GROWTH OF BIOFUEL CROPS ON RECLAIMED MINED LAND IN VEST VIRGINIA

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Reasons for turning to Biofuel:

High Energy Prices

Increasing Energy Imports

Concerns About Petroleum Supplies

Greater Recognition of Environmental Consequences





Bioenergy

Carbon sources derived from photosynthesis

Less green house gas emissions

Less dependence on foreign sources for energy

Supports rural economies

Currently mandated by congress

Renewable Fuel Standard (RFS 1 & 2)

2005 – Energy Policy Act

Transportation fuel sold in the US contains a minimum volume of renewable fuel....
RFS 1 - 7.5 billion gal by 2012

2007 – Energy Independence and Security Act

RFS 2 - 9 billion gal in 2008 to 36 billion gal by 2022

Americans use about 140 billion gallons of gasoline per year



Marcellus Shale Gas Wells



ECA

Biomass Feedstocks

Starch & Sugar based Feedstocks

- Corn
- Wheat
- Sugarcane



Cellulosic Feedstocks

Ag Plant Wastes:

- Corn Stover
- Cereal Straws
- Forest Residues
- Plant Wastes from Industrial Processes
- Sawdust
- Paper Pulp
- **Energy Crops**
- Switchgrass
- Miscanthus, Arundo

Food vs. Fuel

U.S. Total Corn Production and Corn for Ethanol Department of Energy



World pop. > 7 billion Malnutrition: approx. 800 million

SOLUTION = Cellulosic Feedstocks



Food vs. Fuel Debate

Solutions:

1) Grow Cellulosic Crops

2) Use marginal lands

instead of Food Crops

instead of farmland.

LET GO OF

MY FUEL !!!

Torike -----

And included parts cot.

Plants to Fuel

- The Basic Steps...
- 1. Convert feedstocks to simple sugars

2. Fermentation (???)

3. Recovery of Ethanol



West Virginia's traditional energy production... COAL



Mining creates large expanses of reclaimed land.

54,000 acres of land reclaimed in Appalachia in 2010 75% is reclaimed to pasture/hayland

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...much is underutilized and unmanaged



Why not reclaim land for biofuel production?

Large uninterrupted tracts
Good road networks
Access to transportation hubs
Land not previously in ag production

Switchgrass: a viable biofuel?



SWITCHGRASS

Panicum virgatum L.

- Warm season, perennial, bunch grass
- Native to North America
- Well adapted to a variety of sites:
 - pH 4.9 to 7.5
 - soils ranging from sand to loam
 - <u>little to no fertilization or mgt</u>
 - extensive root system
 - two ecotype

Switchgrass versus corn for ethanol production:

Perennial crop
 Conservation benefits
 Reduced erosion
 Improved water quality
 Wildlife habitat

Requires fewer inputs

- Reduces impact on food and feed prices
 Can be grown on marginal acres
- Uses conventional hay equipment
- Lower green house emissions
- Sequesters atmospheric carbon

Example of "Ideal" biofuel crop



Switchgrass versus corn for ethanol production:

Disadvantages:
Slow and difficult to establish
Currently no viable market for switchgrass as a biofuel
Bulky and difficult to transport
More costly to convert to ethanol?

Pelletizing switchgrass

 Reduces shipping costs

 Prepares crop for utilization as a feed stock



Other uses for switchgrass:

Can be so-fired in coal plants

Create synthesis gas through pyrolysis

Burned outright for heat generation

Carbon sequestration credits



Switchgrass Yields

Study	DM Yield (Mt ha ⁻¹)	Description
Fike et al., 2006a	14.1	4 cultivars, 8 sites, 5 states (including WV)
Vogel & Masters (1998)	14.9	3 states in Midwestern US
Fike et al., 2006b	14.2	Years 6 - 9 of production
USDOE (McLauglin & Kszoz 2005)	11 – 19	Cave-in-Rock; 10-year study in 13 states
Schmer et al., 2008	5.2 – 11.1	Marginal cropland
Mulkey et al., 2006	< 7.5	CRP land in South Dakota

Goal would be 5.0 Mt ha⁻¹

What we know....

- Need cellulosic feedstocks (FOOD VS FUEL)
- Switchgrass can produce good yields on agricultural land and even on <u>marginal</u> croplands
- Ethanol production and fermentation process from switchgrass is ongoing and under research

Could switchgrass grow on land even poorer quality than marginal cropland? ... like reclaimed mine lands...

1984 Reclaimed land TX - Alamo

2000 – WV Highways

2008 – Marginal Agric Lands



Objective To grow switchgrass on mined lands and measure soil-properties and yield

Hampshire

Two sites for years 2 to 6 (2008-2013) Planted in 2008.

Hobet

Keep track of where these sites are!

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Experimental design

Three upland varieties of switchgrass

-Carthage

- Cave-in-Rock

- - Shawnee

Three, 1-ac replications of each variety

at each site (Hobet and Hampshire)







•

10 lbs PLS ac⁻¹

Seed was carefully measured for each plot

Mister

WEST TRGI

¹⁹¹⁸¹⁷ 16 15 14 13¹²

Hand seeding at Hobet



Methods - Soil Sampling

Collected top 15 cm
% Fines

pH

• EC

Mehlich I for:
 P, K, Ca, Mg, Mn,
 Fe, Al, Ni, Cu, Zn



Soil Chemical and Physical Properties

<u>Hobet</u>

55% Fines

pH = 8.0
EC = 109 μs/cm
P = 50 mg kg⁻¹ soil
Ca = 2.0 cmol_c kg⁻¹

Hampshire - 74% Fines - pH = 7.4 - EC = 421 μs/cm - P = 8.0 mg kg⁻¹ soil - Ca = 50 cmol _ kg⁻¹

Results - Yield Hobet (Poor site) 3rd Yr Meha **Ucultivars**



Results - Yield 6th Yr Hampshire Hobet Variety Mt ha⁻¹

Cave in Rock Carthage Shawnee

 19.0
 1.8

 5.7
 1.5

 10.0
 1.5
Hampshire Oct 2012 - 5th Year About 9 Mt ha⁻¹

10/05/2012

Hampshire Oct 2013 - 6th Year About 12 Mt ha¹

Hobet Aug 2011 - 4th Yr About 1.0 Mt ha⁻¹





Research Questions

Can switchgrass be grown on reclaimed surface mines?

Produce yields similar to agricultural soils?

Where do our numbers stand?

Agricultural Land:13 - 16 Mt ha⁻¹Cave-in-Rock at Hampshire:12.0 Mt ha⁻¹Shawnee at Hobet:1.9 Mt ha⁻¹

Goal of 5.0 Mt ha⁻¹

What about other crops

Miscanthus

Illinois Photo credit John Caveny





Objective: Switchgrass, Miscanthus, Arundo growth on mined lands and determine yield

- 1. Two switchgrass varieties (Kanlow, BoMaster) Two miscanthus varieties (public vs private) **Arundo rhizomes (Illinois)** 2.5 reps Alton
- **3. Planted in 2010.**

Keep track of where these sites are!





Each 0.4 ha or 1 acre

5 plots Kanlow
5 plots BoMaster
5 plots Miscanthus –private
5 plots Miscanthus – public
3 plots Arundo





9006 Mercer Pike, Meadville, PA 16335-9299 (800) 873-3321 or (814) 336-2404

Ernst Conservation Seeds

Switchgrass

Switchgrass, 'Kanlow' Panicum virgatum, 'Kanlow'

N	et	W	eig	,ht:	47.	995	16
							10

Lot Number: FFC6098

Date Tested:February 2010ProductionKSGenetic Origin:KS

Pure Seea:
Other Crop:
Inert Matter:
Weed Seed:
Germination:

93.40% 0.02% 6.57% 0.01% 77.00%

Hard Seed: Dormant: 0.00%

This seed has been treated with GAUCHO XT FUNGICIDE/INSECTICIDE. Do not use for feed, food, or oil purposes. Store away from feeds and foodstuffs. Exposed treated seed may be hazardous to birds. Dispose of all excess seed and packaging to burial away from bodies of water. Cover or incorporate spilled treated seeds.

Switchgrass drilled into killed sod





Miscanthus planting trial at Alton, WV

STAGO

EETLIN



We had tree planters do the sprig planting

INEPLANT

LIVE PLAN



Two months later

29/201







Alton Soils

70% Fines $p_{H} = 7.5$ BARASS STORES $EC = 368 \,\mu s/cm$ P = 40 mg kg⁻¹ soil K = 0.2 cmol, kg⁻¹ $Ca = 3.2 \text{ cmol}_{kg^{-1}}$



Plant Species	2 nd Yr	3 rd Yr	4 th Yr
		Mt ha ⁻¹	
<u>Switchgrass</u>			
Kanlow	4.0 (2.6)	4.9 (1.1)	4.9 (3.5)
BoMaster	2.7 (1.5)	4.0 (3.1)	5.4 (9.8)

Goal of 5.0 Mt ha⁻¹

Kanlow Switchgrass - 3rd Yr

Alton

Looks like about 4-5 Mt ha⁻¹

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Switchgrass – 2012 – 3rd Yr Alton



Switchgrass – 2013 - 4th Yr Alton – about 5 Mt ha⁻¹

Plant Species	2 nd Yr	3 rd Yr	4 th Yr
	Mt ha ⁻¹		
<u>Miscanthus</u>			
Public	2.2 (2.0)	4.9 (3.0)	7.0 (6.6)
Private	6.5 (5.8)	15.5 (10.4)	11.1 (6.8)
Arundo	NA	0.5 (0.18)	0.8 (1.2)

Wide Variation in Yields across plots!

Miscanthus 2011 - 2nd Yr Alton

7 MIt ha⁻¹

Reclaimed site for 20 years, so some soil material.

11/02/2011

Miscanthus – 2012 - 3rd Yr Alton – about 9 Mt ha⁻¹

10/25/2012

Miscanthus – 2013 – 4th Yr Alton – about 11 Mt ha⁻¹

Miscanthus – 2012 - 3rd Yr

Alton

10//25//2012

Plant Species	2 nd Yr	3 rd Yr	4 th Yr
	Mt ha ⁻¹		
<u>Arundo</u>	NA	<0.5 (0.1)	0.8 (1.2)

Wide Variation in Yields across plots!

Arundo (Giant Cane) – 2012 – 2nd Yr Alton



Arundo (Giant Cane) – 2013 – 3rd Yr

Alton



Plant Species	2 nd Yr	3 rd Yr
	Mt	ha ⁻¹
Coal Mac		
<u>Arundo</u>	2.9 (1.6)	12.5 (8.5)

Wide Variation in Yields

Arundo after three months – 1st Yr Coal Mac


Arthrelo – 2012 – 2nd Yr Coal Mac 3.0 Mt ha⁻¹

10/11/2012

The Wilds, OH

Objective: Switchgrass and Miscanthus

Two sites (The Wilds and MWV)
Cave-In-Rock switchgrass
Miscanthus

MeadWestvaco

Keep track of where these sites are!



gaology.com



Planting at MWV





Miscanthus rhizomes Planted

Planting at The Wilds

12201

Switchgrass establishment at MWV



Switchgrass establishment at The Wilds

the as proved and

08/13/2013



Low Yield at the end of one growing season

Conclusions

After the 3rd year on reclaimed land

Switchgrass: 3.0 to 5.0 Mt ha⁻¹ Miscanting: 5.0 to 15 Michael Arundo: < 1.0 Mt ha⁻¹

09/10/2012

Sustainable Energy Parks! Potential Uses of Reclaimed Land

Coal Mined Biomass Planted Forest and Grass Co-fired

Coal – Biomass Fired and Wind

Much Work To Do!

"The fuel of the future is going to come from fruit like that sumac on the road, or from apples, weeds, sawdust – almost anything. There is fuel in every bit of vegetable matter that can be fermented."

Henry Ford, 1925

Questions?