



HARVESTING AND STORING BIOMASS CROPS IN ILLINOIS

8 February, 2010
2010 Alfalfa Workshop –
Positioning for Success

Dr. Kevin Shinnars
University of Wisconsin – Madison






Cellulosic Biomass Crops



Sorghum



Switchgrass



Stover



Miscanthus



Cellulosic Crops

	ton DM / ac / year
Corn stover	3 – 6
Corn cobs	0.5 – 0.8
Small grain straw	1 – 2
Forage sorghum	10 – 13
Miscanthus	4 – 13
Switchgrass	4 – 10
Alfalfa	3 – 8
Willow & poplar	4 – 11






Corn Stover Harvest

- Why consider corn stover :
 - ✓ Abundant – 53 million tons in IL
 - Every 40 bu ~ 1 ton DM stover
 - 2.6 billion gallons ethanol at 50% yield
 - ✓ Good roughage feed for ruminants
 - ✓ Reduces residue issues in spring




Conventional Harvesting

The diagram illustrates the seven-step process of conventional corn stover harvesting. Step 1 shows a tractor harvesting corn. Step 2 shows a tractor with a chopper chopping the stover. Step 3 shows a trailer being filled with chopped stover. Step 4 shows a tractor with a baler creating round bales. Step 5 shows a large stack of bales. Step 6 shows a tractor moving bales. Step 7 shows bales being stored in a shed.

Corn Stover Harvest

- Problems w/ conventional harvest :
 - ✓ Too many operations
 - ✓ High ash content: up to 12%
 - ✓ Low cob capture: < 50%
 - ✓ High storage losses: 10 – 20%

Single-pass Stover Harvest

The image shows a green combine harvester equipped with a stover processor attachment. The harvester is in a field, and the processor is actively chopping and blowing the stover into a red trailer attached to the back of the combine.

Single-pass Stover Harvest

<ul style="list-style-type: none"> • <u>Advantages Single Pass</u> <ul style="list-style-type: none"> ✓ Low ash: ~4% ✓ 100% cob yield ✓ Lowest cost system ✓ Pretreatment possible 	<ul style="list-style-type: none"> • <u>Disadvantages Single Pass</u> <ul style="list-style-type: none"> ✓ Slows grain harvest: 10 – 30% ✓ Managing logistics ✓ High stover moisture ✓ Low bulk density
--	---


Single-pass Stover Harvest



Darr et al., 2010


Single-pass Stover Harvest



Darr et al., 2010


Single-pass Stover Harvest

- Advantages Chopped System
 - ✓ Less handling
 - ✓ Size-reduced product
 - ✓ No bales to dodge
 - ✓ No baler to manage
- Advantages Bale System
 - ✓ Less harvest conflict
 - ✓ Higher-bulk density
 - ✓ Convenient shipping package

Both systems must deal storage issues when moisture content is above 25%.


Two-pass Stover Harvest




Two-pass Stover Harvest

- Advantages Two-pass
 - ✓ Decouples harvests!
 - ✓ Can field cure stover!
 - ✓ Grain harvest rate maintained
 - ✓ Custom harvesting possible
 - ✓ High cob yield: >94%
 - ✓ Can bale or chop
- Disadvantages Two-pass
 - ✓ Slightly higher ash: ~5%
 - ✓ Extra operations needed
 - ✓ Must harvest before snow


Two-pass Stover Harvest



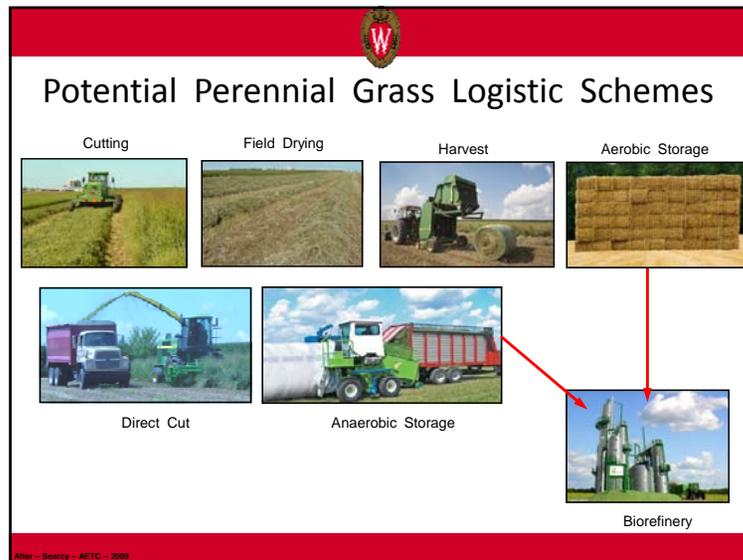
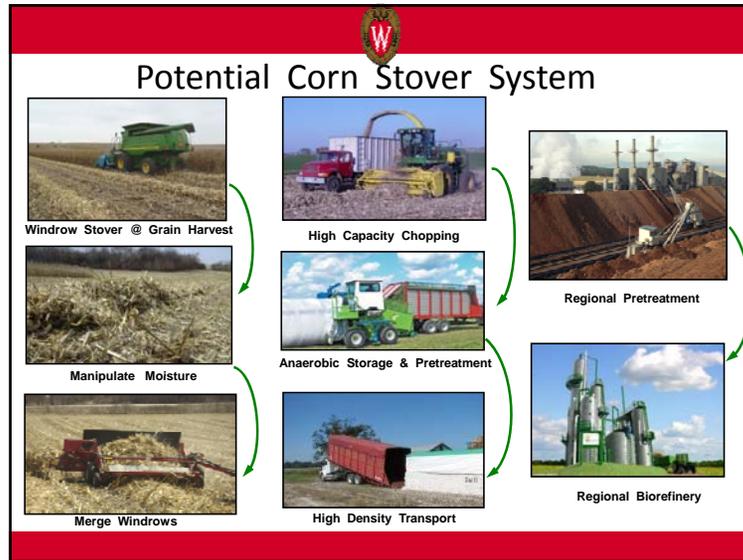

Two-pass Stover Harvest




Two-pass Stover Harvest



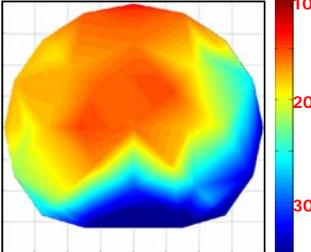
Ensiled Stover	
Average Moisture .. % w.b.	30 – 50
DM losses .. % of DM	2 – 5



Mier - Searcy - AETC - 2009

- ### Potential Perennial Grass Logistic Schemes
- Advantages Dry Bale System
 - ✓ Dense product
 - ✓ Not shipping water
 - ✓ Equipment legacy, shared w/ animal feeding enterprise
 - Disadvantages Dry Bale System
 - ✓ Too many operations
 - ✓ Product not size reduced
 - ✓ Not bulk product
 - ✓ Storing bales outdoors:
 - High losses
 - Non-uniform product

“Dry” Perennial Grass Bales

Perennial Grasses	
Average Moisture .. % w.b.	18 – 25
DM losses .. % of DM	8 – 15

Potential Perennial Grass Logistic Schemes

- Advantages Chopped System
 - ✓ Fewer operations
 - ✓ Bulk product
 - ✓ More uniform product
 - ✓ Pretreatment possible
- Disadvantages Chopped System
 - ✓ Shipping water
 - ✓ Lower bulk density
 - ✓ Fermentation products
 - ✓ Equipment not readily available

Ensiled Storage of Perennial Grasses



Perennial Grasses	
Initial Moisture .. % w.b.	30 – 50
DM losses .. % of DM	1 – 4

Miscanthus Harvest

- Harvest differences :
 - ✓ Almost always dry harvest
 - ✓ Mainly winter/spring harvest
 - ✓ Large brittle stem – higher energy & more losses
 - ✓ Mainly big bales


Miscanthus Harvest



Miscanthus Swathharvest

After Christensen 2010


Alfalfa As Biomass Feedstock

- Advantages Biomass Alfalfa
 - ✓ High yielding perennial
 - ✓ Fixes nitrogen
 - ✓ High-protein co-product
- Disadvantages Biomass Alfalfa
 - ✓ High protein content
 - ✓ Many harvests needed
 - ✓ Bred as animal feed


Alfalfa Harvest-fractionation

- Objective :
 - ✓ At harvest separate:
 - High-fiber stems – biomass feedstock
 - High-protein leaves – high value animal feed
 - Protein not wanted at biorefinery


Harvest-fractionation



Harvest-fractionation

	CP .. % of DM	NDF .. % of DM
Alfalfa		
Stripped	26.6	22.8
Cut	13.1	55.1




Field Cubing of Biomass





Biomass Co-Fire Issues

- Co-Fire Combustion Issues :
 - ✓ Size and mass density
 - ✓ Energy density
 - ✓ Moisture – reduces efficiency
 - ✓ Chemical composition – slagging




Stoker coal
12,000 BTU / lb.
40 – 60 lb./ft³

Stover cubes
7,500 BTU / lb.
30 – 35 lb./ft³

David Rusley – Cedar Fall Utilities

Co-Fire Combustion








David Rusley – Cedar Fall Utilities


Field Cubing Challenges

- Moisture Content – below 18%
- Natural binders – not much there
- Size – reduction – access natural binders
- Energy intensive
- Cooling and storing




Challenges for Illinois

- Equipment Legacy
 - ✓ Dealers and farmers not as well capitalized for producing, harvesting, storing and transporting biomass




Challenges for Illinois

- Fewer Forage Custom Harvesters
 - ✓ Already equipped
 - ✓ Looking for more work
 - ✓ Off-season harvests




Challenges for Illinois

- Nutrient Recycling
 - ✓ Limited number of livestock operations limit ability to recycle nutrients to biomass fields.





HARVESTING AND STORING BIOMASS CROPS IN ILLINOIS

8 February, 2010
2010 Alfalfa Workshop –
Positioning for Success

Dr. Kevin Shinnars
University of Wisconsin – Madison

