Grow Ecology, LLC, Consultants
www.growecology.com

Grow Ecology Green Paper #6
Richard Freeman, Ph. D.
rick@growecology.com

A Primer on Container-Media for *Cannabis sativa* production

For a greenhouse operation, buying container media in bulk is a large investment that involves many risks, including media-borne pest infestations, unbalanced formulations, poorly mixed media, unstable compost and other factors that can lead to toxic root environments. Formulating and mixing a container-media for *Cannabis sativa* plants involves several considerations, because the *C. sativa* plant is a vigorous grower demanding signficiant resources and management. Poorly-built container-media can cause serious losses. Because high-value agronomy involves higher risks (risk being a product of probability and value), the grower must focus on minimizing potential loss resulting from a variety of potential problems that a poor medium could introduce. What's more, vigorous, fast-growing plants require high-quality medium to sustain growth and enable disease- and insect-resistance over a sustained period (8-14 weeks).

A high-quality container media will support vigorous plant growth while reducing agricultural risk by promoting plant health, increasing product quality and reducing opportunities for pests. In the case of a "super soil," the goal is to carry a plant through a production cycle without supplemental nutrients – while providing a healthy environment for seedlings early in the cycle – a difficult balance not achievable in many cases. Furthermore, a well-balanced medium will conserve water and nutrients, saving significantly on long-term labor and nutrient costs. Importantly, a container-media vendor should be able to prove the company's media quality with verifiable testing and certifications.

This primer briefly explains the nutritional and ecological considerations relevant to formulating a growing-media for cultivating *C. sativa* in containers. It begins by outlining the basic functions of a good container medium, briefly describes the container environment, describes the common challenges presented by media materials, and finishes with a brief description of the choices the grower or mixer must make.

The Basic Functions and Properties of Container Media

Container-media formulations should meet the four conventionally defined standards and one in addition. Convention holds that a medium should enable four functions: (1) supply water, (2) supply nutrients, (3) permit gas exchange, and (4) Provide physical support. In addition, formulations should (5) Provide a rich matrix for beneficial biology and a robust inoculation.

Important properties that determine the effectiveness of these functions include:

(a) Air : Water : Solid ratios. Media design should aim at recommended indicators in relationship to preferred container size at container capacity: total air space at container-capacity in a standard height container, as well as air space and water space; particle-size distribution (which determines pore-size distribution, and thus water tension levels and consequent water availability); and substrate variations, within and between substrates.

(b) Water release rates. These rates change through time and are a function of pore size and distribution, electrical charge of the substrate surfaces, evaporation rate and plant use. The largest determinant of release rates is particle size distribution and its effect on pore size distribution and consequent water tension. Media mixes should aim at an equitable relationship between Easily Available Water (tensions between 1-5 kPa and Water Buffering Capacity (tensions between 5-10 kPa) (at the container capacity standard) – which again are largely determined by pore size distribution.

(c) Water absorption rates. These rates are important only in the unfortunate circumstance that the medium is allowed to dry. Media design should aim for strong absorption rates, recognizing the culpabilities of common cultural practices. Effective substrate structures (correctly proportioned bulk materials) are preferable to surfactants like saponin.

(d) Nutrient holding and exchange sites. In container-media, Total Exchangeable Cations is the common proxy measure for Cation Exchange Capacity (CEC), mainly because CEC is built around the colloidal model in field soil, which differs in important ways from container environments. Never-the-less, cation-exchange capacity remains an important function on the surfaces of non-colloidal bulk materials in a functional and biological sense. Soil design should aim for a high CEC compared to common commercial media to support a robust microbial ecology which delivers the nutrients to the plant roots.

(e) Structural and chemical resources for container biology. These properties are important for maintaining the ephermeral populations of fungi, bacteria, protozoa and other beneficial micro-organisms that we aim to nourish in our media.

(f) Biological complexity and diversity to encourage a robust, balanced micro-ecology and effective nutrient-cycling.

(g) Buffers and safeguards against toxic nutrient build-ups, acidification, and anoxic and anaerobic conditions. Container ecologies are dynamic and change quickly, especially in response to common, misguided cultural practices. A full-cycle, high production mix will avoid these conditions.

The Container Environment

The container environment is a drastically simplified version of a natural soil ecosystem, and natural buffering systems are absent or highly constrained. Thus, the container environment is dynamic and fast-changing and the farmer must remain highly-aware of the many relevant environmental and nutritional indicators to avoid problems. The upshot is that quality is crucial.

The container environment in which a medium functions is much more highly-constrained and less buffered than a common field soil environment (unless the soil has been badly abused) in several ways.
(a) A key characteristic of containier media is that it usually functions much lower pH level (**acidity**) than field soil. A container medium will operate at 5-6.5 – one to 1-1/2 times lower on the pH scale than a typical field soil, which is 6.5-7. This acidity results from the inputs (for example sphagnum peat) and from the soil dynamics (several potential acidifying cycles). During the growing cycle, pH

tends to plunge, often to dangerous levels; low pH makes several metals available at toxic levels (including aluminum, manganese, and iron). (b) Plastic containers provide a much **wetter environment**, usually with a perched water table at the bottom of the container. (Cloth containers are less susceptible.) Thus, the danger of anoxic or anaerobic conditions is constant. (c) Container environments **lack the natural buffering systems** (especially pH buffering) found in healthy field soils. (d) Container media have **low cation-exchange capacity** compared to most field soils. (e) Container soils **require feeding** because of lack of mass flow, mycelial networking, and other natural forms of nutrient travel. (f) Container soils are vulnerable to **root disease contamination** due to incomplete soil food webs or complete absence of them.

Materials Concerns

As a rule, nutrient release, pH, and other important characteristics vary drastically between sources and between batches from the same source. This variation is especially common in popular bulk media like coconut coir, sphagnum peat moss, and compost.

High-quality, vegetatation-based, mature compost is key to a good container medium, and good sourcing is a high-priority. Poor-quality compost – which is very common in commercial media – can cause serious problems ranging from nutritional lock-ups and overdoses to adverse biological conditions and disease and arthropod infestation. Generally, commercial compost varies in almost every important detail: pH, C: N ratio, ammonium: nitrate ratio, nutrient content, micronutrient content, biological content and other parameters pertaining to maturity (stability) and available nutrient content. However, a good composter can minimize these ranges by careful attention to detail, and good compost is available.

Due to scarcity and lack of oversight, the majority of commercial compost is not suitable for container media. The farmer should be very careful about sourcing compost. If and when buying commercial media, the farmer should ask for product specifications on the compost and make assurances that these standards reflect the standards actually represented in the product. Vendors of high-quality compost will always provide lab tests for their compost, and mixers or vendors of container media should be able to provide these tests with little effort.

Some of the problem areas and parameters to be aware of include:

a. Heavy metals contamination -- primarily the EPA's 10 most wanted list.
b. Pesticides content.
c. Pathogen content.
d. Maturity. (A good container media requires mature and/or very mature compost.)
e. Salt content.
f. Physical content: primarily no junk and rocks.
g. Phytotoxicity.

Coconut coir (coco) is another key material that can bring problems. Coco sources – and batches within the same source – can vary wildly in quality. Key quality points include sodium-chloride content (though high-quality, washed coir will have minimal amounts) and presence of arthropods (especially fungus gnats and mites). In addition, coco commonly contributes excess potassium, which can cause imbalances with the other base metals, especially Magnesium but also Calcium. Thus, mixers should be very discerning about their coco sources.

Sphagnum peat, another commonly-used bulk material, presents some problems as well. In a container, peat will always contribute to acidity in the rhizosphere, because it varies in pH between 4 and 5.5. So, the mixer must accommodate for these varations in the formulation strategy. Further, from an environmental perspective, peat production is significantly harmful insofar as the yield is not sustainable and mining peat bogs destroys a significant source of carbon sequestration and oxygen production in northern ecosystems.

Formulating Container Media

When formulating container media, the formulator must choose and balance materials and test materials in a number of ways. Balancing requires knowing the nutritional contributions of all components and materials, which in turn requires knowing release rates, loss rates, and reserve rates – a complex interaction. If the goal is to carry a plant through a production cycle without supplemental nutrients, the formulation must supply adequate nutrients at the end of the cycle without damaging plants early in the cycle. Depending upon the strain, that goal is elusive and in some cases unrealistic. However, it does provide a conceptual target.

Having formulated a mix, the farmer should send samples to a laboratory for testing. Container media vendors have a responsibility to test copiously – including conducting and documenting plant growth and survival tests in addition to systematic sampling and lab testing. However, unscrupulous vendors will skimp on lab tests for a variety of reasons.

Mixing the Container Media

Mixing the materials should be verifiably thorough. An even mix is crucial to optimal container media performance – and uneven mixing can cause serious problems ranging from nutrient toxicity to water-logging. If and when buying commercial media, the farmer should assure that the commercial mixing facility uses equipment specifically built to mix container media and agricultural supplements. A vendor should be able to provide receipts to prove that an order has been mixed professionally. Some vendors are not following these precautions, so the buyer should be expecially aware.

Mixing with a farm implement, skid-steer or other such equipment can be feasible only at the farm level – and only if the cost-savings are significant. The resulting optimization will require sacrificing container media performance due to the variation in nutrient and materials distribution, but may work from a cost-benefit perspective. Further, mixing on the ground or concreate pad with machines introduces an opportunity for contamination from pests (arthropods and microbes) that the farmer need consider. Unfortunately, some companies are still mixing media this way.

For large-scale cultivation with large risks, the mixer should routinely test (or demand tests from the vendor) to determine the range of variability on all important physical, chemical, and biological parameters – and if buying a commercial product, the farmer should periodically independently test and verify these values. For example, the farmer buying commercial media for large-scale operations should request product specifications that include the expected ranges on the parameters of concern, which might include C: N ratio, NO3: NH4 ratio, macro-nutrient levels, micro-nutrient levels and bio-assays. The mixer should also test for variation in these parameter values due to uneven mixing – and the farmer should obtain these test results. Periodically, the farmer should independently test all commercial media as a routine practice. Testing can function at many levels and at any intensity depending upon objectives. Levels and intensity of testing depends entirely on the vendor, mixer or farmer's legal, economic, and practical prerogatives. However, in all regards, remaining highly-aware of the container environnment is key to preventing and eliminating problems.

Further, everyone in the chain of custody should definitely be aware of rules and regulations pertaining to testing for biological hazards (*E. coli* and *Salmonella*) and agricultural pest contaminants (such as Fusarium or Phytophthora), which may vary in every state. Failure in this area can result in serious catastrophe. As a further precaution, only vegetation-based composts should always be used in commercial container media production.

Other considerations important to the mixer include availability and cost of materials and cost of processing materials. For example, coconut coir requires a mechanical shredder to obtain a uniform product in a reasonable time frame. To complicate matters, prices vary, causing variations in the ratio of nutritional content to value and cost – changing the entire cost/benefit analysis. The mixer must optimize price and nutritional content, at least within a range, yet provide a sufficiently consistent product.

Once the media is mixed, the mixer or farmer must get it to the farm, which is a logistics problem, unless mixing on the farm. Logistics involves a relationship between the facility, the transporation contractor, a logistics partner, and the farmer (or representative). These relationships are long-term, steady relationships that require a work sub-specialization and significant labor.

Finally, if possible, a container medium – especially a “super soil” – should have the chance to “cook,” which means that the microbes are metabolizing (and sequestering) nutrients and releasing energy as heat. This process builds beneficial bacteria counts (as bacterial incorporate nitrogen and other nutrients), which then become available through the cultivation cycle.

Conclusion

Container media buyers must be careful about their choices to avoid problems. Poor quality-control protocol can yield serious disasters and surprises as product quality fluctuates. This type of problem usually points to other problems as well. Furthermore, buyers should especially be aware of buying products that claim to be “Premium” without substantiating that claim with certification and/or lab testing and plant vigor testing – especially given the prices for these products. No vendor should cut these corners, but some do. Quality and performance inconsistency can present large-scale risks. Without verifiable assurances, “premium” only guarantees a premium in price.