Miscanthus Budget for Biomass Production

Giant miscanthus (*Miscanthus* x *giganteus*) is a sterile hybrid perennial warm-season grass that grows relatively fast on less-than-ideal soils, making it a preferred energy crop. This fact sheet provides an enterprise budget for growing miscanthus. The objective is for growers to understand the inputs, costs, and potential revenues involved in cultivating miscanthus. An example budget is described, but since each situation is different and prices can vary, a spreadsheet is available at **extension.psu.edu/natural-resources/energy/field-crops/resources** for adjusting inputs and prices to individual conditions. The scenario provided in this fact sheet is based on growing the crop in northeastern Ohio/northwestern Pennsylvania. All quantities and prices are on a per-acre basis. The costs are based on farm custom rates published by Ohio State University Extension and Penn State Extension. The budget is based on a 15-year timeline. This fact sheet does not discuss transportation costs of harvested miscanthus from the field to processing facility, which will vary from site to site. This fact sheet focuses on the budget items considered in cultivating miscanthus for bioenergy. Additional information on miscanthus is available at **www.newbio.psu.edu**.

Soil Test

The first step is to evaluate the land quality for growing miscanthus, which includes a soil test. Miscanthus grows well in soil with a pH of 5.5–7.5 and medium to high fertility, but it adapts to a wide variety of soils. A standard soil test is recommended to determine the nutrient availability for miscanthus establishment. The test is generally done based on a grid sampling of five-acre units every three years. Ignoring the cost for collecting the sample, on a per-acre basis, and assuming $15 per soil test, testing will cost $3 per acre in year 1 (establishment year) and $1 per acre for each year thereafter.

Site Preparation

The amount of work needed to prepare a site varies depending on the previous land use. If the growing site is already in crop production, there should be minimal site preparation. For land that has been fallow, clearing undesirable brush with a standard brush mower will cost about $10 per acre. Next, the land should be plowed with a moldboard plow at a one-time cost of around $19 per acre. After plowing, the land most likely will require two disking passes and two soil finishing passes, at costs of roughly $28 per acre and $29 per acre, respectively.

"NEWBio" is the Northeast Woody/Warm-season Biomass Consortium, a regional project funded by the United States Department of Agriculture's National Institute of Food and Agriculture (USDA-NIFA) to promote next-generation bioenergy production in the northeastern United States.

Soil Amendments

Miscanthus does not usually need soil amendments since it adapts to many soil conditions and may even build up soil Nitrogen. Nitrogen, phosphorus, potassium, and lime requirements, as recommended by research at the University of Illinois are as follows. Nitrogen, phosphorus, and potassium are applied at an annual cost of $7 per acre.

- **Nitrogen** fertilizer is typically applied at about 7.5 pounds per ton of biomass after establishment and during the first year of harvest. As the yield increases, these costs will increase. Based on the assumption of yields in this scenario, the first application in year 2 costs $21 per acre, increases to $42 per acre by year 4, and so on.
- **Phosphorus** (P_2O_5) is typically applied at 1.5 pounds per ton of biomass (by soil test recommendation) 6 months before planting and each harvest season thereafter. As the yield increases, these costs will increase. Based on the assumption of yields in this scenario, the first application in year 2 costs $5 per acre, increases to $9 per acre by year 4, and so on.
- **Potassium** (K_2O) is typically applied at 5.5 pounds per ton of biomass (by soil test recommendation) 6 months before planting and each harvest season thereafter. As the yield increases, these costs will increase. Based on the assumption of yields in this scenario, the first application in year 2 costs $13, increases to $26 per acre in year by year 4, and so on.
- **Lime**, if needed, is generally added 6 months prior at 4 tons per acre for about $152 per acre, and then at 2 tons per acre every fourth year, which annualized is about $18 per year. This includes application costs.

Plant Material

Miscanthus is planted with rhizomes using a specialized rhizome planter. About 7,000 rhizomes per acre should be used. The assumed price per rhizome can vary from 10 to 25 cents depending on the vendor. Total seed cost is about $700 per acre. In year 2, replanting rhizomes in places where previous ones did not survive could be required. For this budget, we assume one-eighth (12.5 percent) of the rhizomes will be replanted at a cost of $88 per acre.

Planting Costs

Currently, industry practice is to plant the rhizomes 4 inches deep and 3 feet apart within rows. Maintain 3 feet between rows. Planting costs are based on Aloterra Energy custom rates for their planter, which is $30 per acre. For year 2, replanting one-eighth of the rhizomes while still driving over the whole acre to fill gaps at a cost of $30 per acre is assumed. This can vary depending on where the replanting is needed and how much needs to be done by hand.

Weed Control

Weed management during the planting season is crucial for establishment as the crop is sensitive to weed competition. An initial burndown with 32 ounces of glyphosate is required prior to planting, costing an estimated $7 per acre. A preemergence herbicide treatment of 4 pints of acetochlor and atrazine should be implemented right after planting and in year 1 at an estimated cost of $18 per acre. A postemergence herbicide using 1 pint of 2,4-D is also suggested during the establishment year and in year 2 at a cost around $3 per acre. The sprayer cost for the three passes discussed above is a conservative $7/acre per spray = $21/acre in first year. Due to the relatively recent emergence of miscanthus, contact your county extension office for current herbicide recommendations.

Maintenance Costs

As mentioned above, some fertilizer applications are made over time as needed. By year 2 there should be no need for more herbicides since the grasses shade out the weeds. The cost to maintain a 25-foot field boundary (per the requirements of the Federal Biomass Crop Assistance Program) by brush mowing will cost an estimated $1 per acre of planted miscanthus. Currently no pests are found on miscanthus.

Harvesting Costs

Miscanthus can be harvested in year 2 and every year thereafter. However, in year 2 only 50 percent of the yield is achieved (5 tons per acre); in year 3, 75 percent (7.5 tons per acre) is achieved; and in full production, year 4, 100 percent yield of 10 tons per acre is achieved. Traditional hay mowing and baling equipment is used. Mowing will cost around $13 per acre per year. Baling, assuming 15 percent moisture in the grass and a weight of 1,200 pounds per bale, costs about $117 per acre at full yield (i.e., to bale 10 tons). Baling costs are lower in the first four years since yield per acre is smaller.

Yield and Revenues

Miscanthus yields an average of about 7–10 dry tons per acre per year. At an assumed farm-gate price of $45 per dry ton for a mature yield of 10 tons per acre, annual revenue would be $450 per acre per year. There is no revenue in the first year. In the second year, we assume that only 50 percent of the yield, or 5 tons per acre, is achieved, for a revenue of $225 per acre. Third-year yield is 7.5 tons per acre, for a revenue of $338 per acre. Revenue for years 4 through 15 is $450 per acre.

Net Revenues and Financial Analysis

The last columns of the spreadsheet show the total costs, revenues, and present value of each item. The total costs over 15 years are estimated to be $4,189 per acre while total revenues are estimated at $5,962 per acre. Net revenue is $1,773 per acre for the 15-year budget period. The payback period—which tells investors how long it will take for revenues to cover establishment costs—is six years using the financial assumptions in this scenario.

Since this project occurs over a 15-year period, you need to account for the time value of money to get an accurate value. The time value of money is reflected in an interest (discount) rate used by investors. Revenues and costs not received today are "discounted" to the present, hence net present value (NPV). This allows investors to compare alternative projects over the same lifetime. If the NPV is positive, it implies that investors receive at least their acceptable rate of return. The NPV in this scenario, using a 4 percent rate, is $1,041 per acre. This NPV would obviously change if the discount rate, project length, and the costs and revenues were changed. Annualizing the NPV gives us an equal annual income (EAI) value of $94. The EAI compared to an annual rental on the land expresses NPV as an annual return, so it can, for example, be a good investment.

Miscanthus rhizomes. Photo courtesy of David Marrison.

Summary

Giant miscanthus is one of the faster-growing warm-season grasses that are propagated by rhizome division. These unique planting requirements mean that the up-front costs for miscanthus establishment are higher than for other dedicated energy crops. However, the yields are quite attractive relative to other energy crops. This scenario, albeit conservative, still shows a positive return. The six-year payback period can be shortened, especially if cost-share monies are available for planting costs and prices or yields per ton are higher.

Using the Spreadsheet

This scenario was developed to show the different costs and revenues involved in growing miscanthus. The spreadsheet format shown below can be downloaded from **extension.psu.edu/natural-resources/energy/field-crops/resources** and adapted to fit specific grower conditions. You can change the quantity of inputs and their respective prices (shown in yellow cells), allowing you to adapt costs and revenues to your situation.

		Quantity	Unit	Price/ Unit	Year 1 (Estab.)	Year 2	Year 3	Years 4–15	Total	Present Value
SELECT CASH EXPENSES										
Plant Material										
	Rhizomes	7,000	rhizome per acre	$0.10	$700.00	$0	$0	$0	$700.00	$700.00
Soil Fertility[1]										
	Nitrogen	7.5	pounds per expected ton per acre	$0.56	$0	$20.81	$31.22	$41.63	$551.53	$410.00
	P_2O_5	1.5	pounds per expected ton per acre	$0.63	$0	$4.73	$7.09	$9.45	$125.21	$93.00
	K_2O	5.5	pounds per expected ton per acre	$0.48	$0	$13.20	$19.80	$26.40	$349.80	$260.00
	Fertilizer application	annually	acre	$7.00	$0	$7.00	$7.00	$7.00	$98.00	$74.00
	Lime	see inputs	ton	$38.00	$152.00	$17.54	$17.54	$17.54	$397.54	$337.00
	Soil testing[2]		per soil test	$15.00	$3.00	$1.00	$1.00	$1.00	$17.00	$14.00
Weed Control[3]										
	Burndown	32 ounces	acre	$6.50	$6.50	$0	$0	$0	$6.50	$7.00
	Preemergence	4 pints	acre	$17.50	$17.50	$17.50	$0	$0	$35.00	$34.00
	Postemergence	1 pint	acre	$3.00	$3.00	$3.00	$0	$0	$6.00	$6.00
	Sprayer (3 sprays)	3	acre	$7.00	$21.00	$14.00	$0	$0	$35.00	$34.00
Establishment and Maintenance[4]										
	Brush mowing	1	acre	$10.00	$10.00	$0	$0	$0	$10.00	$10.00
	Moldboard plow	1	acre	$18.20	$18.00	$0	$0	$0	$18.20	$18.00
	Disking (2 passes)	2	acre	$13.70	$27.00	$0	$0	$0	$27.40	$27.00
	Soil finish (2 passes)	2	acre	$14.20	$28.00	$0	$0	$0	$28.40	$28.00
	Rhizome planter	1	acre	$30.00	$30.00	$4.00	$0	$0	$33.75	$34.00
	Brush mowing/field barrier maintenance[5]	0.1	acre	$10.00	$1.00	$1.00	$1.00	$1.00	$15.00	$12.00
Harvesting										
	Mowing[4]	1	acre	$13.00	$0	$13.00	$13.00	$13.00	$182.00	$137.00
	Baling (large, round)[6]	16.67	bale	$7.00	$0	$58.00	$88.00	$117.00	$1,545.83	$1,149.00
TOTAL CASH EXPENSES					$1,018.00	$175.00	$185.00	$234.00	$4,182.00	$3,385.00
REVENUES										
Biomass	Mature yield (estimation)	10	dry ton		0	5	7.5	10	132.5	
	Revenue stream			$45.00	$0	$225.00	$338.00	$450.00	$5,962.50	$4,433.00
REVENUE ABOVE EXPENSES					-$1,018.00	$50.00	$152.00	$216.00	$1,780.00	$1,048.00

EQUAL ANNUAL INCOME (annualized over 15 years)			$94.00
BREAKEVEN PAYBACK PERIOD[7]			6 years

ASSUMPTIONS		
Interest rate	4	percent
Number of years of growth (years 4–15)	12	years
INPUTS		
Establishment lime	4	tons per acre
Maintenance lime	2	tons per acre
Weight of bale	1,200	pounds

Adapted from Michigan State University spreadsheet by Dennis Pennington.
bioenergy.msu.edu/economics.

Table Footnotes

1. Based on 7.5 pounds of nitrogen, 1.5 pounds of P_2O_5, 5.5 pounds of K_2O crop removal per ton of biomass, and 4 tons of lime per acre during establishment and 2 tons per acre every fourth year.
2. Based on a grid sampling of 5-acre units every 3 years.
3. Burndown application is 32 ounces of glyphoshate; preemergence, 4 pints of acetochlor and atrizine; and postemergence, 1 pint of 2,4-D.
4. Custom rates for brush mowing, moldboard plow, disking, soil finish, and harvest mowing are from 2012 Ohio Farm Custom Rates. Custom rate for rhizome planter as charged by Aloterra Energy.
5. Biomass Crop Assistance Program provisions require a 25-foot buffer around each field. Cost will change based on field size/dimension.
6. Harvested at 15 percent moisture with a bale weight of 1,200 pounds.
7. Payback period is calculated by determing when revenues exceed establishment costs.

For more information on the NEWBio project, visit **www.newbio.psu.edu** and Penn State Extension's Renewable Energy website, **extension.psu.edu/natural-resources/energy**.

Prepared by Mike Jacobson, professor of forest resources, Penn State; David Marrison, extension educator and assistant professor, Ohio State; Zane Helsel, extension specialist, Rutgers University; Dennis Rak, owner, Double A Willow; and Barry Forgeng and Nichole Heil, interns, Penn State.

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