UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY — COLLEGE OF AGRICULTURE

Switchgrass for Bioenergy

Introduction

Switchgrass (*Panicum virgatum*) is a tall-growing, warm-season, perennial bunchgrass native to portions of Kentucky. Once a major component of the Midwestern prairies, switchgrass stands have dwindled as natural grasslands have given way to expanding farms and developments.

There has been interest in recent years in re-establishing switchgrass. It is currently most widely recommended for soil and wildlife conservation uses, but switchgrass can also be used to provide mid-summer grazing in pasture systems for beef cattle. In addition, switchgrass is being researched as a potential biomass crop to produce energy. Switchgrass showes promise as a dual-purpose crop; it can be cut/grazed as a forage early in the season and harvested for biomass in late fall.

Biomass is any organic matter that can be converted to electricity or fuel. Organic matter can be transformed to usable energy by direct combustion, liquid fuel production (e.g. ethanol and butanol), and the manufacture of synthetic gases.

Switchgrass appears to be well suited for all of these processes; however, much of the research and testing in Kentucky to date has been focused on co-firing switchgrass with coal to produce electricity. Direct combustion of biomass is similar to the technology used for burning coal. In fact, small percentages of switchgrass can be co-fired with coal in existing power plant boilers. Burning only 10 percent switchgrass with coal generates electricity with lower emissions (fewer pollutants) than burning coal alone. The use of higher percentages of switchgrass, however, can require modifications in burner designs. This has been accomplished at the Maysville, Kentucky Spurlock Power Station, where a relatively new clean coal-generating unit was modified to burn alternative fuels, such as switchgrass.

Switchgrass also shows promise as an economical and efficient source of cellulosic ethanol. Unlike corn for ethanol production, switchgrass can be grown on marginal land and would not compete with food crop production. Some researchers have reported that switchgrass can yield five times more energy than it takes to produce it, a substantial improvement over corn's net energy output.

In addition, University of Kentucky (UK) researchers are currently engaged in a project involving the production of butanol from switchgrass. Butanol, which has a number of benefits over ethanol (e.g., less corrosive, easier to handle, greater energy yields, and can be blended with gasoline at a higher percentage), shows potential as another biofuel.

CENTER FOR CROP DIVERSIFICATION

Renewable energy sources like switchgrass have the potential to help reduce our dependency on finite supplies of fossil fuels,

although most experts believe it is unlikely that biofuels will totally replace them.

Marketing and Market Outlook

Switchgrass is still in the research and development phase in Kentucky. While this crop holds promise as an alternative energy source, there currently are no existing biomass markets for switchgrass in the Commonwealth. Chariton Valley in Southern Iowa and Gadsden in Alabama, where switchgrass is being used at electricity-generating power plants, are currently the nearest markets.

At present, co-firing with coal appears to offer the most realistic potential use of switchgrass for bioenergy in Kentucky. UK researchers have been involved in a co-firing project in which switchgrass was used to supplement coal for electricity production. A number of growers in the vicinity of the Maysville generating plant participated in the study. Researchers are examined cropping systems, analyzed plant composition, considered sustainability, determined net energy output, and evaluated the economics of switchgrass production for biomass. The possibility of compressing switchgrass into fuel pellets for thermal energy production was also examined in UK studies.

In addition to the co-firing study, UK is conducting research on the potential of switchgrass for ethanol production. The conversion of switchgrass to ethanol is a complicated process requiring a biorefinery. While Kentucky does not have one, several states, including Tennessee and Georgia, are building pilot-scale biorefineries.

Production Considerations

Types and cultivars

There are two types of switchgrass (upland and lowland), with many cultivars within each type. While cultivars of both types can be grown in this region, better adaptability and higher yield potential have made lowland cultivars the main focus of UK biomass research. Upland varieties are desirable when switchgrass is grown as a dual-purpose crop for both forage and biomass. Refer to the publication *Switchgrass for Biomass Production in Kentucky* (AGR-201) for more information on cultivar selection, as well as production details.

Site selection and planting

Switchgrass can be grown on marginal land and is adaptable to a variety of soil types. It is most productive, however, when grown on moderately well to well-drained sites of medium fertility. Freshly harvested seed has a low germination rate and must be treated to break dormancy.

Switchgrass can be seeded into a tilled (drilled or broadcast) or no-till (drilled) field in the late spring. Establishment is generally slow and difficult, often taking from 2 to 3 years. In some cases reseeding will be necessary in order to produce a uniformly vigorous stand. However, once established, this perennial grass will continue to yield for 10 or more years. Plants can reach a height of 7 to 10 feet under favorable growing conditions.

Pest management

Switchgrass is a hardy plant that is bothered by few insects and diseases. Grasshoppers, crickets, stem-boring moths, corn fleabeetle, and nematodes have been reported causing minor damage. Switchgrass does not compete well with other grasses and broadleaf weeds until well established. Therefore, good pre-plant weed control is essential to the establishment of a good stand. Herbicides may be necessary for weed management during the first year and in the spring of the second growing season. Once the stand canopy closes, weed competition is reduced.

Harvest

Some biomass can be harvested the first and second years; however, the stand will not come into full production until the third year. Mature switchgrass stands can be harvested either once or twice per year with conventional haying equipment. Cutting once, which research indicates is the optimal harvest system, has the economic advantage of being cheaper than cutting twice. Cutting once will remove fewer nutrients from the soil; harvest will occur after frost when the nitrogen and some of the potassium have moved back into the root system. When grown as a dual-purpose crop, switchgrass can be cut early for hay (or grazed) and then harvested late in the fall for biomass.

When the crop is harvested after frost, it is cut at a height of 6 to 8 inches. The cutting height should be 8 to 10 inches when harvested during the growing season.

Switchgrass can be baled in either round or large rectangular bales; however, the latter are considered easier to handle and transport. Stored bales must be kept dry and off the ground, therefore covered storage is preferred. Switchgrass can also be pelletized for easier handling.

Labor requirements

Labor requirements are approximately 3 hours per acre per year at a 6-ton yield. This includes fertilizer application and all production practices up to moving bales off the field. It does not include loading and trucking which are assumed a separate transportation charge. This compares to roughly 2 hours per acre per year at a 3-ton yield for hay production.

Economic Considerations

From a practical standpoint, most land that would potentially go into switchgrass production would come out of hay production. Most cropland would be more profitable in its current capacity. Switchgrass production would be best suited on marginal ground that also has decent access for tractor-trailers to haul the bales. Thus, the economic analysis presented here compares switchgrass production to land already in hay production. It assumes the same equipment use and the production of large 1,200-pound round bales.

A major factor that impacts profitability of switchgrass compared to hay production is that switchgrass has to be established and this stand would take 3 to 4 years to reach full production. So it is impossible to compare switchgrass to hay production for just the average production year. You need to evaluate the production of both forages over multiple years using an appropriate discount rate for future years' production.

Table 1, below, provides a comparison of switchgrass production assuming a peak yield of 6 tons per acre in years 3 to 6 and a hay yield of 3 tons per acre. In this scenario, the long-term profitability of switchgrass and of hay production over a 15-year time horizon is exactly equal.

Even though the net return to switchgrass is higher than hay during the peak production years, the profitability of switchgrass is reduced because of the establishment costs and the loss of production in the first 2 years. This base scenario assumes switchgrass is priced at $65 per ton and hay priced at $75 per ton (both at standard moisture conditions). These two prices are only used as examples. What can be inferred is that switchgrass prices need to be roughly within $10 of hay prices on a per ton basis for switchgrass to be competitive based on the assumptions used here.

Transportation figures for switchgrass are based on the assumption bales will be trucked 50 miles one way at a cost of $11 per ton. For the detailed budget, along with a listing of the other assumptions used in this comparison analysis, refer to the UK Agricultural Economics switchgrass decision aid on their Web site.

Table 1. Comparative Budget Summary for Switchgrass and Hay (Per Acre)

	Switchgrass Year 1 Production	Switchgrass Full Production (Years 3 to 6)	Hay Production
Yield	3/4 ton per acre	6 tons per acre	3 tons per acre
Price per ton	$65	$65	$75
Total Returns	**$49**	**$392**	**$225**
Variable Costs			
Production	$234	$134	$119
Labor	$11	$34	$24
Trucking and Loading	$9	$69	$0
Total Variable Costs	**$254**	**$237**	**$143**
Return Above Variable Costs	**($205)**	**$155**	**$82**
Total Fixed Costs	**$41**	**$75**	**$45**
Total Variable + Fixed Costs	**$295**	**$312**	**$188**
Return Above Variable + Fixed	**($246)**	**$80**	**$37**

**Parentheses indicate a negative number, i.e. a net loss*

Selected Resources

- Division of Biofuels (Kentucky Energy and Environment Cabinet)
http://energy.ky.gov/biofuels/Pages/default.aspx
- Farm Scale Biomass Production for Electricity Generation and Community Development (University of Kentucky, 2012)
http://www.kfgc.org/KFGC%20Farm%20Scale%20Biomass%20Production.pdf
- Learning Modules for Switchgrass Biomass Production (University of Kentucky)
http://www.uky.edu/Ag/Forage/Forage%20Decision%20Aids.htm
- On-farm Biomass Processing (University of Kentucky)
http://jokko.bae.uky.edu/BRDI/
- Pros and Cons of Growing Switchgrass in Kentucky (University of Kentucky, 2009)
http://www.ca.uky.edu/cmspubsclass/tinymce/jscripts/tiny_mce/plugins/filemanager/files/adreum/biofuels/Switchgrass%20SWOT.pdf
- Switchgrass for Biomass Production in Kentucky (University of Kentucky, 2011)
http://www.uky.edu/Ag/Forage/agr2013.pdf
- Switchgrass vs. Hay Comparative Budgets (University of Kentucky, 2010)
http://www.ca.uky.edu/cmspubsclass/files/ghalich/budget-switchgrassvhay.xls
- Bioenergy Feedstock Information Network
https://bioenergy.ornl.gov/
- Center for Renewable Carbon (University of Tennessee)
http://renewablecarbon.tennessee.edu/
- Costs of Producing Switchgrass for Biomass in Southern Iowa (Iowa State, 2001)
http://www.extension.iastate.edu/Publications/PM1866.pdf
- Economic Analysis of Conditions for which Farmers Will Supply Biomass Feedstocks for Energy Production (University of Tennessee, 2007)
http://www.agmrc.org/media/cms/2007UTennProjDeliverable_9BDDFC4C2F4E5.pdf
- Estimated Costs for Production, Storage and Transportation of Switchgrass (Iowa State University, 2008)
http://www.extension.iastate.edu/agdm/crops/pdf/a1-22.pdf
- Growing and Harvesting Switchgrass for Ethanol Production in Tennessee (University of Tennessee, 2008)
http://utextension.tennessee.edu/publications/Documents/SP701-A.pdf
- Introduction to Bioenergy: Feedstocks, Processes and Products (ATTRA, 2010)
https://attra.ncat.org/attra-pub/summaries/summary.php?pub=342
- Management Guide for the Production of Switchgrass for Biomass Fuel in Southern Iowa (Iowa State, 2003)
http://www.extension.iastate.edu/Publications/PM1710.pdf
- Manufacturing Fuel Pellets from Biomass (Pennsylvania State University, 2009)
http://pubs.cas.psu.edu/freepubs/pdfs/uc203.pdf
- Planting and Managing Switchgrass as a Dedicated Energy Crop (Blade Energy Crops, 2010)
2.6 MB file
http://www.bladeenergy.com/Bladepdf/Blade-Switchgrass-Mgmt_2ed.pdf
- Prairie Lands Biomass Project (Chariton Valley, Iowa)
http://www.iowaswitchgrass.com/home.html
- Switchgrass as a Dual-Purpose Grazing and Bioenergy Crop (Noble Foundation, 2012)
https://www.noble.org/ag/livestock/switchgrass-dual-purpose/
- Switchgrass as a Bioenergy Crop (ATTRA, 2006)
https://attra.ncat.org/attra-pub/summaries/summary.php?pub=311
- Switchgrass Overview (Agricultural Marketing Resource Center, 2012)
http://www.agmrc.org/commodities__products/biomass/switchgrass.cfm/

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