Sorghum: An established crop for sustainable, global production

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- Focused on sorghum
- Market-leading hybrid seed
- Grain, forage and sweet



Tremendous Investment in Sorghum R&D

- Largest sorghum breeding program in U.S.
- Testing and launching new hybrids faster than the industry norm
- New products out performing industry leaders

Pipeline initiated in 2009. Expect many new products in the next 2-3 years.



Molecular Breeding and Genetics

- First tenants in the new Texas Tech Business Park
 - Scientists working on molecular breeding/marker assisted breeding, plant transformations and ARPA-E project.
 - Focus is on sorghum traits that:
 - Enhance Yield

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- Protection against biotic and abiotic factors that reduce yield
- Improving quality
 - Digestibility of grain, forage and biomass
- Farnesene-producing sweet sorghum



Water uses:

Agriculture 70%

Energy + Industrial 19%

Municipal 11%

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Water Consumption in Agriculture (acre feet) <u>2010</u> 2050 2.2 B 2.4 B

Climate models predict severe droughts

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2030-2039



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Water is a limiting resource globally



Water export via agriculture



International Opportunities for Sorghum

Per capita water availability



Sorghum Drought Mechanisms

Drought Tolerance

50% more stomata per in² of leaf than corn

Stomata are smaller

Smaller leaf:root ratio than other crops

Extensive root system

Stay-Green Traits

Perfect flowers*

Drought Avoidance

Heavy wax layer (bloom) on leaves/stems

Slow/hasten maturity under stress

Motor cells at leaf midrib to facilitate leaf curling under stress





Sugars and Feedstocks from Sorghum

- Grain Sorghum
 - Starch from grain
 - Lignocellulose from crop residue
- Dedicated Energy Sorghum
 - Lignocellulosic from biomass
 - Free sugars in some hybrids
- Sweet Sorghum
 - Free sugars in juice
 - Lignocellulosic from bagasse



Tipping Points for Yield and Economics



- Where is the yield tipping point?
- How do economics affect the tipping point?
- World vs U.S. cropping systems

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- How are we going to feed the world in the face of declining water supplies?
- Chromatin is using this approach to target markets and product development

NC Kansas Rainfed		
Category	Corn	Sorghum
Yield (bu/acre)	130	120
Price per bu	3.83	4.58
Total Revenue	497.90	549.60
Seed	93.60	18.90
Pesticides	50.01	49.30
Fertilizer	119.67	104.03
Machinery & Other	278.94	268.47
Total	542.22	440.69
Return over Costs	(44.32)	108.90

Corn yield to equal sorghum returns = 170 bu/acre

Sorghum Mitigates Grower Risk on Marginal Land



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US water limitations are driving a shift to sorghum



Sorghum's Economic Advantages

Sorghum provides an economic advantage for growers at corn yields less than 140 - 100 bushels / acre.

US Sorghum acres have increased by 40% over the past 2 years



Feedstock Supply Challenges: Role of Growers



- For energy crops or crop residue, growers are the key decision makers
- Typically have an opportunity once per year to make a crop plan
 - Key factors:
 - Feasibility (Land / Water / Climate)
 - Market demand
 - Costs of production
 - Risk



Chromatin's Sorghum Ethanol Programs

- In 2012, EPA determined grain sorghum ethanol can be "Advanced Biofuel"
 - Less water use and lower inputs = more favorable greenhouse gas profile than corn
- Improved economics for ethanol plants
- Yield and quality similar / more favorable than corn
 - 2.8 gallons of ethanol per bushel
 - Higher protein DDGs
 - 4% oil

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Higher sugar content in stover







New products: Increased biomass digestibility



Biogas production	(NL CH4 / kg Tot. Solids)	% Increase
Manure	134	
Manure + Sorghum biomass	175	30%
Chromatin Hybrid 1	194	45%
Chromatin Hybrid 2	210	57%



Sorghum & Renewable Energy

- Source of sugar, starch, cellulose for fuel, chemicals, power
- Grain ethanol qualified as Advanced Biofuel
- 4 month growing cycle
- Farmer adoption
 - Infrastructure present
 - Annual crop
 - Market flexibility
- At commercial scale today
- Chromatin is READY!

