Economic Assessment of Biomass Production Systems in Eastern Canada Involving a Perennial Grass, Short-Rotation Forestry and Windbreaks

Patrick S. Girouard,* Roger A. Samson,* John C. Henning** and Ahmad Tayara**

* Resource Efficient Agricultural Production (REAP)-Canada
** Department of Agricultural Economics, McGill University, Canada

Introduction

In an effort to reduce dependence on imported fuel as well as to develop new markets for farm communities, Canada has devoted some effort in recent years to develop renewable energy sources based on biomass. Resource Efficient Agricultural Production (REAP)-Canada, along with McGill University, are involved in an on-farm participatory research program in Eastern Canada. The purpose of the program is to determine which factors are limiting biomass productivity and cost effectiveness for various biomass crops. Two main crops are being investigated: willow trees (*Salix spp.*) grown under a Short-Rotation Forestry (SRF) system and switchgrass (*Panicum virgatum*), a perennial grass. This paper reports estimates of the cost of growing both crops in Eastern Canada, based on quasi-commercial size plots, along with advantages and disadvantages of each crop as an energy source.

Methodology

Fifteen hectares of biomass plantations were established in the provinces of Quebec and Ontario in 1992. An interesting feature of these plots is that woody and herbaceous crops are being evaluated and compared on the same site, based on practices that farmers would be expected to perform (Table 1). Two graduate students in the department of agricultural economics of McGill University have analyzed the economics of Short-Rotation Forestry (SRF) willows and switchgrass.

Table 1. Sequence of cropping practices observed during the first 4 years of SRf and switchgrass monoculture plantations

	SRF	Switchgrass
Plantation Life:	Approximately 20 years	5-15 years
Harvest Cycle:	Every 3-4 years	Annual
Time of Harvest:	Late fall/early winter	Fall (Sept.-Oct.) or spring (May)
First Year Activities:		
Spray with broad spectrum herbicide (fall preceding planting)	Yes	Yes
Plough, disc, harrow	Yes	Yes (but no-till planting is possible on some soils)
Planting	11,000 cuttings per ha; 3.30 ¢ per cutting	Seed at 5.40 $/kg; 6 kg/ha
Herbicides	Grass herbicide	Broad leaf herbicide
Mechanical weeding	Yes	No
Harvest	No	Yes (round bales)
2nd Year Activities:		
Fertilizer	200-20-53 kg/ha[2]	50-10-0 kg/ha
Herbicide	If Necessary (grass herbicide)	No
Harvest	No	Yes
3rd Year Activities:		
Fertilizer	If possible	50-10-0 kg/ha
Harvest	No	Yes
4th Year Activities:		
Fertilizer	If possible	50-10-0 kg/ha
Harvest	Yes	Yes

The economics of SRF forestry willows was investigated for both trees planted in monoculture plantations and in windbreaks on farm land (agroforestry system) while switchgrass was investigated in a monoculture system only (Girouard, 1994; Tayara, 1994). Harvest cycles of 4 years for SRF monoculture plantations and one year for switchgrass were considered and estimates for establishment and other preharvest costs were obtained from REAP-Canada quasi-commercial plots (3 plots of 5 hectares). Harvesting costs were estimated entirely from secondary data. Transportation costs of the biomass to a 40 km processing plant were also included in the analysis. In the case of windbreaks, the design was a two row willow windbreak, with two meters between the trees and between the rows, and a harvest cycle of 8 years. The economic effect of the windbreak on adjacent cash crops was analyzed.

A biomass final supply price was determined using a budgeting approach and was developed on a Microsoft Excel spreadsheet[1]. Full cost budgeting was used, that is, all cash and non-cash costs were considered, including a return to the farmer's land, labour and management. Annual land rent was estimated as 5% of the land purchase value, labour was charged at 3.85 $/hour, while management was estimated as 3% of the purchase value of land and equipment. The analysis did not include government subsidies nor a level of return high enough to enable biomass crops to displace subsidized, conventional, cash crops. Rather, the analysis tried to provide a fair return to farmers for the use of marginal, low opportunity cost, farm land. Since no land set aside program exists in Canada, as long as biomass crops will not be entitled to direct production subsidies, as conventional cash crops, the greatest potential of biomass crops will remain on land unused by conventional agriculture.

Results

Total establishment costs per hectare were estimated at $702 and $169 for SRF and switchgrass respectively. This means that during the establishment year, a farmer must invest approximately four times more money when establishing SRF versus switchgrass. Nonetheless, when establishment costs are amortized over the plantation life, the cost differential narrows due to the likely longer life cycle for the tree plantations[2]: For instance, if a stand of SRF willow is assumed to have a life cycle of 20 years and a stand of switchgrass 10 years, annual establishment costs are $56 and $22 per hectare respectively, using a 5% real rate of interest. The main factors making SRF establishment more

---

[1] All figures in this paper are in US dollar. The exchange rate used was CAN$1.30 for US$1.00.

[2] Although this still need to be verified.

expensive are cutting and planting costs: $358 and $222 per hectare respectively instead of $32 and $19 for switchgrass.

Final supply prices of the biomass, delivered to a processing plant, are presented in Fig. 1[3]. On an equivalent yield basis, switchgrass biomass was estimated to be on average 37% less expensive to grow than SRF willow biomass. REAP-Canada scientists believe that switchgrass yield range in central Canada, given current cultivars, should be in the order of 8-12 odMg/ha. For this yield range, switchgrass biomass could be produced for between 29-39 $/odMg. For SRF monoculture plantations, Samson et al. (1993), after a literature review of yields obtained in large, unirrigated experimental sites in Europe and North America, argue that SRF monoculture plantations will likely not produce more than 7 to 11 odMg/ha per year in Eastern Canada, a moderate rainfall, temperate, region. Based on this range, SRF willow biomass was estimated to be produced for 48-73 $/odMg.

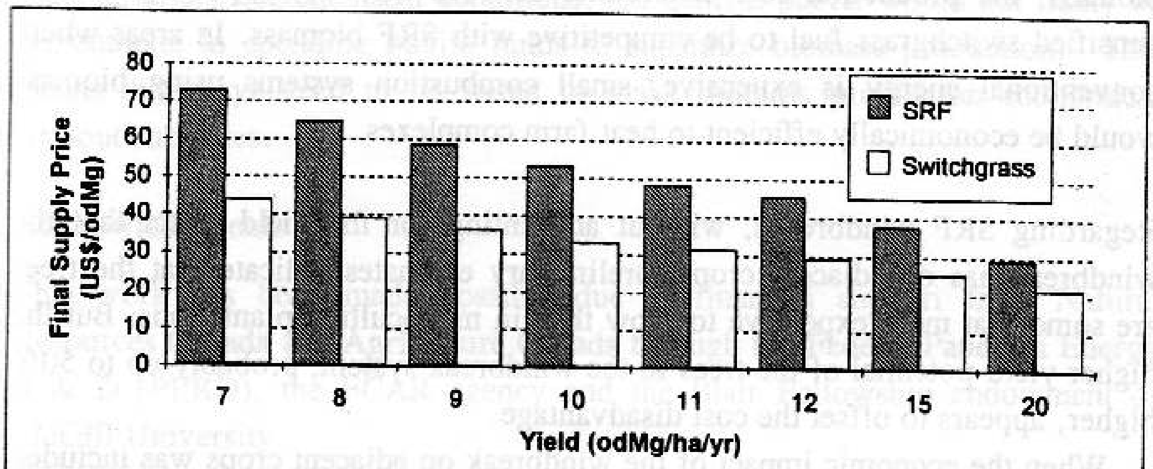

Fig. 1. Final supply price of SRF willow and switchgrass grown in monoculture plantations in eastern Canada. Note: harvest costs are assumed constant per hectare, whatever the yield achieved.

Based on these results, the attractiveness of switchgrass and SRF willow in monoculture plantations for potential markets was assessed as the following:

(1) Alcohol fuel production: switchgrass has significant potential for this market, due to lower production costs. At present, an unsubsidized industry

3 odMg: oven dried Megagram.

would need to pay the biomass feedstock no more than 23 \$/odMg to be profitable. With improvement in production and processing economics, switchgrass has the potential to become economically efficient in the near future.

(2) Electricity generation: Based on current technology, it does not appear to be profitable to build a large-scale electrical generating plant using SRF willow or switchgrass biomass as a feedstock to replace coal (in Central Canada). Nonetheless, if reductions in carbon dioxide emissions were credited to the use of biomass, or if gasification technology would prove efficient on the scale of a commercial power plant, biomass feedstocks could be competitive. Purely on a cost basis, switchgrass would be the best alternative for the electricity generation market.

(3) Heat production: Both crops seem equally promising for the heat production market. Although densification might be necessary for herbaceous biomass, the production cost differential between the two crops might allow densified switchgrass fuel to be competitive with SRF biomass. In areas where conventional energy is expensive, small combustion systems using biomass would be economically efficient to heat farm complexes.

Regarding SRF windbreaks, without accounting for the yield effect that the windbreak has on adjacent crops, preliminary estimates indicate that the trees are somewhat more expensive to grow than in monoculture plantations. But the higher yield potential of the trees in the windbreak system, probably up to 50% higher, appears to offset the cost disadvantage.

When the economic impact of the windbreak on adjacent crops was included in the analysis, it was found that the whole system could be profitable for energy production. That is, the additional revenues obtained from the protected cash crops more than compensated for the economic loss from the sale of the windbreak biomass for energy production.

For a 30 hectare field and a cash crop yield increase of 5%, the windbreak economic impact on adjacent cash crops was equivalent for farmers to receiving an additional \$3.85, \$8.00 and \$3.69 per tonne of corn, soybeans and barley produced in an open field (that is, a field with no windbreak). These estimates are based on cash crop market prices (no subsidy included). In times where profitability of conventional farming is tight, SRF windbreaks represent an interesting opportunity.

Conclusion

Of the systems currently being investigated by REAP-Canada, switchgrass and SRF windbreaks biomass are the most promising energy feedstocks. Switchgrass is more promising than SRF monoculture plantations due to lower production costs, better adaptation to marginal sites (except wetlands) and industry acceptance (no need for farmers to purchase new equipment). Agroforestry (windbreaks) seems the best way to apply the SRF concept on high value cash crop land. The energy sector represents a promising market for biomass, but other markets, such as paper making, need to be investigated if optimal utilization of resources is to be achieved. Biomass should be used in markets where it creates the greatest value to society. As well, at the present time in Canada, under current fiscal conditions, the general public would not likely be sympathetic to spending public funds to subsidize biomass production. This means that ways need to be found to make biomass production economical without subsidies.

Acknowledgments

This work has been made possible due to financial support from Natural Resources Canada and Agriculture Canada through the Federal Panel on Energy R & D (PERD), the FCAR agency and the Blair Fellowship endowment of McGill University.

References

Girouard, P. 1994. *On-Farm Evaluation of Short-Rotation Forestry: Economics of Willow Plantations and Windbreaks in Central Canada*. Master thesis. Agricultural Economics Department. McGill University. 126 pages plus appendices.

Samson, R., P. Girouard, J. Omielan and J. Quinn. 1994. *Technology Evaluation and Development of Short Rotation Forestry for Energy Production*. Annual Report 1993-94. Resource Efficient Agricultural Production (REAP)-Canada. Report written under the Federal Panel on Energy R & D (PERD) for Natural Resources Canada and Agriculture Canada. DSS contract 23440-2-9493/01-SQ. 107 pages.

Tayara, A. 1994. *Evaluation of Switchgrass as an Energy Feedstock: Economic Feasibility and Carbon Dioxide Accounting*. Master thesis. Agricultural Economics Department. McGill University. In progress.