Herbaceous Crops for a Biofuels/Bioproducts Industry on Reclaimed Mine Lands

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Summary

In 2007, a biofuel species comparison was begun to investigate yield capacity of several feedstock species with potential suitability for revegetating mined land. Feedstock treatments included panicgrass, switchgrass, a 1:1 seed mix of panic- and switchgrasses, and two species established from vegetative propagules: hardy sugarcane and miscanthus. Plants were established at the Powell River Project Research and Education Center on 30 May 2007. Miscanthus plants were re-established in 2008: The original miscanthus species was mis-identified and this species was thus removed and replanted. Conditions for establishment were difficult due to drought, but about 70% of plants set out the previous season had new growth as of May 2009. Dead plants will be re-placed in May 2009. Initial survival and growth suggest miscanthus may be well-suited to production on mine lands. Across three harvests, average yields from all biofuel species are low (about 0.5 tons per acre at first harvest) with about 33% yield loss with delayed harvest. Growing season conditions and fertility have been limited, but N has not been applied in order to help reduce weed competition during establishment. Fertilizer N is to be applied in May 2009.

I. Introduction:

Renewable, bio-based chemicals and energy sources are of increased interest for nation, environmental, and economic security reasons. Few arising agricultural enterprises have the potential for such broad-scale impact as biorenewables industries, whether in terms of economics or land-use change. Sites with limited agricultural production capacity are of particular interest, because using such lands will avoid competition between food and fuel production. Evaluation and discovery of species with potential adaptation to mined land conditions may be an important part of meeting the nation's future needs.

Yield per land area will be an important determinant for economic viability of a biomass-to-biorenewables industry. Because raw biomass will be a low-value commodity (in dollars per ton), yields must be sufficient to warrant producer adoption and market entry. Given the extensive nature of sometimes difficult terrain, these sites will also need to be productive with minimal inputs.

II. Objectives:

1. Evaluate and compare stand establishment of potential biofuel/bioproduct crops (switchgrass, coastal panicgrass, and a mix of these two native grasses, along with two non-natives, miscanthus, and hardy sugarcane) on reclaimed mine lands in Southwest Virginia.
2. Evaluate these crops for growth traits such as plant height, crown width, tiller number, lodging, and leaf:stem ratio that relate to yield and feedstock quality.
3. Quantify yields in the establishment year and succeeding years.
4. Examine feedstock quality (cellulose, hemicellulose, lignin, nitrogen, and ash) of these potential biomass crops.
5. Determine the carbon sequestration potential of these biomass crops.

III. Methods and Procedures:

Plant species: Switchgrass, coastal panicgrass, and a 1:1 mixture of these species were seeded into plots with a plot seeder on 30 May 2007. At the same time, 100 plants/plot were established for both miscanthus and hardy sugarcane. Subsequent research determined that the miscanthus species planted in 2007 was not the species intended, and these plants were killed out and replaced in summer of 2008.

Measurements: Stand counts and plant growth measurements such as height, crown width, and tiller number were in October 2007 to determine initial production. Biomass samples were collected in January 2008, and plots also were evaluated for frost heaving. In March 2008, plots were evaluated for winter kill.

Biomass harvests were again conducted in Fall-Winter '08–'09 (three harvests) to determine change in yield of senesced plants over time. Survival of miscanthus plants established in 2008 also was measured in April 2009.

IV. Brief progress report:

Hardy sugarcane, the plant with best establishment in 2007, has suffered from large winter losses (greater than 50% in two of three reps). This species has been productive in some sites, but appears susceptible to soils with greater potential for freezing. Individual plants in better soil conditions have been highly productive, but use of this species would require high level of site selection. We continue to monitor these plants, but limited plant material – coupled with the large death losses – is leading us to abandon this species for use in mineland energy cropping.

Miscanthus survival has been 70% or more across all reps. Survival rates for plants (as opposed to root pieces) are often in the 80% range in Illinois (Tom Voigt, personal communication), so this level of survival should be a positive indicator. Observation suggests miscanthus is quite drought tolerant once established, but it is sensitive to drought during the establishment phase. Drought was an issue for this planting, so survival rates may be greater with higher summer precipitation.

Panic and switchgrasses produced greater amounts of biomass on a land area basis due to their distribution across the plot. Frost heaving has been a persistent issue on sites where soils hold water in the winter. We have replanted one rep with these soil conditions in April 2009.

Yields to date have been limited. About 0.5 t of standing biomass was harvested in November 2008, and yield declines were about 33% by March 2009 harvest. Although delayed harvests can improve feedstock quality (and often with limited yield losses), any gains in feedstock quality would be more than offset by such large yield losses.

We anticipate fertility is part of the limitation for plant productivity in these systems. Although much of the biomass research literature suggests little yield response to nitrogen fertilization for miscanthus and native grasses such as switchgrass, we anticipate greater yields with nitrogen applications given the lack of nitrogen in these soils.

Students are lined up to work on this and other biofuels projects through the coming year. We are meeting our objectives and excited to learn more about the potential of these species to produce biofuels on reclaimed lands.