Estimated Cost of Establishment and Production of 'Liberty' Switchgrass

The current Renewable Fuels Standard was passed in 2007. In it, Congress proposed a significant shift in biofuel production, targeting the development of cellulosic energy sources. As part of that effort, the U.S. Department of Agriculture (USDA) established a series of grants to spur development of alternative biofuel sources. Some of the work from those grants has reached the stage where commercial development of cellulosic feedstocks for biofuel is feasible.

Switchgrasses have been a popular target crop for bioenergy development for several reasons: they are a perennial crop that can produce harvestable yields for several years between seedings; they can be produced on marginal cropland, but can also offer significant environmental benefits; and there are a number of varieties that are suited to the conditions in the central U.S.

The 'Liberty' switchgrass variety, developed by a team from the USDA-Agricultural Research Service in Lincoln, Nebraska, led by Rob Mitchell and Ken Vogel, is a high-yielding, winter-tolerant switchgrass that was specifically created for bioenergy use. 'Liberty' switchgrass is a cross of two other switchgrass varieties: Summer, a variety that has proven to be very hardy, surviving the winters in the upper Midwest and Kanlow, a high-yielding switchgrass from the Southern Plains. This report presents production cost estimates for 'Liberty' and an example case for 'Liberty' switchgrass production, detailing inputs required and procedures involved in establishment, yearly operation, and harvest.

Establishment of 'Liberty' Switchgrass

Similar to row crop, improvements have been made to increase production and ease the costs and effort to grow perennial grasses. Native warm-season grasses, such as big bluestem, indiangrass, and switchgrass, have a reputation for being difficult to establish and taking at least a couple of years to produce a usable stand. But new cultivars, such as 'Liberty', and new technology have made it feasible to plant grasses in one year and have a harvestable crop the next year.

In the central Great Plains and Midwest, warm-season grasses, such as 'Liberty', can be planted

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2 or 3 weeks before to 2 or 3 weeks after the recommended planting dates for corn, typically from late April to early June. A recommended practice for preparing land for grass or forage production is to plant the field with herbicide tolerant soybeans the year prior (Mitchell, et al., 2005) (1). This set-up helps in three ways: 1) weed issues can be addressed as the soybean crop develops, 2) the soybean crop provides income from the field during the preparation for grass production, and 3) soybean stubble has proven to be an excellent cover for grass establishment. Historically, weed pressure has been the major reason switchgrass stands are hard to establish. The soybean crop in the previous year allows the producer to create a clean seed bed prior to planting 'Liberty'. In addition, some herbicides can be used immediately after planting 'Liberty'.

Select the species and cultivars of perennial grasses you are interested in testing 'Liberty' should be seeded with at least 30 pure live seed per square foot, depending on the quality of the seed. Nitrogen fertilizer is not recommended during the planting year since it will encourage weed growth, increasing competition for the grass seedlings. Soil tests are recommended prior to planting. Since warm-season grasses, such as 'Liberty', are deep rooted, soil samples should be taken to a depth of 5 feet. When phosphorus is less than 10 parts per million), fertilize with phosphate at 20-40 pounds per acre before planting to encourage root growth and promote rapid establishment. Given a good grass stand and good management, it is possible to harvest 2-3 tons of dry matter per acre in the establishment year.

Production Practices after Establishment

Once the grass is established, it should compete very well with any weeds, limiting the need for large scale herbicide applications. However, if broadleaf weeds are an issue, an early spring application of herbicide is feasible. Nitrogen fertilization is also recommended, with the general rule of thumb of 10 pounds of nitrogen per acre for each ton of expected yield per acre. The typical fertilization window would be in late April to early May.

Harvesting

Like many plants, 'Liberty' switchgrass senesces in the fall when nutrients translocate to the roots, making the nutrients available for plant growth in the following spring. So harvest is targeted after a killing frost, once all of the green has faded from the plant bases. In the establishment year, the harvest cut should leave at least 6 inches of stubble in the field. In the following years, the minimum amount of stubble reduces to 4 inches. As with other grasses, there is a tradeoff of delaying harvest between biomass loss, usually due to leaf loss, and a lower moisture content that makes the grass biomass more suitable for combustion, processing, or storage. Also, some patience is required during harvesting to produce clean bales to deliver to the energy plant for combustion or processing.

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Estimated Costs of Production

The estimated cost of production for 'Liberty' switchgrass is presented in four sections, reflecting particular production years in the life of this perennial crop. The first section and table 1 present production cost estimates for pre-establishment. Section 2 estimates costs of production in the establishment year. Utilizing an amortization factor, a pro-rated estimate is also provided illustrate the yearly cost of establishment spread across the life of the stand. Section 3 provides cost of production estimates for the second year of production. Since grass stands mature by year 3, the cost estimates are assumed to remain the same from year 3 and beyond. These estimates are shown in section 4. For the last 3 sections, the production costs are divided into (i) pre-harvest machinery costs, (ii) operation costs, and (iii) harvesting costs. For simplicity, we have not considered storage and transportation costs to the processing facility in this report.

Assumptions for the Budget

Based on the above discussion on 'Liberty' switchgrass establishment and production, we have made the following specific assumptions for developing this cost budget.

1. Yield is assumed to be 6 dry tons per acre.
2. The stand-life is assumed to be 10 years.
3. The land charge is assumed to be the average cash rental rate for land under current use of improved pasture. Cash Rental Rates for Iowa 2014 Survey(AgDM, File C2-10) reports that the state average cash rent for improved pasture is $77/acre. (**For 2018 rates see**: https://www.extension.iastate.edu/agdm/wholefarm/html/c2-10.html)
4. A herbicide tolerant crop (round-up ready soybeans) is assumed to be grown in the year prior to planting 'Liberty' as part of pre-establishment field preparation.
5. A winter cover crop (oats) is assumed to be grown in the winter before 'Liberty' establishment to help weed and soil erosion control.
6. Production costs of roundup ready soybeans and oats are taken from readily available existing crop budgets at Iowa State Extension.
7. The only fertilizer application in year one would be in the case where phosphorus is found to be short. From year two forward, it is assumed to follow the recommended level by agronomic research to recover annual estimated nutrient removal: Nitrogen - 10 lbs. per ton of biomass removed.
8. Seed prices are assumed at $15 per pound. It is assumed 5 pounds of seed would be required per acre. In year two, it is expected that 10% of the field would need to reseeded.

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9. For weed control, it is assumed that before planting, a burndown is applied, and after planting, a pre-emergence herbicide will be applied. A second pass of pre-emergence herbicide will be applied in the following years as well.

10. In year one, a reduced yield equal to 50% of maximum potential yield is assumed. From year 2 forward, the harvest yield is expected to reach the maximum potential.

11. Biomass will be harvested in large square bales weighing 1,500 pounds.

12. The interest rate for pro-rating establishment costs is assumed to be 8%, while on operating expenses the interest rate is assumed to be 5%.

1. Cost of production in year 0 (Pre-establishment)

In the year before planting 'Liberty' switchgrass (called here year 0), an herbicide tolerant crop (round-up ready soybeans) is assumed to be grown as part of the pre-establishment field preparation. Following the soybean production, a winter cover crop (oats) is grown to help weed and soil erosion control. For production cost of these pre-establishment crops, we utilize the per acre production cost of Herbicide Tolerant Soybeans following Corn production from Iowa State University Extension publication "Estimated Costs of Crop Production in Iowa – 2014 (AgDM File A1-20.). **For 2019 see** https://www.extension.iastate.edu/agdm/crops/html/a1-20.html. Since we apply a separate land charge in this budget, we estimate the cost of production per acre for soybeans to be the total production cost per acre minus the land rental payment. For oats as the winter cover crop, we impute the per-acre cost of production estimates from Iowa State University's Extension publication "Cover Crop Cost Calculator," (https://www.iowalearningfarms.org/content/cover-crop-resources) assuming 70 pounds of seeds per acre will be sown.

Since we are considering conversion of land from pasture or grassland, we include the costs of conversion for soybean production. We assume the field preparation would incorporate brush mowing, disking, and soil finishing. The total cost for converting the field for pre-establishment crop production is $67.60 per acre. The cost of production for soybeans is $268.85 per acre and the cost for the winter cover crop, oats, is $31.39 per acre. Including the rent for land, the total cost in year 0, the pre-establishment year, is $444.84 per acre.

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2. Cost of production in year 1 (Establishment)

The costs incurred in year 1 are for establishment of the 'Liberty' stand. Pre-harvest machinery includes equipment for herbicide spreading and seed planting. No nitrogen fertilizer application in the first year is assumed. However, fertilizer and lime application rates can vary with the soil conditions. A soil test prior to planting would give information about required nutrient application rates. In our example, total establishment pre-harvest machinery cost in year one is $31.15 per acre. Total operating cost to be incurred on soil testing, herbicides, and seed totals to $89.72 per acre. Assuming an interest rate of 5% on an 8 month operating loan to finance establishment costs and operating expenses in year 1 results in a total interest payment of $4.03. Given that 'Liberty' can produce a harvestable yield in the first year roughly equal to half of the long-term expected yield, harvesting cost of $77.80 are included in year 1. Total costs of production in year one are estimated at $279.70.

3. Cost of production in year 2

In year 2, an additional application of a pre-emergence herbicide is recommended as part of establishment. Total pre-harvest machinery cost plus cash rent for land is an estimated $105.60 per acre. Total operating expenses on fertilizer and herbicides would be $32.80. Given a 10% reseeding rate, an additional $7.50 per acre is used for seed. An interest payment of $2.30 will be incurred. Total harvesting costs including mowing, baling, windrowing, and moving to storage would sum to approximately $141.40. Total cost of production in year two is $289.60 per acre.

Figure 1. 'Liberty Switchgrass'. Photo courtesy of Rob Mitchell USDA-ARS

4. Cost of production in year 3 and beyond

Since establishment is completed by year 2, production costs from year 3 and beyond are expected to remain the same. In year 3, production costs include operating expenses, a land charge and a harvest cost. Production costs include machinery cost and land rent of $89.55, operating expenses of $32.80, and an interest expense of $1.51. From year 3, maximum yield of 6 tons/acre is expected to be harvestable. Total harvesting costs would be $141.40. Total cost of production is $265.26 per acre.

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Total Establishment Cost

All of the establishment costs are incurred in year 0 and year 1. From year 2 forward, all other costs are production costs. Combining the establishment costs across the first couple of years, total establishment cost excluding interest expense totals $642.71 per acre. A stand life of 10 years and an 8% interest rate implies a prorated yearly establishment cost of $95.78 per acre.

Table 1: Cost of pre-establishment field preparation and crop production in year 0

	Price Per Unit	Units Used	Cost
Land charge	$77.00/Acre	1 Acre	$ 77.00
Field preparation			
Brush mowing	$10.00/Pass	1 Pass	10.00
Disking, tandem	$14.20/Pass	2 Passes	28.40
Soil finishing	$14.60/Pass	2 Passes	29.20
Crop production			
Herbicide tolerant crop (soybeans)	$268.85/Acre	1 Acre	268.85
Winter cover crop (oats)	$31.39/Acre	1 Acre	31.39
Total cost of field preparation and pre-establishment			367.84
Total Cost			**$ 444.84**

Table 2: cost of production in year 1

	Price Per Unit	Units Used	Cost
Land charge	$77.00/acre	1 acre	$ 77.00
Pre-harvest machinery operations			
Spraying chemical	$7.55/pass	2 passes	15.10
Seed drilling	$16.05/acre	1 acre	16.05
Total establishment machinery cost			31.15
Operating expenses			
Soil test (test covers 5 acres)	$8.00/soil test	0.20	1.60
Seed	$15/pound	5 pounds	75.00
Herbicide			
Pre-emergence	$0.21/ounce	32 ounces	6.72
Post-emergence	$0.20/ounce	32 ounces	6.40
Total operating cost			89.72
Interest on operating and establishment expenses	5 percent for 8 months		4.03
Harvest machinery operations			
Swathing	$14.20/acre	1 acre	14.20
Baling	$12.60/bale	4 bales	50.40
Moving to storage	$3.30/bale	4 bales	13.20
Total harvesting cost			77.80
Total Cost			**$ 279.70**

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Table 3: Cost of production in year 2			
	Price Per Unit	**Units Used**	**Cost**
Land charge	$77.00/acre	1 acre	$ 77.00
Pre-harvest machinery operations			
Fertilizer spreading	$5.00/pass	1 pass	$ 5.00
Spraying chemical	$7.55/pass	1 pass	$ 7.55
Seed drilling	$16.05/acre	1 acre	$ 16.05
Total pre-harvest machinery cost			$ 28.60
Operating expenses			
Seed	$15/pound	0.5 pounds	$ 7.50
Fertilizer			
Nitrogen (n)	$0.44/pound	60 pounds	$ 26.40
Herbicide			
Post-emergence	$0.20/ounce	32 ounces	$ 6.40
Total operating cost			$ 40.30
Interest rate on operating expenses	5 percent for 8 months		$ 2.30
Harvest machinery operations			
Swathing	$14.20/acre	1 acre	$ 14.20
Baling	$12.60/bale	8 bales	$100.80
Moving to storage	$3.30/bale	8 bales	$ 26.40
Total harvesting cost			$141.40
Total Cost			**$289.60**

Table 4: Cost of production in year 3			
	Price Per Unit	**Units Used**	**Cost**
Land charge	$77.00/acre	1 acre	$ 77.00
Pre-harvest machinery operations			
Fertilizer spreading	$5.00/pass	1 pass	5.00
Spraying chemical	$7.55/pass	1 pass	7.55
Total pre-harvest machinery cost			12.55
Operating expenses			
Fertilizer			
Nitrogen (n)	$0.44/pound	60 pounds	26.40
Herbicide			
Post-emergence	$0.20/ounce	32 ounces	6.40
Total operating cost			32.80
Interest rate on operating expenses	5 percent for 8 months		1.51
Harvest machinery operations			
Swathing	$14.20/acre	1 acre	14.20
Baling	$12.60/bale	8 bales	100.80
Moving to storage	$3.30/bale	8 bales	26.40
Total harvesting cost			141.40
Total Cost			**$265.26**

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Additional Resources

- **CenUSA Project Resources** - Research-based information on the opportunities and challenges in developing a sustainable system for the thermochemical production of biofuels from perennial grasses grown on land marginal for row crop production is available at www.cenusa.iastate.edu

- Rob Mitchell, Ken Vogel, Bruce Anderson, and T. J. McAndrew. "Renovating Pastures with Glyphosate Tolerant Soybeans." Forage and Grazinglands: Online, April 2005, doi:10.1094/FG-2005-0428-01-BR.

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