Using Willow Riparian Buffer Strips for Biomass Production and Riparian Protection

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Abstract

There is increasing interest in the development of willow biomass as a renewable source of energy and woody lignocellulosic feedstock for bioproducts. Riparian buffers have been identified as an effective barrier to soil and nutrient movement from agricultural fields into watercourse. Willows are ideal riparian species in that they are well adapted to growing conditions in riparian zones and they vigorously re-grow following coppicing which allows them to be harvested for biomass in 3-4 year cycles. Characteristically riparian edges are highly productive due to water availability, therefore it is anticipated that willow biomass yield per unit area in riparian zones would be attractive. Research is being conducted to determine if using riparian buffer strips for willow biomass production provides energy alternatives and economic opportunities for land owners, but also leads to environmental benefits such as reduced erosion and nutrient leaching and preservation of water quality.

Project Overview

This Canadian Biomass Innovation Network (CBIN) funded thread concerns the dedicated production of willow and herbaceous crops on marginal agricultural land for processing into bio-products and bio-energy. The three year project includes seven research centres across Canada which are cooperating to develop short-rotation willow plantation/agroforestry systems for energy production and GHG reduction

Potential biomass production in the Prairies is significant because of the large agricultural land area. However, moisture deficits are generally higher than in eastern Canada. The role of riparian and/or wetland buffers, which include willow as a high-yielding source of woody biomass, in improving moisture availability and use and maximizing biomass is being studied in this project. Riparian buffers will be designed to optimize the production of woody biomass while reducing net carbon emissions in the riparian buffer systems.

Willow Biomass Production System

The willow biomass cropping system being adopted in the project is commonly sued in biomass production systems in eastern United States and Europe (Abrahamson et al. 2002). The production system can be summarized as follows:

1. Suitable land is prepared using agricultural practices (clean and/or conservation tillage), trees are mechanically spring planted at 12,000 stems per hectare using the double-row system described as follows:
2. Willow cuttings planted 0.75 meters apart within each double row that are 0.75 meters feet apart, with the double rows being 1.75 meters apart),
3. Coppice cycles of three to four years (three years normally, except for the 1-year cutback after the establishment year to promote multiple stems),
4. Weed control accomplished using UV resistant plastic mulch into which cuttings are planted.
5. Dormant season biomass is harvested with modified agricultural round baler and stored until chipped for end use.
6. Approximately seven coppice harvests over 21 to 28 years are expected following establishment.
7. The willow crop can be re-established whenever tree vigor, health or survival declines substantially and reduces productivity, or new-improved clones become available and it is economically justified to replant..

Biomass harvesting is done during the dormant season. This maximizes tree nutrient and carbohydrate allocation to roots during the autumn, thus promoting vigorous coppice re-growth the following spring, and ensures that leaves have fallen and will enter the site's nutrient cycle. In addition, leaves with their relatively high nutrient contents may be problematic in some conversion processes. Winter harvesting ensures that the ground is hard and trafficable, and does not interfere with normal farm harvesting operations in the summer and autumn.

Willow biomass production uses agricultural practices and equipment to produce wood biomass. By analogy, the willow biomass crop system is established like a annual crop, but managed like a hay crop with multiple harvests from a single planting. In addition to the use of agricultural type site preparation techniques and equipment, planting and harvesting machines and operations are more similar to agriculture than traditional forestry.

Riparian Buffer Strips for Biomass Production

Traditionally willows for biomass production are grown in monoculture plantation style production systems as described above. This project involves evaluating the use of native and non-native willow clones as vegetation filters decreasing leaching and runoff of nutrients from agricultural fields to riparian zones. The principle is based on the theory that nutrient retention by vegetation uptake and de-nitrification by micro-organisms is increased by longer water transmit times and is mainly confined to upper soil profiles, thus affecting surface water and shallow groundwater. Characteristically riparian edges are highly productive due to consistent

water availability; therefore biomass yield per unit area could be attractive. The multiple benefits derived from producing willow biomass in riparian buffers would increase the value of buffers to landowners while at the same time providing a valuable environmental role in protecting riparian areas.

The riparian productions system consist of planting four double rows of willow using conventional double row spacing as described above. The willows are planted adjacent to the riparian zone in previously cropped agricultural land. Total width of the buffer is 12 meters.

The objectives of the project are: to evaluate the impact willows on riparian protection compared to traditional grass buffers; to evaluate the potential of woody biomass production from riparian buffers; and to evaluate the impact of coppicing (harvesting) willows on nutrient interception and uptake. Project sites are located at Indian Head, Saskatchewan, Guelph Ontario La Pocatière, Québec; and Charlottetown and Summerside, Prince Edward Island.

Table 1: Willow Riparian Biomass Test Sites

Test Site	Number of Willow Clones	Data Collection			
		Water sampling	Willow nutrient status	Willow Growth	Belowground biomass
Indian Head	10	X	X	X	X
Ontario	6	X	X	X	
Quebec	6	X	X	X	
Prince Edward Island	4	X	X	X	X

Data being collected at the test sites in table 1 is described below. Results will be available beginning in 2008.

1. Water sampling: Three transects, with two nests of sampling instruments each will be installed one at the crop field – grass interface and one at the willow - stream interface. Each nest of instruments will include a piezometer and/or lysimeter (depending on site characteristics) and surface runoff collector. Sampling will begin in 2007 and continue annually for the duration of the project. Runoff collectors will be used to sample surface runoff after significant rainfalls at the bottom of the cropped land, at the bottom end of the headlands, and within the first few metres of the riparian buffer. Water samples will be analyzed for nitrate, ammonia and phosphorous. Attenuation of the concentration of nitrate, ammonium and phosphorus will be used as the indicator of filtering effectiveness of the riparian buffer.

2. Willow nutrient status will be determined by sampling stem tissue annually in early fall beginning in year two. Tissue will be analyzed for nitrate, ammonium and phosphorus.

3. Willow Growth: Permanent sampling plots are set up in each treatment plot. The sampling plots consist of 5 trees/shrubs in each row. Beginning in 2008, the height (cm) and diameter (at 20cm above ground line) of each tree in sampling plot will measured annually in the

fall. In year three, willow stems from coppiced plots will be harvested and total biomass (ODW) recorded for each tree in the harvested treatment plots.

4. Belowground biomass: In years three and six, two 2.5cm diameter soil cores will be extracted from below each of the willows (coppiced and non-coppiced treatments) field crop, grass and adjacent field crop in one permanent sampling plot in each replication. Cores will be separated into depths associated with soil horizon depths. Soils will be wet sieved and roots collected, dried and weighed.

Summary

The biomass production system being proposed is primarily an agricultural based system that is similar to perennial cropping systems being used by farmers. The advantage of using areas adjacent to riparian zones for biomass production is that the willow crop can benefit from the higher moisture conditions normally associated with these areas as well as nutrient attenuation from surface and subsurface movement of nutrients from the adjacent agricultural field. Research being conducted in the project will quantify the potential biomass production as well as the impact of coppicing and the protective function of the willow buffer.

References

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