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GREEN RIVER RESEARCH

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Towards a Balanced, Organic Growing Medium

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Introduction

Over the past several years Woods End Lab has cooperated with Green River Tools in research and development of a fully organic seedling-starting mix. Although initially intended for the soil-blocking system for vegetable seedling production, the work has been extended to cover the raising of the best seedlings in every system, whether we deal in blocks, pots or flats, household or vegetable plants.

It is not an 'organic whim' which lies behind this research push. The author is concerned that substantial, scientific work in the arena of natural plant starters is virtually lacking and that, ironically, the presence of commercial growers of organic produce has down little to spur such work. The current attitude that "in the greenhouse, anything goes" can only erode consumers' confidence in claims that the produce is "organic." It was our interest to determine how organic growing media performed and what the ideal nutrient content should be in order that they be viable and competitive in seedling-raising systems.

Seedling Stage as Stress Period

The idea behind soil blocks was to minimize transplant shock, a very significant form of stress, but what about the way the seedlings are grown?

There are obviously all degrees of stress involved in growing plants, some avoidable and many not, but the chief stress in our view occurs in the early seedling stage, say between two to four weeks of growth. Here a combination of cultural factors, including moisture, lighting, and nutrient supply, make this period the most complained-about aspect in plant culture. These difficulties may be why organic growers have not been able to deal successfully with the certification issue where seedling culture is concerned. Most systems which growers use have been developed by trial and error and many work well -- on the surface they appear very different and growers apply them inflexibly -- areas which contribute to confusion if you try to discover, as we did, the common thread.

Early Seedling Stage Determines Later Quality

One should not under-estimate the importance of early seedling nutrition; the first several weeks of development significantly affect the growth and quality in subsequent months, most particularly in northern climes. We can analyze a seedling at 60 days and say much about how it was grown; even to some extent whether or not it was organically grown. Similarly in farming we can analyze corn at 25 days old and predict closely the yields for 120 days. So significant is this early stage that I suspect growers rarely achieve the days-to-maturity figures assigned to commercial seeds. Growers who admonish that what one does in this early stage does not matter are certainly deceiving themselves. Those growers who deal substantially with the pre-season development requirements, even if they are not aware of their special abilities in this realm, will be the successful growers. That's our reason to emphasize research on early cultural practices. It's a very good reason to look at your seedling situation and ask: how can it be improved?

Examples of growing stresses run the gamut from the more common problems in moisture supply and proper lighting to trace element deficiencies and cases of salt concentration from high evaporation. All of these are likely to be more serious in contained seedling systems than in field soil-culture.

An illustrative example of plant stress is seen in hydroponic systems, fed from tanks and hoses of nutrient solution. In both commericial and our own laboratory settings we have measured acidity fluctuations of a few orders of magnitude (e.g., pH 5.0 to 8.0) in a matter of 24 hours! This happens by nature of the narrow design of the system. Lacking a soil-substrate, with its ionic exchange capability, there is virtually no buffering ability in hydroponic solutions; hence nutrient salt concentration and balance my fluctuate rapidly. Soil-grown plants don't experience such pH changes even over years of culture. We don't fully understand the possible impact on quality and pest resistance of such a fluctuating system, but we do know that plants are sensitive to pH and nutrient changes and lack sophisicated means to deal with them.

Similarly significant fluctuations may take place in container-grown seedling systems. This is by nature of the constrained environment, limited rooting area, high evapo-transpiration rate and more. By removing plants from the soil and placing them in more or less artificial circumstances, whether that be clay pots or Styrofoam containers, we must appreciate what the consequences may be.

Soil-less Cultures

The development of soil-less culture instead of loams for potting mixes was an inevitable outcome of dealing with problems of handling and standardization of soil- and loam-based mixes. Here peats found a natural application. Some modern cultural techniques, as the use of Speedlings and soil blockers, were specifically designed with peat-based mixes in mind. The potting mix we've developed for Green River Tools is not strictly speaking a soil-less composition, such as a peat-vermiculite-perlite mix, for the compost is soil-like and may contain soil-based minerals.

It is indeed very practical and convenient to substitute peat for soil in potting mixes. However, the addition of lime, inorganic major and minor nurtients, and surfactants as conveniently practiced is a bit of a patch-up job, although widely accepted and more or less successful. We don't feel, however, that the long-term health of the plant or soil into which it is transplanted have been taken into account. We take our position from the viewpoint that even with these common measures an essentially unbalanced situation exists and that a more natural solution can be found, provided adequate research is performed.

If we agree with the convenience and inoffensiveness of using peat we must nonetheless deal with its several problems, such as peat's semi-sterile, hydrophobic nature and it's tendency to lose nutrients through leaching, all quite unlike soil. And there is the fundamental question of feeding plants from organic sources -- how would composts behave when mixed with peats? Well, the literature contains many of the answers for an inorganic approach but few for the more natural approach preferred by most consumers.

Following, we'll look at some of the specific problems we encountered in developing a peat-based mix, and how we went about solving them.

Peats as Growing Media

We may justify the use of peats in growing media on grounds of porosity and low bulk density alone, but what about their intrinsic qualities relating to plant growth? We investigated this point by growing a variety of seedlings in white and black peat with and without lime and fertilizer.

Not surprisingly, considering the low pH, unlimed peat performed very poorly. We observed inhibition of germination and poor weight gain of the plants. By providing limestone (2%), however, we observed a 40-55% increase in growth and, with full nutrients added, 60-75%. Concommitant with liming was a significant increase in microbial respiration and enhanced nutrient release. For example, nitrate uptake increased 3- to 5-fold and potassium 6-fold in response to liming. The peat simply "came alive." Obviously, however, lime alone was not sufficient for sustained development, but these observations underscored our sense that properly managed peat is a responsive medium for natural plant development. One would hardly expect to reach the same conclusions with perlite, vermiculite, sand, or polystyrene media.

Sterility vs. Disease

In the past, many producers of growing media sterilized their soil with chemicals now highly suspect (the bromides) or with very hot steam. It is generally accepted now that semi-sterile environments can provide ground for epidemic fungal and other disease development, through the sheer lack of microbial competition. Mediums most likely to have problems are sand and soil-based types, followed lastly by peats. To take the approach that by pre-sterilising the medium we avoid all problems is naive. As soon as the medium contacts the environment (via pots or soil or seeds or your hands) microbial inoculation quickly commences. There is the further complication that if slow-release nutrients and soil are present, the sterilization heat treatment may induce rapid ammonia hydrolysis or manganese release, leading to phytotoxic results. This is generally unlikely to occur with the peat-based mixes, hence their popularity.

The addition of compost to peat complicates the matter, as compost may or may not contain pathogens (or weed seeds). We had to develop a means to assess whether or not the compost used in our mixes would be a problem -- we had to locate mixes with an aerobic or oxidative history which included a period of sufficient heating. On top of this the compost had to have the correct nutrient disposition; more on this later. In any event, steam sterilizing of garden compost at 60 degrees C for 30 minutes has not created problems in our experience. We have been able to rid it, when necessary, of pythium and weed seeds at this temperature. Growers who feel the need for heat treatment should first test their product for phytotoxicity.

Precautions against diseases such as *Fusarium* damping-off may depend more on post-germination cultural treatment than on initial conditions. Over-watering when conditions are warm is a sure way to invite damping-off. Research has clearly shown that, in general, risk of disease is lessened by improving the microbial environment, typically by adding rich soil or compost. So we had ample reason to believe that *if the compost was properly selected,* only good would come of incorporating non-sterilized compost into the peat base for the mix.

Nutrient Leaching

Peats drain well, and leach awfully well, despite their high apparent cation-exchange capacity. This means that we can't assume that soluble nutrients which are provided initially will remain in the mix. Even potassium and phosphate, which are normally retained fairly well by soil, will leach readily from the peats. Owing to this, the plant may experience a swing in the ionic composition that could easily be stressful. For this reason most systems recommend watering with soluble nutrients after a few weeks, even though many mixes provide nutrients ample for several more weeks of growth. How does one assess what plants really need? If you wait until you see it, you have waited too long. A danger in periodic watering with soluble nutrients is that, under conditions of high evapo-transpiration as occur in the greenhouse, salts may accumulate in the mix to the point of inhibiting growth. One has to know how much to add, and not exceed it. Growers should at least check the conductivity of their medium periodically.

Providing an organic or sparingly soluble nutrient basis goes a long way toward alleviating this source of stress as it provides for a continuing supply of key nutrients. We are aware that most studies comparing base-fertilization on the one hand with periodic watering with soluble nutrients on the other conclude that growth is better with the latter approach. Despite this, we find excellent continued growth in our mixes. More on this in the nutrient section.

Dessication; Hydrophobia

Both sphagnum and black peats are porous, and dessicate rapidly. When remoistened, they behave hydrophobically, and resist wetting. If you have waited too long in between waterings, you may find your plants wilting long after you water them. Adding synthetic surfactants, or wetting agents, to the mix or to the water, will partly correct the problem and surfactants are commonly added to peat-based mixes. However, a real problem is the largely unknown toxicology of surfactants. They are very surface-active compounds, interfering with normal membrane activity. Studies by Woods End Lab on sprouting seedlings revealed significant decreases in plant root-hair development where surfactants were used in the water, even at one-tenth normal recommended dilution. Remember that root hairs are responsible for 90% of the liquid intake of the normal plants as compared to primary and secondary roots. When these root hairs are diminished in number (down to zero for some of the species we tested), a normal level of intake is impossible without continued feeding with nutrient-and-surfactant; mycorrhizal associations are also greatly diminished in capacity. Complexing on peat may lessen these effects, but certainly not eliminate them. The point is that, in considering that plant feeding is conducted primarily via root hairs, the loss thereof may impose more stress, or increase nutrient requirements significantly.

Our approach was to consider what kind of desirable materials would lessen the hydrophobic nature while contributing to growth. We found that rock powders must be used in very large amounts before significantly improving water movement and were therefore not helpful for that purpose. But the addition of compost, with its water attracting properties, in sufficient quantity can make a major difference. Also, we discovered that the biodynamic preparation of valerian extract aided the wettability via natural surfactants while promoting root development.

Studies on Nutrient Supply

When it came to assessing nutrient provision to plants from organic sources, we were essentially in the dark. Although to some extent it was possible to extrapolate what we needed from information provided in conventional seedling nutrition studies, clearly a gap existed that needed to be filled.

For one, a study had to be performed under actual seedling-raising circumstances, such as occur in a gardening situation. A discriminating gardener's eye was needed to rate the quality of growth. We needed to look at what other growers were using and at the composition of several commercial mixes. Finally, using this viewpoint, an experimental structure was imposed on a multi-crop seedling system, and data collected on performance of several mixes. we drew correlations between the growth rate, dry matter accumulation, appearance, and the composition of mixes used.

No study such as this can be complete. However, information gathered to date had provided a clear indication of an acceptable nutrient range within which seedlings perform very well over 6-8 weeks of growth in flats or soil-blocks. We identified the upper extremes in salt tolerance. We looked at the need of trace elements in compost based mixes. We looked at how far nitrogen can be pushed before nitrate is too high in crops.

The nitrate issue relating to seedling culture, and ultimate ingestion by the consumer, deserves more attention than currently afforded. In general, nitrates are harmful eaten in quantity, owing to reduction of nitrates to nitrites in the stomach and upper intestines. Aside from nitrites combining with the blood's hemoglobin to form methemoglobin, preventing oxygen absorption, they may combine with amines in the intestine to form carcinogenic nitrosamines, suspected to be a major cause of gastro-intestinal cancer, the incidence rate of which is high in countries with high nitrate levels in water. We have found that many growers apply excessive nitrogen, both in the seedling stage and later, resulting in elevated tissue nitrate in the crops. At Woods End Lab, we have traced high nitrates in green leafy vegetables from early growth through to 100 days, when the crop could be eaten. Many starting mixes used by organic growers are very high in nitrogen. This nitrogen has been in both organic (e.g., manure) and inorganic (e.g., ammonium sulfate) forms. In our view, a responsible approach is to develop a growing medium which gives adequate growth yet does not contribute to a nitrate problem.

The list of additional points would be a long one; in any event we have distilled them into a potting mix formula. The formula, which is open to revision as new information is gathered, serves most importantly as a yardstick for interpretating information on potting mixes. With it, we relate the composition of source materials to the desired analysis, and decide on relative mixing quantities. Thus, for anyone wishing to benefit from the research process, any sample received at the laboratory is weighed against our best information and recommendations provided accordingly. The precise formula and mixing instructions are available, of course, at the discretion of Green River Tools. With regard to our nutrient goals, we are working to substantiate them as scientifically as possible towards making an eventual public contribution to the subject of organic care of seedlings.

Conclusions

We'd like to close the paper by way of highlighting aspects of the research process.

1.) The simple idea of adding compost to peat proved much more difficult to implement than expected. Most composts did not meet our nutrient criteria. Either they were too mineralized, in other words had a high salt index per amount of useful nutrients, or too unstable -- poorly decomposed and not rich enough in available nutrients. Mineralization of organic nitrogen from composts mixed in peat was too slow by itself to promote rapid early growth. As a result we've become 'mission oriented': to find the compost of correct composition! A great effort has been expended in this direction. Green River Tools now makes its own compost with materials carefully selected and monitored by Woods End Lab.

From the point of view of home production, a curing period for compost is essential: it must be on the dry rather than wet side and be kept from the weather (preferably over winter in a root cellar or under cover with air circulation around the pile). It must be friable, earthy smelling and have a pH less than 7.0, with an ample supply of soluble nutrients. Woods End Lab is willing to aid anyone in identifying the proper materials.

2.) Adequate levels of potassium in mixes are essential, particularly to offset high nitrogen and poor lighting situations, which weaken plant stems. It was virtually impossible to get enough potassium from compost sources without getting too much salt -- hence we discovered the great value of dried seaweed. We also found that many seaweeds failed to meet our criteria; they had to contribute a certain amount of potash without contributing too much soidium or chloride. Potassium in commercially available seaweeds ranged from 1.5 to 6.0 percent!

3.) Fritted trace elements gave no response when a balanced mix as above described was used. The maximum response occurred with compost plus seaweed, and could not be improved on by chemical additions.

4.) Adding biodynamic valerian extract at 100-200 ppm significantly stimulated rooting and aided as a natural surfactant. Independent seedling studies have confirmed this effect.

5.) Highly soluble nitrogen in mixes results in overly high nitrate in edible crops even at 90 days. Some commerical mixes were found to be unnecessarily high. The breakoff point in acceptable NO_3-N content in a mix was about 250 ppm or about 50 mg/liter (50 ppmv), slightly below the normally recommended level. On the other hand, ammonium, the breakdown product of organic matter decay, contributed significantly to seedling nutrition in most cases without leading to nitrate formation.

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