

Estimated Costs for Production, Storage and Transportation of Switchgrass

Introduction

The bioeconomy is the focus of research and discussion as a way to reduce dependence on imported oil, provide some relief from green house gas emissions and increase the use of agricultural products. Biofuels are a significant component of the bioeconomy. Ethanol and biodiesel are the primary biofuels used today.

In the United States, ethanol is primarily produced from corn. However, there is a considerable amount of research and development occurring to develop the capability to produce ethanol from cellulous material.

Switchgrass is one of the major plants considered in discussions of cellulous ethanol. Switchgrass (*Panicum virgatum L.*) is a perennial warm-season grass native to Iowa. In the past, it has been evaluated as an energy crop but primarily to replace coal. Using switchgrass to produce ethanol is a new use.

This report updates earlier production cost estimates for switchgrass. The earlier estimations were completed as a part of the study using switchgrass to replace coal. This information is available in Iowa State University (ISU) Extension publication *Costs of Producing Switchgrass for Biomass in Southern Iowa*, PM 1866). For more information on the agronomic aspects of switchgrass production, see the ISU Extension publication *Switchgrass* (AG 200).

The estimated costs of production are presented here in two sections. The first is the estimated costs. This is followed by a discussion of what could happen if we change the initial assumptions used to estimate the costs. Switchgrass costs are presented in three categories. The first is the production costs, which include establishment, reseeding and annual production. Next are the transportation costs; the final cost category considered here is storage.

Production

Establishment

We make several assumptions based on 2001 research findings, with costs updates using 2007 estimates. The ISU Extension Publication *2007 Iowa Farm Custom Rate Survey* (FM 1689) was used to compute machinery costs. Other costs come from the ISU Extension Publication *Estimated Costs of Crop Production in Iowa - 2007* (FM 1712). Seed and chemical prices come from expert opinion.

Assumptions

(Note that these assumptions will be relaxed later, but they are used for the illustration that follows)

- The switchgrass is frost-seeded with a 25 percent probability of needing to reseed the stand
- The land charge assumed is \$80 per acre
- Switchgrass yield is 4 tons per acre
- The switchgrass stand is assumed to last 11 years
- The reseed is assumed to last 10 years
- The interest rate used for prorating the establishment costs is 8 percent, while the operating interest rate is 9 percent
- Operating costs are assumed to be borrowed for six months
- The field is initially prepared by adding phosphorous and potassium. There is also an application of lime assumed.



Production Costs

Table 1: The estimated costs of establishing the switchgrass, presented in dollars per acre.

Land Charge	\$80.00
Preharvest Machinery Operations Custom Charges	
Disk	\$9.45
Harrow	6.25
Airflow spreader (seed and fertilizers)	7.70
Spraying chemicals	5.15
Total	\$28.55
Operating Expenses	
Seed	Price/unit Units
Seed	\$7.50/lb 6 \$45.00
Fertilizer	
P	\$0.37/lb 30 11.10
K	\$0.23/lb 40 9.20
Lime	\$21/ton 3 63.00
Herbicides	
Pursuit +	\$53/gal 3 oz 1.24
MSO	\$1.75/pt 32 oz 3.50
2,4D	\$16/gal 1.5 pts 3.00
Total Operating Costs	\$136.04
Total Establishment	\$244.59
11 years at 8% amortization (.14008 factor)	
Prorated Yearly Establishment Cost per Acre	\$34.26

Table 2: The estimated reseeding costs per acre

It is assumed that a field needs to be reseeded 25 percent of the time. Basic ground preparation and lime are not included for the reseeding.

Reseeding Probability	25%
Land Charge	\$80.00
Preharvest Machinery Operations Custom Charges	
Airflow Spreader (seed and fertilizers)	\$7.70
Spraying chemicals	5.15
Total	\$12.85
Operating Expenses	
Seed	Price/unit Units
Seed	\$7.50/lb 6 \$45.00
Fertilizer	
P	\$.37/lb 30 11.10
K	\$.23/lb 40 9.20
Herbicides	
Pursuit +	\$53/gal 3 oz 1.24
MSO	\$1.75/pt 32 oz 3.50
2,4D	\$16/gal 1.5 pts 3.00
Total Operating Costs	\$73.04
Total Reseeding Costs	\$165.89
Expected Reseeding Costs (25% probability)....	\$41.47
Prorated Yearly Reseeding Cost per Acre	\$ 6.18
10 years at 8% amortization (.14903 factor)	

Assumptions

- A 4 ton per acre yield.
- 100 pounds of nitrogen (N) is used. The herbicides listed are examples. Phosphorus and potassium are at removal rates.
- Harvesting is done in mid to late November. It will be mowed, raked and baled, using a large square baler. Bales are 3x4x8 feet, with a weight of 950 pounds.
- The bottom of Table 3 also presents the total estimated costs for producing switchgrass. Production costs are the sum of the establishment costs, the prorated reseeding costs and the annual production costs.

Table 3: Estimated yearly production costs per acre

Expected yield per acre 4 tons
 Weight of large square bale 950 lbs
 Bales per acre 8.42

Land Charge	\$80.00
Preharvest Machinery Operations Custom Charges	
Liquid N application	\$4.80
Bulk fertilizer spreader	3.20
Sprayer	5.15
Total	\$13.15
Operating Expenses	
Fertilizer	Price/unit Units
Nitrogen	\$.31/lb 100 \$31.00
Phosphorus (lbs/ton removed) ..	.37/lb 1.94 2.87
Potassium (lbs/ton removed)23/lb 22.8 20.98
Herbicides	
Pursuit	\$53/gal 3oz 1.24
MSO	\$1.75/pt 32oz 3.50
2,4D	\$16/gal 1.5pts 3.00
Total	\$62.59
Interest on Operating Expenses, 6 mths @ 9%	\$3.41
Harvest Machinery Operations, Custom Charges	
Mow/conditioning	\$10.75
Rake	5.30
Baling; large square (\$10.70/bale)	90.11
Staging (\$2.75/bale)	23.16
Total	\$129.31
Yearly Production Costs per Acre	\$288.46
Prorated Establishment Cost	34.26
Prorated Reseeding Cost	6.18
Production Costs per Acre	\$328.91
Production Costs per Ton	\$82.23

Storage

Previous studies estimated the costs for storing switchgrass. The options considered include storing in: an open field, an open field on crushed rock covered with a tarp, an enclosed structure, and a pole building with open sides. These studies found that the enclosed building is the most expensive type of storage, but, because maintaining quality of switchgrass is very important for ethanol production, it is the method selected here. (Note that if switchgrass is used as a coal replacement, the quality consideration is not as critical and another storage option might be considered.)

The costs of storing include not only the cost for the facility or method used but also include the value of the switchgrass in storage and dry matter loss associated with the various storage methods.

The estimated storage costs are presented in Table 4 for an enclosed building. (These cost assumptions are relaxed in later discussions.)

Since there are various types of enclosed buildings, we make several assumptions.

Assumptions

- The structure is a tarped hoop type structure and holds 5,454 bales or 2,591 tons.
- Assume a cost of \$12 per square foot for the finished building.
- Dimensions are 100x300 feet (30,000 square feet).
- The bales weigh 950 pounds or 0.475 tons and are 3x4x8 feet.
- The bales are stacked 20 feet high or six bales high.
- The building and area are assumed to take two acres. The extra space is for building edging, driveways and turnaround space for semi-trucks.

One issue that is not addressed is who owns the switchgrass while it is in storage. This aspect of the cost of production has not been decided. Therefore, we chose not to estimate it. There are at least two major costs that are not considered because of this decision. First, there is the value of the switchgrass over the time it is in storage. Second, and perhaps more important, is the insurance for the switchgrass and building. Storing this much dry hay could create a fire hazard.



Table 4: Storage

Building costs \$12 per square foot.....	\$360,000
Yearly Costs:	
Land, 2 acres.....	\$160
Building; yearly ownership cost at 12%	\$43,200
Storage Cost per Ton.....	\$16.67

Transportation and Handling

Transportation and storage logistics will vary depending on the situation, so again, we make some assumptions.

Assumptions

- For these estimates, the switchgrass bales are staged along the edge of the field. This cost is included in the production budget. A farmer with a typical tractor and bale fork can perform these duties.
- Another transportation cost is collecting, delivering and unloading the bales into a storage facility. A semi-trailer holding 20 tons (or 42 bales) is used to haul the switchgrass. Estimated times are 30 minutes to load the truck and 20 minutes to unload. The charge for the semi is \$70 per hour.
- A typical tractor and bale hauler will not work to stack large square bales 20 feet high. More specialized equipment is needed for this task. Estimated costs of such a tractor were \$20 per hour and \$10.78 worth of fuel per hour. The operator charge is \$12 per hour.

Table 5 shows the estimated transportation costs. These are shown in two categories; field to storage (5-mile trip) and storage to plant (30-mile trip). It is assumed that the

unloading will be done at the plant at plant expense.

There are two comments regarding these cost estimates. The loading and travel time to take the semi from field to field and then to a storage facility may be underestimated. It is possible, too, that if enough farmers raise switchgrass, they can haul it to the facilities themselves. This would change the cost estimates. However, the estimates used here present the opinions of several farmers who grow switchgrass.

Table 6 shows the total estimated costs for switchgrass. This includes production, storage and transportation.

Table 6: Total Costs for Switchgrass:

Production	\$82.23
Storage.....	16.67
Transportation to Storage.....	6.10
Transportation to Plant.....	8.65
Total Cost per Ton	\$113.66

Table 5: Transportation and Handling Costs

Field to Storage Costs:

5 miles to storage at 25 miles per hour;

Truck Costs

Load .5 hour; unload .33 hour; travel .4 hour
1.23 hours x \$70 \$86.33

Loader Costs (labor, tractor and fuel)

(\$12 + \$20 + \$10.78 = \$42.78/hour)
0.83 hours x 42.78 \$35.65

Total Hauling Cost to Storage \$121.98

Transportation to Storage

Cost per ton..... \$6.10

Storage to Plant Costs:

30 miles one-way to plant at 45 MPH
Plant will do the unloading at their cost

Truck Costs

Load .5 hour; unload .33 hour; travel 1.33 hour
2.16 hours x \$70 \$151.67

Loader Costs (labor, tractor and fuel)

(\$20 + \$10.78 + \$12 = \$42.78/hour)
0.5 hour x \$42.78..... \$21.39

Total Hauling Cost to Plant \$173.06

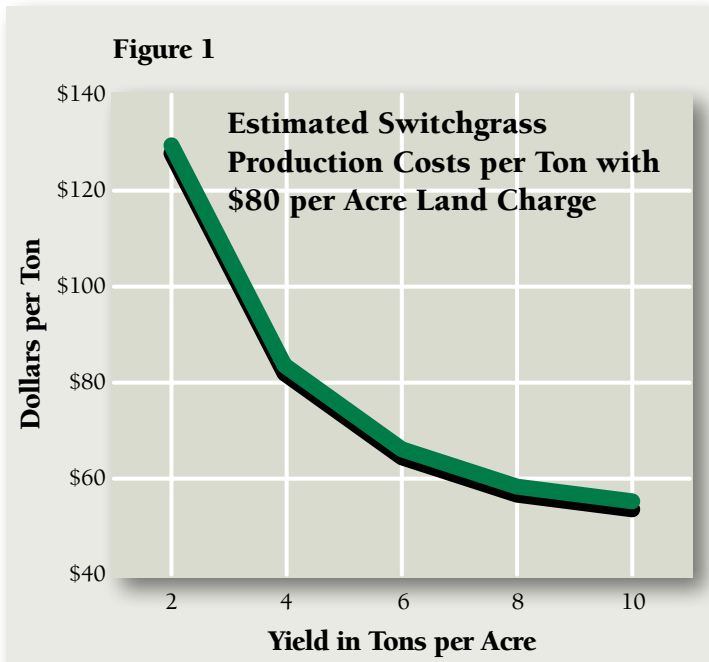
Transportation to Plant

Cost per ton..... \$8.65

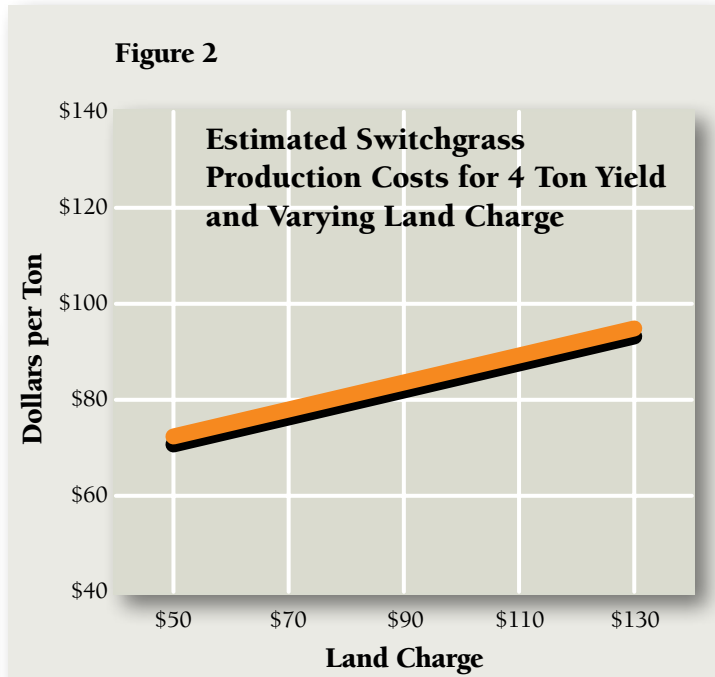


Alternative Assumptions

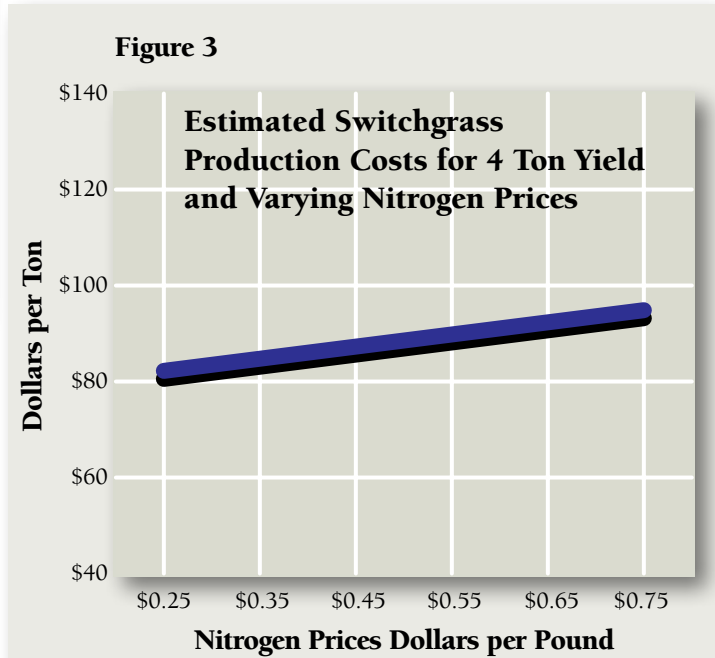
Estimating the cost of producing any crop will vary depending upon the assumptions made. Making assumptions is necessary, however, because we can't model each individual farm, field, and situation. By varying some of the key assumptions we can determine areas that are the most critical in estimating the costs of production.



What happens as the assumed yield is changed. These cost estimates are for production costs only. Notice that as the yield increases, the costs decrease, first at a rapid rate and then at a lessened rate. As the yields increase, the fixed costs of production are spread over more tons and the cost per ton decrease.

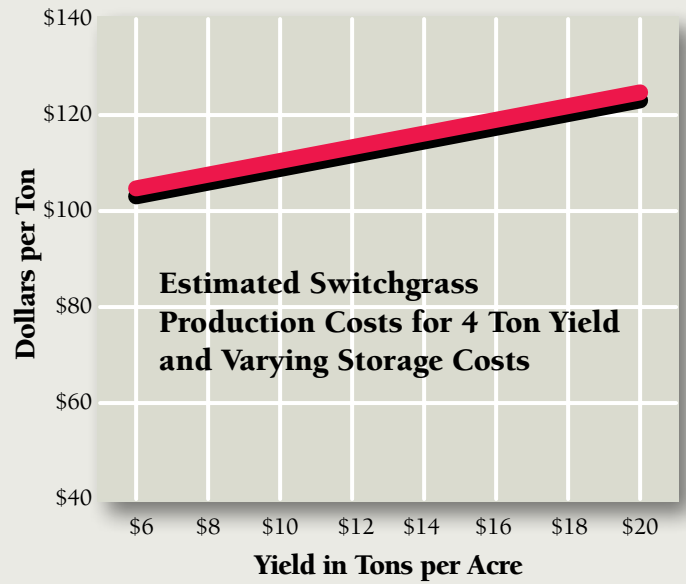


What happens using alternative land charges, while holding the yield constant at 4 tons per acre. With these assumptions, the cost of production increases in a linear rate as the cost per acre increases.



The cost of switchgrass production alters as the cost per pound for nitrogen changes. Here, too, there is a direct relation between nitrogen prices and costs of production.

Figure 4



There is also a direct relation between the cost to construct the particular type of storage assumed and the total cost of switchgrass.



Figure 5

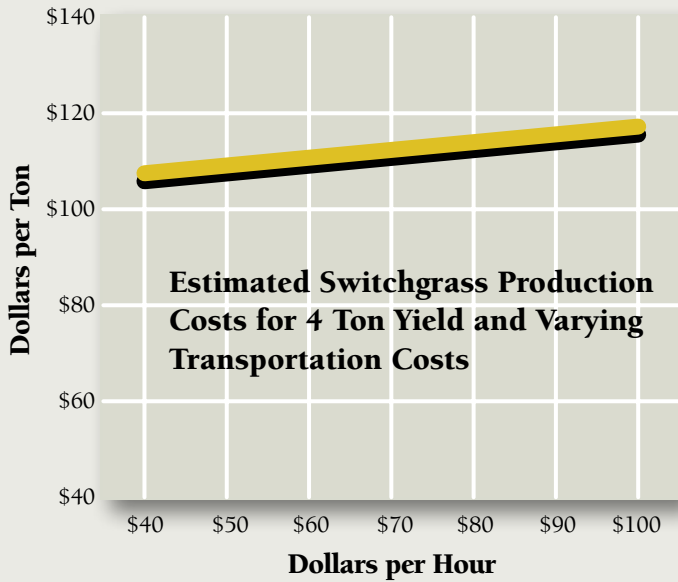
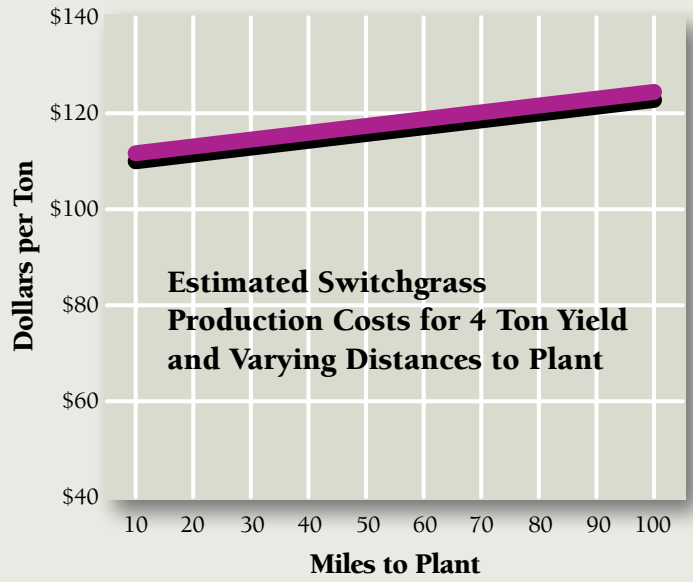


Figure 6



There is an impact on production when transportation costs vary. As the cost per hour increases, the total cost per ton increases but at a slower rate than when we increase the distance from the plant.



The Future

The future of switchgrass production depends upon its potential commercial uses. If switchgrass is used as a feedstock for ethanol, replacement for coal or other technologies, further research is needed to increase yields.

As shown in Figure 1, increasing yield will have the biggest impact on reducing the costs of switchgrass for any energy use.

The Conservation Reserve Program (CRP) may also play a role in the future of switchgrass. If green payments would be added to a switchgrass rotation on CRP land, there would be a larger economic incentive for producers. Switchgrass is a good alternative because it can be grown on marginal land and offers erosion control as well as other environmental benefits.

For switchgrass to become a commercially viable crop, there must be available markets. For cropland, there must be a sufficient economic incentive for producers to change their rotation systems. More efficient harvesting and transportation methods must be adapted to improve profitability. In addition, logistical issues must be addressed and, perhaps most important, the issues of handling and storage must be addressed.

Switchgrass can become a viable bioenergy crop. The engineering is being refined. But, before switchgrass can become viable commercially, key farmer issues must be addressed.

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