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Biomass Crop Residue Research and Development for Bioprocessing Opportunities in Canada

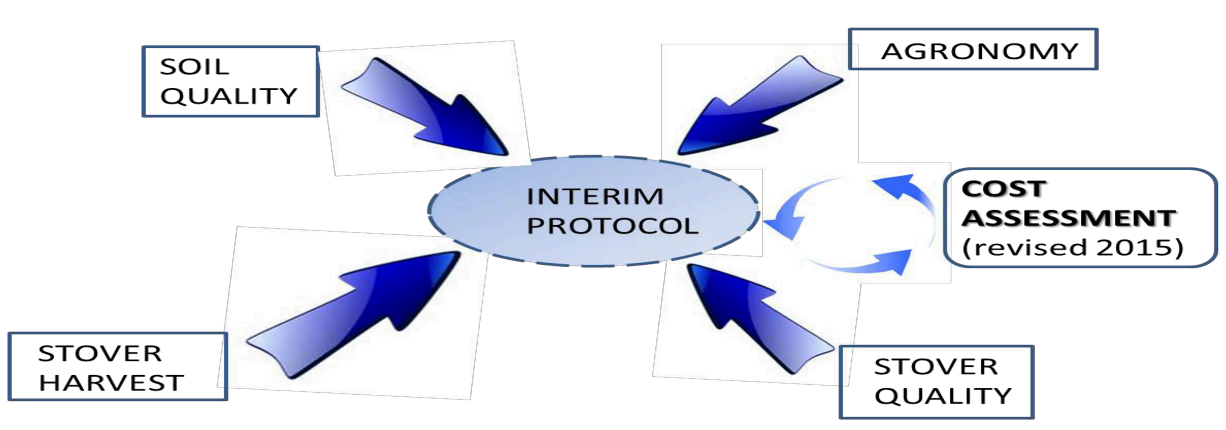
Charles Lalonde[1], Craig Drury[2], Xueming Yang[2], Jingyi Yang[2], Patrick Girouard[3], Hicham Bencharki[4], Maria Wellisch[5]

[1] Ontario Federation of Agriculture Crop Residue Project (Canada),
[2] Soil Management & Biochemistry, Agriculture and Agri-Food Canada,
[3] Renewable Energy & Bioproducts, La Coop fédérée (Canada),
[4] Agri-environment, La Coop fédérée (Canada),
[5] Strategic Policy Branch, Agriculture and Agri-Food Canada

INTRODUCTION

In order to proactively manage crop residue harvesting at sustainable levels, agricultural stakeholders, producers and future bio-processors require information that is relevant to conditions in Eastern Canada.

Documentation of four key agri-environmental areas guided the development of an Interim protocol for a cost-effective sustainable harvest of corn stover:



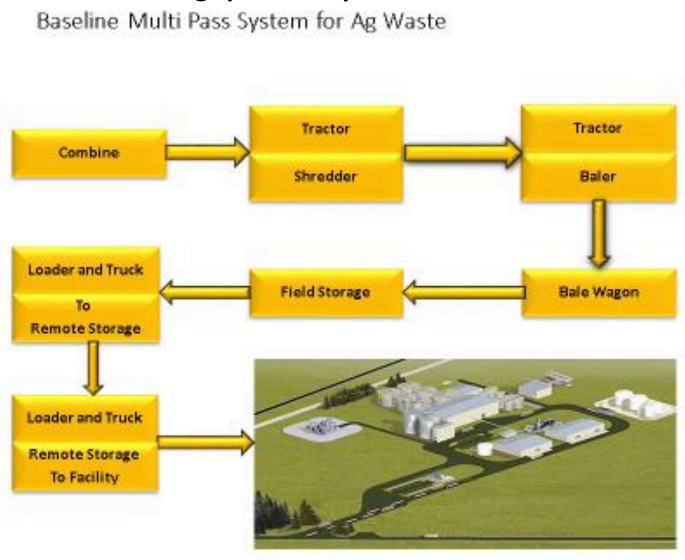
- Soil quality factors determine whether harvesting is possible.
- Agronomy factors (e.g. tillage, crop rotation) help mitigate potential environmental impacts with respect to soil physical quality (structure, compaction, erosion) and soil health.
- Once both are deemed acceptable, stover harvest procedures and stover quality factors determine economic feasibility.
- These four areas drive the development of an interim protocol that will be adjusted over time as more agri-environmental information becomes available.

MATERIALS AND METHODS

A coalition of private sector farm organizations, government researchers and policy staff was created to pool knowledge and resources to support the development of an interim protocol for sustainable corn stover harvesting systems for bioprocessing in Southwestern Ontario.

- Soils of 40 high yield grain farms in Ontario and Quebec were tested for soil organic matter (SOC), particulate organic matter (POM) and total nitrogen (TN). Analysis was conducted using a new FTIR technique developed by Dr X.Yang.[1]
- Tillage practices, crop rotation practices, grain yields, residue management practices, fertilization including any manure applications and use of cover crops were collected by interviewing each producer. Soil classification, type, structure, environmental features were documented using provincial agri-environmental databases and mapping.
- Soil structure characteristics were identified and provided to J Gan et al.[2] and reported in the IEA Poster "Determining Optimal Removal Rate and Regional Supply of Corn Stover in Ontario, Canada".
- Crop insurance yield data is monitored annually by the Ontario Federation of Agriculture and crop rotation data was derived from annual crop inventory reports prepared by Agriculture and AgriFood Canada.[3]
- Corn grain yield was used to assess stover yields using a 1:1 ratio.
- A two pass stover harvest system was used to collect performance data for supply cost modelling[4].
- Stover quality was defined based upon ash and moisture content, shredding predisposition and bale weight/density.

Baseline Multi Pass System for Ag Waste

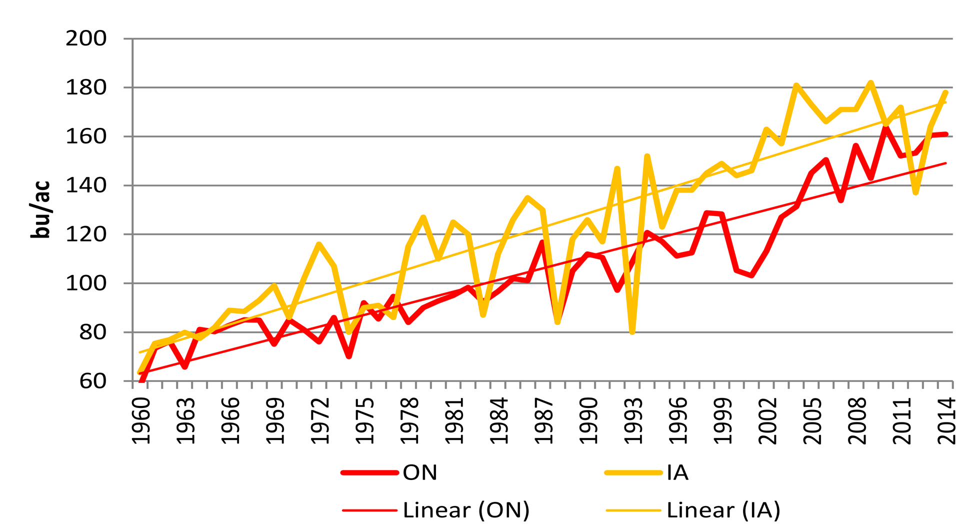


- Supply Cost modelling was carried out in 2013 by Duffy et al.[5], and repeated in 2015 by Marchand et al.[6] using the information contained in this interim protocol, literature results, field work and interviews with value chain partners. The results were benchmarked against Iowa stover harvesting information.

RESULTS & DISCUSSION

Agronomy

- Crop rotation - corn – soybean – winter wheat or a corn - soybean rotation under a variety of tillage practices is typical to the area. No till & minimum tillage account for 20% of farm acreage. The use of cover crops is gaining popularity after a winter wheat crop.
- Corn yields in both Ontario (Canada) and Iowa (US) have risen consistently over the past 10 years. At current levels, producers have excess crop residue to manage; accordingly, partial removal of stover eliminates the need for additional field passes to work residue in the soil. Producers also report sooner crop emergence and yield increases when some residue is removed.



Soil Quality[7]

Compared 10 paired field sites and evaluated the SOC and TN in 4 depth increments and the POM-C and POM-N in the top 2 depth increments. A typical farm result is represented below:

	Soil OC (g C/kg soil)			Soil Total N (g N/kg soil)		
Depth (cm)	Grain	Silage	Pr (T < t)	Grain	Silage	Pr (T < t)
0-5	37.2	34.3	0.254	2.63	2.58	0.800
5-10	26.8	25.0	0.300	2.26	2.18	0.573
10-20	26.6	23.0	0.164	2.26	1.97	0.216
20-30	23.9	22.1	0.694	2.04	1.92	0.855
	POM-C (g/kg soil)			POM-N (g/kg soil)		
0-5	6.19	5.10	0.09	0.39	0.31	0.114
5-10	4.53	4.33	0.749	0.28	0.29	0.962

- There is generally more SOC in the top 10 cm of the soil.
- More significant effects reported for the POM-C and POM-N fractions than from the SOC and TN fractions which are attributed to POM being the more labile C and N pool.
- Soils sampled had SOC values from 2.5 to 5.0% indicating sufficient soil carbon to support crop residue harvesting.

Stover Harvest & Quality

- Approximately one third of the available stover was removed.
- It was not possible to use a one pass system due to the high moisture levels experienced in the fall. A two-pass harvest system will likely be the preferred choice.
- Bale moisture content varied according to the season of harvest. Fall harvest introduced more moisture than a spring harvest (30% vs 10%). Ash content of stover harvested on clay soils was less than 5%, an excellent level.
- Stover cost plays a very important role in determining the viability of the supply chain from the perspectives of both the agriculture producer and the processor. The Ontario Federation of Agriculture has been conducting field tests since 2012 to determine the best harvesting equipment and systems to reduce field harvesting costs. Based on this information, a farm gate budget was established.

2015 Harvest Costs:

	$/tonne at 15.5% moisture
Flail chopper/inverter	9.43
Large square baling	14.03
Stack end of field	5.72
Storage end of field, tarped[1]	8.30
Nutrient replacement	9.86
Production management	7.10
Corn Stover Cost – farm gate	54.44

NEXT STEPS

- Farm trials will continue to assess the best protocols for harvesting of corn stover under Canadian climatic conditions. Cost models will continue to be revised to support investment opportunities.
- The use of satellite imaging will be expanded to develop a new producer and bioprocessor tool to more accurately predict corn yields in time to make sound cornstalk harvesting decisions.
- Further work is underway to identify best transport and delivery options to minimize costs.
- The impact of different levels of stover removal on different soil types needs to be more closely examined. Experimental plots have been set up that will assess the impact of 0, 25, 50, 75 and 100% stover harvest in a continuous corn crop system for 5 years. SOC and POM levels will be measured annually to determine the "sustainable soil carbon" harvest threshold.

CONCLUSIONS

- High yield corn production in Eastern Canada compares favorably to Iowa (US) where research on sustainable harvesting was first reported and stover harvest is active.
- Conditions in Southwestern Ontario are adequate to proceed with partial corn stover harvesting in the fall and spring, as long as harvesting protocols are adhered to and monitored.
- A protocol based on a minimum 10 t/ha grain production, a system of crop rotation, the use of cover crops and minimum tillage can mitigate potential long term environmental impacts associated with a 30% stover harvest.
- Further research is required to assess the long term impacts of stover removal on different soil types and for different crop rotations.

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OFA Ontario Federation of Agriculture

La Coop fédérée