Estimated Cost of Establishment and Production of Miscanthus in Iowa

Ag Decision Maker

File A1-28

To reach the cellulosic biofuel mandate set for 2022 in the US, Giant *Miscanthus* is expected to play a significant role as a promising feedstock for cellulosic ethanol. Giant *Miscanthus,* a non-invasive biomass, grows well in the Midwestern and Northern states of the U.S., especially in areas with at least thirty inches of rainfall per year (USDA, 2011). *Miscanthus* can adapt well to marginal land, which implies significant potential for marginal land currently under crop or forage production, and land currently enrolled in the Conservation Reserve Program to be converted into future commercial-scale *Miscanthus* production.

Miscanthus has a low ash and water content and a high energy output to input ratio relative to similar biomass feedstocks. However, the idea of utilizing *Miscanthus* for biofuel production is relatively new. Thus, commercial scale production of *Miscanthus* is not yet well-established. This report presents production cost estimates for *Miscanthus* and an example case for *Miscanthus* production, detailing inputs required and procedures involved in establishment, yearly operation, and harvest.

Establishment of *Miscanthus*

Miscanthus can be adopted to various kinds of soil conditions but yields best on USDA NRCS capability class I or II lands (USDA, 2011). Fields need to have well drained soils, and the soil pH level is recommended to be in the range of 5.5-8 (Heaton et al., 2011). A soil test in the year before establishment can suggest the amount of lime that would be required to attain the recommended pH level. Lime needs to be applied at least six months prior to planting of *Miscanthus*.

Since giant *Miscanthus* is a sterile hybrid, the crop cannot be planted from seeds, but instead must be established with vegetative materials such as rhizomes or plugs (Anderson et al., 2011; USDA, 2011). A plant population of 5,000-6,000 plants is optimal in an established *Miscanthus* stand. To achieve the target population, over-planting in the first year is recommended since 20-30% of the plants may not grow. For good soil contact, rhizomes should be planted at a depth of 2-4 inches. May to early June is the recommended planting time, and a longer growing season in the first year helps rhizome growth.

Fertilizer application in the first year is highly recommended to encourage healthy growth of the plant. Nitrogen, phosphorus, and potassium are three key nutrients that are vital for growth of *Miscanthus* and can be applied any time before or after planting. Water is also vital for rhizome growth, so irrigation is highly recommended in drier areas.

Field preparation for *Miscanthus* should start a year before rhizome planting. Compared to other energy grasses, this is unique; making the establishment period for this crop two years instead of one. Weed control is very critical for *Miscanthus*, especially in the early establishment stage. Competition from weeds could lower the establishment rate or even cause a complete establishment failure for the *Miscanthus* stand (USDA, 2011). Compared to land currently under conventional crop production, weed control is more difficult if land is to be converted from fallow or forage. In these types of land, weed control should be started the year before rhizome planting by pre-planting herbicide tolerant crops

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followed by a winter cover crop. In the spring of the planting year, tillage, burndown, and application of a pre-emergence herbicide are recommended to help control weeds.

Production Practices after Establishment

Once properly established, the *Miscanthus* stand can outperform weeds and should not require any herbicide application after establishment (year 2 and beyond). Fertilizer amounts in the first year are recommended at the same level as would be applied for growing corn. From the second year forward, fertilizer application is linked to removal of nutrients through harvesting, and there is a recommended rate by USDA (2011) accounting for the removal of each dry ton of *Miscanthus* biomass during harvest.

Harvesting

Besides sequestering carbon, *Miscanthus* is very efficient in nutrient management. The plant senesces in the fall when nutrients translocate to the roots, making the nutrients available for plant growth in the following spring. Harvesting of *Miscanthus* is optimal when moisture content in the biomass is less than 20%. Heaton et al. (2010) report that the typical moisture curve for *Miscanthus* in Illinois is 50% in October and less than 20% in February. The tradeoff of delayed harvest will be biomass losses, mostly due to leaf loss; but a lower moisture content will make the biomass more suitable for combustion, processing, or storage. As was mentioned before, another advantage of delaying harvest until after senescence is that removal of biomass does not remove nutrients from the soil. Based on growing conditions, *Miscanthus* dry-matter yields range from 10-15 tons per acre in the U.S. with lower yields at more northern latitudes due to harsher winters. Harvesting of biomass can be done with a silage harvester or a mower-conditioner, if baled. When harvesting, 2-4 inches of stubble should to be left in the field to reduce moisture and soil content in the biomass bales by avoiding contact with the soil and picking up leaf litter (USDA, 2011; Heaton, 2010). Overall, caution while harvesting is required to produce clean bales to deliver to the energy plant for combustion or processing.

Estimated Costs of Production

The estimated cost of production 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.

Information used in developing this budget was obtained from existing agronomic research, expert opinions, and economic data such as the *2014 Iowa Farm Custom Rate Survey* (**Ag Decision Maker, File A3-10**). Input prices, fertilizer, chemical and rhizome costs were taken from existing crop enterprise

budgets published by Iowa State Extension or from enterprise budgets developed by Extension services at other universities. Since there is currently no reliable cost estimate for rhizome planting from commercial sources, we have utilized the rhizome planting materials and cost from the document "*Proposed Plan for Miscanthus Grass*" from the University of Iowa's *Miscanthus* Pilot Project. Herbicides prices are taken from "*Miscanthus Budget for Biomass Productio*n", published by Penn State Extension.

Assumptions for the Budget

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

(i) The stand-life is assumed to be 20 years.

(ii) 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* (**Ag Decision Maker, File C2-10**) reports that the state average cash rent for improved pasture is $77/acre.[1]

(iii) A herbicide tolerant crop (round-up ready soybeans) is assumed to be grown in the year prior to planting *Miscanthus* as part of pre-establishment field preparation.

(iv) A winter cover crop (oats) is assumed to be grown in the winter before *Miscanthus* establishment to help weed and soil erosion control.

(v) Production costs of roundup ready soybeans and oats are taken from readily available existing crop budgets at Iowa State Extension.

(vi) Soil pH level is recommended to be around 6 and will need to be determined by a soil test. If the soil test determines the pH level is low, lime should be applied accordingly. In the current budget, lime is assumed to be a one-time pre-establishment cost and is applied at the rate of 3 tons per acre.

(vii) Fertilizer application in year one will follow the current recommendation for corn. From year two forward, it is assumed to follow the recommended level by agronomic research to recover annual estimated nutrient removal:

- Phosphorus - 1.5 lbs. per ton of biomass removed,
- Potassium - 8 lbs. per ton of biomass removed, and
- Nitrogen - 8 to 10 lbs. per ton of biomass removed.

(viii) *Miscanthus* is assumed to be established vegetatively by planting rhizome pieces.

(ix) Rhizome prices are assumed to be 9 cents each. A planting rate of 7,000 rhizomes per acre is assumed to establish the target population of 5,250 plants per acre, following existing research predicting that 25% of the rhizomes will not survive.

(x) 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 year 2 as well.

[1] www.extension.iastate.edu/agdm/wholefarm/pdf/c2-10.pdf.

(xi) No harvesting in year one is assumed. In year two, a reduced yield equal to 50% of maximum potential yield is assumed. From year 3 forward, the harvest yield is expected to reach the maximum potential.

(xii) Biomass will be harvested in large square bales weighing 1,200 pounds.

(xiii) 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 *Miscanthus* (called here year 0), a 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"*, **File A1-20**.[2] 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,*" assuming 70 pounds of seeds per acre will be sown.[3]

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.

2. Cost of production in year 1 (Establishment)

The costs incurred in year 1 are for establishment of the *Miscanthus* stand. The field preparation includes disking and soil finishing. Pre-harvest machinery includes equipment for soil preparation, fertilizer and herbicide spreading, and rhizome planting. Fertilizer application in the first year is assumed to be the same as the recommended rates for corn. Fertilizer and lime application rates can vary with the soil condition. A soil test prior to planting would give information about required nutrient application rates. In our example, total establishment machinery cost in year one is $149.10 per acre. Total operating cost to be incurred on soil testing, fertilizer, herbicides, and rhizomes totals to $871.52 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 $34.02. There will be no harvestable yield in the first year, so harvesting cost is $0 in year 1. Total costs of production in year one are estimated at $1,131.64

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

[2] www.extension.iastate.edu/agdm/crops/pdf/a1-20.pdf

[3] www.extension.iastate.edu/ilf/content/cover-crop-resources

cost plus cash rent for land is an estimated $89.55 per acre. Total operating expenses on fertilizer and herbicides would be $50.50. An interest payment of $2.10 will be incurred. In the second year, 50% of the maximum possible expected yield is harvestable. If the expected maximum yield per acre is 10 tons in year 2, 5 tons per acre will be harvestable. Assuming each bale would weigh 1,200 pounds, approximately 8.33 large square bales will be produced on each acre of *Miscanthus*. Total harvesting costs including mowing, baling, windrowing, and moving to storage would sum to approximately $134.83. Total cost of production in year two is $276.98 per acre.

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 $82, operating expenses of $65.95, and an interest expense of $2.37. From year 3, maximum yield of 10 tons/acre is expected to be harvestable. Total harvesting costs would be $243.17. Total cost of production is $393.48 per acre.

Total Establishment Cost

Almost all of the establishment costs are incurred in year 0 and year 1. Only the costs of a pre-emergence herbicide application in year 2 is part of the establishment cost. 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 $1,567.53 per acre. A stand life of 20 years and an 8% interest rate implies a prorated yearly establishment cost of $159.66 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			
Disking, Tandem	$14.20/pass	2 passes	$ 28.40
Soil Finishing	$14.60/pass	2 passes	$ 29.20
Fertilizer Spreader	$5.00/pass	1 passes	$ 5.00
Spraying Chemical	$7.55/pass	2 passes	$ 15.10
Rhizome Planter (NEF Planter)	$50.00/planter lease	1 planter	$ 50.00
Tractor for Planting (250 horsepower)	$0.27/horsepower-hour	50 HP-hours	$ 13.50
Land Rolling, Post Planting	$7.90/acre	1 pass	$ 7.90
Total Establishment Machinery Cost			$ 149.10
Operating Expenses			
Soil Test (test covers 5 acres)	$8.00/soil test	0.20	$ 1.60
Rhizomes	$0.09/rhizome	7,000 rhizomes	$ 630.00
Fertilizer			
Nitrogen (N)	$0.44/pound	186 pounds	$ 81.84
Phosphorus (P)	$0.43/pound	62 pounds	$ 26.66
Potassium (K)	$0.41/pound	50 pounds	$ 20.50
Annual Lime (including application)	$29.00/ton	3 tons	$ 87.00
Herbicide			
Burndown	$0.20/ounce	32 ounces	$ 6.40
Pre-emergence (acetochlor and atrazine)	$4.38/pint	4 pints	$ 17.52
Total Operating Cost			$ 871.52
Interest on Operating and Establishment Expenses	5% for 8 months		$ 34.02
Total Cost			$1,131.64

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 Spreader	$5.00/pass	1 pass	$ 5.00
Spraying chemical	$7.55/pass	1 pass	$ 7.55
Total Establishment Machinery Cost			$ 12.55
Operating Expenses			
Fertilizer			
Nitrogen (N)	$0.44/pound	35 pounds	$ 15.40
Phosphorus (P)	$0.43/pound	7.5 pounds	$ 3.23
Potassium (K)	$0.41/pound	35 pounds	$ 14.35
Herbicide			
Pre-emergence (acetochlor and atrazine)	$4.38/pint	4 pints	$ 17.52
Total Operating Cost			$ 50.50
Interest Rate on Operating Expenses	5% for 8 months		$ 2.10
Harvest Machinery Operations			
Mowing/Conditioning	$13.60/acre	1 acre	$ 13.60
Baling	$10.50/bale	8.33 bales	$ 87.50
Windrowing	$12.90/acre	1 acre	$ 12.90
Moving to Storage	$2.50/bale	8.33 bales	$ 20.83
Total Harvesting Cost			$134.83
Total Cost			$276.98

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 Spreader	$5.00/pass	1 pass	$ 5.00
Total Pre-establishment and Establishment Machinery Cost			$ 5.00
Operating Expenses			
Fertilizer			
Nitrogen (N)	$0.44/pound	70 pounds	$ 30.80
Phosphorus (P)	$0.43/pound	15 pounds	$ 6.45
Potassium (K)	$0.41/pound	70 pounds	$ 28.70
Total Operating Cost			$ 65.95
Interest Rate on Operating Expenses	5% for 8 months		$ 2.37
Harvest Machinery Operations			
Mowing/Conditioning	$13.60/acre	1 acre	$ 13.60
Baling	$10.50/bale	16.67 bales	$175.00
Windrowing	$12.90/acre	1 acre	$ 12.90
Moving to Storage	$2.50/bale	16.67 bales	$ 41.67
Total Harvesting Cost			$243.17
Total Cost			$393.48

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