

Cooperative Extension

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With the current and future needs for clean, renewable energy, numerous crop plants, often referred to as biomass energy crops, have received significant attention. Switchgrass (*Panicum virgatum*) and other warm season perennial native grasses are among those being considered by the U.S. Department of Energy, United States Department of Agriculture (USDA), and others because of their broad geographic adaptation and ability to produce significant amounts of quality biomass even on marginal, non-food crop lands. While many factors are involved in considering crops like switchgrass as a bioenergy crop, potential economic returns are one of the most important. This publication contains budget information on current costs and returns of producing switchgrass as a bioenergy crop along with sensitivity analyses and a table for growers to develop their own estimates.

Some general comments are in order before reviewing specific budgets. From the growers' standpoint, switchgrass will be managed much like a perennial hay crop except there will be only one cutting per year in the late fall (or early winter, if desired). We used custom rates for many of the operations to capture machinery, labor, fuel and related costs. Costs of many inputs vary, so we, in general, have chosen the higher ranges of costs to provide growers with a conservative estimate of the potential costs and returns of producing switchgrass (Table 1 presents budget number assumptions). This bulletin will focus on baling the switchgrass as any normal hay crop, then selling or further processing into small pellets to be sold wholesale, retail or used on farm in pellet burning stoves or boilers.

Seeding Year

Table 1 presents the budget for the seeding year. We assume a grower will start with marginal land currently in sod/weeds or similar vegetation where plowing, disking and additional preparation will be needed. If the field was previously cropped, is fertile and in good condition, no-till planting could significantly reduce establishment costs. Conversely, if the field is in rough shape, a cover or smother crop may be needed to improve soil conditions before planting switchgrass a second year. Planting costs assume using a grain drill or similar

equipment with a grass seed box and planting 10 pounds per acre of pure live seed in late May or early June on a firm seed-bed about 1/4-1/2" deep. Nutrient needs will likely include the need for lime, phosphorus (P), and potassium (K), tilled into the soil in advance of planting. For budget purposes, the costs of P and K are assigned to the year the crop is harvested (second and subsequent years). A small amount of nitrogen (N) (20 lbs), as slow release N, will be placed in or near the drill rows.

Weed control is perhaps the most critical establishment practice because switchgrass is slow to germinate and grow, giving weeds (likely heavy populations from unmanaged lands) a head start. Repeated mowing at the tops of the small switchgrass plants is one way to attempt to manage weed pressure and we compared that to the use of 2,4-D which is one of the few herbicides labeled for weed control. A newly registered herbicide, quinclorac (sold as Paramount™), shows much promise for even better weed control by controlling numerous grasses not controlled by 2,4-D. Our analysis showed using 2,4-D was about equal in cost to mowing one time. Custom mowing one-time costs \$13.40 per acre, whereas as a custom application of herbicide costs \$12.00 per acre for labor and chemicals. Harvest costs are based on traditional mower-conditioner, one raking followed by making big round bales (~1000 lb). Because of the slow growing nature of switchgrass, no harvest is made in the seedling year. In some years switchgrass will produce up to two tons per acre of hay in the seeding year; but in a separate analysis (not presented here, unpublished field data, 2010), it was not economical to harvest that limited amount. Irrigation costs are estimated at \$18 per acre-inch for a moderate depth well and traveling gun or similar type of application. We assumed that a typical year would require two acre-inches of water, but this will vary depending on annual rain-fall. Costs could also change significantly depending on ease of water access and equipment used. Irrigation in the seedling year is considered a necessity because of the shallow planting and slow growth rate. Marketing, overhead and related costs are explained in the foot-notes of Table 1 and further discussed in the section below on established year (harvest) stands.

Table 1. Budget - Switchgrass per Acre - Seeding Year

ITEM	UNIT	PRICE	QUANTITY	TIMES	TOTAL	MY COST
REVENUE						
Yield	Tons	\$160.00	0	1	—	
COSTS						
VARIABLE COSTS						
Production						
Land Preparation^a						
Soil Test ^b	\$/acre	\$1.00		1	\$1.00	
Plowing (Custom Hire ^c)-Moldboard-Sod	\$/acre	\$20.00		1	\$20.00	
Disking (Custom Hire)	\$/acre	\$15.00		2	\$30.00	
Harrowing (Custom Hire)	\$/acre	\$13.90		1	\$13.90	
Planting						
Drilling (Custom Hire)	\$/acre	\$17.60		1	\$17.60	
Seeds	lbs/acre	\$17.00	10		\$170.00	
Nutrients^d						
Nutrient application (Custom Hire)	\$/acre	\$8.00		2	\$16.00	
Lime (Custom Hire & materials)	Tons	\$40.00	2	1	\$80.00	
Nitrogen	lb.	\$0.50	20		\$10.00	
P ₂ O ₅	lb.	\$0.80	0		—	
K ₂ O	lb.	\$0.70	0		—	
Weed Control						
Herbicide (Custom Hire) ^e	pts/acre	\$2.00		2	\$4.00	
Application (Custom Hire)	\$/acre	\$8.00		1	\$8.00	
Mowing for Weed Control (Custom Hire)	\$/acre	\$13.40		1		
Harvesting^f						
Mowing (Custom Hire)	\$/acre	\$13.40	0	1	—	
Raking (Custom Hire)	\$/acre	\$8.55	0	1	—	
Baling (Custom Hire)	\$/ton	\$18.00	0	1	—	
Storage ^g	\$/bale	\$2.00	0	1	—	
Irrigation	acre-inch	\$18.00	1	2	\$36.00	
Total Production Costs					\$406.50	
Marketing						
Drying					—	
Grinding, Pelletizing, and Bagging	Ton	\$80.00	0	1	—	
Selling Charge	\$/acre	4%			—	
Transportation & Handling ^h	Ton-miles	\$.50	0	30	—	
Total Marketing Costs					—	
Total Production & Marketing Costs					\$406.50	
Interest on Operating Capitalⁱ		4%			\$8.13	
TOTAL VARIABLE COSTS					\$414.63	
OVERHEAD COSTS						
Taxes and assessments	Acre		1		\$60.00	
Land Charge	Acre	\$50.00	1		\$50.00	
Miscellaneous (10% of operating costs) ^j	Acre	10%	1		\$40.65	
TOTAL OVERHEAD COSTS					\$150.65	
TOTAL OVERHEAD AND VARIABLE COSTS					\$565.28	
Management Fees ^k		7%			\$36.07	
TOTAL COSTS					\$601.35	
NET RETURNS					\$(601.35)	

Notes:

^aPlant on May 15 in South Jersey and June 1 in North Jersey.

^bThe \$20 soil test kit is used for 20 acres. Lime is based on soil test, and usually occurs every three years.

^cFarm must be 20 acres or larger to custom hire.

^dWhen we do not harvest in the establishment year because the yields are low, fertilizer requirements will be less for P and K in year two, thus we are eliminating the cost of P and K in this seedling year budget.

^eHerbicide 2,4-D is applied 25 days post planting.

^fHarvest October through March.

^gBales are stored on a crushed rock or railroad ties, and covered with a tarp.

^hCalculated at \$0.50/ton-mile.

ⁱCalculated at 4% of total production and operating costs and assuming operating capital is borrowed for six months.

^jIncludes office supplies, legal and accounting expenses, membership dues, insurance, subscriptions, utilities, and other costs. Calculated at 10% of variable costs.

^kCalculated at 7% of total production and operating costs except for the land charge.

Established Year

Assuming a successfully established crop, year two will provide a harvestable crop that can be taken in late fall (usually a couple of weeks after a killing frost) and even throughout the winter, if conditions allow. Table 2 presents per acre costs associated with the second and subsequent harvest years of an assumed eight year stand (one seeding year and seven harvest years) where processed pellets will be sold by the grower in the retail market comparing irrigated to non-irrigated. The following discussion pertains to irrigated management. The \$601.35 total establishment costs calculated in the seeding year is spread over each of the seven harvest years resulting in an annual cost to the grower of \$85.91. For nutrients, we have estimated for this high production irrigated field that 120 pounds per acre of N, 80 lbs P_2O_5 and 120 pounds of K_2O will be needed to produce the six tons of hay per acre. For the non-irrigated crop, we estimated that 80 pounds per acre of N, 60 lbs P_2O_5 and 80 pounds of K_2O will be needed to produce the four tons of hay per acre. This is a high estimate and assumes a harvest in October. Yields normally range from five to eight tons per acre for irrigated switchgrass and three to five tons per acre for a non-irrigated crop. Switchgrass is known to recycle/redistribute nutrients back down into the basal stem and roots within a month or two of a killing frost. Thus, if switchgrass is harvested later than two months after the last killing frost, nutrient needs for the next year should be less than if harvested earlier. Harvest costs each established year consist of mowing (haybine or discbine) and raking on a per acre cost basis and baling on a per ton cost basis, all based on custom rates. Storage costs are assumed to be covered bales stored for an average of two months on a nearby outdoor location and pellet storage costs are for bags of pellets stored on pallets under roof for two months before sale.

Marketing costs consist of transporting the large round bales up to 15 miles to a "regional" pelletizing operation. At that site, bales will be processed through a tub grinder or hammer-mill to reduce size to 3/8"-1/2" pieces suitable for a pelletizer. From the pelletizer, pellets will be bagged into 30-40 lb plastic bags and placed on pallets holding one ton. The bagged pellets are then transported back to the grower's farm. A selling charge of 4% of market value covers advertising, credit card sales, salesperson's labor, and other related expenses.

While production costs are very important and obvious, it is also important for growers to account for other less obvious costs such as interest on operating capital, overhead costs, miscellaneous costs, and management fees. "Interest on Operating Capital" is assumed to be 4% of all variable costs except for establishment costs which were already accounted

for in the seeding budget. "Overhead costs" include property taxes and assessments, land charges and miscellaneous charges. If indeed this is marginal land and/or land on which absentee owners may actually pay a farmer to grow a crop, then this amount could be significantly less. A "Miscellaneous Charge" of 10% production costs covers things not directly used in the field such as office supplies, legal and accounting expenses, member-ship dues, insurance, subscriptions, utilities, and other costs. It is calculated at 10% of variable costs except for establishment costs. A "management fee" of 7% supports the growers overall time investment in this crop enterprise.

We assumed a retail value of \$240 per ton which is based on 90% of the average of prices obtained for wood pellets in New Jersey and neighboring states in the 2009-10 winter season. The 90% figure was used because most grass pellets have about 90% of the heating value of wood pellets. Overall, Table 2 demonstrates an actual loss of \$32.50 per acre for irrigated switchgrass. Comparing this to non-irrigated conditions, input costs related to yield (fertilizer, harvest, etc.) are less for a non-irrigated crop than an irrigated one. Revenue is also less from the estimated four tons per acre for non-irrigated switchgrass, six tons per acre for irrigated switchgrass.

The bottom line is that non-irrigated switchgrass production is less profitable than irrigated; but the difference is about \$40 per acre. This suggests that if growers have easy access to low cost water, and soils are very drought prone, then irrigation use should be considered. Irrigation reduces yield risks in addition to increasing net returns per acre compared to non-irrigation. On soils that are not seriously drought-prone the high cost for irrigation suggests not using irrigation except in the seeding year.

Figure 1 presents comparisons of different retail prices at different yield levels. In the winter of 2008-09 retail wood pellet prices were over \$300 per ton. As can be noted, if energy prices rise, and if yield can be improved, then a \$200-400 profit per acre can be realized. For example, at a yield of six tons per acre and a retail price of \$280 per ton, the profit is \$200 per acre. At a price of \$280 per ton, profit increases to \$400 per acre if the yield increases to about 7.5 tons per acre. Thus, if energy prices rise again from today's level, selling switchgrass pellets retail can become a profitable venture for farmers with available land.

Table 2. Budget-Retail Switchgrass Pellets per Acre
Irrigated and Non-Irrigated-Established Year - 8 Year Stand

ITEM	IRRIGATED	NON-IRRIGATED	MY COST
Yield-Tons/A	6	4	
Gross Income @ \$240/T of pellets	\$1,440.00	\$960.00	
COSTS			
VARIABLE COSTS			
Production			
Establishment Costs	\$85.91	\$85.91	
Nutrients			
Nutrient application (Custom Hire)	\$16.00	\$16.00	
Nitrogen	\$61.00	\$40.00	
P ₂ O ₅	\$65.00	\$48.00	
K ₂ O	\$85.00	\$56.00	
Harvesting			
Mowing (Custom Hire)	\$13.40	\$13.40	
Raking (Custom Hire)	\$8.55	\$8.55	
Baling (Custom Hire)	\$108.00	\$72.00	
Storage bales of switchgrass	\$4.00	\$2.67	
Storage bags of switchgrass pellets	\$4.00	\$2.67	
Irrigation	\$54.00	—	
Total Production Costs	\$504.86	\$345.20	
Marketing			
Grinding, Pelletizing & Bagging	\$480.00	\$320.00	
Selling Charge (4%)	\$54.16	\$38.40	
Transportation & Handling	\$90.00	\$60.00	
Total Marketing Costs	\$624.16	\$418.40	
Total Production and Marketing Costs	\$1,129.02	\$763.60	
Interest on Operating Capital (4%)	\$41.72	\$30.54	
TOTAL VARIABLE COSTS	\$1,170.74	\$794.14	
OVERHEAD COSTS			
Taxes and assessments	\$60.00	\$60.00	
Land Charge	\$50.00	\$50.00	
Miscellaneous (10%)	\$104.31	\$76.36	
TOTAL OVERHEAD COSTS	\$214.31	\$186.36	
TOTAL OVERHEAD AND VARIABLE COSTS	\$1,385.05	\$980.50	
Management Fees (7%)	\$87.44	\$65.13	
TOTAL COSTS	\$1,472.49	\$1,045.63	
NET RETURNS (LOSS)	(\$32.49)	(\$85.63)	

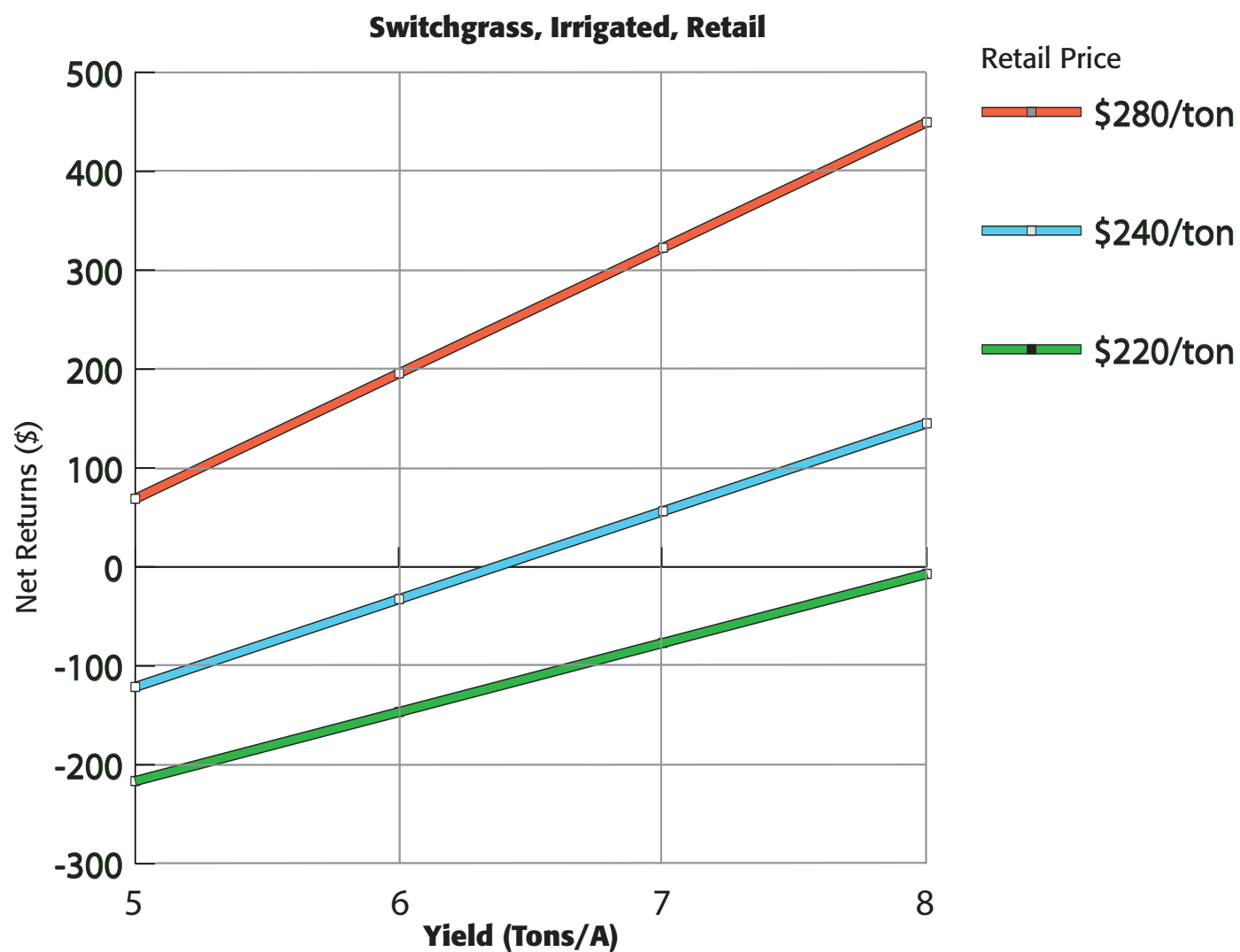


Figure 1. Sensitivity analysis for irrigated switchgrass sold at three different retail prices and at yields ranging from 5 to 8 T/A.

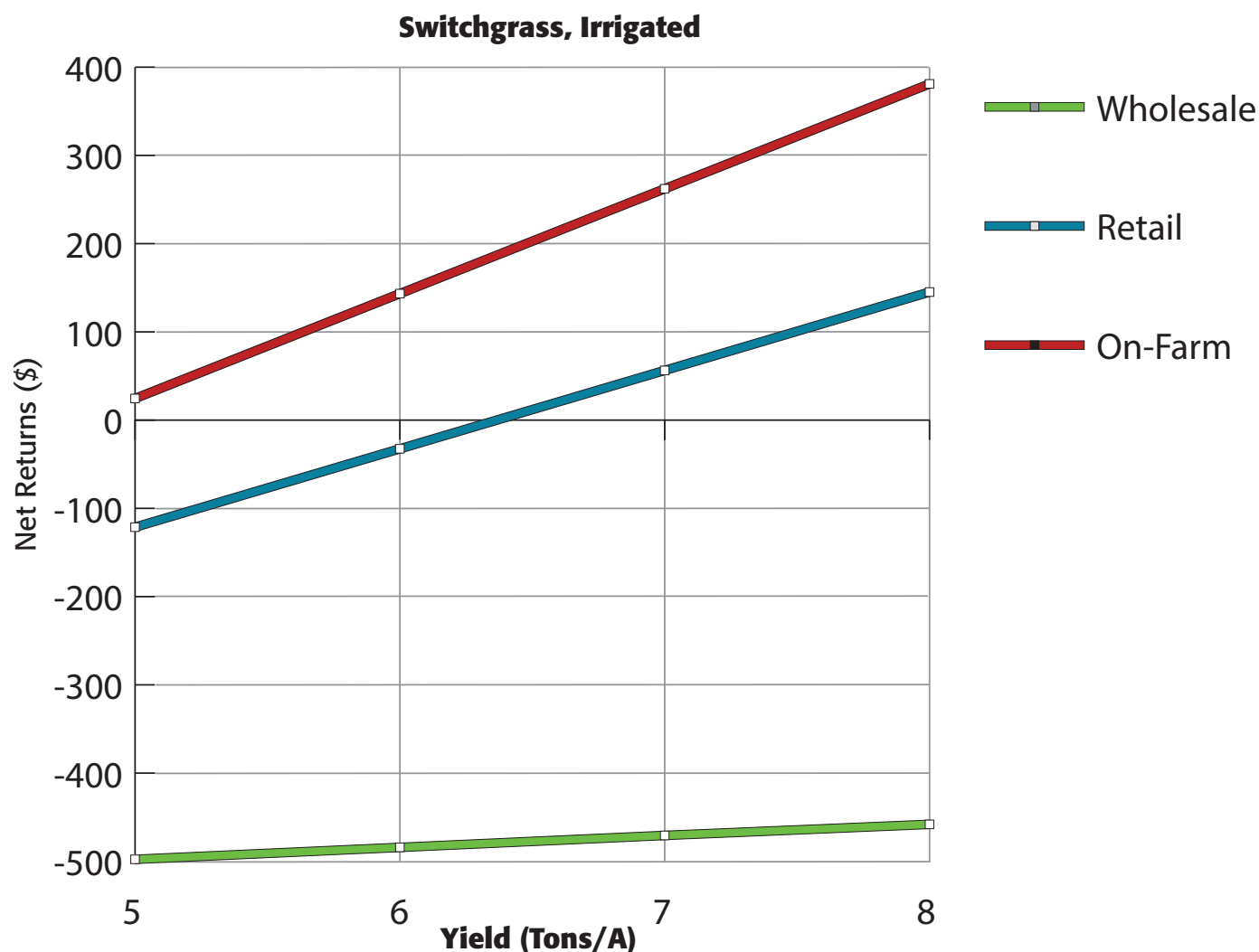


Figure 2. Sensitivity analysis for irrigated switchgrass sold retail, wholesale, or kept for on-farm use at yields ranging from 5 to 8 T/A.

Farmers may not want to be involved in retailing, so Figure 2 shows a comparison of wholesaling and on-farm use compared to retailing. The wholesale price per ton was assumed to be \$160 per ton which was estimated to be 90% of wood pellet wholesale prices this past winter. On farm use value was assumed at a value of \$240 because growers would need to pay that price on the open market. Even though several costs for wholesaling were lower than retail, the significantly lower prices resulted in losses under all yield levels. Conversely on-farm use provided a positive return at all yield levels. It provided the greatest return compared to wholesale and retail sales because ash was returned to the field to reduce fertilizer costs and there were no selling charges.

From Table 2 it was evident that pelletizing and associated costs were greater by far than any other input costs. We developed data presented in Figure 3 to evaluate several levels of pelletizing costs. As would be expected, reducing pelletizing costs from the assumed level of \$80 per ton to \$50 per ton produced profits of over \$400 per acre for a yield of eight tons per acre.

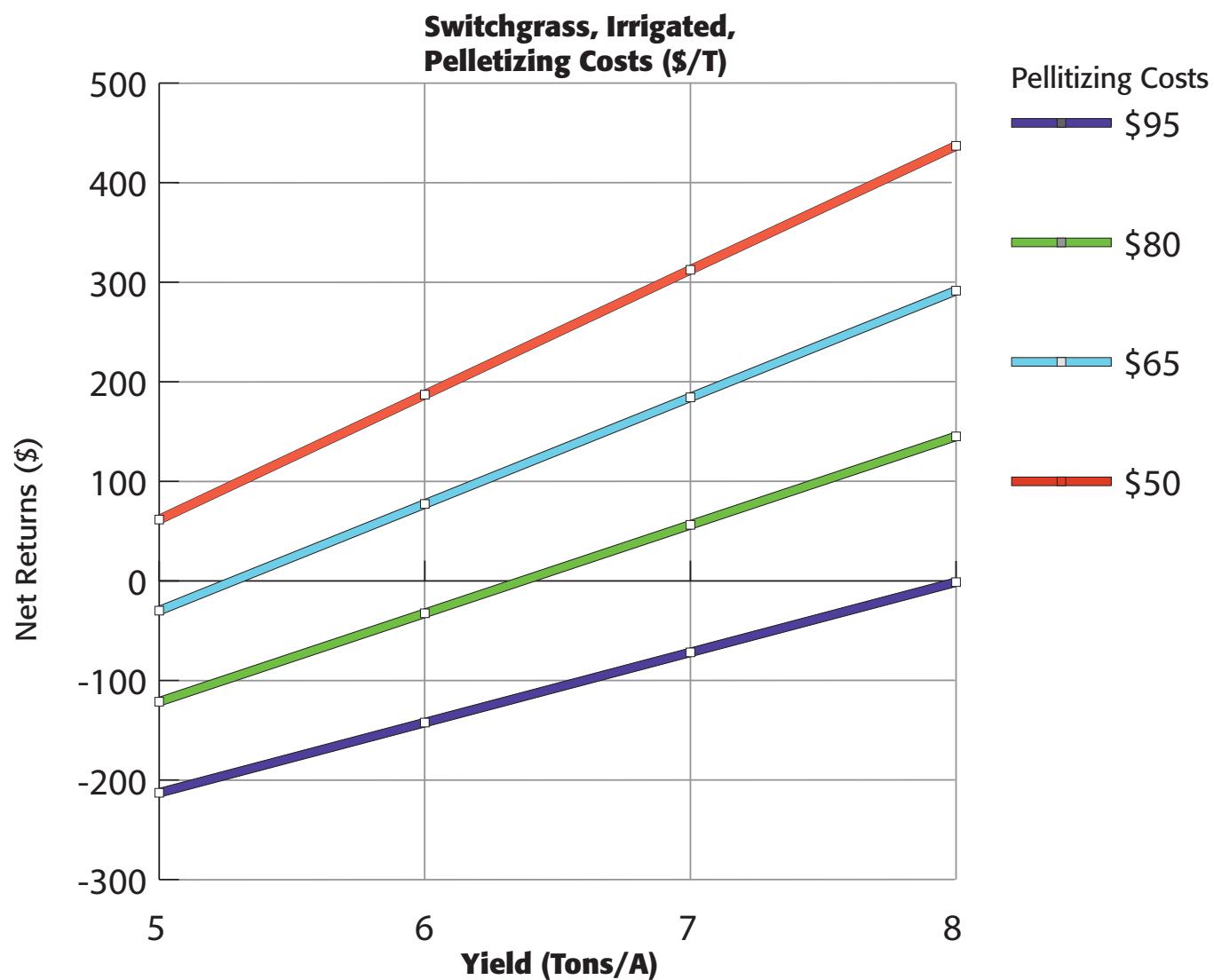


Figure 3. Sensitivity analysis for irrigated switchgrass sold retail as pelletizing costs were varied from \$50 to \$95 per ton.

Table 3. Switchgrass Hay per Acre
Irrigated and Non-Irrigated-Established Year - 8 Year Stand

ITEM	IRRIGATED	NON-IRRIGATED	MY COST
Yield-Tons	6	4	
COSTS			
VARIABLE COSTS			
Production			
Establishment Costs	\$85.91	\$85.91	
Nutrients			
Nutrient application (Custom Hire)	\$16.00	\$16.00	
Nitrogen	\$61.00	\$40.00	
P ₂ O ₅	\$65.00	\$48.00	
K ₂ O	\$85.00	\$56.00	
Harvesting			
Mowing (Custom Hire)	\$13.40	\$13.40	
Raking (Custom Hire)	\$8.55	\$8.55	
Baling (Custom Hire)	\$108.00	\$72.00	
Storage bales of switchgrass	\$6.00	\$4.00	
Storage bags of switchgrass pellets	—	—	
Irrigation	\$54.00	—	
Total Production Costs	\$502.86	\$343.86	
Interest on Operating Capital (4%)	\$16.68	\$10.32	
TOTAL VARIABLE COSTS	\$519.54	\$354.08	
OVERHEAD COSTS			
Taxes and Assessments	\$60.00	\$60.00	
Land Charge	\$50.00	\$50.00	
Miscellaneous (10%)	\$41.70	\$25.80	
TOTAL OVERHEAD COSTS	\$151.70	\$135.80	
TOTAL OVERHEAD AND VARIABLE COSTS	\$671.23	\$489.88	
Management Fees (7%)	\$37.47	\$24.78	
TOTAL COSTS	\$708.70	\$514.66	

Table 4. Break Even Prices for One Ton of Switchgrass Hay

YIELD	BREAK EVEN PRICE	
	NOT-IRRIGATED	IRRIGATED
3 tons/acre	\$163.86	\$213.06
4 tons/acre	\$128.69	\$165.59
5 tons/acre	\$107.59	\$137.11
6 tons/acre	\$93.52	\$118.12
7 tons/acre	\$83.47	\$104.55
8 tons/acre	\$75.95	\$94.38
9 tons/acre	\$70.07	\$86.47

Farmers may not want to be involved in grinding, pelletizing and bagging, so Table 3 and 4 compare the cost of production only, and not any of the post-production functions of grinding, pelletizing, bagging, transporting, handling and formal marketing. We compared the costs of producing one acre of switchgrass hay using irrigation vs. no irrigation. We assumed that the yield would be six tons per acre using irrigation and four tons per acre if the crop is not irrigated. Storage costs are assumed to be covered bales stored for an average of four months on a nearby outdoor location. Table 4 shows that with these yields, the farm-gate break-even price that the farmer would need to receive, is \$118.12 per ton for irrigated switchgrass and \$128.69 per ton without irrigation. However, if higher yield levels are realized, breakeven prices drop below \$100 per ton.

Summary

These results do not necessarily present a favorable case for producing biomass energy for sale, but as stated at the outset, we used the higher ends of price ranges for the various costs and we encourage growers to estimate their own costs in the blanks provided. Our various analyses here also suggest some alternatives, to alleviate the high pelletizing, baling, and nutrient costs. Growers who have the ability to delay harvest to allow nutrient recycling and/or utilize manure or other non-purchased on-farm or local nutrient sources can significantly reduce purchased fertilizer costs. Growers who wish to utilize their switchgrass for on-farm energy use can bale the biomass and purchase “big bale burners” where the whole pelletizing process can be avoided. These “big bale burners,” while generally less efficient than burning pellets, can significantly reduce capital costs. Another possibility is for growers to use the traditional direct cut flail forage harvester (livestock farmers call this product “green chop”) to harvest in the late fall and through the winter when moisture and ash levels have dropped to low levels. But, while ideal for direct combustion quality, weathering can result in yield loss when further delaying harvest through the winter months. This direct chopping, however, saves the mowing, raking, and baling operations and provides a chopped material that may be conveyed directly into a boiler from a “silage self-unloading wagon” or minimally further processed into pellets or briquettes. Finally, as presented in Tables 3 and 4, if farmers don’t have the need for supplemental energy or do not wish to engage in the whole pelletizing process, they can sell their hay to others who are engaged in biomass energy production. We calculated that growers would need to receive, in general, between \$80-\$140 per ton (assuming normal yield ranges of the production systems presented) of switchgrass hay at the farm gate to break even. We should again note, this breakeven figure includes compensation to the grower for labor and management and thus any amount above this is profit to the farm enterprise.

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