Development of Sustainable and Alternative Substrates for Nursery Container Crops

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Significance to the Industry: Recent instability in fuel costs have caused tremendous price increases and reduced availability of bark. Added to this, the decline in housing and construction has contributed to a decline in domestic forest operations which in turn have led to a decline in bark supply. Objectives are to develop alternative substrates from three different broad sources: 1) currently underutilized and/or waste biomasses (logging slash, forest residuals, corn stover, cotton stalks); 2) biomass generated from statewide efforts to remove invasive plant species (Eastern red cedar); or 3) biofuel crops that can be grown and harvested specifically as a substrate (willow, switchgrass, giant miscanthus). Once substrates are indentified, Best Management Practice Guides will be developed, demonstrated and disseminated to stakeholders.

Nature of Work: The long term goal of this project, funded by the Floriculture and Nursery Research Initiative with guidance from the Horticultural Research Institute, is to identify and develop regional and sustainable sources of horticultural substrates for the nursery industry. Our team's approach for developing new substrates is a four-phase process. First, materials are identified that might be used a substrates on a regional basis in each of our respective regions. Actual availability and potential cost for securing these materials are investigated with the help of local experts (agriculture economists, forestry consultants, etc.). Potential of using these materials on a cross-regional basis is also discussed amongst our group (we are currently exploring the idea of using bamboo biomass as a substrate in all of our regions). Some materials may have a limited range of utility (for example invasive red cedar in the Kansas region or reed-sedge peat in the upper Midwest region).

The second phase of the investigation involves taking the material from its parent form and processing it into a usable substrate. Once materials are identified and secured, their initial processing, particle size reduction, storage, and base physical properties are measured. Organic materials respond differently to processing (chipping and hammermilling), thus a range of processes must be explored to determine which combination of processes results in a substrate with suitable particle properties that would facilitate potting operations at a nursery and provide an ideal environment for plant growth.

The third phase of the process involves observation of the materials in the container. Our current process is to use fast-growing herbaceous crops to quickly ascertain how the substrates interact with common fertilizers and amendments typically used by nursery producers. These factors would include substrate pH, physical properties, development of nuisance organisms (mushrooms, algae, weeds, etc.) in the substrate, insect or disease problems, and overall plant performance. By analyzing foliar nutrient content, we can quickly ascertain the effect these materials have on overall plant nutrition and whether or not special nutrient supplements are necessary.
The fourth phase is to determine the suitability of these materials over a period of 4 to 12 months, which is the typical production cycle for woody nursery crops. All materials evaluated to date have lower lignin content than pine bark. Lignin is a complex polymer that binds to cellulose fibers to strengthen and harden plant cell walls. It is thought that the lesser the lignin content, the less stable the material will be in the container environment. Thus changes in substrate physical properties over time is the primary concern during this phase of evaluation.

Results and Discussion: Most of this research has been under the first three phases described above: identifying potential alternative source materials for substrates, understanding the necessary processing steps required to convert source materials into a usable substrate, and observation of short-term crops growing in newly developed substrates.

Thus far, our team has been working with the following plant biomass sources: switchgrass (*Panicum virgatum*), willow (*Salix* spp.), corn (*Zea mays*) stover, giant miscanthus (*Miscanthus ×giganteus*), poplar (*Populus* spp.), bamboo (*Phyllostachys* spp.), and eastern red cedar (*Juniperus virginiana*).

All of the above listed materials have higher pH than pine or Douglas fir bark. Amendment with peat moss or compost at rates typical of nursery producers (varies by region) lowers pH in alternative substrates to a more moderate level (6.0 to 6.5). However, this has led us to eliminate lime from the fertility package, as pH is already at the upper end of the ideal range. In some early plant trials, we have documented nutrient deficiencies in calcium (Ca) and magnesium (Mg) as a result of lime omissions. We have also observed iron (Fe) deficiencies in some substrates, despite addition of a general micronutrient package. We are currently working with sulfate and oxide forms of Ca, Mg, and Fe as fertilizer supplements to avoid deficiencies manifesting in plants. We have found that materials processed through a hammermill equipped with a 3/8 in screen produces substrates with particle size distribution similar to bark substrates currently used. Despite similarities in particle size distribution, alternative materials tend to hold less water and have greater air space than pine bark. Amendment with sphagnum peat moss and compost decreases air space and increases water holding capacity to levels considered more ideal, and to levels similar to pine bark. Despite similar physical properties (a static measurement), water use efficiency for alternative substrates may still be lower. Addition of hybrid poplar incrementally decreased water use efficiency (7 g/mL).

We are also studying nitrogen (N) dynamics in the alternative substrates. One of the initial concerns with all the aforementioned alternative substrates was N immobilization. As these substrates are probably more easily decomposed than pine or Douglas fir bark, they are also more likely to immobilize N to aid in the decomposition process. We have observed slow initial growth of some plants in alternative substrates compared to pine bark, however, after 6 to 8 weeks plants in alternative substrates had ‘caught up’ and outperform those in pine bark. We attribute this to temporary immobilization and subsequent release of N in alternative substrate materials. To eliminate the initial stunting of crops in alternative substrates, we are evaluating fertilizer application techniques that would turn this phenomena from a disadvantage to an advantage. We are currently evaluating how dibbling controlled release fertilizers (placement of the fertilizer beneath the liner rootball at the time of potting) can alleviate N immobilization. We found that dibbling fertilizers in switchgrass substrates resulted in similar or superior growth to all application methods in pine bark substrates. Furthermore, switchgrass substrates are leaching less N compared to pine bark, regardless of fertilizer rate or application method. The implication is that with a simple modification of fertilizer application technique, plants can be grown in alternative substrates with no initial stunting and greater levels of retained N (greatly reduced N leaching).

A great deal of other research is being conducted concurrently to evaluate pH amendments, plant susceptibility to pathogens in alternative substrates, silicon (Si) availability from alternative substrates, water and nitrogen use efficiency, herbicide efficacy and phytotoxicity with alternative substrates, and others.

Our immediate goal now is to identify two or three materials with the greatest potential for use in the nursery industry, and focus our efforts on those materials to better understand how they react in the vast and complex environments typical of nurseries throughout North America.