By James Altland

WEANING OFF BARK

As pine bark inventories decline, researchers evaluate alternative substrates

Most nursery growers east of the Rocky Mountains use pine bark as their primary potting component. Pine bark is typically generated by paper and lumber mills in the southern U.S. It was once a waste material that was difficult to dispose of, until about 30 years ago when it was realized that pine bark made for a cost-effective and high-quality potting component.

Pine bark inventories have been declining for the past five to 10 years. In 2008 the perfect storm hit, making pine bark more scarce and expensive. First high fuel prices forced lumber and paper mills to use their excess bark as a fuel to power their mills. Then the economic crisis followed, reducing the need for forest products. The result was a drastic reduction in pine bark inventories in most regions of the U.S., which was most sharply felt by nursery growers in the Midwest. These growers were also paying higher transportation fees to import pine bark from mills located in southern states.

The outlook for pine bark doesn't look any better. When former President George W. Bush enacted the Energy Independence and Security Act, he set a goal for the amount of biofuel added to gasoline to be raised from 4.7 billion

Roses grow vigorously in substrates composed of either pine bark or switchgrass. *Photos by James Altland*

Willow chips harvested from a willow farm in western New York.

gallons in 2007 up to 36 billion gallons by 2022. Not to be outdone, President Obama set a goal of 60 billion gallons of biofuel by 2030. The Department of Energy predicts that at least 27 percent of that goal will be met with forest feedstocks, with southern pine plantations being the ideal source for trees. And energy entrepreneurs all over the country are starting bio-reactors and biofuel burners to generate energy from agricultural and industrial waste materials. The days of finding an abundant organic waste material to serve as a potting substrate have past.

As a research horticulturist for the USDA in Wooster, Ohio, I began a process of identifying alternatives of pine bark. Scientists in other regions of the U.S. have been seeking pine bark alternatives for several years. All of this research has centered on the idea of chopping and grinding the entire pine tree, not just the bark. This concept has been proven successful. But most pine tree plantations occur in the south-central and southeast U.S., making this option less likely to succeed for nursery growers in the Midwest and upper Midwest states.

With Midwest growers in mind, alternative resources that could be used for container substrates were considered. While this area of the U.S. lacks softwood forests and forest products, there is an abundance of farmland. So a thought occurred that we might be able to grow biomass or biofuel crops and harvest them to use as a substrate.

Alternative contenders

Potential substrate alternatives must be regionally available, affordable, manageable with the same technology (soil mixers, fertilizers, pesticides, etc.) currently used to mix and manage pine bark substrates, and availability of the material must be controlled by the nursery grower.

With these criteria in mind, a list of biofuel crops was created that are grown, or could be grown, throughout the Midwest.

Switchgrass (*Panicum virgatum*) is native throughout most of North America. It stole headlines in 2006 when President George W. Bush touted it as an alternative energy source during the State of the Union Address. It's not widely grown compared to other agronomic crops, but it may be the most widely grown biofuel plant today. Seed for growing switchgrass, as well as resources for technical information are abundant and readily available. Yield estimates for switchgrass range from 1.5 to 6 tons/acre/year. Farm-scale research has shown the cost to produce switchgrass is about $50 to $60 per ton, but this is largely dependent on yield. At these prices, considering the density of switchgrass, the price is estimated to be $5 to $6 per cubic yard.

Willow (*Salix spp.*) is currently being grown on about 500 acres throughout New York and other northeast states as a biofuel. Willows are planted and harvested after four years, then harvested every three years thereafter. Yields are about 5 tons/acre/year when averaged across the three-year harvest cycle. This production system has been developed in the U.S. by State University of New York researchers Larry Abrahamsom, Tim Volk and Larry Smart. They have developed a handbook for willow production and published it on the Internet (www.esf.edu/willow/). Cost estimates for this material are less certain, but probably around $6 per cubic yard.

Giant miscanthus (*Miscanthus × giganteum*) is a sterile miscanthus hybrid. The popular landscape miscanthus (*Miscanthus sinensis*) has been reported as invasive in many parts of the U.S., however, the sterile nature of giant miscanthus presumably negates any weediness. It can produce 10 to 15 tons/acre/year of biomass. Economic analyses on the cost for producing giant miscanthus have not been determined (to my knowledge); however, production cost is primarily dependent on land value and yield. Assuming land value for growing giant miscanthus and switchgrass are equal, greater yields from giant miscanthus would likely lead to a lower cost per ton of product.

Corn stover (*Zea mays*) is all the above-ground parts of the corn plant left after the grain is harvested. The biomass potential for corn stover is about 2 to 4 tons/acre, which varies depending on tillage practices. While this yield is lower than some other biomass crops, corn is already grown on more than 80 million acres in the U.S., with very little stover currently being harvested or sold. Estimates suggest corn stover could be sold for $40/ton resulting in additional profits for the farmer. Cost for substrate would be about $4 per cubic yard.

Research results

All of the previously listed materials have higher pH than pine bark. Amendment with peat moss or compost at typical rates 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 fertilizer package. We are currently working with sulfate and oxide forms of Ca, Mg, and Fe as fertilizer supplements to avoid deficiencies in plants. If effective, these supplements will be inexpensive and easily incorporated in substrate blends.

USDA-ARS researchers harvest bamboo from a northern Ohio planting, with some canes as tall as 30 feet.

We found that biofuel materials processed through a hammermill equipped with a $\frac{3}{16}$-inch 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.

We are also studying nitrogen (N) dynamics in alternative substrates. As these substrates are probably more easily decomposed than pine 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, but after six to eight weeks, plants in alternative substrates had caught up and outperformed 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 how dibbling controlled release fertilizers (placement of the fertilizer beneath the liner root ball at the time of potting) can alleviate N immobilization. Dibbling fertilizers in switchgrass substrates resulted in similar or superior growth to all application methods in pine bark substrates. And 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 and reduced N leaching.

Potential pitfalls

There are exciting possibilities for using biofuel crops and other alternative materials as substrates, but there are still some challenges and potential pitfalls. We found the herbicide clopyralid, when used in the farming of switchgrass, persisted on the harvested and baled materials used in our initial studies. This herbicide residue caused severe injury to sensitive crops in greenhouse trials (zinnias, sunflowers, etc.). Fortunately, clopyralid is not always used in switchgrass production, and other similar phenoxy or auxinic herbicides (2,4-D, for example) did not leave persistent residues or cause injury on sensitive crops.

Switchgrass and similar grass-based substrates must not be overwatered. When overwatered or allowed to remain saturated, the grass will rot and develop a putrid odor. This is generally true for all substrate types. However, switchgrass and similar materials are much less forgiving than pine bark in this respect.

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