Potential of Reed Canary Grass as a Biofuel in Michigan's Eastern Upper Peninsula

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Introduction

Biofuels represent a potential means to reduce carbon emissions, reduce dependency on increasingly expensive fossil fuels, and provide jobs for the local economy. Biofuels can be used as feedstock for production of liquid fuels or for solid fuel for direct combustion for heating. This project examined the potential of reed canary grass, a cool-season, perennial grass, as a pellet fuel for heating.

Perennial grasses are good candidates for biofuels since they do not have to be planted every year, nor do they require application of agricultural chemicals. Since the crop value for bioenergy use is the carbohydrates, not the protein, the grasses can be harvested after they die back in the fall, and thus after the nitrogen and other nutrients have been translocated back into the roots and crowns. This late harvesting means that the nutrients stay in the perennial parts of the plants which in turn means that the crop does not need high levels of fertilization each year.

Grass biofuels can be harvested conventionally. In other words, growers would not have to purchase new harvesting equipment. While grass bales could be burned in large appliances such as boilers, for convenience and efficiency of handling, the grasses would typically be pelletized. Wood pellets are becoming a popular fuel for stoves, thus grass pellets represent a familiar technology. But compared to wood pellets, grass pellets have a relatively high ash content and must be burned in a stove capable of handling the ash (such as a corn stove).

Because they don't need to be planted, sprayed or fertilized each year, the energy inputs to grow perennial grasses are substantially less than that of annual crops such as corn and soybeans. Also, perennial grasses can grow in land unsuitable for row-crop production and thus do not represent competition for the world's food supply. In addition, wildlife can use perennial grass fields throughout the spring and summer. The fall harvest would be after, for example, bird species have nested and fledged their young.

Reed canary grass (*Phalaris arundinacea*) may be an ideal biofuel source for Michigan's Eastern Upper Peninsula. It grows luxuriously in fields that are too wet for other uses and it is already abundant across the EUP. (It is not a native species to the EUP. It was widely planted during the 1930s and then expanded beyond its planted areas.) It thrives in wet fields, which are common in the EUP. Although it is highly productive, these naturalized strains of reed canary grass are not as good of forage as the other hay grasses, such as timothy, planted in the EUP. It is not considered a desirable grass for forage in the EUP and wildlife agencies consider it a nuisance species. Although wildlife such as sharp-tail grouse can use reed canary grass fields through the spring and summer, deer do not eat it in large quantities.

Reed canary grass is presently used as a pellet fuel in Scandinavia and is described as a potential pellet fuel source in biofuel research projects at Cornell University. Grass biofuel researchers across the United States are concentrating their efforts on switchgrass, a highly productive warm-season grass. The cold, wet climate and poorly drained clay soils of the EUP are not suitable for growing switchgrass, but reed canary grass grows abundantly in the EUP, often in large fields in which reed canary grass is practically the only species growing.

The objective of this project was to assess the energy yield (BTUs per acre) and ash content of reed canary grass on a range of sites in the EUP, and to assess the potential for reed canary grass pellets as a locally produced energy source and potential economic base. Specific questions were 1) the energy yield per acre 2) the ash content 3) whether the energy yield and ash content vary with mid and late fall harvesting 4) the cost comparison of reed canary grass to other fuels.

Methods

We selected six reed canary grass fields in Chippewa County (Table 1). To evaluate production, we harvested 20, ¼ m^2 (50 cm by 50 cm) plots in each field. Plots were systematically placed to encompass the length and width of the field. We harvested the plots on 16-23 October 2007 then again during the week of 17-20 November 2007. We harvested the plots with grass shears, cutting the plants to a 3” stubble height. Harvested material was collected into paper bags, which were air dried in a lab at LSSU and weighed. We took a subsample of the air-dried material to obtain an oven-dried equivalence (oven dried at 60 C).

To obtain the energy content of the material, we ground oven-dried samples in a Wiley Mill to pass a 40-mesh screen then ran approximately 0.1 g samples through a Parr Microbomb Calorimeter. Energy content of the sample was corrected for fuse wire and acid content. Due to the consistency of the energy content values, we analyzed only two samples from each harvesting date for each field. Energy content in calories was then multiplied by the oven-dry proportion to get an energy content for air-dried material. This value was then multiplied by the air dried biomass to get an energy content per ¼ m^2 plot. These values were then converted to BTUs per acre.

Ash content was obtained from subsamples of the material placed in a muffle furnace using the loss-on-combustion method. A known mass of oven-dried material was fired at 500 C for 90 to 120 minutes then the residual ash weighed and ash content expressed on a percentage of air-dried mass. Due to the consistency of the ash values, we analyzed ash content on only 10 plots from each field for each harvest.

Data were analyzed by analysis of variance.

Results

The minimum yield on an air-dried basis was 1.5 tons/acre air on field 1 in the October harvest; the maximum yield was 2.5 tons/acre on field 2, also in the October harvest. Field 1 had a lower average harvest than the other fields (Figure 1). No consistent differences were observed between the October and November harvests.

Energy content per sample ranged from 4032 calories/gram to 4457 cal/g but no consistent differences were observed by field or harvesting date. The average energy content was 4298 cal/g with a 95% confidence interval of (4255, 4342) cal/g. The average energy content equates to 6958 BTU/lb, slightly less than the 8000 BTU/lb reported for grass pellets by Cornell University (www. grassbioenergy.org).

The resulting average energy yield per acre in the fields sampled in this study ranged from 22.08 MBTU/acre for field 1 to 32.05 MBTU/acre for field 2.

Ash content was consistently 6 to 9 percent with no consistent differences found by field or harvest date. The average ash content was 8% with a 95% confidence interval of (7.5, 8.3) percent ash.

Discussion

The calculated BTU per acre yields represent a maximum since these plots were harvested manually and all of the material was recovered. A typical mechanical harvesting of cutting, raking and baling would lose some amount of material. Even if the harvesting process captures only 80 percent of the material, the energy yield would still be 17 to 25 MBTUs per acre.

One measure of effectiveness of biofuels is the energy ratio – the amount of energy obtained from the fuel compared to the amount of energy required to obtain the fuel. According to two hay farmers in the EUP, under the conventional harvest described above, up to 4 gallons of diesel fuel could be required to harvest the reed canary grass, based on a one gallon/acre fuel consumption and four passes (cutting, raking, baling, moving the bale off the field). Each gallon of diesel fuel represents 130,500 BTUs. The energy efficiency of the harvested material is thus between 17/(4*0.1305) = 32.5 and 25/(4*.1305) = 47.9.

The energy efficiency of the final fuel product would depend on the yield and energy requirement for pelletizing and the efficiency of the stove used to burn the pellets. Reports indicate that pelletizing is an efficient process. The energy required to run the pelletizer is a small fraction of the energy in the grass (200 BTU/lb – www.reap.com). The process is also efficient in terms of the product produced (88% of the grass input is captured as pellets – www.cns-snc.ca/events/CCEO/graphics/ 2a_jannasch_paper.pdf). Pellet stoves are presently about 80% efficient, according to manufacturers' reports (e.g., www.pelletheat.org). Thus with 88% of the biomass energy made into the pellets, and energy yield of 97% compared to the energy required for pelletizing and 80% efficiency of combustion, the final energy yield would still be 11.5 to 17 MBTU/acre of heat produced in the stove, based on the average reed canary grass yield reported here. Our estimate of 30+ fold return on energy input is greater than the 14x roughly estimated by Cornell University (www.grassbioenergy.org).

Another final processing step would also have to be added to the finished product. To make the fuel convenient to use and to keep it dry, the pellets would have to be bagged. For example, wood pellets are generally sold in 40 lb bags. The bagging would add some small amount of energy requirement and cost to the final product.

For comparison, a home that presently requires 800 gal of propane for winter heating would require just over 4 tons of reed canary grass pellets, which represents 4 acres of reed canary grass at 1.5 ton/acre and including losses in the production process.

From an economic perspective, with diesel fuel approaching $5/gallon, the cost of fuel for conventional harvesting would be $20/acre. Other harvesting costs beyond just the fuel are difficult to determine. Machine wear and tear, depreciation, labor, and so on add production costs. Presently, hay is selling for about $100/ton, thus those other costs are the majority of the cost of hay production.

By comparison, wood pellets are presently selling for $200/ton, which, with a reported energy content of 8000 BTU/lb computes to $12.50/MBTU. Reed canary grass pellets would be economically competitive with wood pellets, and much lower cost than propane, the main heating source for rural applications. Propane is presently selling in the EUP for $2.50/gal, which equates to $27/MBTU. Even if the cost of pelletizing were extremely high, reed canary grass is very favorable economically to propane.

Whether from an energy or a cost standpoint, the efficiency would be much greater if the harvesting could be done in a single pass. By mowing and baling in a single pass (without raking), 2 passes through the field would be eliminated and the thus the harvesting costs halved. The three-pass harvest is for hay for animal feed which is harvested moist and needs to dry before baling. Reed canary grass to be used for biofuel would be harvested late in the fall when the standing stalks are senescent and thus already dry.

Also from an energetics and cost perspective, transportation of the reed canary grass bales and the resulting fuel pellets should be minimized. Efficiency would be maximized if the pelletizer were centrally located in the eastern UP, say in Dafter or, even better, a mobile pelletizer which would be moved from farm to farm. In either case, a group of farmers could create a co-operative to share the costs of the pelletizer. Pellets could then be marketed through the co-op to customers in the EUP.

Based on aerial images and idle hay acreage reported in the USDA’s Agricultural Census for Chippewa County, we estimate that the EUP presently has several hundred acres presently in reed canary grass. These acres represent a substantial source of biofuel energy. More reed canary grass could be planted in just a part of the several thousands of acres of hay. By planning improved varieties of reed canary grass, yields could be increased, but that planting would add production costs and compete for food production. Also, as mentioned above, reed canary grass has an unfavorable reputation in the EUP thus landowners may prefer to use what's already there rather than bringing new fields into reed canary grass.

With escalating costs of shipping it may not be feasible to market reed canary grass pellets to distant markets. Thus the prospect of a large energy industry for the EUP based on reed canary grass pellets may not be realistic. But a localized fuel co-op could represent a significant economic advantage to the EUP by reducing fuel costs and thus production costs for farmers and businesses. Lower home heating costs add to farmers bottom line. Greenhouses, shops, animal facilities all need to be heated and if heated with a local energy source, could reduce their costs of production and keep farming economically feasible. Similarly, small business such as repair shops could remain in the black if they had access to lower cost heating. The pellets produced beyond what the co-op members needed could be sold to local customer and thus would represent an additional source of income for co-op members.

Reed canary grass thus represents an economic potential for the EUP both in terms of reducing fuel costs and providing another source of income for area farmers. A demonstration project is now required to show that the cost of producing and using the fuel is much less than propane and competitive with wood pellets.

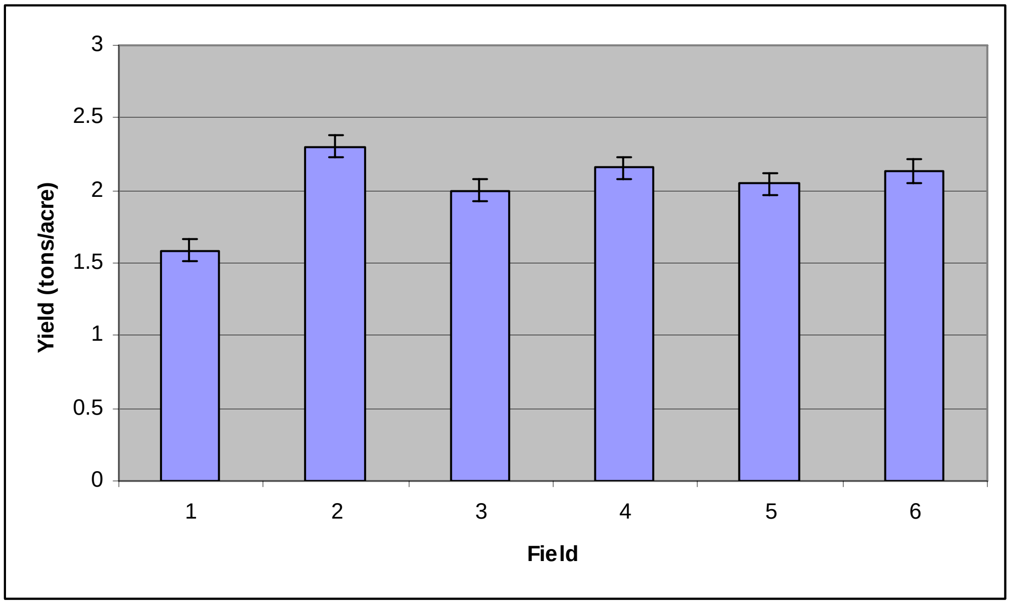

Figure 1. Average yield (both harvests) in six reed canary grass fields in Eastern Chippewa County, Michigan Fall 2008.

Table 1. Field locations for reed canary grass harvest, fall 2008.

Field	Site Name	Location Description
1	W 8 Mile	One mile S of 6 Mile Road on Taylor Side Rd, then ½ mi west on 7 Mile Road
2	E. 9 Mile Rd.	N side of 9 Mile Road, E of Riverside Drive
3	Dafter Post Office	NW corner of intersection of Soo Line Road & Dafter Road: just N of Dafter Post Office parking lot.
4	Wilson Rd.	Across road from 10184 S. Wilson Road.
5	Country Road Greenhouse	1718 S M-129
6	Sterlingville	Pennington Road & Riverside Road