UF UNIVERSITY of FLORIDA IFAS Extension

FE900

Economic Potential of Switchgrass as a Biofuel Crop in Florida[1]

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Introduction

Switchgrass (*Panicum virgatum*) has been recognized by the United States Department of Energy (DOE) as a potentially important source of ethanol. Not only has the DOE stepped up its research on the role of switchgrass in biomass production, but it has selected this grass as a model species. Reasons for the selection include the demonstration of relatively high, reliable productivity across a wide geographical range; suitability for marginal-quality land; low water and nutrient requirements; and positive environmental attributes (Mitchell, Vogel, and Sarath 2008). The selection of switchgrass as a "model" or "prototype" species was made around 1990 (Wright 2007).

Florida is interested in biofuels because of its comparative advantage of a long warm growing season. Businesses have been developing technologies to convert crops like sugarcane, energycane, and sweet sorghum into energy, but they have given little priority to switchgrass. University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS, http://www.ifas.ufl.edu) currently is involved in several research projects that are exploring the potential of selected biofuels. There has been only limited work with switchgrass because some ecologists have suggested that switchgrass in Florida is beyond its primary zone of adaption. Preliminary results, however, have been encouraging and warrant further examination.

The purpose of this publication is to evaluate the economic potential of producing switchgrass as a perennial bioenergy crop in Florida. Switchgrass can normally be planted by seed in early March in South Florida and through mid-April in North Florida. It is slow to establish, needing adequate weed control and water to develop a productive stand. One to two months after heading (or later) it can be harvested as "hay" for biofuel. In South Florida, two cuts are possible, whereas in North Florida, one cut would normally be taken after frost in late fall. These two harvest systems are compared in the following economic evaluation. While there is no known commercial production of switchgrass for biofuel in Florida, a UF/IFAS EDIS publication (Newman et al. 2011) summarizes the potential of this grass as an alternative energy source. Other EDIS publications in this series report the economic potential of sugarcane (http://edis.ifas.ufl.edu/sc090), energycane (http://edis.ifas.ufl.edu/sc089), and sweet sorghum (http://edis.ifas.ufl.edu/fe896). This fact sheet provides some cost estimates to indicate where further research may be necessary to improve future economic potential and to help potential producers determine whether they should

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consider switchgrass production for biofuel. The budgets contained herein might also be useful in a preliminary evaluation of other similar perennial hay grasses well-adapted to Florida.

Assumptions

It is assumed in this study that switchgrass is grown on a 640-acre farm (usually referred to as "one section"). The farm is broken down by section for management decisions. Because the hypothetical farm is assumed already established, there are no development costs to defray. The soil is classified as mineral (sand) and subdivided into 16, 40-acre blocks. For the two-cut system in South Florida, there are 14 half-mile-long field ditches (7 miles total) and two mile-long seepage canals, allowing it to be compatible with other crops grown in the area. Therefore, after deducting 65 acres of roads, canals, and ditches, net acreage is 575 acres. For the one-cut system in North Florida, there will be 620 acres because of fewer roadways and ditches. A managed fallow period was budgeted for South Florida because it is traditionally used when perennial crops are replanted or changed. That practice is less common and not as necessary in North Florida and, for that reason it was not included in the budget.It was also assumed that switchgrass in the two-cut/year system produced only one crop in the first year and two thereafter for four years to follow, which results in the use of 1.8 times per year in **Table 1**. In North Florida, harvest is not scheduled in the first year, hence the use of 0.9 times per year in **Table 2**. Switchgrass is budgeted as being harvested as hay at 15 percent moisture, with standard haying equipment currently in use on Florida livestock farms, then transported to the processing plant. Various costs and production estimates come from research data, local practices, and/or custom rates in related grass hay industries. Because numerous costs change with purchased product prices (fertilizers, pesticides, fuel, etc.) and actual practices differ among production and processing systems, growers and others using this document are encouraged to utilize their own cost information and thereby provide for a more accurate estimate of financial outcomes.

Long-term production and commercial ethanol processing data for switchgrass do not exist. This study uses the information developed by Frosch (2008) on ethanol production and processing, which may be optimistic until the industry's technology improves to the level expected from current research studies. One dry ton of switchgrass was assumed to yield between 70 and 90 gallons of ethanol at an estimated processing cost of approximately $1.35 per gallon, with a range of $1.00 to $1.65 using a cellulosic ethanol conversion process (Ingram 2009). These were the same estimates used for energycane (http://edis.ifas.ufl.edu/sc089).

Results

The production budget for the two-cut/year system in South Florida (**Table 1**) shows a total per-acre, per-year cost of $1,009 at the seven tons per acre (7T/A) dry matter (8.05T/A field moisture) production level. This equals about $144 per dry ton, which a farmer would need to receive to breakeven. Harvesting and transport, and fertilizers and chemicals account for the largest share of variable costs, which may range between three- and four-fifths of those expenses.

In North Florida in the one-cut/year system (**Table 2**), a total cost of production of approximately $460 per-acre per year ($460/A/year) at the four tons per acre (4T/A) dry matter (4.6T/A field moisture) level was calculated. This implies ethanol revenues from switchgrass must be at least $115 per ton to break even, or $29 per ton less than the breakeven prices for South Florida switchgrass growers. In the one-cut/year system, harvesting and transport accounted for about 28 percent of the total costs, and fertilizers and chemicals accounted for 51 percent of the total costs.

Results from both South and North Florida indicate that fertilizers are a significant input cost. A summary of previous research (Mitchell, Vogel, and Sarath 2008), primarily on the heavier soils in the northern United States, has shown that switchgrass can perform well on limited fertility soils, probably because of its nutrient recycling ability. However, the longer, higher rainfall season, along with the sandy soils of Florida, could suggest a potential need for greater nutrient application, which we have fully budgeted for here. Because this is a significant cost, and if switchgrass is to be used as a bioenergy crop under these conditions, further research will be needed both to determine actual nutrient needs in different production systems and levels, and to assess the potential utilization of nutrients in the residuals from processing.

Harvest costs were also high, particularly in South Florida where two cuts per year were made. Baling certainly provides opportunity for storage and greater transport flexibility. However, another evaluation in New Jersey (Brumfield and Helsel 2011) showed a significant reduction in harvest costs where direct cut flail type harvesters were evaluated. Use of such equipment would likely be limited to the dry season, where switchgrass moisture contents would be low enough to direct harvest, particularly if processing plants were close enough. In South Florida, the challenge would be to make first-cut hay at 15 percent moisture during the rainy season. Unlike hay for livestock feed, the value of which drops if rained upon, hay for energy might actually benefit from weathering, which lowers its ash content. Offsetting this potential benefit, however, may be lower overall harvestable tonnage.

Establishment costs were a significant initial expense and were prorated over five years. Some agronomists, however, estimate switchgrass stands could last longer. If true in Florida, a longer production period between replanting would significantly reduce the per-year, per-ton costs attributed to stand establishment.

Assuming an ethanol processing cost of $1.35 per ton of dry matter, and yields of both 70 and 90 gallons of ethanol per dry ton, **Figure 1** represents the breakeven costs of ethanol production from switchgrass from 4–10 ton yields of dry matter per-acre, per-year for the two-cut/year system, and from 4–6 ton yields of dry matter per-acre, per-year for the one-cut/year system.

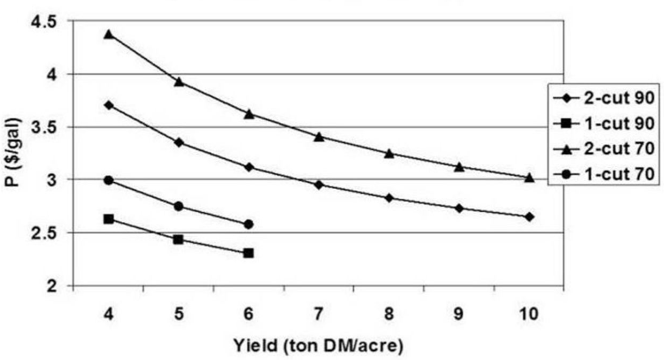

Figure 1. Breakeven prices of ethanol from switchgrass yielding 70 and 90 gallons per ton of dry matter (DM) in the two-cut/year and one-cut/year systems (at $1.35/gallon processing cost)

It is clear that the one-cut/year system, at both 70 and 90 gallons of ethanol yields, shows lower breakeven costs than the two-cut/year system, mainly because of reduced fertilizer and harvest costs. The more costly production in the two-cut/year system may suggest that livestock grazing on the second growth during the dry season may provide valuable feedstuff, eliminate harvest costs, and recycle nutrients from the manure. Such an option would have to be more fully evaluated in the whole farm management system.

While we have used an expected average processing cost for the conversion of biomass to ethanol, estimates in the literature have ranged from about $1.00 per gallon to as much as $1.65 per gallon. Although not presented in this publication, the reader can also refer to the EDIS energy-cane publication (http://edis.ifas.ufl.edu/sc089) mentioned above for an estimation of the breakeven costs for these higher and lower estimates of processing costs since they are similar for switchgrass production.

Summary

Switchgrass, although not typically thought of as being adapted to Florida, may fit into several areas where livestock enterprises exist, and alternatives are being considered. It may find use on marginal lands as part of a hay/pasture rotation where ecosystem services (water quality, wildlife refuge, etc.) may be desired. Nutrient use along with harvest management alternatives and economics thereof will need further elucidation before switchgrass will be considered as an important bioenergy crop in Florida.

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Table 1. Estimated per-acre, per-year costs of cultural activities performed on a one-section (640 acres) switchgrass farm maintained for five years on mineral (sand) soils in South Florida with a two-cut/year system, 2010

Activity	Unit	Years	Rate	# Times	Price	S/A/Y	% Share	
							Variable costs	Total costs
Fallow land maintenance								
Herbicide + surfactant	quart	1	2.00	2	7.50	30.00	0.034	0.030
Herbicide application	$/acre	—	—	2	4.00	8.00	0.009	0.008
Total	$	—	—	—	—	38.00	0.043	0.038
Prorated per year in cycle	$	0.20	—	—	—	7.60	—	—
Land preparation								
Soil testing and consulting	$/acre	1	—	1	1.11	1.11	0.12	0.11
Disking	$/acre	1	—	2	15.00	30.00	3.37	2.97
Lime (dolomite) application	$/acre	1	—	1	5.00	5.00	0.56	0.50
Lime material	ton/acre	1	2.00	1	28.00	56.00	6.28	5.55
Laser leveling[a]	S/acre	1	—	1/5	60.00	12.00	1.35	1.04
Total	$	—	—	—	—	104.11	11.68	10.32
Prorated per year in cycle	$	0.20	—	—	—	20.82	—	—
Planting								
Drilling	$/acre	1	—	1	12.00	12.00	1.35	1.04
Seed[b]	lbs/acre	1	6.00	1	17.00	102.00	11.44	10.11
Total	$	—	—	—	—	114.00	12.79	11.30
Prorated per year in cycle	$	0.20	—	—	—	22.80	—	—
Cultural activities								
Fertilizer application[c]	$/acre	5	—	1.80	6.00	10.80	1.21	1.07
Nitrogen[c]	lb/acre	5	80.00	1.80	0.60	86.40	9.69	8.56
P2O5[c]	lb/acre	5	40.00	1.80	0.60	43.20	4.85	4.28
K2O[c]	lb/acre	5	80.00	1.80	0.60	86.40	9.69	8.56
Micronutrients[c]	lb/acre	5	15.00	1.00	0.51	7.65	0.86	0..76
Chemical applications[d]	$/acre	1	—	2.00	6.00	12.00	1.35	1.19
Herbicide[d]	oz/acre	1	6.00	1.00	3.75	22.50	2.52	2.23
Herbicide[d]	pt/acre	1	2.00	1.00	1.50	3.00	0.34	0.30
Total	$	—	—	—	—	271.95	30.51	26.95
Miscellaneous[e]	$/acre	—	—	—	—	32.32	3.63	3.20
Interest[f]	$/acre	—	—	—	—	271.95	30.51	26.95
Harvesting activities								
Mowing	$/acre	5	1.00	1.80	13.40	24.12	2.71	2.39
Raking	$/acre	5	1.00	1.80	8.55	15.39	1.73	1.53
Baling[g]	$/ton	5	8.05	1.80	16.00	231.84	26.01	22.98
Transportation & handling[h]	$/ton/trip	5	8.05	1.80	10.00	144.90	16.26	14.36
Total	$	—	—	—	—	416.25	46.70	41.25
Total variable costs	$	—	—	—	—	891.38	100.00	88.34
Overhead activities								
Supervising and vehicles	$/gross acre	5	—	1.00	10.00	10.00	—	0.99
Road and ditch maintenance	$/gross acre	5	—	0.20	9.00	1.80	—	0.18
Water management[i]	$/gross acre	5	—	1.00	50.80	50.80	—	5.03
Taxes and assessments	$/gross acre	5	—	1.00	55.00	55.00	—	5.45

Activity	Unit	Years	Rate	# Times	Price	S/A/Y	% Share	
							Variable costs	Total costs
Total	$/acre	—	—	—	—	117.60	—	11.66
TOTAL COSTS	$	—	—	—	—	1008.98	—	100.00

[a] Land leveling prior to planting represents a per-year cost.

[b] Switchgrass seed is typically low in germination and rates are recommended in pounds of pure live seed.

[c] Nutrient levels assumed to be optimum at establishment; then N, P, and K applied prior to spring green-up to replace nutrient use. A micronutrient mix is also applied once per year with macronutrients.

[d] Paramount® and 2,4-D applied post-emergence separately after planting in the first year only.

[e] At 10% of above prorated variable costs.

[f] At 8% of total prorated variable costs before harvesting.

[g] An estimated 4.6T/A field half-harvested during the late fall (during dry season preferably after frost or numerous consecutive days of cold weather).

[h] Assumes a cost of $0.50/ton mile for pickup and delivery, 20 miles roundtrip to the processing plant.

[i] Assumes three, one-inch applications of water during planting year at $18 per application.

Table 2. Estimated per-acre, per-year costs of cultural activities performed on a one-section (640 acres) switchgrass farm maintained for five years on mineral (sand) soils in North Florida with a one-cut/year system, 2010

Activity	Unit	Years	Rate	# Times	Price	S/A/Y	% Share	
							Variable costs	Total costs
Land preparation								
Soil testing and consulting	$/acre	1	—	1	1.11	1.11	0.29	0.24
Disking	$/acre	1	—	2	15.00	30.00	7.84	6.52
Lime (dolomite) application	$/acre	1	—	1	5.00	5.00	1.31	1.00
Lime material	ton/acre	1	2.00	1	28.00	56.00	14.64	12.17
Laser leveling[a]	S/acre	1	—	1/5	60.00	12.00	3.14	2.61
Total	$	—	—	—	—	104.11	27.22	22.63
Prorated per year in cycle	$	0.20	—	—	—	20.88	—	—
Planting								
Drilling	$/acre	1		1	12.00	12.00	3.14	1.86
Seed[b]	lbs/acre	1	6.00	1	17.00	102.00	26.66	22.17
Total	$	—	—	—	—	114.00	28.80	24.77
Prorated per year in cycle	$	0.20	—	—	—	22.80	—	—
Cultural activities								
Fertilizer application[c]	$/acre	5	—	1.00	6.00	6.00	1.57	1.30
Nitrogen[c]	lb/acre	5	80.00	1.00	0.60	48.00	12.55	10.43
P2O5[c]	lb/acre	5	40.00	1.00	0.60	24.00	6.27	5.22
K2O[c]	lb/acre	5	80.00	1.00	0.60	48.00	12.55	10.43
Micronutrients[c]	lb/acre	5	15.00	1.00	0.51	7.65	2.00	1.66
Chemical applications[d]	$/acre	1	—	2.00	6.00	12.00	3.14	2.61
Herbicide[d]	oz/acre	1	6.00	1.00	3.75	22.50	5.88	4.89
Herbicide[d]	pt/acre	1	2.00	1.00	1.50	3.00	0.78	0.65
Total	$	—	—	—	—	171.95	44.74	37.19
Miscellaneous[e]	$/acre	—	—	—	—	21.48	0.056	0.047
Interest[f]	$/acre	—	—	—	—	18.90	0.05	0.04
Harvesting activities								
Mowing	$/acre	5	1.00	0.90	13.40	12.06	3.15	2.62
Raking	$/acre	5	1.00	0.90	8.55	7.70	2.01	1.67
Baling[g]	$/ton	5	4.60	0.90	16.00	66.24	17.32	14.40
Transportation & handling[h]	$/ton/trip	5	4.60	0.90	10.00	41.40	10.82	9.00
Total	$	—	—	—	—	127.40	33.30	27.69
Total variable costs	$	—	—	—	—	382.54	100.00	83.14
Overhead activities								
Supervising and vehicles	$/gross acre	5	—	1.00	10.00	10.00	—	2.17
Road and ditch maintenance	$/gross acre	5	—	0.20	9.00	1.80	—	0.39
Water management[i]	$/gross acre	5	3.00	0.20	18.00	10.80	—	2.35
Taxes and assessments	$/gross acre	5	—	1.00	55.00	55.00	—	11.95
Total	$/acre	—	—	—	—	77.60	—	16.86
TOTAL COSTS	$	—	—	—	—	460.14	—	100.00

[a] Land leveling prior to planting represents a per-year cost.

[b] Switchgrass seed is typically low in germination and rates are recommended in pounds of pure live seed.

Activity	Unit	Years	Rate	# Times	Price	S/A/Y	% Share	
							Variable costs	Total costs

[c] Nutrient levels assumed to be optimum at establishment; then N, P, and K applied prior to spring green-up to replace nutrient use. A micronutrient mix is also applied once per year with macronutrients.

[d] Paramount® and 2,4-D applied post-emergence separately after planting in the first year only.

[e] At 10% of above prorated variable costs.

[f] At 8% of total prorated variable costs before harvesting.

[g] An estimated 4.6T/A field half-harvested during the late fall (during dry season preferably after frost or numerous consecutive days of cold weather).

[h] Assumes a cost of $0.50/ton mile for pickup and delivery, 20 miles roundtrip to the processing plant.

[i] Assumes three, one-inch applications of water during planting year at $18 per application.