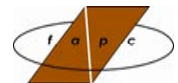




“Never doubt that a small group of thoughtful committed citizens can change the world. Indeed, it is the only thing that ever has.”

Margaret Mead





Sweet Sorghum Has Great Potential as an Energy Crop

- ◆ Can be grown in temperate climates
- ◆ Relatively low input requirements
- ◆ Very positive energy balance
- ◆ 12-21% directly fermentable sugar
(i.e. no starch to convert)





Small-Scale Conversion of Ethanol from Sweet Sorghum

Dani Bellmer¹, Ray Huhnke²

¹Assoc. Professor, Biosystems Engineering & Food and Agricultural Products Center

²Professor, Biosystems Engineering

Oklahoma State University





Sweet Sorghum Processing Options: Scale Matters

**Scenario #1: 10,000 contiguous acres in a
tropical climate**



Scenario #2: 1000 acres in a temperate climate

- **Smaller Scale Production**
- **Short Harvest Window**

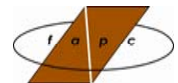




Our Hypothesis

There are clear benefits to economies of scale....

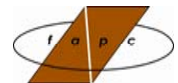
BUT for biomass processing these may not be sufficient to overcome the increased transportation costs associated with larger plant sizes





Potential Benefits of In-Field Production of Ethanol

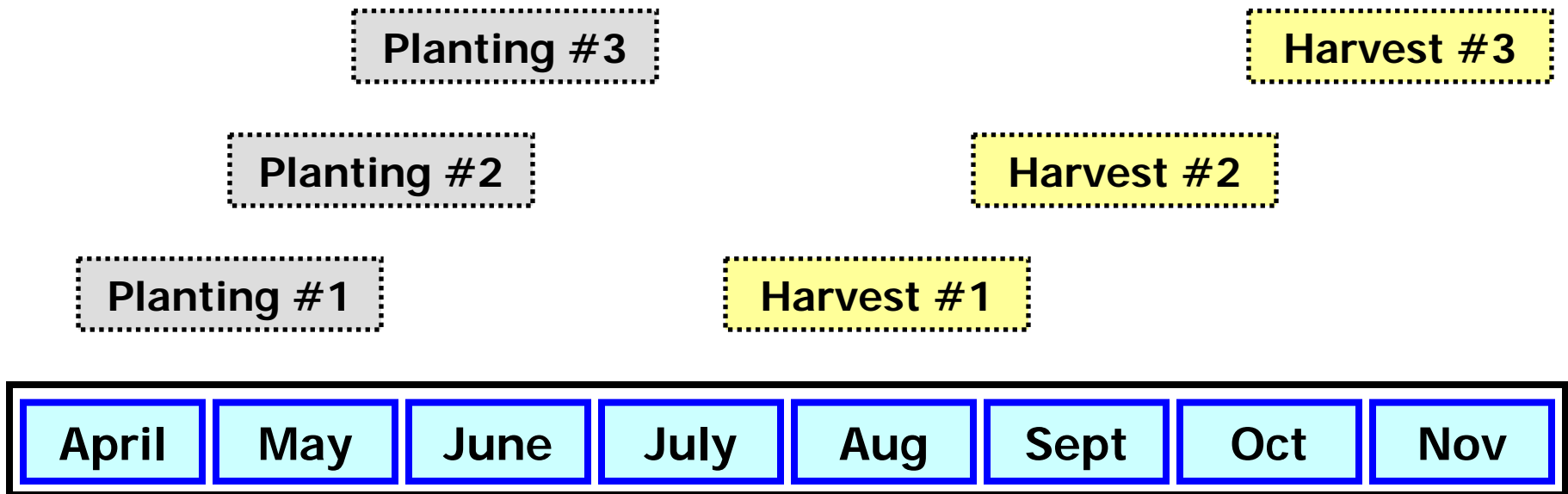
- **Lower capital costs**
- **Lower transportation costs**
- **Direct use of byproducts (bagasse and vinasse)**
- **Stimulate rural economies**





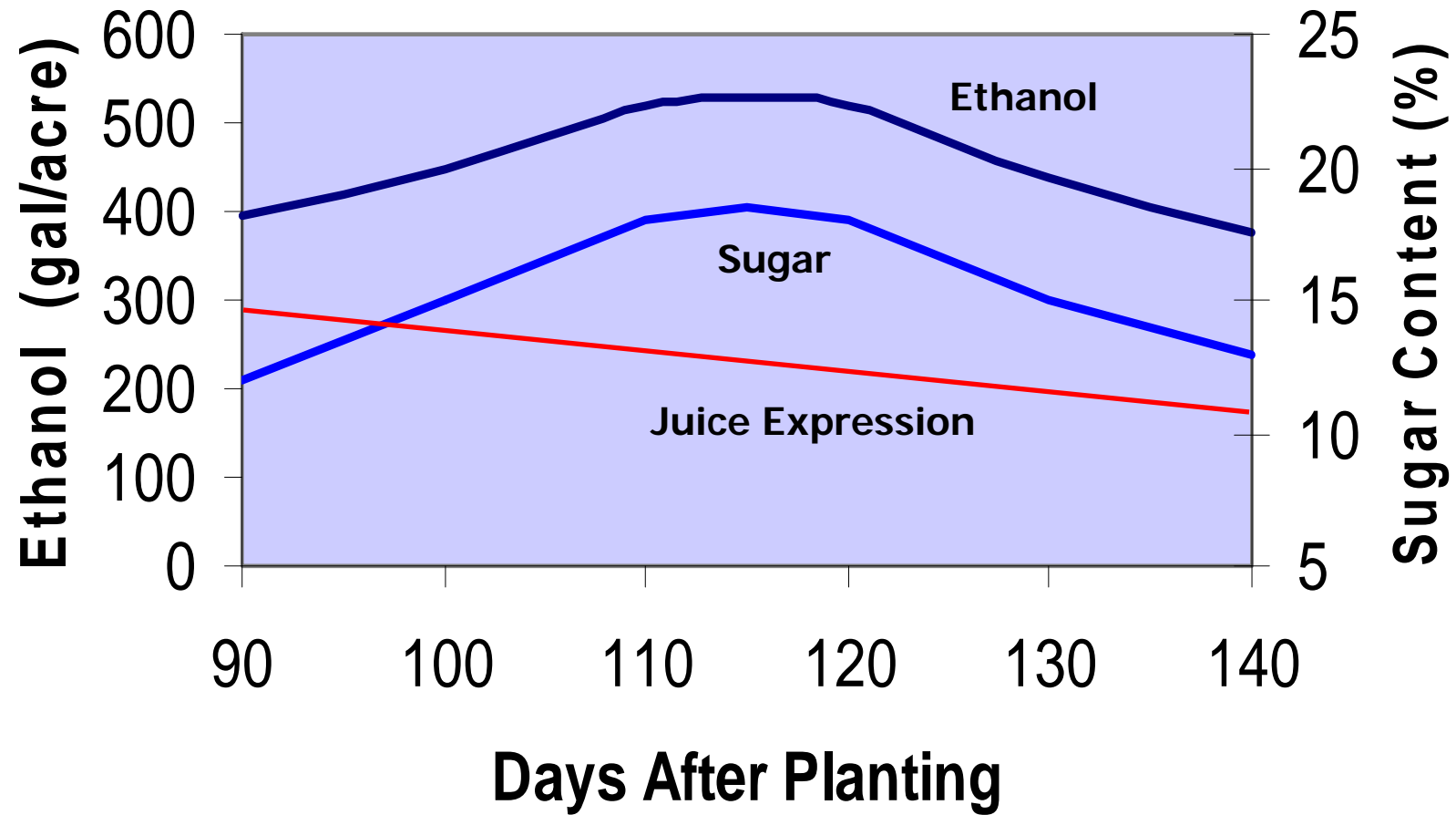
A Possible Scenario in Oklahoma

Staggered Plantings to Maximize Harvest Window





Extended Harvest Scenario





Major Factors Affecting Ethanol Yield

- ◆ Biomass Yield
- ◆ Sugar Content
- ◆ Juice Expression Efficiency
- ◆ Fermentation Efficiency

Potential Ethanol Yield (gallons/acre)

Biomass Yield	Sorghum Juice Sugar Content		
	15%	17%	19%
25 tons/acre	288	326	372
35 tons/acre	404	457	511
45 tons/acre	518	586	656

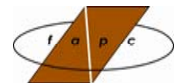
* Assumes 0.55 juice expression ratio and 90% conversion efficiency





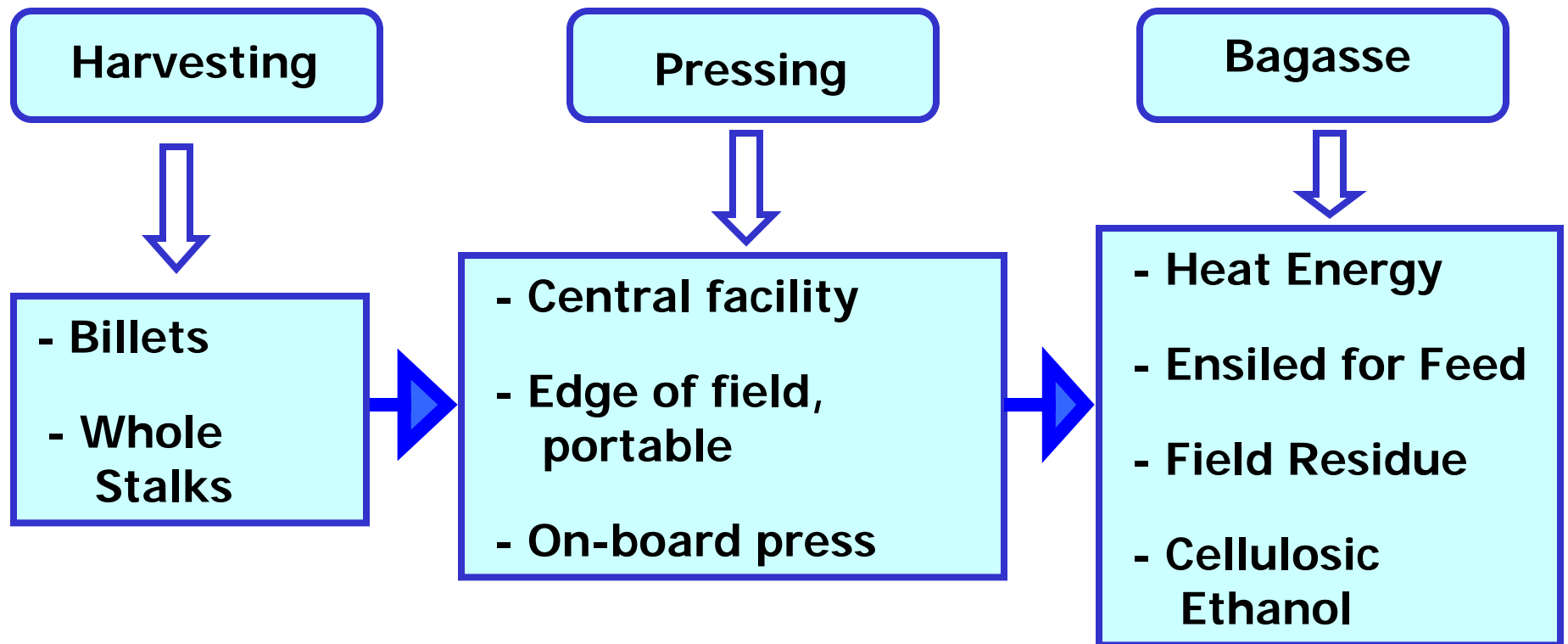
Critical Issues

- ◆ **Develop optimum harvest equipment**
- ◆ **Evaluate efficiency of large scale in-field fermentation**
- ◆ **Evaluate uses of bagasse**
- ◆ **Develop cost effective on-site distillation/dewatering systems**





Processing Options for "Short Harvest Window" Regions



Harvest Equipment Development

- ◆ Harvest equipment is directly tied to process scale
- ◆ Pressing efficiency must be optimized
- ◆ Bagasse utilization may be a design factor







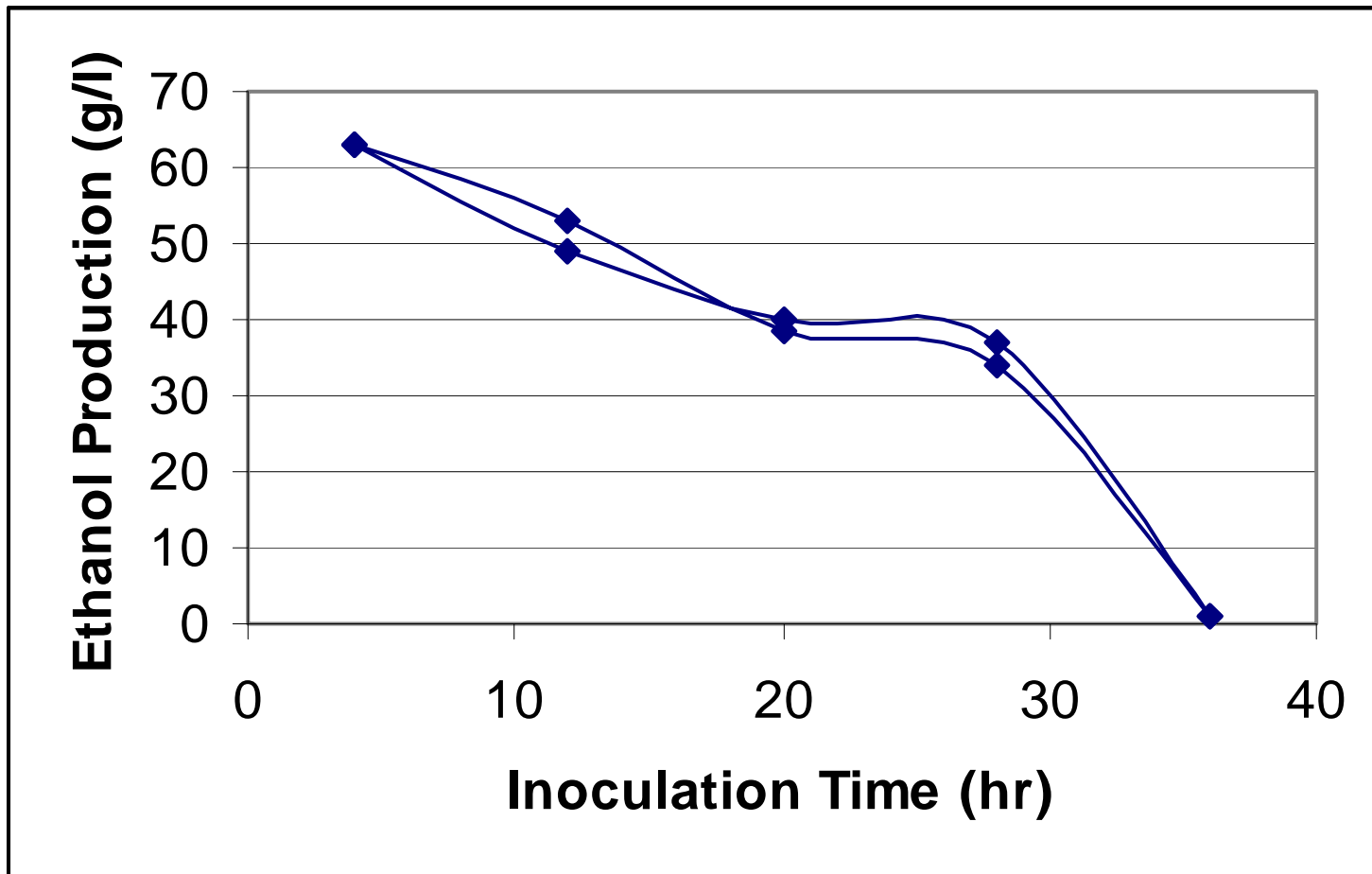
In-Field Fermentation

What we've learned

- ◆ In-field fermentation is possible, with no added nutrients and no temperature control
- ◆ Fermented ethanol product is stable for long-term storage
- ◆ Delayed inoculation results in significant losses



Effect of Delayed Inoculation

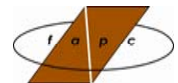




In-Field Fermentation Issues

Large scale in-field fermentation must be conducted to evaluate:

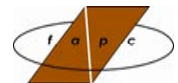
- **Conversion efficiency at large scale**
- **Mixing requirements**
- **Sterilization/Cleaning requirements between batches**





Evaluate Uses of Bagasse

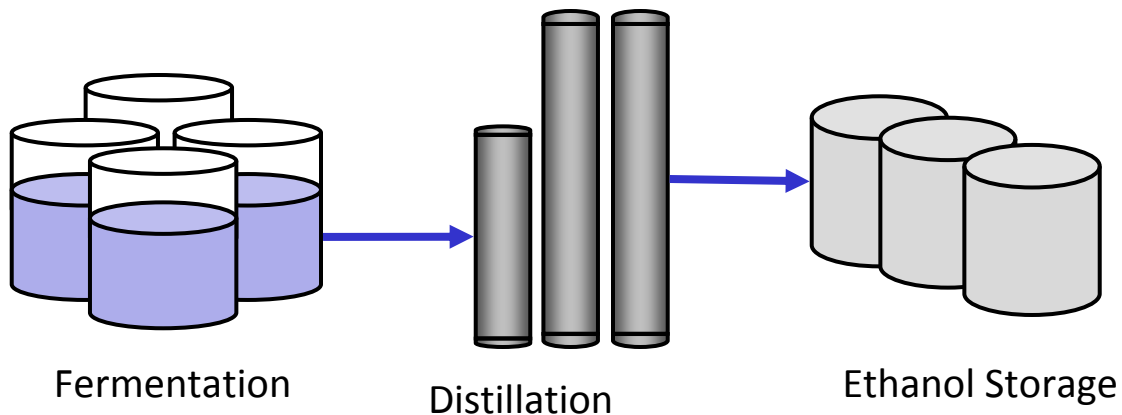
- ◆ **Energy content**
- ◆ **Animal feed value**
- ◆ **Value as a soil amendment**
- ◆ **Ease of hydrolysis for cellulosic ethanol**





On-Site Dewatering System

- ◆ Most capital-intensive part of the system
- ◆ Must determine optimum distillation/dewatering technology for smaller scale
- ◆ Economic evaluation of on-site vs. central facility





Critical Issues

- ◆ **Develop optimum harvest equipment**
- ◆ **Evaluate efficiency of large scale in-field fermentation**
- ◆ **Evaluate uses of bagasse**
- ◆ **Develop cost effective on-site distillation/dewatering systems**



The Future is Sweet...





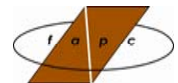
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Small Scale Roller Press

