Background

- Energy Sorghum Development
  - high biomass yield
    - Structural carbohydrates
    - Non-structural carbohydrates
  - drought tolerance
  - established production systems
  - annual life cycle
  - genetic resources and potential for further improvement

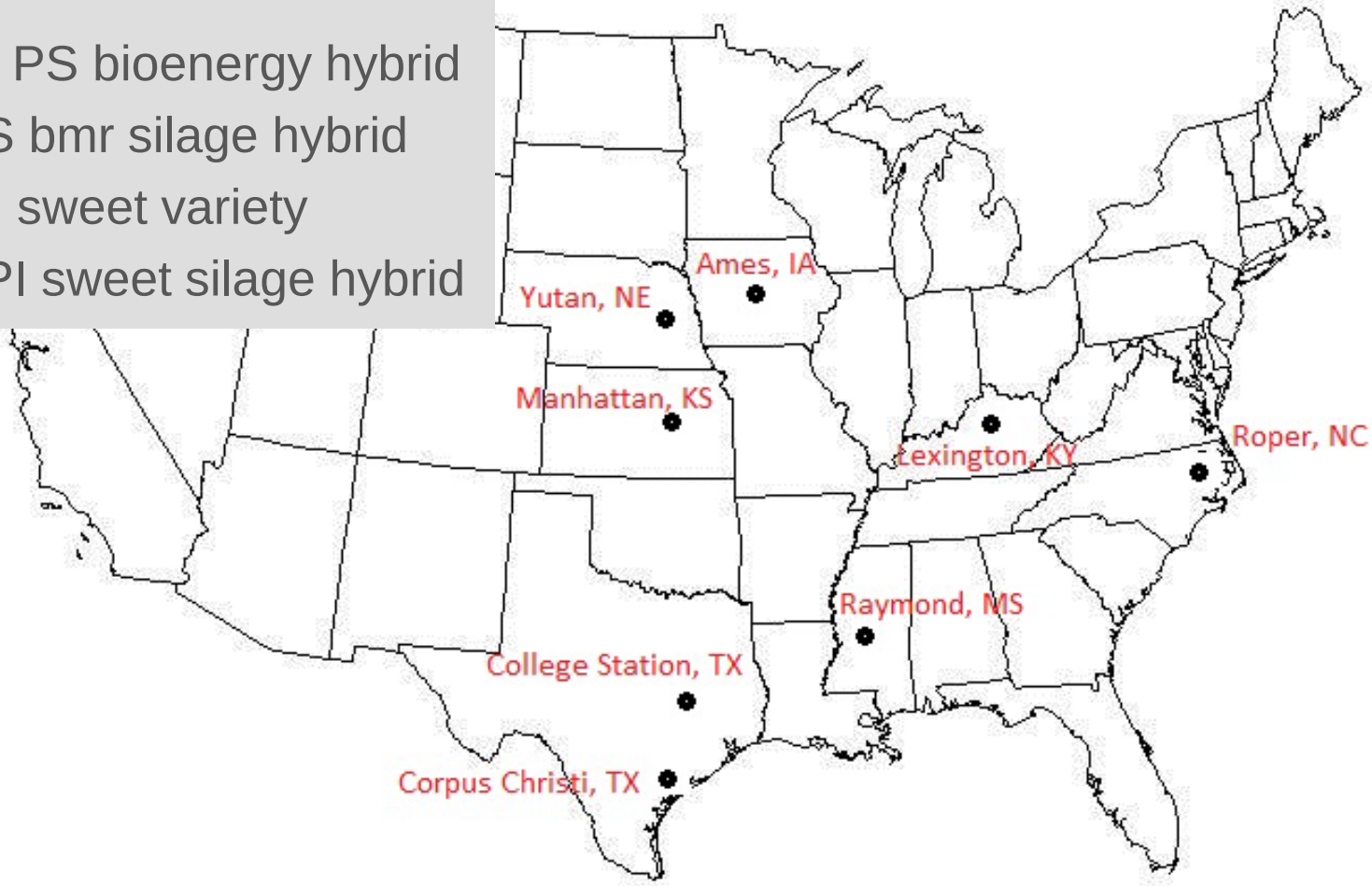
  - Optimization within Constraints

Background and Goal

- Assess the productivity and composition of sorghum as a bioenergy crop using a diverse set of sorghum genotypes
  - Five years
  - Eight locations
- Look at production logistics, extended season on hybrid choice and planting times.

Genotype and Test Locations

- Graze All, PI forage hybrid
- Graze-N-Bale, PS forage hybrid
- TX08001, PS bioenergy hybrid
- 22053, PS bmr silage hybrid
- M81-E, PI sweet variety
- Sugar T, PI sweet silage hybrid



Gill et al., 2014 Bioenergy Research

Table 2 Means and ranges for fresh weight biomass, dry weight biomass, moisture concentration, and brix averaged over all genotypes and years for each location

Site	Fresh weight (MT/ha)		Moisture (%)		Dry weight (MT/ha)		Brix (%)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Corpus Christi, TX (CC)	30.5e	4.1–84.4	70.3b	39.8–90.7	7.1f	1.5–25.8	9.1e	6.0–13.7
College Station, TX (CS)	40.1d	5.7–89.0	73.9a	52.9–83.8	10.4e	1.8–25.8	11.5 cd	6.2–18.2
Ames, IA	58.4b	29.3–105.5	73.0a	66.4–79.8	15.5c	8.9–28.5	13.5a	7.5–19.3
Manhattan, KS	41.5d	13.9–79.8	67.3c	51.0–80.5	13.3d	4.4–24.6	13.2ab	8.4–16.3
Lexington, KY	52.0c	28.4–91.9	69.6b	51.7–89.6	17.2ab	4.8–30.8	12.2bc	6.0–17.2
Raymond, MS	63.8a	17.5–117.8	74.0a	53.3–85.0	16.3bc	4.1–34.1	8.2e	4.1–15.4
Roper, NC	61.2ab	15.4–127.8	69.3b	54.4–80.8	17.5a	5.8–41.1	10.7d	5.0–18.7
HSD ($P<0.05$)	3.7		1.3		1.1		1.3	

Means within a column followed by the same letter were not significantly different at the 0.05 probability level based on Tukey's honestly significant difference [21]

Table 4 Means and ranges for fresh weight biomass, dry weight biomass, moisture concentration, and brix averaged over all environments for each genotype

Genotype	Fresh weight (MT/ha)		Moisture (%)		Dry weight (MT/ha)		Brix (%)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
22053	41.9d	4.2–79.9	70.7b	45.8–88.2	11.9e	1.5–25.5	10.7bc	5.0–17.7
Graze All	35.1e	4.1–113.3	68.4c	39.8–86.1	10.1f	1.8–21.0	10.0c	4.1–16.8
Graze N Bale	55.3b	7.9–116.0	73.1a	44.0–89.6	14.6c	3.3–29.4	10.1bc	4.6–18.7
M81-E	58.2ab	5.4–118.7	72.6a	52.6–87.8	15.6b	2.2–34.1	12.0a	5.2–18.2
Sugar T	51.3c	12.3–108.5	73.2a	51.7–90.7	13.3d	3.1–26.8	11.9a	4.3–19.3
TX08001	58.6a	9.1–127.8	69.5c	55.0–86.8	17.9a	2.8–41.1	10.9b	6.4–16.0
HSD ($P<0.05$)	3.2		1.1		1.0		0.9	

Means within a column followed by the same letter were not significantly different at the 0.05 probability level based on Tukey's honestly significant difference [21]

MT/ha metric tons per hectare

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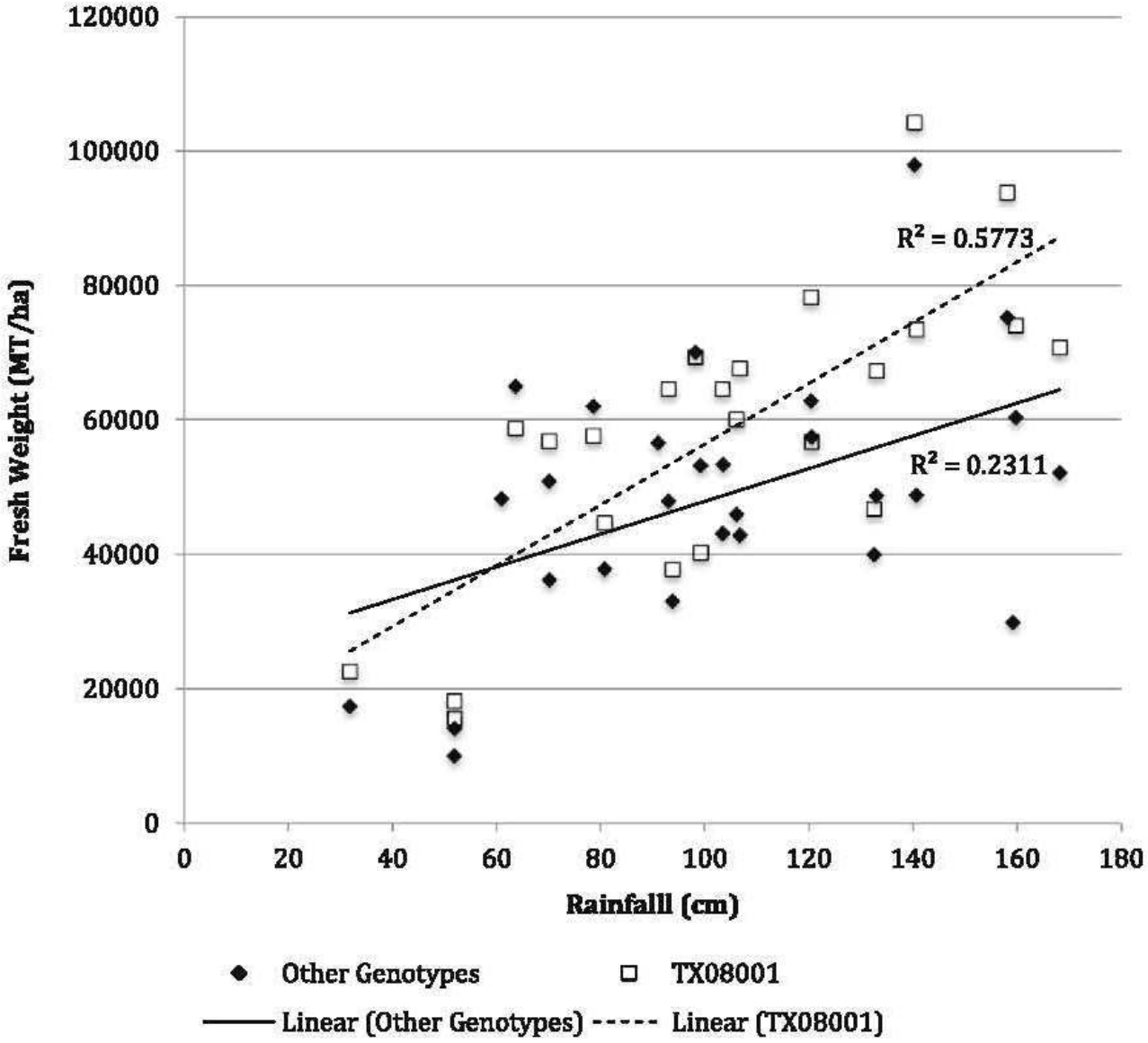
Table 5 Agronomic performance of the biomass sorghum hybrid TX08001 in College Station, TX; Ames, IA; Raymond, MS; and Roper, NC in four consecutive years (2009–2012)

Location	Year[a]	Fresh weight (MT/ha)	Moisture concentration (%)	Dry weight (MT/ha)	Brix (%)
College Station, TX	2009	64.5a[c]	71.0b	18.7ab	8.4c
	2010	56.8a	76.3a	13.5b	7.7c
	2011	15.6b	72.3b	4.3c	10.4b
	2012	64.5a	67.7c	20.9a	12.9a
LSD ($P<0.05$)		18.6	3.1	5.7	1.9
Ames, IA	2009	40.2b	71.4bc	11.5b	12.9a
	2010	56.7a	72.7ab	15.5ab	12.7a
	2011	57.6a	69.8c	17.4a	12.8a
	2012	58.7a	74.5a	14.9ab	11.0a
LSD ($P<0.05$)		15.4	2.4	4.6	2.7
Raymond, MS	2009	74.0b	72.0a	20.7b	nd
	2010	69.3b	67.1bc	22.9ab	11.6a
	2011	78.2ab	65.5c	27.0ab	9.6ab
	2012	93.8a	69.8ab	28.5a	8.1b
LSD ($P<0.05$)		18.2	3.4	7.3	2.1
Roper, NC	2009	104.3a	66.6a	34.7a	9.9b
	2010	73.4b	66.2a	24.8b	14.1a
	2011	46.7c	65.4a	16.1c	10.2b
	2012	67.3b	68.0a	21.4b	11.5b
LSD ($P<0.05$)		16.1	3.0	4.3	2.1

Means within a column followed by the same letter were not significantly different at the 0.05 probability level based on Fisher's least significant difference test

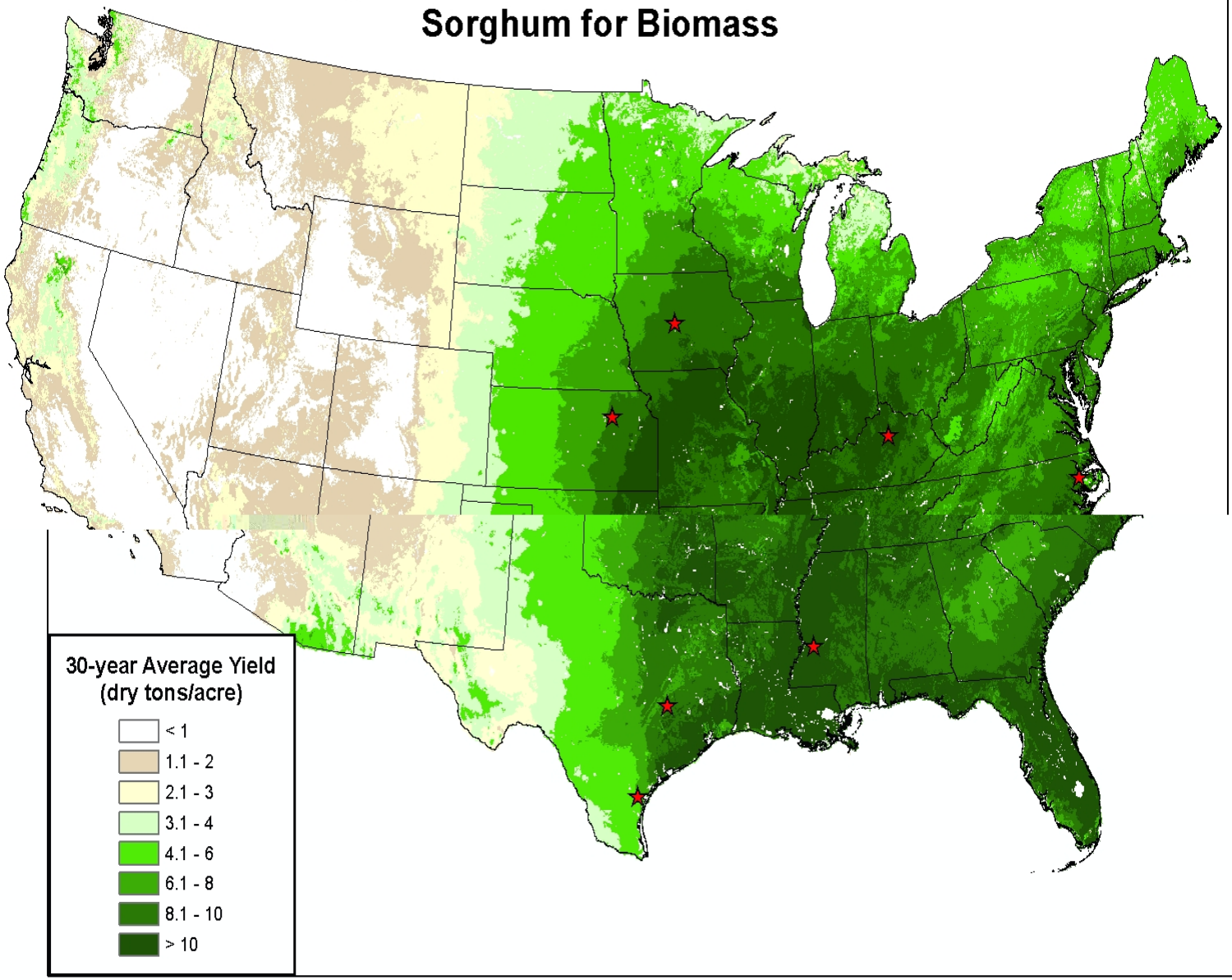
MT/ha metric tons per hectare, *nd* no data

[a] TX08001 was not included in 2008

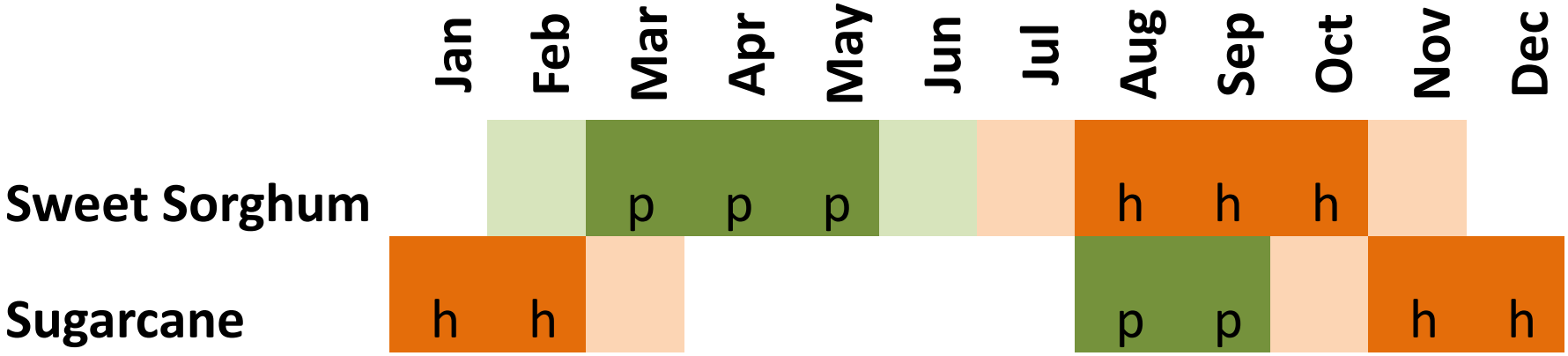


Texas A&M AgriLife Research

Average Annual Yield Potential, 1981 - 2010
Sorghum for Biomass



Complementary Crops: U.S. Gulf Coast



May Planting	April Planting

Burks et al., 2013 Agro. Journal

Maturity group	Sugar yield	Fresh yield	Dry yield	Sugar conc.	Plant height	Days to anthesis
	Mg ha^{-1}			°Bx†	cm	d
Late	4.4 a‡	63.5 a	22.6 a	13.2 b	361.9 a	122.0 a
Medium	4.1 a	57.2 b	19.0 b	13.3 b	357.5 a	111.0 b
Early	2.7 b	33.0 c	9.5 c	14.0 a	267.5 b	67.0 c

† 1 degree brix (°Bx) is 1 g sucrose in 100 g solution.

‡ Letters within a column indicate that means are statistically different.

Month planted	Sugar yield	Fresh yield	Dry yield	Sugar conc.	Plant height	Days to anthesis
	Mg ha^{-1}			°Bx†	cm	d
April	4.2 a‡	57.6 a	19.8 a	14.0 a	359.5 a	101.0 a
May	4.0 a	54.3 a	18.0 b	13.7 b	344.9 b	101.0 a
June	2.9 b	41.8 b	13.3 c	12.8 b	282.4 c	97.0b

† 1 degree brix (°Bx) is 1 g sucrose in 100 g solution.

‡ Letters within a column indicate that means are statistically different.

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Burks et al., 2013 Agro. Journal

Planting date	Maturity group	Sugar yield	Fresh yield	Dry yield	Sugar conc.	Harvest date
		Mg ha^{-1}			°Bx†	
April	late	5.1 a‡	75.2 a	27.2 a	13.6 a	Sept. 14
	medium	4.7 a	63.3 b	22.1 b	14.4 a	Aug. 31
	early	2.6 b	32.8 c	9.2 c	14.0 a	July 25
May	late	4.2 a	61.6 a	22.1 a	13.0 b	Oct. 11
	medium	4.1 a	60.0 a	19.9 a	12.3 b	Sept. 29
	early	3.7 a	41.3 b	12.2 b	15.8 a	Aug. 18
June	late	3.6 a	52.6 a	17.8 a	13.0 a	Nov. 16
	medium	3.5 a	48.0 a	14.9 b	13.1 a	Nov. 08
	early	1.6 b	25.3 b	7.1 c	12.2 a	Sept. 16

† 1 degree brix (°Bx) is 1 g sucrose in 100 g solution.

‡ Letters within a column indicate that means are statistically different.

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Burks et al., 2013 Agro. Journal

Table 5. The planting date and hybrid maturity group that produced the highest yield in each of eight consecutive harvest windows in College Station, TX, in 2010 and 2011. In some harvest windows, only one maturity group was available for harvest, while others had multiple options.

Harvest date	Planting date	Maturity group	Fresh yield	Sugar yield
			Mg ha^{-1}	
16–31 July	15 Apr.	early	32.9	2.6
1–15 Aug.	15 May	early	41.3	3.7
16–31 Aug.	15 Apr.	medium	63.5	4.7
1–15 Sept.	15 Apr.	late	76.4	5.3
16–30 Sept.	15 May	medium	60.0	4.1
1–15 Oct.	15 May	late	61.6	4.2
16–31 Oct.	15 June	medium	48.0	3.5
1–15 Nov.	15 June	late	52.5	3.6

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Burks et al., 2013 Agro. Journal

Table 6. Projected planting dates, maturity groups of hybrids, and the harvesting schedule required to provide 1000 Mg of sweet sorghum biomass to a mill facility on a daily basis.

Month planted	Maturity group	Fresh yield	Area planted	Harvest date
		Mg ha^{-1}	ha	
April	early	32.9	486	16–31 July
	medium	63.5	252	16–31 Aug.
	late	76.4	209	1–15 Sept.
May	early	41.3	387	1–15 Aug.
	medium	60.0	266	16–30 Sept.
	late	61.6	260	1–15 Oct.
June	medium	48.0	333	16–31 Oct.
	late	52.5	305	1–15 Nov.
Total			2498	

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Conclusions from Production

- Rainfall defines yield potential
  - Average Yield 12-16 MT/ha
  - High Yield, 35-40 MT/ha
- Moisture Contents
  - Significant source of Sugar
  - Drier types possible but cost?
- Seasonal Crop
  - Biomass from July – November
- Better Hybrids now available
  - Biomass
  - Sweet Sorghum
  - Dual Purpose

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