Farm Energy IQ

Farms Today Securing Our Energy Future

Bioenergy Feedstock Production for Agricultural Producers

Greg Roth, Penn State Department of Agronomy

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Objectives

- Review adaptation of crops and residues such as corn, corn cobs, oilseed crops such as canola and soybean, and biomass crops such as Miscanthus and shrub willow
- Review crop management and infrastructure requirements to produce feedstocks
- Estimate production costs of various feedstocks

Corn

- Most widely used feedstock for bioenergy
- Provides an experience base for other potential bioenergy commodities
- Main bioenergy is ethanol with distillers grains, corn oil, and CO_2 as co-products
- Key drivers in production have been RFS, exports, expanded co-product markets and reduced energy use

Production Costs

- For 2014, costs of production are estimated to be $4.67/bushel but could vary with yield.
- Ethanol returns can vary with prices
- Good long term returns for producers and processors are essential

	Price	Amount	Total
Corn Price	$5.00	160 bu/ac	$800
Variable costs			
Seed	$3.44 /1000	34,000	$117
Fertilizer	NPK +Lime		$134
Pesticides			$51
Other	Trucking, Ins., Interest, Drying		$126
Fixed Costs			
Land			$150
Labor			$45
Machinery			$124
Net			$53

Source: http://aede.osu.edu/research/osu-farm-management/enterprise-budgets

Corn Cobs

- Corn cobs are a potential additional product that can be harvested and used for bioenergy
- Historically used as heat source in Midwest and Europe
- Cob removal has little to no environmental impacts

Corn Cob—Management

- Corn cobs can be:
  - Shelled from ear corn
  - Cleaned from a corn cob mix harvested with the combine and then cleaned from the grain
  - Collected from the back of the combine, sometimes mixed with husk and stover

Corn Cob—Combine Separation

- One example is this H120 cob harvester from Redekop
- Tow-behind cleaner separates cobs and discharges into wagon
- Adjustable to include material other than cob

Photo credit: http://www.cobharvest.com/h120-cob-harvester/

Corn Cob—Harvest from Windrow

- POET developed a system (EZ bale) that consists of a headed that stomps and rolls the stalks and then discharges the cobs and upper stover into a windrow.
- In the second pass, cobs and stover from plant tops are collected with a baler set to minimize soil contamination

Photo credit: http://poet-dsm.com/biomass

Corn Cobs—Management

- Cobs collected with other materials coming out of the combine (material other than cob, or MOC)
- MOC increases the yield per acre and also captures some of the best fraction of the stover above the ear.

Corn Cobs—Production Cost

- While most production costs are covered by the corn production, harvesting results in additional costs
- This Purdue study indicated that cob harvesting cost approximately $54/ton
- Some farmers feel it can be done for less

	Price	Amount	Total
Cob Price	$100	1 ton/ac	$100
Variable costs			
Storing, Piling			$4.72
Fertilizer Replacement			$8.62
Other (Fuel, labor, lubrication, etc.			18.76
Total			32.10
Fixed Costs			
Machinery (Harvest wagon)			$22.34
Net Return			$46

Source: https://www.extension.purdue.edu/extmedia/ID/ID-417-W.pdf

Corn Cobs/Stover—Added Value Uses

- Corn cobs have alternative markets such as mushroom compost, animal bedding, and metal polishing compound
- Stover removal can reduce the need for "residue management" practices like stalk chopping or tillage and provide some value to cob harvest.

Soybean

Typical yield: 3,000 lb/acre (50 bu/acre)

Potential use: Biodiesel

Animal ag co-product: Soybean meal

Other potential products:

Straw (1,000 lb/acre)

Biodiesel yield/ac:74 gal/ac or 9.1 million Btu

Adaptability to no-tillage: High

Existing infrastructure: High

N fertilizer Inputs: 0 lb/acre

Other Comments: Widely grown for protein on livestock farms; oil used for food and biodiesel. Good rotational crop to break pest cycles and produce nitrogen for subsequent crops. Also, soybeans are drought tolerant and can be double cropped following barley or wheat. Soybean straw can be used as direct combustion feedstock.

Soybean—Production Costs

	Price	Amount	Total
Soybean Price	$14.00	55 bu/acre	$770
Variable costs			
Seed	0.41/ 1000	180000	$74
Fertilizer	NPK +Lime		$59
Pesticides			$32
Other	Trucking, Ins., Int., Drying		$63
Fixed Costs			
Land			$150
Labor			$30
Machinery			$108
Net			$254/acre

Canola/Rapeseed

Typical PA yield: 2500 lb/acre (50 bu/acre)

Potential use: Biodiesel

Animal ag co-product: Canola meal

Other potential products:

Straw (1000 lb/acre)

Biodiesel yield/ac: 143 gal or 17.5 million Btu

Adaptability to no-tillage: Medium

Existing infrastructure: Medium

N fertilizer inputs: 100 lb/acre

Other Comments: Limited production in PA but widely grown in Europe because of high oil yield per acre and low saturated fat in oil, which contributes to high quality for biodiesel. Canola meal is high protein feed comparable to soybean meal. Winter and spring varieties exist. Winter canola is more adapted to southern half of state. Higher N requirement than soybeans.

Canola—Production Costs

	Price	Amount	Total
Canola price	$0.20	2,000 lb	$400
Variable costs			
Seed			$27
Fertilizer	NPK + Lime		$58
Pesticides			$16
Other	Trucking, Ins., Int., Drying		$21
Fixed costs			
Land			$75
Labor			$15
Machinery			$102
Total costs			314
Net			$86/acre

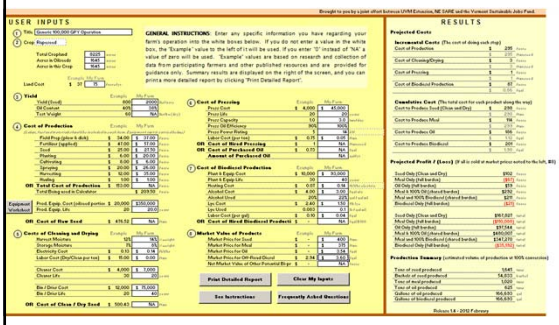
Photo credit: http://www.ksre.ksu.edu/bookstore/pubs/mf2421.pdf

Canola is managed like a small grain, but the straw has little value, reducing its potential to compete with wheat in some areas

Canola Pressing

Canola Meal

Oilseed Economics



Source: http://www.vsjf.org/resources/reports-tools/oilseed-calculator

Switchgrass

Typical PA yield: 8,000 lb/acre

Potential use:

Direct combustion (DC), cellulosic ethanol

Animal ag co-product: Aftermath grazing

Other potential products/benefits:

Wildlife habitat, bedding, absorbent

Energy yield/ac: 56.4 million Btu (DC)

Adaptability to no-tillage: High

Existing infrastructure: High

N fertilizer inputs: 0-100 lb/acre

Other Comments: Widely adaptable, especially on droughty soils. Provides excellent conservation and wildlife habitat. Can be slow to establish. Harvest schedule can impact wildlife benefits and ash content.

Switchgrass—Management

Month	Operation	Inputs
March	Harvest	Fertilizer, Diesel
April	Bale and Store	Diesel
May	Spread Fertilizer	Seed, Fertilizer, Diesel
May/ December	Haul to market	Diesel

Switchgrass—Production Costs

	Year 1	Years 4-15
Yield (tons/acre)	0	7
Price ($/ton)	$0	$385
Returns	$49	$450
Variable Costs		
Seed	$80	$0
Soil Fertility	$155	$136
Weed Control	$53	$0
Establishment and Maintenance	$140	$0
Harvesting	$0	$141
Total Costs	$567	$277
Net Return/Acre	($567)	$108
Annual Income over 15 yr		$46

Source: http://www.newbio.psu.edu/Extension/resources.asp

Switchgrass—Biomass Issues

- Low impact production system
- Cost of production: $60-80/ton and need for densification
- Competition with wood chips in Northeast
- Some alternative uses can provide alternative markets: absorbents, animal bedding, mulch, wildlife cover, conservation program crop and hunting preserve use are some examples
- Can production costs be offset with other benefits (conservation, wildlife, hunting, recreation, off season land management, subsidies)?

Miscanthus—Adaptation

- Widely adapted warm season perennial grass, native to eastern Asia. Grown in Europe and the Southern, Eastern and Midwestern U.S.
- Although a warm season species, it can grow early in the spring even at relatively low temperatures (43°F). Growth stops with autumn frost.
- Once established, yields up to 10 tons/acre may be possible

Miscanthus—Management

Establishment Year

Month	Operation	Inputs
April	Mow	Diesel
April	Plow site	Diesel
April	Fertilize	Fertilizer Diesel
May	Plant Rhizomes	Diesel
May	Apply Herbicide	

Current industry practice is to plant the rhizomes four inches deep and three feet apart within rows. Maintain three feet between rows. Some replanting to fill gaps may be necessary in the second year.

Source: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1045274.pdf

Miscanthus—Management

Post Establishment Years

Month	Operation	Inputs
April	Spread Fertilizer	Seed, Fertilizer, Diesel
March	Harvest	Fertilizer, Diesel
April	Bale and Store	Diesel
May/December	Haul to market	Diesel

Miscanthus—Production Cost

	Year 1	Years 4-15
Yield (tons/acre)	0	10
Price ($/ton)	$0	$45
Returns	$0	$450
Variable Costs		
Rhizomes	$700	$0
Soil Fertility	$155	$134
Weed Control	$48	$237
Establishment and Maint.	$115	$155
Harvesting	$0	$75
Total Costs	$1018	$312
Net Return/acre	($1018)	$80
Annual income over 15 yrs		$94

Photo credit: http://www.newbio.psu.edu/Extension/resources.asp

Miscanthus Biomass Issues

- Low impact production system- Nutrient removal for N-P2O5-K20 is approximately 7.5-1.5-5.5 lbs per ton
- Cost of production: $30-35/ton and need for densification
- Need for buffer surrounding field to monitor and prevent spreading

Willow—Adaptation

- Willows can grow well on marginal soils
- Soils should be 18 in. deep and not droughty or excessively wet
- Slopes should be less than 8% to facilitate harvest under winter conditions

Photo credit: http://willow.cals.cornell.edu

Willow—Management

Year	Operation	Inputs
1	Prepare field Fertilize, Plant Weed Control	Cuttings, Fertilizer, Diesel
2	Coppice first year plants to shrub	Diesel
5	Harvest	Diesel
9	Harvest	Diesel
13	Harvest	Diesel
17	Harvest	Diesel
21	Harvest	Diesel

Photo credit: http://willow.cals.cornell.edu

Willow—Production Costs

	Year 1	Years 4-21
Yield (tons/acre/3 years)	0	12
Price ($/ton)	$0	$45
Returns /Harvest (Harvest: yrs 4,7,10,13,16,19,22)	$0	$3780
Variable Costs		
Site Prep	$193	$0
Planting	$640	$0
Weed Control	$186	$0
Other Establishment	$115	$0
Harvesting	$0	$2520
Total Costs	$1019	$2520
Net Return/acre every 3d yr	($1019)	$267
Annual income over 21 yrs		-$16

Willow—Biomass Issues

- Low impact production system
- Cost of production: $31/ton with 20 year investment
- Competition with wood chips in Northeast
- Some alternative uses
- Harvest costs can be reduced relative to crops with annual harvests

Summary

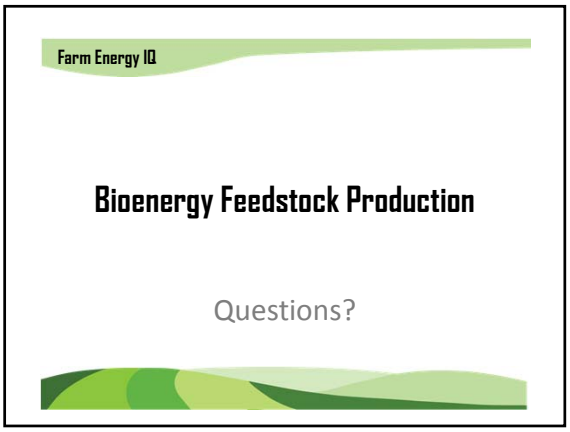
- Various options exist for growing bioenergy crops in our region
- Markets vary for these crops—be sure you have a market before investing
- Some crops have alterative uses that can add to profitability
- Co-product values are also important for some crops such as corn and soybeans

Summary

- Based on corn ethanol experience, having a value chain that provides returns to farmer, landowner, industry, and processor is critical
- The ideal bioenergy crop has multiple uses, prices above production costs, stable long term demand, minimal environmental impact, and low carbon footprint

Summary

- There is potential to grow bioenergy feedstocks in our region
- Markets are limited for a few options, but are developing, along with alternative markets
- Developing higher yielding and lower cost production, use of marginal soil resources and higher prices could lead to more production potential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Questions?