What Lies Beneath

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Properties, potentials and perceptions of cannabis substrates.

The North Carolina State University Horticultural Substrates Laboratory opened its doors in the mid-1980s and has since become one of the only laboratories in the world that solely focuses on substrate science to assist growers, retailers and consumers with substrate-related issues and opportunities. Currently, we (Dr. Brian Jackson (director) and Dr. Bill Fonteno (founder)) operate the lab, conducting grower and industry trials, substrate diagnostic testing, soil/substrate certification, graduate student training and course instruction.

In 2018, we received permits to grow and research cannabis (low THC/high CBD), and now we are broadening our research palette to include the needs and opportunities of the ever-growing cannabis industry.

This industry, due to legal hurdles and crippling stigmas, is somewhat deprived of scientific literature on many production practices and issues. Growers and industry professionals rely heavily on personal experience and information from other industries (e.g., floriculture and greenhouse science). Although hands-on experience is an invaluable source of knowledge, having scientific information to fall back on can greatly expedite the learning process for growers, both experienced and inexperienced. A specific area in need of information is that of container substrates.

Overview of Substrates & Soils

Substrates can be composed of organic or inorganic components, or a mixture of both, that create the container environment in which a plant will grow and thrive. Numerous organic and inorganic components have been used in container crop production over the years. One of the most important things to remember is that these materials are not "soil" and cannot (should not) be handled like soil. Unlike mineral soil (field soil) that can be stored anywhere for any length of time and moved with any heavy equipment, soilless components must be handled as little as possible and with care so they maintain their inherent physical structures and properties.

In the "2018 Growing Media Guide" research report published in *Cannabis Business Times'* January issue, 73 percent of survey respondents stated that field soil was used in their growing media in some capacity, while 6 percent said it was their sole material for growing their crops. Many discussion points could be addressed in detail regarding the choice to use field soil in container production. While it may be cheap and easily available, it does

Substrates are the foundation of plant growth, performance and yield.

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THE DIRT ON SUBSTRATE TESTING

METHODS OF PHYSICAL ANALYSIS INCLUDE DETERMINATION OF:

- **Total porosity:** The percent volume of substrate/soil comprised of pores. The pores are filled with either water or air. Total porosity of a mineral soil will be around 50 percent, while the porosity of a soilless substrate will usually be between 80 percent to 95 percent.
- **Container capacity:** The percent volume of the total pore space of a substrate/soil that is filled with water after it has been saturated and allowed to freely drain.
- **Air space:** The percent volume of the total pore space of a substrate/soil that is filled with air after all water has freely drained from the container.
- **Bulk density:** The ratio of the mass (weight) of a substrate/soil to its bulk volume.
- **Particle-size distribution:** The relative amount, typically by mass, of particles in a substrate according to size classes; typically conducted using sieve analysis.
- **Particle-shape quantification:** Determining the form/shape of particles, which can influence substrate/soil behavior and properties.
- **Hydrophobicity:** The difficulty or inability of a substrate to dissolve or absorb water.
- **Wettability:** The ability of a surface to reduce liquid surface tension, allowing the liquid to wet the surface.
- **Penetrability:** The ability or ease of water entering the substrate.
- **Available water:** The percent volume of container capacity that is available to the plant (subtract unavailable water percent from container capacity).
- **Unavailable water:** The percent volume of container capacity that is unavailable to the plant (held so tightly to the substrate particles that prevent a plant from accessing and using it).
- **Hydration efficiency:** The ability of a material to capture and retain water in the fewest number of water applications.
- **Water release curves:** Shows the water stored in a substrate at various tensions. Water release curves are used to understand how soils hold and release water.
- **Capillarity:** The ability of water to move (laterally or vertically), with or against gravity in a container.

- **Evaporation:** The process by which water turns from a liquid to a gas or vapor.
- **Hydraulic conductivity:** Describes water movement through saturated or unsaturated substrates/soils.
- **Shrinkage measurement:** Substrate shrinkage is the specific volume change (loss) of substrate in containers over time due to setting after irrigations, substrate decomposition, etc.
- **Oxygen diffusion:** Movement (intake or internal exchanges) of oxygen into and through a substrate while in a container.
- **Compaction:** The increase of bulk density (weight per unit volume) or decrease in porosity of a substrate as a result of settling, decomposition, compression/pressure, etc.

THE ANALYSIS FOR CHEMICAL PROPERTIES INCLUDE:

- **pH:** A logarithmic scale of the hydrogen ion concentration in a solution; describes the acidity or basicity of an aqueous solution.
- **Electrical conductivity (EC):** The ability of a solution to conduct electricity due to dissolved or suspended ionic solutes; used as a measure of soluble salt content of water.
- **Nitrogen immobilization (tie-up):** The conversion of inorganic nitrogen (applied fertilizer) to organic nitrogen by micro-organisms, which can deplete nitrogen in the substrate solution. Reduced nitrogen in the substrate can lead to plant deficiencies.
- **Phytotoxicity:** A toxic effect by a compound/chemical naturally present in substrate materials that have negative impacts on plant growth.
- **Alkalinity:** A measure of water's capacity to neutralize acids.

LASTLY, THE BIOLOGICAL ANALYSIS TECHNIQUES CAN DETERMINE AND MEASURE:

- **Substrate stability:** The ability to maintain structure, form, and/or function over time even with some degree of material degradation. Usually applied to the porosity, air and water relations of a substrate in containers for long periods of time during crop production.
- **Microbial populations and activity:** Assessment of the changes (increases or decreases) in microbial biomass over time in relation to substrate stability, nutrient immobilization, oxygen diffusion, etc.
- **Potential biodegradability:** Biodegradation is the disintegration of organic materials over time by bacteria, fungi or other biological means.

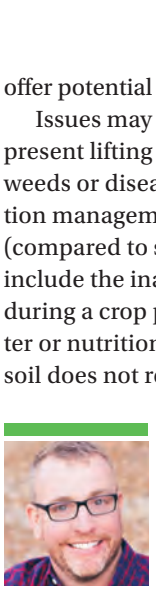
ARTICLE CONTINUES ON NEXT PAGE

offer potential barriers, issues and even missed opportunities.

Issues may include the material weight (which could present lifting difficulties for your employees), introduction of weeds or disease if not properly sterilized, challenging irrigation management, variable soil types and lessened root growth (compared to soilless culture). Missed opportunities may include the inability to be "precision growers," meaning that during a crop production cycle, if there is a need to adjust water or nutrition to the crop quickly to slow or speed up growth, soil does not respond as readily as soilless mixes. One of the marvels of today's greenhouse and floriculture professionals is their ability to leverage highly technical and precise monitoring and adjusting of crop inputs and environmental parameters that allow them to control plant growth (based on weather conditions, shipping date, size requirements, etc.). One of the main reasons they can do this is because of the engineered soilless substrates they use to grow their crops, which are highly responsive and easily adjusted.

Many questions, misconceptions and unknowns exist regarding the soilless components used in mixes. We caution readers to be careful where they receive their information not only about substrates, but also about all topics related to cannabis production. We highly encourage cultivators to rely on scientific literature whenever possible or consult with professionals whose information comes from science-based research and experience. Among the reasons we encourage this is that we often hear statements such as "perlite is toxic," "peat is running out," "coconut coir is local and more sustainable than peat." (All three of these comments are 100-percent false, by the way.)

When searching information on the internet about a growing topic, I suggest following up your keywords with "PDF" in your search. This will narrow the scope of the information you find to typically more formal, scientific, published, etc., content compared to open forums, small grower or business websites trying to sell



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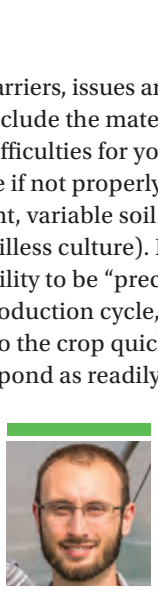

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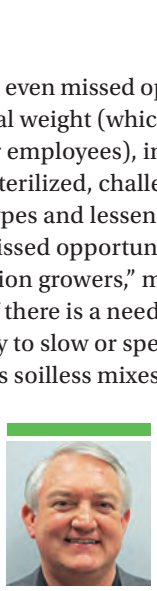

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Substrate wettability, hydration efficiency and water retention can be tested using a variety of laboratory procedures.

Substrate Diagnostics

In the spirit of elucidating those mysteries, let's look at what makes for a good substrate for cannabis production.

Substrate quality begins at the source: the supplier. We highly encourage cultivators to choose a substrate supplier (there are many to choose from) and build a strong working relationship with them. When looking for a substrate supplier, do your homework and be prepared to ask questions about the products and their production needs. Ask about technical-support offerings in the event that a problem arises and you need assistance. Ask about product performance compared to other products or competitors' products. Cost is important, of course, but that should not be the sole driving force behind the decision to choose one company or product over another. A higher-priced mix that comes with technical support and experienced grower experts is well worth the extra cost if problems arise or help is needed. As is true in many things in life, you get what you pay for.

something, or online blogs where opinions flow freely, and facts are sometimes elusive. Google Scholar is also a good place to search for this type of content.

Different substrates will vary in their appearance, function and management needs based on many variables, including container type/height and irrigation delivery method.

Diagnostics & Testing

To help ensure substrate quality and performance—substrate manufacturers and university or independent laboratories offer a broad range of testing options, which give reliable and replicable indications of the performance of container substrates with respect to water, nutrition and physical, chemical and biological properties. Most methodologies used to develop tests for substrates over

IT CAN BE HELPFUL TO KEEP A SAMPLE OF "GOOD SUBSTRATE" FROM A PREVIOUS DELIVERY AND USE IT TO COMPARE TO FUTURE SHIPMENTS FOR VISUAL CONSISTENCY.

the past four decades have been adopted and modified from soil science analytical methods. (*See the sidebar on p. 36-37 for details on available testing.*)

The tests noted in the sidebar are usually conducted as part of a product's research and development (R&D), but they can also be conducted on substrates to identify problems that occur during production.

Ideally, someone at every growing operation should be responsible for checking every load of substrate that is delivered to ensure quality and consistency. If one person holds this responsibility, it improves the chances of catching inconsistencies and being confident that the substrates are correct. A visual inspection of the product should be conducted (not every bale/bag, but spot checking a few) to make sure it looks as it should (as it always has in the past). It can be helpful to keep a sample of "good substrate" from a previous delivery and use it to compare to future shipments for visual consistency. It is also vital that a few samples be taken and checked for pH and EC before crops are planted in the mix. These simple steps do not require much time (typically seconds to just a few minutes), but can offer grower confidence in product quality.

If problems or inconsistencies do occur, growers should contact their substrate suppliers for a technical consultation. This is one of the advantages of buying premixed substrates from suppliers: They have technical support that can help if problems arise. Growers who choose to make or blend their own mixes may have to find experts elsewhere to assist with the problems.

Laboratories, Research & Cannabis

Numerous professional laboratories across the country can be used for diagnostic testing of the substrate itself. A simple online search of "growing media analysis laboratory" will yield many results. Many universities have analytical labs as do many states in the U.S. through their Departments of Agriculture. Several independent labs are also available including PAT²H Horticultural Research Services, JR Peters Lab, MMI Labs and Waypoint Analytical.

Current and future understanding of cannabis-substrate interactions will increase drastically as more state (and private) institutions are legally permitted to research and study these crops.

Accurate and replicable grower trials and experimentation will also continue to provide reliable information about containerized cannabis production. Research does not have to be conducted in a laboratory. The perfect balance of science and application exists in grower and researcher partnerships, which has been the key to success for numerous other horticultural industries.