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Biomass Gasification: A Comprehensive Demonstration of a Community-Scale Biomass Energy System



Final Report to the USDA Rural Development
Grant 68-3A75-5-232

Chapter 2: Best Management Practices: Managing Cropping Systems for Soil Protection and Bioenergy Production

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Introduction

Energy use in our modern society is dominated by using fossil fuels for heat, power and transportation. Fossil fuels are petroleum, natural gas and coal. The cost of these fuels has risen. Burning fuels releases carbon dioxide back into the atmosphere that had been stored for millions of years in these fossil fuels. This is contributing to the increased amount of heat trapping gases, which are called greenhouse gases. Greenhouse gases change the ratio of the sun’s energy trapped in the atmosphere compared to the amount that escapes the planet. When the amount of these greenhouse gases increases, the planet slowly warms; this in turn causes global climate changes. Renewable bioenergy also releases carbon dioxide back to the atmosphere, but it is “young carbon”; that is, carbon already involved in the carbon cycle, rather than carbon released from long-term sequestration in fossil fuels.

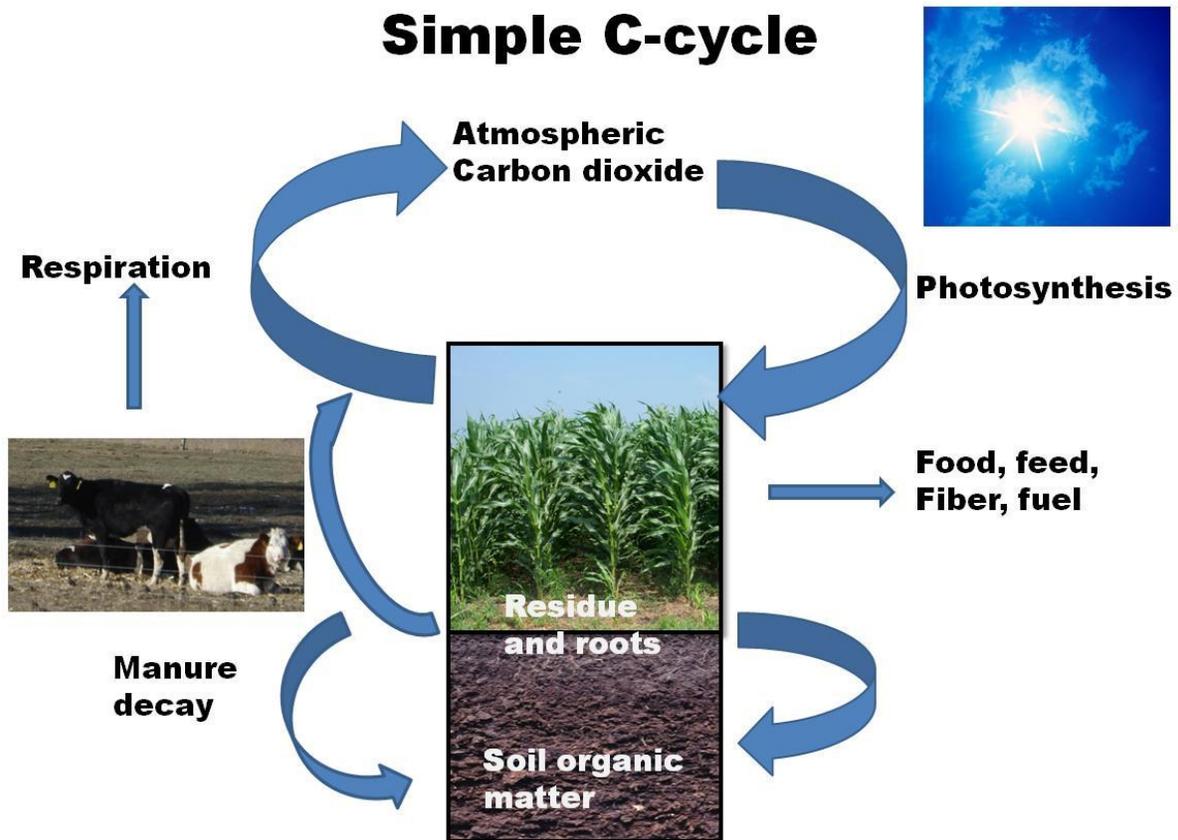


Figure. 1. During photosynthesis, plants use the energy from light to convert atmospheric carbon dioxide and water into plant material. Unharvested parts of the plant provide the building blocks for organic matter. In addition, residue on the soil surface protects the soil from erosion. When the food,

feed or fuel are used by animals, the energy stored in the plant material is used and carbon dioxide is released into the atmosphere by a process called respiration.

Crop residues can be used as a renewable bioenergy to produce power, heat and transportation fuels, but this use must be balanced against other roles. Crop residue is a generic term used to describe what is left in the field after grain harvest. While some have referred to this material as “trash” or as an unused or under-utilized material; kept on the soil surface these materials are the first line of defense against the erosive forces of wind and water. The USDA-NRCS has well established conservation technical standards for residue management, which can be found at:

<http://www.nrcs.usda.gov/technical/Standards/nhcp.html>.

1. What is the Value of Crop Residues on the Field?

- 1.1 Protect the soil surface from the erosive forces of wind and water (provided they are not plowed under)
- 1.2 Increase the amount water that infiltrates into the soil rather than running-off.
- 1.3 Provide the basic food and energy to support the soil ecosystem.
- 1.4 Provide the basic building blocks for generating soil organic matter.

2. Characteristics of a Highly Productive Soil

Characteristics of a highly productive soil are related to the presence of soil organic matter. They include:

- 1.1 Soil organic matter supports cycling of crop nutrients, such as nitrogen, phosphorus, and many others.
- 1.2 Soil organic matter increases soil cation exchange capacity (CEC), so it better adsorbs and retains nutrients.
- 1.3 Soil structure or tilth is improved by soil organic matter as it aids in the formation of soil aggregates, which results in soil stabilization.
- 1.4 Increasing soil organic matter increases a soil’s resilience against soil compaction.
- 1.5 Increasing soil organic matter improves water holding capacity.

1.6 Increasing soil organic matter keeps more carbon in the soil, which reduces atmospheric carbon dioxide concentrations.

The attributes listed above for increasing soil organic matter are associated with increased inherent crop productivity, and improved soil, water and air quality.

Across a landscape or farm, individual parcels of land will have different production potentials and erosion risks. Areas near surface water should provide a perennial buffer to prevent movement of nutrient or other agrochemicals into water ways. Parcels with a high erosion risk (e.g. steep grade) may have potential for producing perennial species that protect the land with limited biomass harvest. Parcels with low productivity,



perhaps due to periodic flooding or other production challenges, may be well suited for raising perennials tolerant of high or low water conditions. Low-risk, high production lands could be used for producing food crops or managed to harvest food crop and a bioenergy crop; for example, corn grain and corn cobs.

There are a series of questions from a conservation perspective for determining whether or not to harvest residues or a perennial dedicated crop from a given land parcel.

Figure 2. Aerial view of Central Minnesota, showing complex landscape features.

Photo by Don Reicoskv.

3. Conservation Decision Key

- 1.5 Question 1: Is the land classified as highly erodible land?
 - 1.5.1 If yes, no residue should be harvested; land should be managed for soil conservation.
 - 1.5.2 If no, go to question 2.
- 1.6 Question 2: Is the land Conservation Reserve Program (CRP) eligible land?
 - 1.6.1 If yes, this may be a candidate for growing a dedicated perennial species for bioenergy, provided sufficient cover is maintained to avoid erosion. Choice of grass or tree species planted depends upon landscape position and soil type.
 - 1.6.2 If no, go to question 3.
- 1.7 Question 3: Is the land at moderate risk for erosion?
 - 1.7.1 If yes, options may be available for harvest using this parcel of land for bioenergy.
 - 1.7.2 Option 1: Raise a dedicated grass or tree species for bioenergy, provided sufficient cover is maintained to avoid erosion during establishment and harvest.
 - 1.7.3 Option 2: Harvest limited residue (cobs only), reduce or eliminate tillage and increase residue coverage. If small grain is grown consider adding a cover crop.
 - 1.7.4 If no, go to question 4.
- 1.8 Question 4: Are these agricultural lands low erosion risks?
 - 1.8.1 If yes, then land may be available for producing and harvesting bioenergy feedstocks, consult local USDA-NRCS or UMM extension experts.
 - 1.8.1.1 Option 1: Raise a dedicated grass or tree species for bioenergy, provided sufficient cover is maintained to avoid erosion during establishment and harvest.
 - 1.8.1.2 Option 2: Harvest limited residue (cobs only), reduce or eliminate tillage and increase residue coverage. If small grain is grown consider adding a cover crop.
 - 1.8.1.3 Option 3: Harvest some residue or cobs only, reducing or eliminating tillage.

Visiting an USDA-NRCS office that uses a soil conditioning index (SCI) tool can provide guidance, based on your specific management, yields, tillage and erosion risks to determine if harvesting residue is likely to cause a loss in soil organic matter. More information on the SCI can be found at http://www.pa.nrcs.usda.gov/technical/Fact_Sheets/SCI%20Fact%20Sheet.pdf.

Harvest options and harvest timing also need to be considered. One-pass harvesters capable of harvesting both grain and cob or stover are being developed. As this technology becomes available it has the advantage of reducing trips across the field. However, current technology for window and baling forage or bedding are the most readily available options. Harvesting crop or perennial residue removes nutrients that previously would have been cycled back to the land.

4. Nutrient Management Considerations

Harvesting annual crop residue removes more nutrients compared to harvesting only grain. Thus, nutrient management may need to be adjusted. Continued removal of nutrients without replacement by applying fertilizer, manure or compost depletes the soil fertility, which reduces soil productivity. It is straight forward to calculate the amount of nutrients removed (concentration multiplied by dry mass); however it is challenging to predict the impact on soil fertility. The impact will vary among nutrients, soil type and other management practices (e.g., manure application). Producers will need to monitor soil fertility, scout crops for deficiency symptoms and apply appropriate fertilizer mixtures as necessary.

| Table 1. Concentration of elemental N, P and K in several residues. | | | |
|---------------------------------------------------------------------|-------------------|------|------|
| Residue | N | P | K |
| | % in plant tissue | | |
| Corn stover | 0.74 | 0.13 | 1.15 |
| Corn cobs | 0.56 | 0.05 | 0.63 |
| Wheat straw | 0.68 | 0.10 | 0.78 |
| Soybean straw | 1.5 | 0.18 | 1.3 |
| Perennial grasses | 0.75 | 0.08 | 0.39 |

Based on Johnson et al. (2010a and 2010b)

5. References and Resources

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<http://www.extension.umn.edu/distribution/cropsystems/M1243.html>

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SCI fact sheet: http://www.pa.nrcs.usda.gov/technical/Fact_Sheets/SCI%20Fact%20Sheet.pdf.

Soil quality: <http://soils.usda.gov/sqi/>