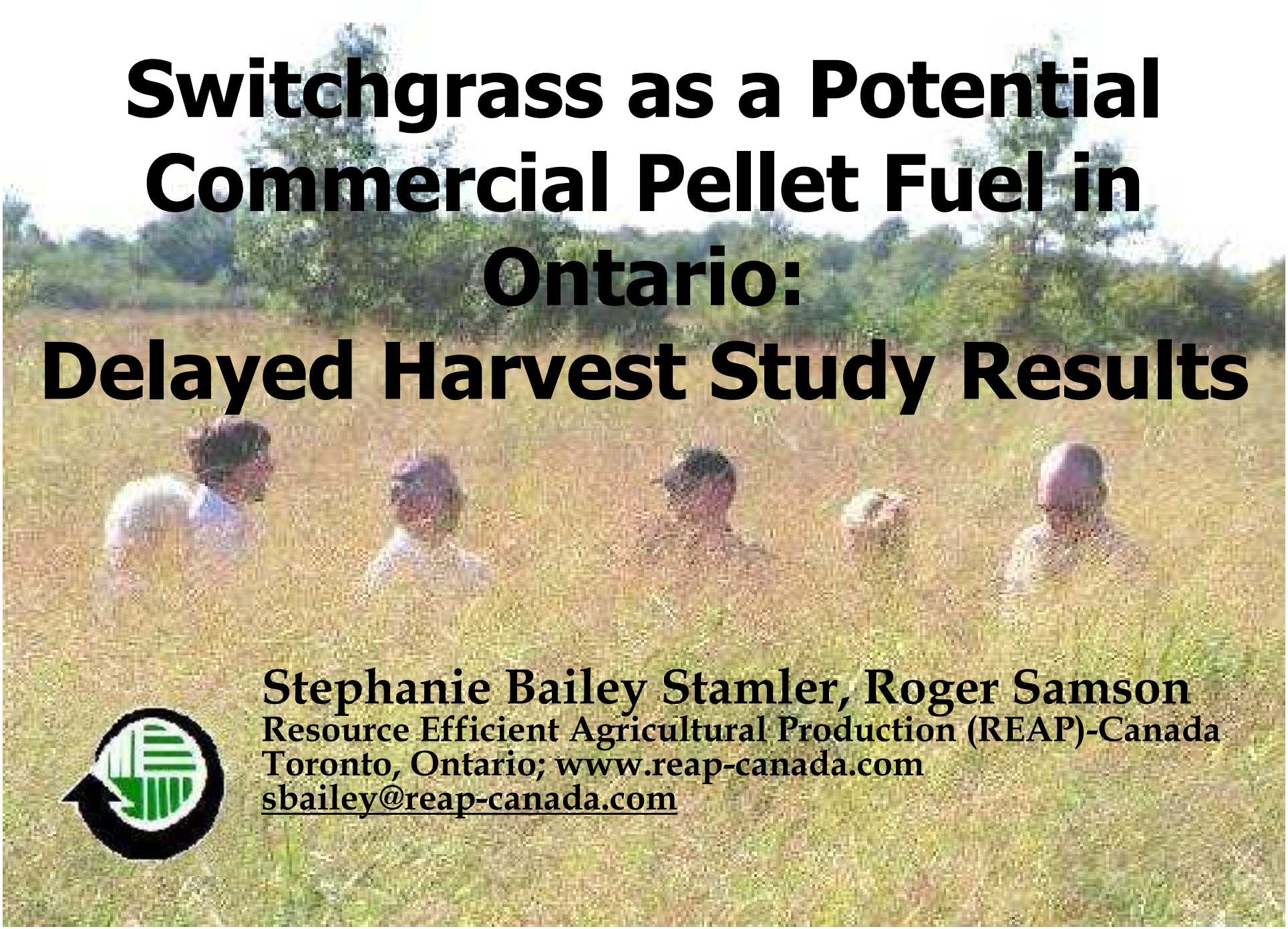
Switchgrass as a Potential Commercial Pellet Fuel in Ontario: Delayed Harvest Study Results



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REAP-Canada

- Providing leadership in the research and development of sustainable agricultural biofuels and bioenergy conversion systems for greenhouse gas mitigation
- 17 years of R & D on energy crops for liquid and solid biofuel applications
- Working in China, Philippines and West Africa on bioenergy and rural development projects

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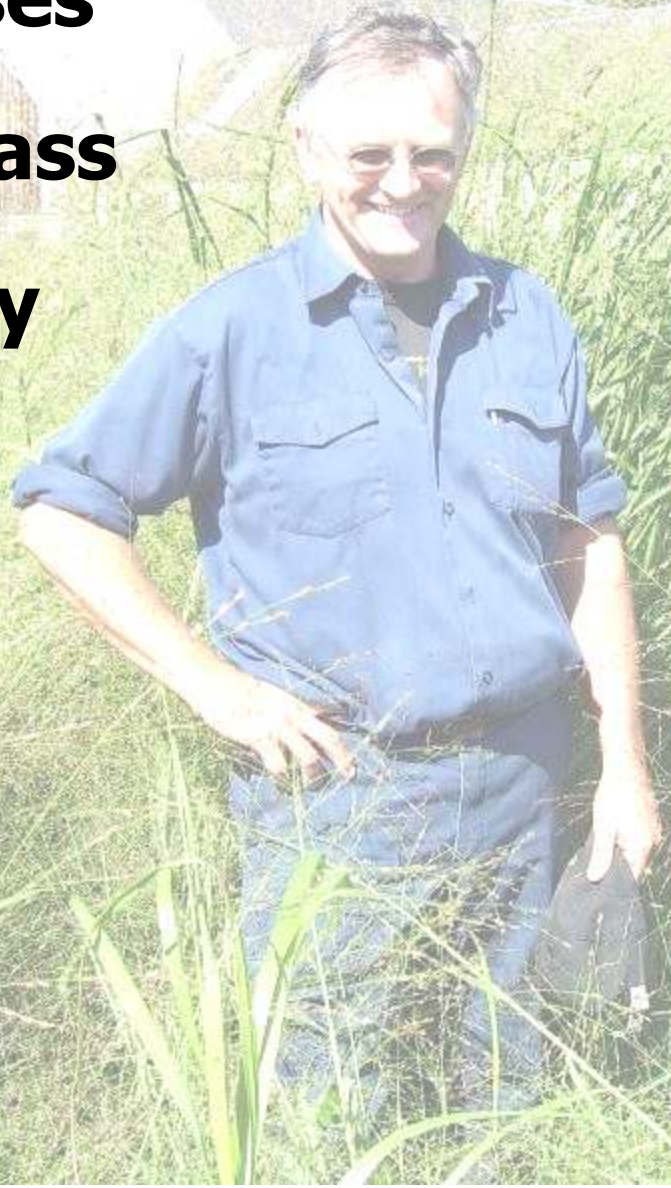
Warm Season Grasses

C4 Grasses such as switchgrass are ideal bioenergy crops



- **Moderate to high productivity**
- **Stand longevity**
- **Drought tolerant**
- **High nutrient use efficiency**
- **Low cost of production**
- **Adaptability to marginal soils**
- **Benefit biodiversity and soil fertility**

Developing Switchgrass Pellets for Energy Since 1991

- Relatively easy crop to grow and produce into pellets for thermal energy
- Thermal energy from SG pellets is leading strategy to provide GHG offsets and energy security for Ontario
- Main outstanding challenge has been how to burn without causing: 1) clinker and boiler corrosion, and 2) ambient air pollution

Low aerosol forming pellets (i.e. low in K, Cl, Na and S) burn well and cleanly in multi-fuel coal/pellet boilers

Biomass Quality of Switchgrass vs. Wood Pellets and Wheat Straw

Unit	Wood pellets	Wheat straw	Switchgrass	
			Fall harvest	Overwintered Spring harvest
Energy (GJ/t)	20.3	18.6-18.8	18.2-18.8	19.1
Ash (%)	0.6	4.5	4.5-5.2	2.7-3.2
N (%)	0.30	0.70	0.46	0.33
K (%)	0.05	1.00	0.38-0.95	0.06
Cl (%)	0.01	0.19-0.51	n/a	n/a

Source: Samson *et al.*, 2005

Delayed Harvest Cause Important Losses

- SG Research in Quebec (Girouard and Samson 1997) and Pennsylvania (Adler *et al.,* 2006) indicated recovered spring biomass is 46% and 49% of fall biomass using a mower conditioner and baling system

Losses come from:

- Loss of cell solubles (~7-10%)
- Field breakage (~20-25%)
- Harvest system losses (~20-25%)

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Switchgrass Harvest Study

Location: 8 yr old Cave in Rock switchgrass field near Arnprior ~2650 CHU

Treatments: Fall mow & spring bale vs. spring mow & bale –side by side paired comparison with 6 reps

Main parameters assessed:

- Machine harvest yields, Unrecovered biomass residues, biomass quality changes

Harvest Experimental Design

Fall Mow, Spring Bale:

- *Fall mow took place on November 25th, 2006*
  - 12’ disc mower conditioner, cut height of 10.1 cm
- *Spring baling operations took place on May 3, 2007*
  - Raking was performed prior to baling

Spring Mow, Spring Bale:

- *Spring mowing and baling operations took place on May 3rd and 4th, 2007*
  - No raking necessary

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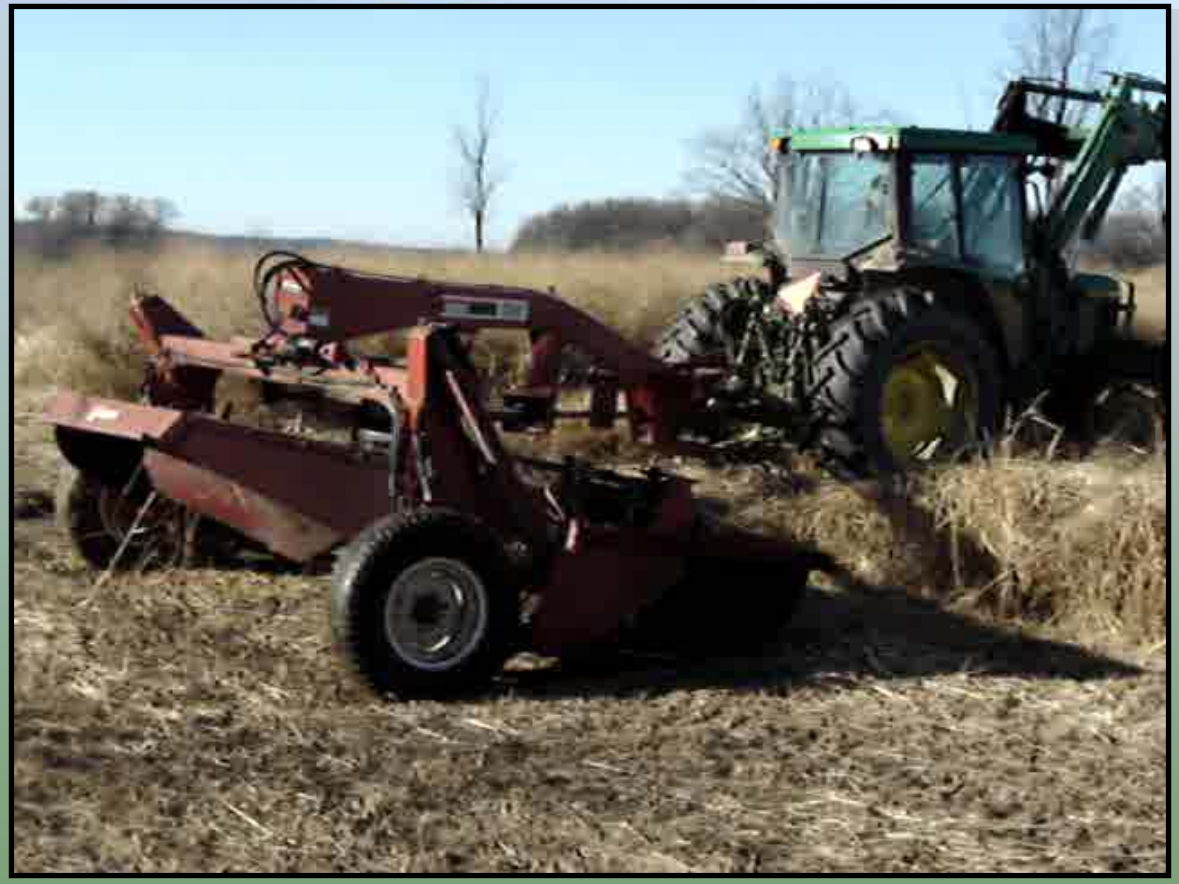
Fall Switchgrass Harvest



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FALL
WINTER
SPRING

Harvest Period and Biomass Composition Changes

Biological Component	Fall m.c. (%)	Composition	
		Fall 2006	Spring 2007
Head	4	12.5 %	5.2%
Leaf	15	25 %	13.2%
Sheath	13	14.8 %	17.9%
Stem	25	47.7 %	63.7%

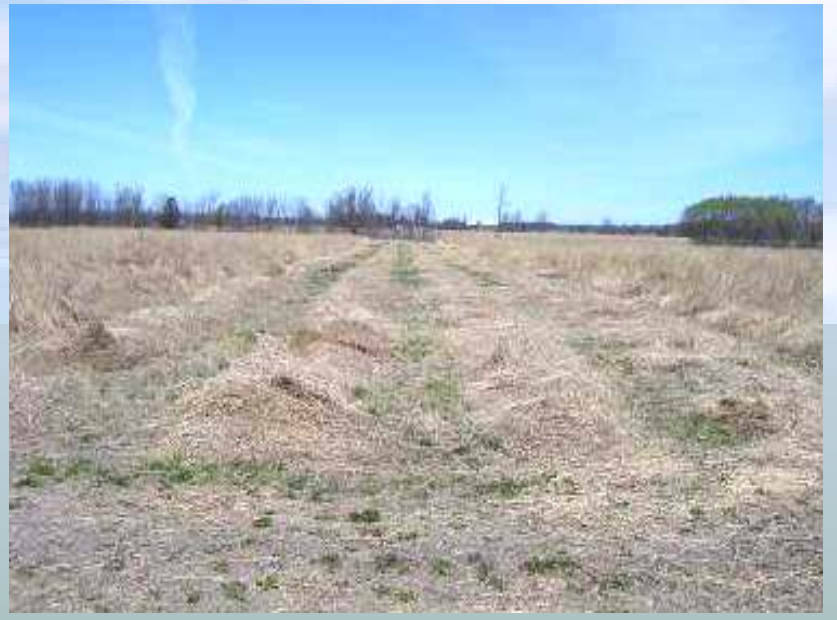
Whole plant moisture content was reduced to ~7% at baling in the spring

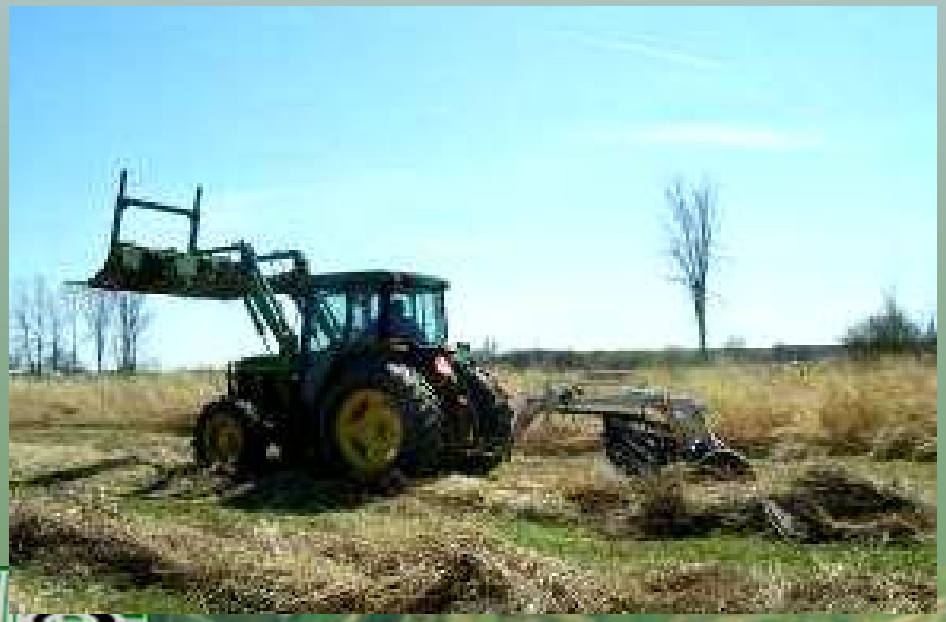
Where Are We Primarily Losing Biomass Through Overwintering?

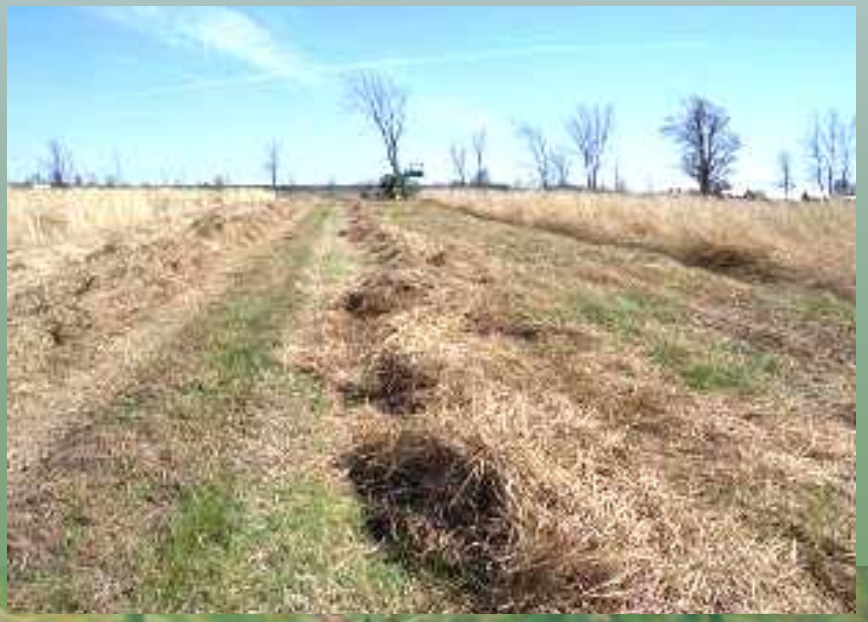
Botanical Component	Fall yield (kg/ha)	Spring yield (kg/ha)	Net loss (kg/ha)	Net loss (%)
Head	1,363	364	999	73%
Leaf	2,725	924	1,801	66%
Leaf sheath	1,613	1,253	360	22%
Stem	5,199	4,459	740	14%
Total	**10,900**	**7,000**	**3,900**	**36%**

1. Fall Mow, Spring Bale

Mowed section was too wide for baler pickup so raking was used







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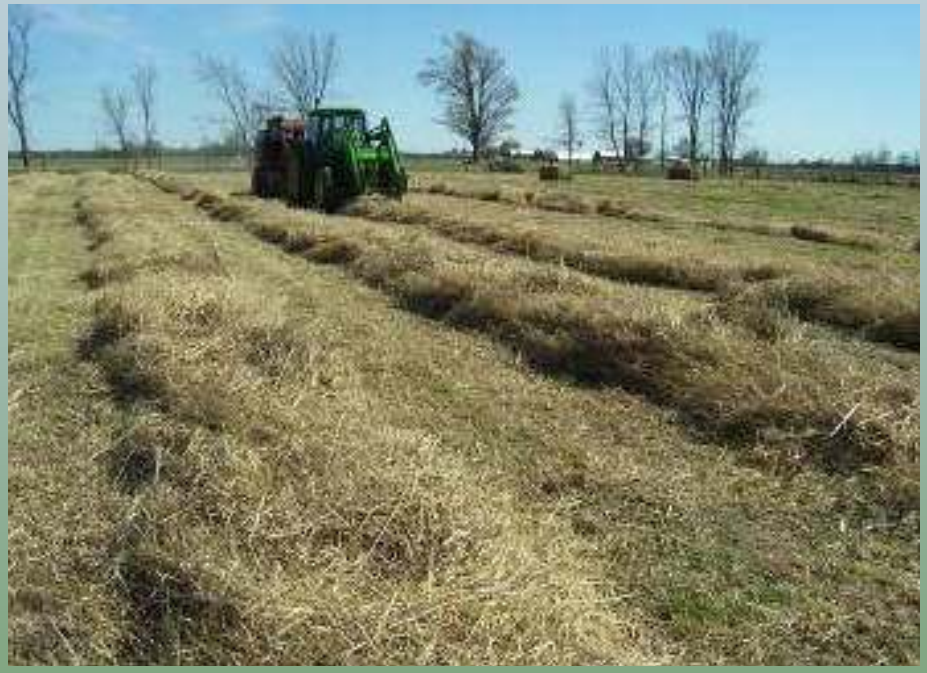
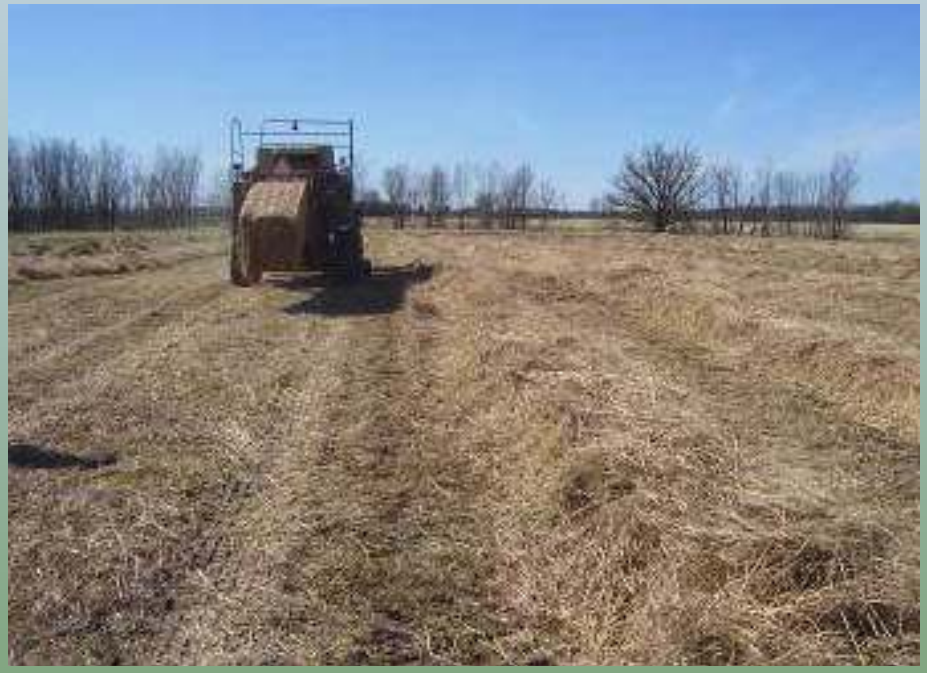
Fall Mowing: Biomass losses were mainly a result of raking losses in dead furrows and wheel tracks

2. Spring Mow & Bale

No raking was employed but shattering losses occurred during mowing which could not be harvested by baler





Machine Harvested Recovered Yields

Treatment	Yield (ODT/ha)	Moisture Content (%)	Bale Density (kg/m3)
Fall mow & spring bale	6.57*	6.0	116.8*
Spring mow & bale	5.44	7.8	109.3

*Significantly different ($p<0.05$)

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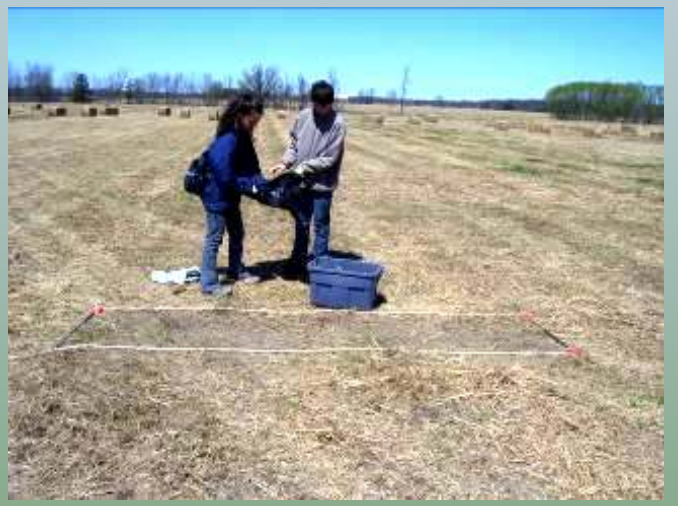
Field Operation Losses

1. Fall mow, Spring baled-total field loss **1688 kg/ha**
   - Mainly non-uniformly distributed long pieces of switchgrass (primarily raking misses-in dead furrows and tire tracks)



2. Spring mow and baled-total field loss **2072 kg/ha**
   - Uniformly distributed small pieces of switchgrass fibre covering the plot (shattering losses from mowing)

Biomass Quality

Parameter	Control (Fall 2006)	1. Fall mow & spring bale	2. Spring mow & bale
Energy (GJ/t)	18.6	18.7	18.8
Ash (%)	4.63	5.20	4.30
N (%)	0.47	0.39	0.38
P (%)	0.08	0.05	0.04
K (%)	0.33	0.11	0.10

No major quality differences between fall and spring mowing. Main quality change was ~70% reduction in potassium from fall 2006 composite which was 0.33%K

Ash and Energy Content of Overwintered Switchgrass

Plant Component	Ash Content	Energy Content (GJ/ODT)
Stems	1.03%	19.6
Seed Heads	2.38%	19.5
Leaf Sheaths	3.07%	18.7
Leaves	6.98%	18.4

*Overall weighted SG average ash content of 2.75% and 3.25% on sandy and clay sites respectively (Samson *et al*, 2005)

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Further Improvements in Biomass Quality

- Increase stem content through breeding or use high stem species like big bluestem
- Avoid clay soils which are high in silicic acid (and create high ash feedstocks)
- Fractionate grasses and use stems for residential pellet markets and higher ash plant components for commercial/industrial markets

Summary

New system of fall mowing and spring baling is highly promising

- 21% increase in yield: attributed to reduced winter breakage and shattering losses during machine operations
- Promotes earlier soil warming & increases harvest window for farm machinery and enables ideal harvest moisture
- Overall losses can be improved further through improving mowing technique (needs to be non-wavy and facilitate baling without raking)

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Summary (Continued)

- Biomass quality of overwintered switchgrass appears to be the best to date of all agri-fibre fuels we have examined
- There are no major agronomic or combustion constraints for developing switchgrass fuel pellets in Ontario
- Federal and Ontario government need to create incentives for farmers to develop this promising opportunity

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