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Understanding Soilless Media Test Results and Their Implications on Nursery and Greenhouse Crop Management

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Soilless media, sometimes called growth media or substrates, are one of the most important components of crop production in containers or raised beds with restricted volume. The word media is the plural of medium. The physical and chemical properties of media greatly influence optimal management protocols. Primary components of these media may be peat, pine bark, perlite, vermiculite, compost and/or perhaps coarse sand. Understanding the chemical and physical properties of optimal media, or the chosen medium for a production system, allows more effective system management. Although choosing or formulating media with optimum physical properties (such as pore air space and water holding capacity) for a given production environment and crop plant is important, this publication focuses on the chemical properties of soilless media determined with a laboratory test as conducted through the University of Kentucky Cooperative Extension Service at the Division of Regulatory Services Soil Testing Laboratories.

Timely and routine media tests provide valuable information to the crop production manager as decisions are made relative to a fertility program or changes in water source and quality before beginning a crop and during crop developmental stages. Samples may also be taken for analysis to help diagnose crop abnormalities.

Proper interpretation of results differs with method of nutrient extraction. Most commercial and university laboratories use a simple water extraction method for soilless media called a saturated media extract (SME) to obtain a solution for analysis of macronutrients. Since macronutrients are water soluble in soilless media, a water extraction is all that is necessary to evaluate the concentration available to plants. This method is unlike testing field soil, where nutrients are insoluble and various acids and chelates are present in the extract to dissolve a portion of the nutrients available to plants. Micronutrients are insoluble in soilless media due to binding to organic matter in the media. The complexed micronutrients are still available to plants, and DTPA (diethylenetriaminepentaacetic acid) in the extracting solution has been found to enhance the level of micronutrients extracted and the interpretation of sufficiency levels for plant growth. The DTPA extraction method was adopted as the method for soilless media by the UK Soil Testing Laboratories in July 2014. This method is different from field soil testing, in which chemicals in an extract solution act to dissolve nutrients from the solid phase. The field soil test methods are not used for soilless media.

Most media tests will include analysis for pH, electrical conductivity (soluble salts) and selected macronutrients, and some tests will include micronutrients. Below are general descriptions of these parameters.

- **pH** is the measure of the relative concentration of hydroxide ion (OH^-) and hydrogen ion (H^+) present in the media solution. pH is measured on a scale of 1 to 14, with 7 being neutral. Distilled or deionized water has a pH of 7. A pH below 7 is acidic, and a pH greater than 7 is basic. Most crops grow best in media with a pH in the range of 5.5 to 6.5.
- **Electrical conductivity** is used to measure total dissolved salts (free ions) in the media solutions. Soluble salts are detected by measuring the electrical conductivity of dissolved ions that conduct the electrical current through the water. Pure, distilled water does not conduct electricity. Electrical conductivity (EC) may be reported as mmho/cm, which is the reciprocal of the ohm, a unit of electrical resistance and the scientific standard for measuring EC. The metric equivalent for the mho is Siemens (S) (1 mmho/cm = 1 dS/m = 1 mS/cm). The level of soluble salts that is acceptable or optimum differs with each plant species but ranges from 1 to 3 dS/m.

- **Nutrients** are required within a range of concentration and in a proper balance with each other. The optimum concentration and ratios of nutrient ions differ between crop plants, but general ranges for a wide array of plants have been determined. Macronutrients are required in higher concentrations than micronutrients, but micronutrients are just as essential for optimum plant growth and development. Most media have some innate nutrients, and irrigation water may contain nutrients as well. However, the majority of nutrients are typically supplied by fertilizers. The fertilization program must be designed to meet crop needs and take into account any nutrients already present in the irrigation water.

Plant macronutrients included in most soilless media tests are nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na) and sulfur (S). Micronutrients often included in tests are boron (B), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu). Low growth medium pH increases the availability of most micronutrients and when extremely low can result in the uptake of toxic levels in some plants.

Sampling Procedures

Growth media samples should be representative of the bed or bench of a given crop. A sampling strategy should consider crop species, planting time, container size and environmental parameters such as shading, location in a greenhouse or nursery bed, etc. Ideally, a sample should be taken from plants representing each of the possible variations in these factors. However, circumstances may not allow crop management to differ with each of these variations. Therefore, it is best to select several subsamples from plants that will be managed as a block and submit a composite sample.

Collect 6 to 8 subsamples from several locations in beds or from 6 to 8 representative containers in a block. Each of these subsamples should include the growth medium from the whole root zone from the surface to the bottom of the raised bed or container. This is necessary because the soluble salts and other parameters can differ with depth in a container or bed. Thoroughly mix the subsamples together to create a pooled sample and take one pint of the mixture and send it as your sample.

Sampling time should also be considered relative to recent management activities or environmental events such as rainfall. If a crop is receiving routine liquid fertilization, it is generally accepted to wait four to six hours after the application before sampling.

Interpretation of University of Kentucky Media Test Results

General recommendations are provided here with the realization that production systems, crops and environments differ significantly within and between the nursery and greenhouse industries. More precise recommendations for unique crops or cropping systems are required in some instances. Such recommendations can be obtained through your county extension office and the UK Department of Horticulture. The UK Soil Testing Laboratories use the saturated media extract (SME) procedure with DTPA, and the interpretations provided reflect the accepted standards for that analysis.

Hundreds of different plants grown in soilless media in container and raised bed systems require somewhat different chemical properties and nutrient levels for optimum growth and development. Change of nutrient level over time can be important and illustrates the importance of keeping records of media test results. The general ranges provided here for the SME test are for herbaceous crops; woody plants have a slightly lower nutrient requirement. Young seedlings or cuttings with tender roots and salt sensitive plants, such as azaleas, require only half the EC and can tolerate only about half the level of nutrients recommended for most plants. The stage of crop plant development can also impact the optimum nutrient level of soilless media. For example, tomatoes require a higher N level in growth media than many other vegetables, especially as the plants mature beyond the second and third cluster of fruit set. Poinsettia requires higher levels of fertility during the middle of the production cycle than at the beginning or as the crop begins to show color in the bracts. Refer to publications such as the *Ball Redbook Volume 2* for more crop-specific recommendations.

General interpretation of nutrient levels from the UK media test are presented in the nutrient concentration rating table.

- A **low level** indicates that adjustment must be made to bring that parameter to at least an acceptable level. Plants would be expected to respond to additional nutrients.
- An **acceptable level** indicates an adequate level for plant growth, but in the lower part of the range concentration levels could easily fall into the low level and limit growth. Plants may or may not respond to additional nutrients when media test results are in this range. Depending on the stage of production, retesting is sometimes warranted to make sure an acceptable range is being maintained and to track changes over time.

- An **optimal level** rating indicates that the level is within the range for optimal growth and development of most nursery and floriculture crops.
- A **high level** rating indicates that the level may not be causing crop quality issues but should be monitored closely. Here too, more frequent testing may be warranted and changes over time should be recorded.
- A **very high level** rating gives reason for concern. There may be reduced growth and quality without any observable visual symptoms on plant leaves. Management strategies to reduce nutrient levels, such as leaching, should be initiated. However, keep in mind the methods and timing for fertilizers. Controlled-release fertilizers have an expected release rate over time, generally starting out lower and increasing to a maximum release before decreasing as the nutrients are depleted. The release rate is generally greater during the higher temperatures of summer. Knowing where you are on this nutrient-release curve at the time of sampling could affect your interpretation of the results.

Nutrient concentration rating

Nutrient	Low	Acceptable	Optimal	High	Very High
pH	< 5.0	5.0-5.6	5.7- 6.5	6.6-7.0	>7.0
Soluble salt (dS/m)	< 1.5	1.5-2.4	2.5-3.4	3.5-4.5	>4.5
Nitrate nitrogen (NO_3N) (ppm)	< 40	40-99	100-199	200-300	>300
Phosphorus (P) (ppm)	< 3	3-5	6-10	11-18	>18
Potassium (K) (ppm)	< 60	60-149	150-249	250-350	>350
Calcium (Ca) (ppm)	< 80	80-139	140-219	> 220	
Magnesium (Mg) (ppm)	< 30	30-59	60-99	100-150	>150
Sodium (Na) (ppm)			<70	> 70	
Iron (Fe) (ppm)	< 5	5–10	11–30	> 30	
Manganese (Mn) (ppm)	< 5	5–10	11–30	> 30	
Zinc (Zn) (ppm)	< 5	5–10	11–30	> 30	
Boron (B) (ppm)	< 0.05	0.05–0.5	0.6–1.0	1.0–2.0	> 2.0
Copper (Cu) (ppm)	< 0.5	0.5–1.0	1.1–1.5	> 1.5	

Note: 1 ppm = 1 mg/L; 1 dS/m = 1 mmhos/cm = 1 mS/cm.
Source: Adapted from Warnke.

Management Strategies

The optimal management strategy in response to media test results depend upon the normal production protocol for a particular crop, the stage of crop development and even time of year. There are expected nutrient release rates for fertilizers as stated above, and it is important to know where the crop is on the release curve. Heavy rainfall on outdoor crops may diminish the potential for a controlled-release fertilizer to supply optimum nutrient levels. However, a moderate rainfall event may just leach the readily available nutrients from the medium but more nutrients will be released. In fertigated plants, low levels of nutrients revealed in a media test usually indicate the crop should be fertilized. Tracking the level of nutrients over time will allow adjustment in the fertilization rate or schedule to maintain optimal levels. High levels of nutrients indicated in a media test may indicate that leaching of media to reduce soluble nutrients is warranted.

A routine media test is highly recommended to document the ratios of nutrients. This practice may be less critical if liquid fertilization is being applied at each irrigation on a short-term crop. The ratios would not likely change quickly in such systems. However, in longer-term crops fertilized by controlled-release fertilizers or combinations of fertilizers, the ratios can change and routine media tests are more important. With either type of crop or fertilization strategy, growers should be equipped to monitor the status of media on a regular basis using the "pour-through" procedures described below.

Pour-through technique to monitor soilless media pH and soluble salts

Nursery and greenhouse managers are encouraged to routinely monitor the pH and soluble salts of media in containers and raised beds and to send periodic samples to a laboratory for a more complete analysis. The pour-through technique, developed by Dr. Robert Wright at Virginia Tech, provides a way to non-destructively sample the medium solution and has been used in the nursery and greenhouse industry for many years. With simple pH and electrical conductivity meters, growers can measure and chart changes over time. The desired frequency of measurement differs by crop. Weekly measurements are recommended for short-term greenhouse crops and for nursery plants being fertigated. Record all measurements for each block of plants so changes and trends can be detected. Select containers to be sampled using the same strategy as noted above for the media test.

Pour-through procedures:

1. Irrigate the crop one hour before taking the sample; however, a recent study indicated that irrigating 30 minutes before sampling is adequate. The key is to be consistent so changes in electrical conductivity and pH over time can be monitored most accurately.
2. Place a saucer under the container. It is best to elevate the container above the bottom of the saucer by placing a plastic block, or a short section of PVC pipe in the saucer.
3. Pour enough distilled water on the surface of the container medium to yield approximately 50 ml (1.7 fluid oz.) of leachate into the saucer. The amount of water added to yield this amount will depend on container size and media characteristics.
4. Collect the leachate and pour it into a sample beaker or tube.
5. Use calibrated pH and electrical conductivity meters to measure pH and EC of the leachate.
6. Record the measurements and compare them to recommended levels.

Pour-through guidelines for most crops suggest leachate electrical conductivity levels should range between 0.5 dS/m to 1.5 dS/m (mmhos/cm or mS/cm) and have a pH of 5.0 to 6.5 during periods of active growth. The optimum level within that range differs by crop. Detecting changes and significant trends are the expected outcome for a recorded, routine pour-through. Graphing the results over time has proven to be a valuable management tool.

References

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