Costs of Producing Switchgrass for Biomass in Southern Iowa

by Mike Duffy and
Virginie Y. Nanhou

The different costs associated with producing switchgrass primarily for biomass in southern Iowa are presented in this fact sheet. It does not include recommendations on switchgrass production techniques. For more details about switchgrass and its production and cultural practices, please see these Iowa State University Extension publications:

- *Management Guide for the Production of Switchgrass for Biomass Fuel in Southern Iowa,* February 1997 (PM 1710)

- *Switchgrass Seeding Recommendations for the Production of Biomass Fuel in Southern Iowa,* November 1998 (PM 1773).

The cultural practices used to produce switchgrass are presented under seven different scenarios. Switchgrass production costs vary from one scenario to another and also vary individually within scenarios depending on yield. To estimate the costs of production, four yield levels have been considered: 1.5, 3, 4, and 6 tons/acre.

What is switchgrass?

Switchgrass is a perennial grass native to Iowa, suitable for marginal land primarily because it grows well with relatively moderate inputs and can effectively protect soil against erosion. Switchgrass offers additional environmental benefits such as helping to improve water quality and wildlife habitat, helping to reduce carbon emissions through carbon sequestration in the soil, and serving as a replacement for fossil fuels in electricity generation. Switchgrass may be used as a pasture or hay crop. More recently, it has been examined as a biomass crop to produce energy.

Description of the scenarios

Cultural practices vary considerably among farmers and by the stage of production: establishment year versus production year. The cultural practices are presented in seven scenarios, each representing a possible production strategy that could be chosen depending on the particular situation (land type, skills, machinery availability, etc.). The scenarios are based on the time of the year when the seeding is done and the land type used to produce switchgrass.

Criteria used to define the scenarios include:

- the time of year when the switchgrass is planted, which affects the production costs through the amount of seed used, the success rate of the seeding, and the need to reseed.

- the type of land on which switchgrass is planted, which affects the land charge and thus the overall cost of producing switchgrass.

- the type of machinery used for the seeding (airflow planter, drill, and no-till drill).

Research sponsored by the Bioenergy Feedstock Development Program of the U.S. Department of Energy under contract with the University of Tennessee–Battelle LLC

IOWA STATE UNIVERSITY
University Extension

PM 1866 April 2001

The seven scenarios are:
1. frost seeding on cropland with airflow planter,

2. frost seeding on grassland with airflow planter,

3. spring seeding on cropland with airflow planter,

4. spring seeding on cropland with a drill,

5. spring seeding on cropland with a no-till drill,

6. spring seeding on grassland with a drill, and

7. spring seeding on grassland with a no-till drill.

(See Appendix 1 for more details on these scenarios.)

Cropland refers to land previously allocated to crop production while grassland indicates a pasture or land used for grass production before being used for switchgrass. This designation determines the land charge attributed to the scenario.

General assumptions

The following assumptions are used for the cost figures in the budgets:

- A normal switchgrass stand has a life span of 10 years.
- Land costs per acre are $75 for cropland and $50 for grassland.
- Harvest is done in large square bales with an average weight of 875 pounds per bale.[1]
- The planting is not harvested in the seeding (establishment) year.
- Harvest activities start in the second year of the stand life if there has not been any reseeding.
- Reseeding probability is 25 percent for frost seeding and 50 percent for spring seeding.
- Amortization of establishment costs and reseeding costs is at 8 percent on the 10 years of the stand's life span.
- Machinery operations are charged at the custom rates.

A. Assumptions on input costs

Machinery

Preharvest machinery operations vary by scenario. Some scenarios require more seed bed preparation while others rely more on chemicals. The cost for each preharvest machinery operation comes from the *2000 Custom Rate Guide,* ISU Extension publication, FM 1698.

Seed

Seed cost is estimated at $4 per pound of pure live seed (PLS). A variety commonly used in southern Iowa is Cave-in-Rock. The seeding rate for frost seeding is a minimum of six pounds PLS per acre, whereas the spring-seeded scenarios use a minimum of five pounds PLS per acre.

Herbicides

Each scenario is assumed to follow a standard herbicide treatment. Scenarios 1, 3, 4, and 5 use a combination of atrazine and 2,4 D for weed control, while scenarios 2, 6, and 7 use Roundup™ in addition to atrazine and 2,4 D. Roundup™ is used here for land preparation in association with the mowing. The price per unit for herbicides reflects 2000 prices.

Fertilizers and lime

During the establishment year, it is assumed that 30 pounds of phosphorus and 40 pounds of potassium are applied per acre. To avoid competition between the new switchgrass stand and weeds, no nitrogen is applied in the establishment year.

During production years, the phosphorus and potassium fertilization program varies by yield to compensate for the removal rate in potassium (K) and phosphorus (P). There are 1.94 pounds of P_2O_5 and 22.8 pounds of K_2O removed with each ton of switchgrass. Nitrogen fertilizer is applied at 100 pounds per acre. Prices for fertilizers are reported in *Estimated Costs of Crop Production in Iowa, 2000,* ISU Extension publication FM 1712.

Lime needs will vary by field. It was assumed, however, that lime would be applied at some time over the life of the switchgrass stand. Therefore, a fixed charge per acre per year was added to the cost estimates.

[1]Even though the bales are rectangular in shape (3 feet high 3 4 feet wide 3 8 feet long), the terminology "square bales" is common.

B. Harvesting data

Harvesting activities involve mowing, raking, baling, staging, and loading. Depending on the equipment used, the estimates for the time and costs of harvesting can vary considerably. Switchgrass harvesting differs from hay or alfalfa harvesting because of the difference in plant density (switchgrass is less dense than hay) and height (switchgrass is taller than hay). Some variations in the estimations also can occur due to the type of bale (large round bale or large square bale). These differences influence the harvesting time and thus the cost. It is assumed that harvesting costs are not linear; that is, as the yield increases, the harvesting costs per acre increase, but the costs per ton decrease. For the budget estimations, it is assumed that harvest is done in large square bales weighing 875 pounds each (average weight observed for bales harvested in southern Iowa). In addition, since the production costs are farm gate costs, this means that they don't include any costs associated with lengthy on-farm storage or transportation to final biomass facility. Estimated transportation costs are about $0.10 per dry ton per mile for hauling distances of less than 50 miles. Typical transportation costs are expected to be $5–$10/dry ton for distances less than 75 miles. In a study of the economic feasibility of growing herbaceous biomass energy crops in Iowa, researchers obtained a transportation cost of $4.15/ton for a distance of about 30 miles.

The cost estimate for mowing and raking is on a per acre basis, while cost estimates for baling and staging are on a per ton basis. The harvest costs come from the *2000 Custom Rate Guide,* ISU Extension publication, FM 1698.

Summary of costs

Establishment and production costs are the two main expenses of switchgrass production. Reseeding adds a third cost component.

The creation of the budgets starts with estimating the establishment costs. These costs are prorated over 11 years to obtain a yearly establishment cost. They consist of standard components for seed, fertilizer, and pesticides, as well as the land preparation and land charge.

The second step consists of estimating the expected reseeding cost, including seeds, fertilizers, pesticide-related costs, and a land charge (there is no land preparation cost included). Based on switchgrass producers' experience in southern Iowa, the probability of reseeding is set at 25 percent and 50 percent for frost seeding and spring seeding, respectively. The reseeding costs are multiplied by the estimated probability of reseeding to obtain the expected reseeding cost. This expected reseeding cost is prorated over 10 years to obtain a yearly reseeding cost that is added to the cost of production estimates.

The last step is estimating the annual production costs. These costs include the standard components for pesticides and fertilizers plus a yearly land charge. They also contain harvest costs, which will vary depending on the switchgrass yield.

The overall estimated yearly costs of producing switchgrass are comprised of three main components:

- the prorated establishment costs,
- the prorated expected reseeding costs (which equal reseeding costs times the probability of reseeding), and
- the annual production costs.

Table 1 presents estimated establishment budgets for switchgrass under scenarios 1 and 2, frost seeding with an airflow planter on cropland and on grassland respectively. Scenario 1 has the lowest cost of production among all the scenarios on cropland for either frost seeding or spring seeding. Scenario 2 has the lowest production cost among all the scenarios. The two scenarios are presented for illustration. Summarized budgets for the other scenarios may be found in Appendices 3 and 4.

The estimation of the establishment budget for scenario 1 assumes that land preparation for planting is done through disking and harrowing. The budget of scenario 2 was constructed assuming that mowing and Roundup™ herbicide would be used to prepare the land for planting.

It is assumed that there is a lime application. Lime may or may not be needed during the establishment year. However, given that switchgrass is a 10-year crop, it is necessary to account for the lime needs at some point. Initial fertilization of only potassium (K) and phosphorus (P) is assumed: 30 pounds of phosphorus and 40 pounds of potassium are applied per acre. Nitrogen application is not recommended in the establishment year in order to reduce the competition between switchgrass stand and weeds. Prices for fertilizers are reported in *Estimated Costs of Crop Production in Iowa, 2000,* ISU Extension publication, FM 1712.

Table 1. Estimated establishment budgets under frost seeding (scenario 1, switchgrass conversion from croplands, scenario 2, switchgrass conversion from grasslands)

Preharvest Machinery Operations	**Scenario 1 Cost Per Acre***	**Scenario 2 Cost Per Acre***
Disking	$8.00	—
Harrowing	3.85	—
Mowing	—	$6.80
Airflow spreader (seed and fertilizers)	4.50	4.50
Spraying Roundup™	—	4.30
Spraying atrazine and 2,4 D	4.30	4.30
Total machinery cost	**$20.65**	**$19.90**

Operating Expenses	**Unit**	**Price/Unit**	**Amount**	**Scenario 1 Cost Per Acre**	**Scenario 2 Cost Per Acre**
Seed	lb of PLS	$4.00	$6.00	$24.00	$24.00
Fertilizer	(0-30-40)**			13.70	13.70
Lime (including its application)	ton	11.50	3.00	34.50	34.50
Herbicide					
⁎atrazine	qt.	2.93	1.50	4.40	4.40
⁎2,4D	pt.	1.63	1.50	2.45	2.45
⁎Roundup™	qt.	9.39	2.00	—	18.77
Total operating cost	**$/acre**			**$79.04**	**$97.81**

		Scenario 1	**Scenario 2**
Land Charge (cash rent equivalent)	$/acre	$75.00	$50.00
Total Establishment Costs		$174.69	$167.71
Prorated Establishment Costs (11 yrs. @ 8 percent)		$24.47	$23.49

*Source: *2000 Iowa Farm Custom Rate Survey,* FM 1698, March 2000

**Phosphorus price = $.27/lb; potassium price = $.14/lb

Finally, a land charge is included in the costs. (Note the prorated establishment costs presented in the last line of Table 1.) This represents the yearly establishment cost that will be added to the annual production costs estimate. Instead of prorating the establishment cost over the 10 years of the stand's life, 11 years is used to account for the additional year for reseeding. It is assumed that there is no harvesting during the establishment year because the stand is not strong enough to justify harvesting.

Table 2 shows estimated reseeding budgets for scenarios 1 and 2. Unlike the establishment budget, they do not include any land preparation costs (no disking, harrowing, mowing, and Roundup™ application). In addition, a reseeding rate of four pounds of pure live seed is recommended. The fertilization program applied during the establishment is followed here except there is no lime application. The herbicide program is similar to the one applied during the production year. A land charge is included in the cost. Note that the expected reseeding cost is equal to the total reseeding cost multiplied by the 25 percent probability of reseeding. Note also that the last line gives the prorated reseeding cost (over the 10 years of a stand's life) that will be added as a yearly reseeding cost to the prorated establishment cost and to the annual production cost. It is assumed that there is no harvest in the reseeding year as indicated for the establishment year.

Table 2. Reseeding estimated costs under frost seeding, switchgrass conversion from cropland and switchgrass conversion from grassland (Probability of reseeding is approximately 25 percent.)

Scenario 1 and Scenario 2				
Preharvest Machinery Operations		**Cost Per Acre***		
Airflow spreader (seed and fertilizers)		$4.50		
Spraying chemicals		4.30		
Total machinery cost		**$8.80**		
Scenario 1 and Scenario 2				
Operating Expenses	**Unit**	**Price/Unit**	**Amount**	**Cost Per Acre**
Seed	lb of PLS	$4.00	$4.00	$16.00
Fertilizer	(0-30-40)**			13.70
Herbicide				
✲ atrazine	qt.	2.93	1.50	4.40
✲ 2,4D	pt.	1.63	1.50	2.45
Total operating cost	**$/acre**			**$36.54**
			Scenario 1	**Scenario 2**
Land Charge (cash rent equivalent)	$/acre		$75.00	$50.00
Total Reseeding Cost	$/acre		$120.34	$95.34
Expected Reseeding Costs			$30.09	$23.84
Prorated Reseeding Cost (10 yrs. @ 8 percent)			$4.48	$3.55

*Source: *2000 Iowa Farm Custom Rate Survey,* FM 1698, March 2000

**Phosphorus price = $.27/lb; potassium price = $.14/lb

Table 3 presents estimated production year budgets for switchgrass under scenarios 1 and 2, frost seeding with an airflow planter on cropland and grassland respectively, assuming a four-ton yield level. These budgets include fertilizer and herbicide applications. The fertilizer application rate varies by the yield to compensate for the removal rate of potassium (K) and phosphorus (P). There are 1.94 pounds of P_2O_5 and 22.8 pounds of K_2O removed with each ton of switchgrass harvested during the fall period. (See Appendix 2 for different removal rates for K and P for four yield levels and for fall and spring harvest periods.) For nitrogen, the recommended application rate is 100 pounds per acre. The herbicide program is representative of programs followed by southern Iowa growers. Prices for fertilizers are reported in *Estimated Costs of Crop Production in Iowa, 2000,* ISU Extension publication, FM 1712.

Table 3 assumes that an interest rate of 9 percent applies to operating expenses. It also assumes that harvesting costs are not linear; that is, as the yield increases, the harvesting costs per acre increase, but the costs per ton decrease.

In addition, it is assumed that switchgrass is harvested in large square bales weighing 875 pounds each. The cost estimate for mowing and raking is on a per acre basis, while cost estimates for baling and staging are on a per ton basis.

The transportation cost to a biomass facility or the costs associated to lengthy on-farm storage are not included since the production costs are farm gate costs.

In Table 3, the prorated establishment and reseeding costs are added. This produces the total annual estimated costs of production. This estimate also is based on the assumed yield: for illustration, the assumed yield is four tons per acre.

Table 3. Estimated production year budgets (scenario 1, switchgrass conversion from croplands, scenario 2, switchgrass conversion from grasslands) Expected yield: 4 tons/acre, approximately 9 large square bales: 875 pounds/bale

Scenario 1 and Scenario 2				
Preharvest Machinery Operations		**Cost Per Acre***		
Spreading liquid nitrogen		$4.35		
Applying P & K		3.15		
Spraying chemicals		4.30		
Total machinery cost		**$11.80**		

Scenario 1 and Scenario 2				
Operating Expenses	**Unit**	**Price/Unit**	**Amount**	**Cost Per Acre**
Nitrogen	lb.	$.21	$100.00	$21.00
P	lb.	.27	7.76	2.10
K	lb.	.14	91.20	12.77
Herbicide				
⁎atrazine	qt.	2.93	1.50	4.40
⁎2,4D	pt.	1.63	1.50	2.45
Total operating cost	**$/acre**			**$42.71**

Interest on operating expenses (9 percent) **$/acre** **$1.92**

—continued

Table 3. Continued

Scenario 1 and Scenario 2 Harvesting and Storing Expenses	Cost/Ton	Cost Per Acre
Mowing/conditioning	$2.18	$8.70
Raking	1.03	4.10
Baling (large square bales)	16.34	65.37
Staging and loading	6.51	26.04
Total harvesting cost	**$26.05**	**$104.21**

	Scenario 1	Scenario 2
Land Charge (cash rent equivalent)	$75.00	$50.00
Prorated Establishment Costs (11 yrs. @ 8 percent)	$24.47	$23.49
Prorated Reseeding Costs (10 yrs. @ 8 percent)	$4.48	$3.55
Total Production Costs Per Acre	$264.59	$237.68
Total Costs Per Bale	$28.36	$25.48
Total Costs Per Ton	$66.15	$59.42

*Source: *2000 Iowa Farm Custom Rate Survey,* FM 1698, March 2000

Appendix 3 summarizes the costs of producing switchgrass under each of the seven scenarios and for four different yield levels (1.5, 3, 4, and 6 tons/acre). Yield is an important determinant of the level of costs. As a result, the successful production of switchgrass for biomass depends on the use of practices that increase yields such as planting higher yielding varieties.

Switchgrass yields observed in the field range from slightly less than 1 to more than 4 tons per acre per year of biomass. It should be noted that, in most cases, biomass producers have not yet implemented all of the best management techniques that will likely improve yields.

Appendix 4 summarizes the switchgrass production costs under various land charges.

Overall, it appears that switchgrass production for biomass is a viable activity, primarily on marginal land using best management techniques.

Summary

The cost of producing switchgrass varies considerably. The two major components affecting the cost are the land charge and the expected yield.

The appropriate land charge depends on the alternative uses for the land. In this case, converting land from pasture or hay ground produces the lowest costs of production.

Switchgrass is a new commercial crop in Iowa. Only recently has work begun to improve yields. As new varieties become available, the cost of production will decrease. Farmers must consider the costs and possible returns from switchgrass before planting. They also must consider the costs and returns of the alternatives when making a decision.

At this time, the expected price for switchgrass grown for biomass is uncertain. However, given the versatility and environmental benefits of switchgrass, it is anticipated that public subsidies and markets may develop to encourage its production. Farmers must consider all financial and environmental aspects of land use decisions before selecting the crop to plant and the land on which to plant it.

Appendix 1. Description of different scenarios

Scenarios	Description of Scenario
1. Frost seeding on cropland with airflow planter	Use of disk and harrow for land preparation, airflow planter to seed (6 pounds of pure live seed) and spread fertilizers, frost seeding on land previously under crop production, use of atrazine and 2,4 D.
2. Frost seeding on grassland with airflow planter	Mowing and use of Roundup™ for land preparation, airflow planter to seed (6 pounds of pure live seed) and spread fertilizers, frost seeding on land previously under grass production or pasture, use of atrazine and 2,4 D.
3. Spring seeding on cropland with airflow planter	Use of disk, harrow, and roll for land preparation, airflow planter to seed (5 pounds of pure live seed) and spread fertilizers, spring seeding on land previously under crop production, use of atrazine and 2,4 D.
4. Spring seeding on cropland with a drill	Use of disk and harrow for land preparation, drill seed (5 pounds of pure live seed), spread fertilizers, spring seeding on land previously under crop production, use of atrazine and 2,4 D.
5. Spring seeding on cropland with a no-till drill	No-till drill seed (5 pounds of pure live seed), spread fertilizers, spring seeding on land previously under crop production, use of atrazine and 2,4 D.
6. Spring seeding on grassland with a drill	Mowing and use of Roundup™ for land preparation, drill seed (5 pounds of pure live seed), spread fertilizers, spring seeding on land previously under grass production or pasture, use of atrazine and 2,4 D.
7. Spring seeding on grassland with a no-till drill	Mowing and use of Roundup™ for land preparation, no-till drill seed (5 pounds of pure live seed), spread fertilizers, spring seeding on land previously under grass production or pasture, use of atrazine and 2,4 D.

Appendix 2. Potassium (K) and phosphorus (P) removal rates and cost estimates

Yield levels and harvest periods	Estimation of the amount of P and K to apply according to the potential removal rates					
	Removal Rates (lb)		Amount of Nutrients to Apply (lb)		Cost of Nutrients/Acre ($/acre)	
	Phosphorus	Potassium	Phosphorus	Potassium	Phosphorus	Potassium
1.5 tons/acre						
Fall harvest	1.28	28.50	2.91	34.20	0.79	4.79
Spring harvest	0.23	1.80	0.51	2.16	0.14	0.30
3 tons/acre						
Fall harvest	2.57	57.00	5.82	68.40	1.57	9.58
Spring harvest	0.45	3.60	1.02	4.32	0.28	0.60
4 tons/acre						
Fall harvest	3.42	76.00	7.76	136.80	2.10	19.15
Spring harvest	0.60	4.80	1.36	8.64	0.37	1.21
6 tons/acre						
Fall harvest	14.40	114.00	11.65	136.80	3.14	19.15
Spring harvest	4.80	7.20	2.04	8.64	0.55	1.21

Source: Adapted from Lemus (2000) for P data and Radiotis et al. (1999) for K data

Appendix 3. Cost summaries for the seven scenarios

Scenario	Yield (ton/acre)	Establishment costs (prorated) ($)	Reseeding costs (prorated) ($)	Yearly production costs ($)	Total cost per acre ($)	Total cost per ton ($)
1	1.5	24.47	4.48	168.80	197.75	131.84
	3.0	24.47	4.48	208.90	237.86	79.29
	4.0	24.47	4.48	235.64	264.59	66.15
	6.0	24.47	4.48	289.11	318.07	53.01
2	1.5	23.49	3.55	143.80	170.85	113.90
	3.0	23.49	3.55	183.90	210.95	70.32
	4.0	23.49	3.55	210.64	237.68	59.42
	6.0	23.49	3.55	264.11	291.16	48.53
3	1.5	24.47	8.97	168.80	202.24	134.83
	3.0	24.47	8.97	208.90	242.34	80.78
	4.0	24.47	8.97	235.64	269.08	67.27
	6.0	24.47	8.97	289.11	322.55	53.76
4	1.5	24.95	8.97	168.80	202.71	135.14
	3.0	24.95	8.97	208.90	242.82	80.94
	4.0	24.95	8.97	235.64	269.55	67.39
	6.0	24.95	8.97	289.11	323.03	53.84
5	1.5	23.50	8.97	168.80	201.27	134.18
	3.0	23.50	8.97	208.90	241.38	80.46
	4.0	23.50	8.97	235.64	268.11	67.03
	6.0	23.50	8.97	289.11	321.59	53.60
6	1.5	23.97	7.10	143.80	174.87	116.58
	3.0	23.97	7.10	183.90	214.98	71.66
	4.0	23.97	7.10	210.64	241.71	60.43
	6.0	23.97	7.10	264.11	295.19	49.20
7	1.5	24.19	7.10	143.80	175.09	116.73
	3.0	24.19	7.10	183.90	215.19	71.73
	4.0	24.19	7.10	210.64	241.93	60.48
	6.0	24.19	7.10	264.11	295.41	49.23

Appendix 4: Summary of switchgrass production costs per ton with varying land charges

Scenario	Yield (ton/acre)	Land charge			
		$25	$50	$75	$100
1	1.5	*	115.17	131.84	148.50
	3.0	*	70.95	79.29	87.62
	4.0	*	59.90	66.15	72.40
	6.0	*	48.84	53.01	57.18
2	1.5	97.23	113.90	*	*
	3.0	61.98	70.32	*	*
	4.0	53.17	59.42	*	*
	6.0	44.36	48.53	*	*
3	1.5	*	118.16	134.83	151.49
	3.0	*	72.45	80.78	89.11
	4.0	*	61.02	67.27	73.52
	6.0	*	49.59	53.76	57.93
4	1.5	*	118.48	135.14	151.81
	3.0	*	72.61	80.94	89.27
	4.0	*	61.14	67.39	73.64
	6.0	*	49.67	53.84	58.00
5	1.5	*	117.51	134.18	150.85
	3.0	*	72.13	80.46	88.79
	4.0	*	60.78	67.03	73.28
	6.0	*	49.43	53.60	57.76
6	1.5	99.92	116.58	*	*
	3.0	63.33	71.66	*	*
	4.0	54.18	60.43	*	*
	6.0	45.03	49.20	*	*
7	1.5	100.06	116.73	*	*
	3.0	63.40	71.73	*	*
	4.0	54.23	60.48	*	*
	6.0	45.07	49.23	*	*

* Amounts are out of range of possibilities.

References

ISU Extension. 1998. *Switchgrass Seeding Recommendations for the Production of Biomass Fuel in Southern Iowa,* PM 1773. Ames, Iowa.

ISU Extension. 2000. *2000 Iowa Farm Custom Rate Survey.* FM 1698. Revised March 2000. Ames, Iowa.

ISU Extension. 2000. *Estimated Costs of Crop Production in Iowa—2001,* FM 1712. Revised December 2000. Ames, Iowa.

Lemus, R. W. L. 2000. *Cultivar and Fertility Effects on Switchgrass Biofuel Production in Southern Iowa.* Unpublished MS thesis, Iowa State University, Ames.

Park, Y. W. 1996. *Economic Feasibility of Growing Herbaceous Biomass Energy Crops in Iowa,* Ph.D. dissertation, Iowa State University, Ames.

Radiotis, T.; J. Li; K. Goel; and R. Eisner. 1999. "Fiber Characteristics, Pulpability, and Bleachability of Switchgrass." *Tappi J.* 82: 100–105.

Teel, A.; Barnhart, S.; and Miller, G. 1997. *Management Guide for the Production of Switchgrass for Biomass Fuel in Southern Iowa,* ISU Extension, PM 1710. Ames, Iowa.

Walsh, M. E. 1994. "The Cost of Producing Switchgrass as Dedicated Energy Crop" in *Biologue,* 4th Qtr.

Walsh, M. E.; D. Becker; and R. L. Graham, 1996. *The Conservation Reserve Program as a Means to Subsidize Bioenergy Crop Prices.*

Prepared by Mike Duffy, ISU Extension economist, and Virginie Y. Nanhou, research assistant

File: Economics 1-8

[B]

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Stanley R. Johnson, director, Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa.