottom profile of the media from that container (or where there is active root growth) after removing the top 1/2 to 1 inch of media where salts are concentrated.

Pool these samples, remove large masses of roots, and send the required quantity – usually 1-2 cups – to the lab. The sample's moisture content isn't critical to the SME procedure, so media doesn't have to be dry.

A common zippered lock plastic bag, well-labeled, can substitute for an official laboratory sampling container. But be sure to tell the lab if controlled-release fertilizers or fungicides were used

SOILLESS MEDIA

MANAGEMENT PRACTICES

with the media. These may affect the interpretation of the salts (EC) readings.

It's Test Time

For high-value crops, testing every 2-3 weeks is fine as long as weekly tests are done on-site. Samples should be taken at the same interval after fertigation and sent quickly to the lab.

Test a portion of that same sample using in-house equipment and correlate those results with the lab's (see Figure 1, page 36). The values will probably be different, but test results should be consistently different.

In problem situations, appropriate comparative sampling between affected and unaffected media and plant tissue can determine if the cause is nutritional. Tissue sampling without corresponding media sampling is almost worthless. Both are needed to make accurate assessments.

If the results don't provide a definitive answer, then examine your environmental or cultural practices. Not all problems with crops result from "bad media."

The recent trend toward "pour-through" sampling requires growers to develop comparative databases for conventional testing results vs. pour-through results. There is no universal set of reference points at this time for

pour-through analyses. All growers must develop these for their particular operation in cooperation with a professional lab.

In-House Testing

Every professional greenhouse and nursery should have a method of testing pH and soluble salts. EC comes from many sources, so verifying the source of the salts needs to be done periodically.

EC and pH can't be accurately measured in the container. It is important to sample uniformly and consistently so that the only variables in the process are the changes in media chemistry.

Soluble salts are best measured by EC meters. Meters which read in total soluble salts or total dissolved solids require conversion of those figures before interpretation.

Reliable EC meters are available for less than \$200, including calibration solutions. Good pH meters are available in this price range, as well. pH "pens" will need periodic electrode replacement. But keep in mind that measurements are practically useless if this equipment is not carefully calibrated and maintained.

Many university researchers and industry consultants recommend testing major crops in-house weekly (see Figure 2). Generally, the pH and EC give growers a good idea of the crop's nutritional status.

The specific source of the soluble salts and the plant nutrition can be obtained through periodic samples submitted to the professional lab. Then growers can graph the results to better track the crop's nutritional progress.

Graphical Tracking

Graphical test results from the lab and from in-house testing provide a picture of your crop's past and its likely future. Graphical tracking makes it easier to see if lab and in-house tests are in sync. It's also easier to relate past fertilizer applications or that stretch of cloudy weather to what's happening in your media.



Most professional soil mix companies have their own laboratories or contract with a professional laboratory that specializes in soilless media testing. Photo courtesy of Premier Horticulture.

The Final Analysis

The authors of this series on the best management practices for soilless media are all from different manufacturers. While growers expect quality products from the soilless media industry, the manufacturers expect growers to understand their media, its properties, and its best management practices.

Soilless media are dynamic systems. The raw materials are somewhat variable, the growing conditions in which they are employed change yearly, and the very plants that are grown in them have an effect on the physical and chemical changes that occur. Yet, through careful monitoring and effective management those same media are the foundation for a very healthy industry.

In the future look for even more combinations of materials and additives developed to satisfy environmental and market demands. And remember that change requires adjusting one's habits and systems, and it requires testing and understanding the product. GG

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Week No.	Lab pH	My pH	Lab EC	My EC
1	5.96	5.6	1.8	1.0
2		5.8		0.9
3	6.01	5.9	1.8	1.1
4		6.1		1.0
5	6.33	6.1	1.9	1.4
6		6.5		1.4
7	6.80	6.7	2.1	1.5
8		6.6		1.6
9	6.50	6.4	1.9	1.3
10		6.1		0.9
11	6.20	5.8	1.3	0.8

Figure 2. Recording results from weekly in-house tests and periodic lab tests shows crop history and makes graphical tracking easy.