Theoretical Ethanol Yield for Potential Bioenergy Sorghum Genotypes of Differing Compositions

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Rationale

Sorghum: promising potential biofuel feedstock; high yield; NUE and drought tolerance; many genotypes (forage, grain, sweet, biomass)

Nitrogen: Environmental sustainability; landscape impact

Biomass Yield: Potential energy production capacity

Composition: biochemical degradability; bioconversion method

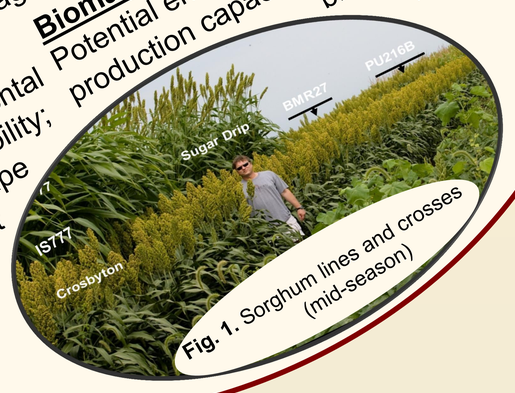

Fig. 1. Sorghum lines and crosses (mid-season)

Objective

To evaluate theoretical ethanol yield derived from biomass yield and composition of Sorghum bicolor (L.) Monech as influenced by environment and N application rate

Hypothesis

Biomass yield and composition will vary among genotypes and N application rate and thus will differ in theoretical ethanol yield

Conclusions

Theoretical Ethanol Yield: in all sorghum lines were similar to, or greater than maize. Photoperiod sensitive sorghum yielded the highest and sweet sorghum follows.

Composition: varied with lines. Ethanol from fiber was higher than from grain and sugars in all lines.

Nitrogen Rate: had varied yield responses. All sorghum lines had decent yields at moderate N rates.

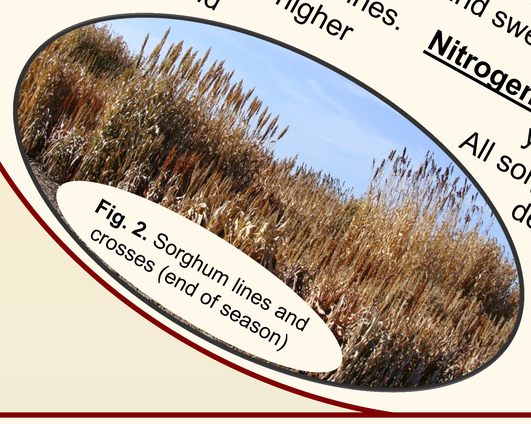

Fig. 2. Sorghum lines and crosses (end of season)

Environments

- 2008 & 2010 Agronomy Center for Research & Education (ACRE)
- 2008 Pinney Purdue Agricultural Center (PPAC)
- 4 N application rates (0, 67, 135, and 202 kg/ha)
- 5 sorghum lines and a hybrid corn control
- 4 row plots (randomized block design)
- 4 replicate plots for each line and N-rate

Yield / Composition / Biofuel Production

Yield: Grain; Stover

Composition:
- *Lit. Values*[a]: 0.441 L EtOH = 1 kg yield (2.96 g EtOH = 1 bu grain yield)
- *Stoichiometric values*[b,c]:
  - (Glucose:Ethanol = 0.51)*
  - (Starch:Glucose = 1.11 or Cellulose:Pentose = 1.156) or Hemicellulose:Glucose = 1.11)*
  - (Density=0.789 kg/L of EtOH)*
  - (% biomass constituent by weight)

Biofuel Production

[simple sugar ethanol*(0.95)+ starch ethanol*(0.9)+ cellulose ethanol*(0.9)+Hemicellulose ethanol*(0.8))*1000]

Analyses:

- Grain and Stover: 10 plant subsample; hand harvested from soil level.
- Fresh weights immediately measured; dried at 55ºC; ground at 1mm
- Fiber: Cellulose, Hemicellulose, Lignin (ANKOM 2000 Protocols)
- Sugars (Anthrone Assay)
- Starches (Trinder Assay)
- ANOVA and LSDs – SAS

Results

Yield

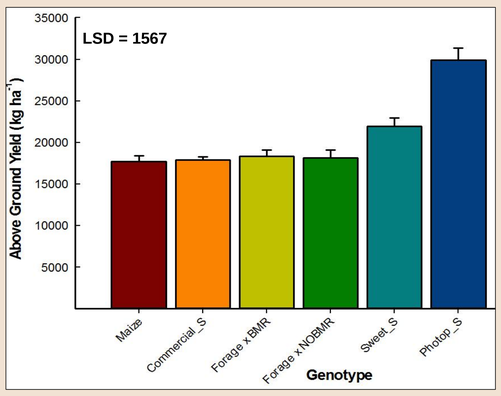

Fig. 3. Means ± standard error above ground yields. Photoperiod sensitive and sweet sorghum yield highest. Yields of other sorghum lines are similar to maize.

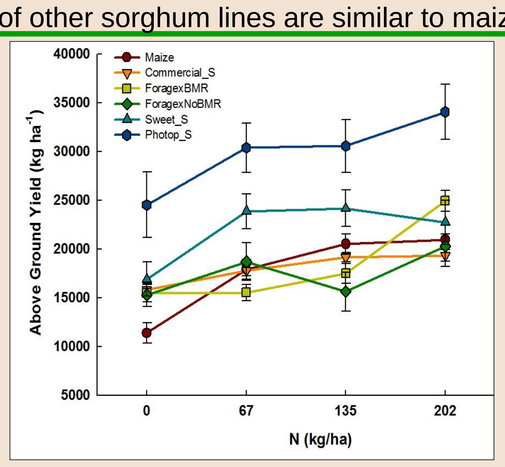

Fig. 4. Means ± standard error of above ground yields. Majority of N response of sorghum lines were with the first increment of N (compared to maize). All sorghum lines yielded more than maize with 0 N applied.

Sorghum Genotypes and Maize Hybrid

Line #	LINE NAME	CHARACTERISTIC NAME	DESCRIPTION
1	AgriGold AG585RR	Maize	Control – Maize Hybrid
3	Crosbyton A747 x R50	Commercial_S	Commercial sorghum line
5	PR915A x BMR27	Forage x BMR	Forage sorghum line – low lignin; F1 from: sterile female BMR mutation on gene 6 x male BMR mutation on gene 6
8	PU216A x P90344	Forage x NOBMR	Forage sorghum line; F1 from : sterile female w/o BMR mutation x male w/o BMR mutation
9	Sugar Drip	Sweet_S	Sweet sorghum line; base of stover would be $C_6H_2O_6$
10	Is7777	Photop_S	Photoperiod sensitive sorghum line (18'...no flowers)

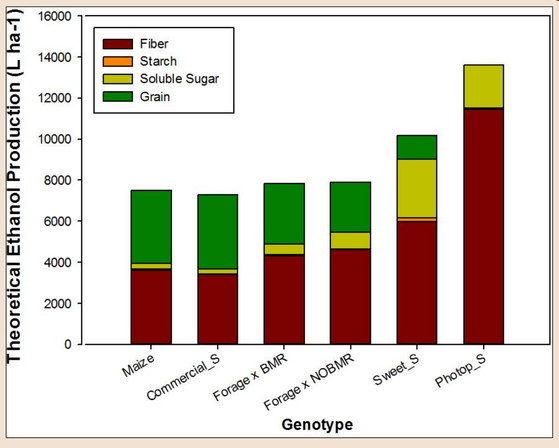

Fig. 7. Preliminary theoretical ethanol production (TEP) of sorghum lines and maize. Fiber is the greatest contributor to TEP. Sweet and Photoperiod sorghum produced the highest TEP from sugar. The highest grain ethanol yields were from commercial sorghum and maize.

Composition

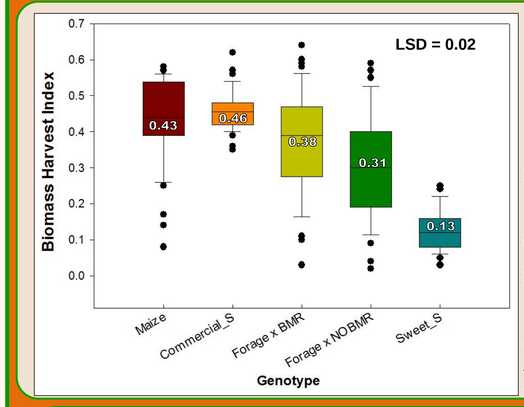

Fig. 5. Box plots showing median and range; numbers showing means of biomass harvest index (grain / above ground yield). Commercial sorghum appear similar to maize. Note: Low HI in Sweet Sorghum is due to low grain yields.

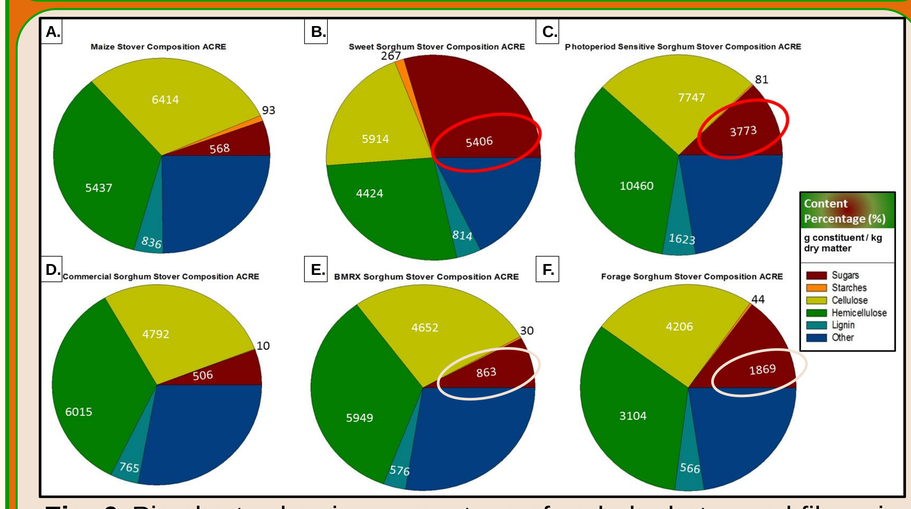

Fig. 6. Pie charts showing percentage of carbohydrates and fibers in stover. Numbers give the total mean per hectare content of constituent in stover. Preliminary results suggest content soluble sugar were highest in sweet and photoperiod sensitive lines (red circles) but percent of sugar in stover differed. The forage line with BMR trait had a lower sugar percent and content than the non-BMR (tan circles); but values were greater than commercial sorghum.

Next Steps

- Conduct full statistical analyses for theoretical ethanol production
- Determine the best combination of composition and yield for plant breeders to explore
- Determine optimal environmental conditions and evaluate potential environmental impacts

Acknowledgements

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