Expanding Bio-based Energy Crop Options for Dryland Systems

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Sorghum is a well-adapted crop for the dryland areas in the Southern High Plains. The rural economies of this region depend on healthy and sustainable agricultural bases. Grain and forage sorghum production contributes to stabilizing these rural economies. Expanding the marketing crop options of sorghum by increasing its utilization for ethanol production would raise grower profit and bolster rural communities (Dept. of Energy, 2001). The development of high starch grain sorghum has the potential to increase ethanol yield (gallons of ethanol produced per bushel) by 40 to 50% (Seed Quest 2001; McLaren, et al., 2002). .

Grain sorghum is not the only sorghum feedstock available for ethanol production in the Southern High Plains. The stalk juice of sweet forage sorghum is readily fermentable and requires much less energy for processing than ethanol made from grain (Undersander, et al., 1990). Because of the potential of sweet sorghum for higher per acre ethanol production and reduced energy conversion input, there is national interest in using sweet sorghum as an ethanol feedstock.

Brazil is an international example of ethanol's potential. Brazil has become energy independent by producing ethanol from the juice of sugarcane (Luhnow and Samor, 2006). Sugarcane production requires higher moisture conditions and longer growing seasons than are found in the Southern High Plains. Fortunately, many forage sorghums with high stalk sugar are adapted to the drier, shorter growing season conditions of our region (Larson, et al., 2004).

Objectives

Production of ethanol from grain and forage sorghums should increase income of both local ethanol plants and growers, while improving the economic stability of surrounding rural communities. One of our goals is to identify regionally adapted sweet sorghums with higher stalk sugar and potentially higher ethanol production than the adapted forage sorghums currently grown. We also plan to develop a model to estimate *in situ* ethanol yield of these sweet and forage sorghums. This model would require only simple plant measurements of plant density, plant height, and stalk diameter for silage estimates, and stalk Brix readings for ethanol production estimates. Another goal is to compare conventional starch to high starch grain sorghum hybrids for increased ethanol production. If higher ethanol gains are realized from high starch grain sorghums, these high starch grain sorghums would merit price premiums for growers.

Results and Conclusions

In our pursuit to develop ethanol production models for forage and sweet sorghums, using simple plant measurements to estimate silage yield and ethanol production from stalk juice, we found that a Brix reading from the 6^{th} internode was a good representative for percent sugar in the juice of the entire stalk. However, our predictive models for silage yield, juice yield, and ethanol production were valid within their respective year, but were not suitable across years.

The feasibility of ethanol production from forage and sweet sorghum stalk juice was dampened by our use of a manual cane press, which only extracted a small percentage of total stalk juice. Nonetheless, in a related study, we discovered that total juice extraction was achievable by finely chopping stalks, heating them with water, and pressing the diluted juice out with a fruit press. As part of the ethanol feasibility study, we identified NB 305F, a forage sorghum, and Topper 76-6, a sweet sorghum, as adapted and high ethanol producing sorghums.

From our grain ethanol production comparison of high starch and conventional starch grain sorghum hybrids, we found that high starch grain sorghum hybrids did not produce higher average grain yields, higher ethanol yields, or higher ethanol production than the conventional starch grain sorghums. Without higher grain ethanol yield, none of the high starch grain sorghums would garner price premiums.

When we compared total ethanol production of sweet sorghums to grain sorghums, we found that ethanol production from the juice of sweet sorghums averaged one-third more ethanol per acre than ethanol produced from the grain of grain sorghums. To take advantage of increased ethanol production of forage and sweet sorghums would require renovation of existing ethanol plants or construction of new plants to handle both grain and forage sorghum feedstocks. With greater feedstock diversity and lower operating costs, these hybrid ethanol facilities may become more profitable, while expanding the energy crop options and income of sorghum growers.

Materials and Methods

<u>Procedure: Forage and Sweet Sorghums, First Year, 2007</u>

Four sweet sorghum varieties and four forage sorghum hybrids were planted into a dryland no-till system on June 5, 2007. Early in the season, notes were taken at emergence and plant densities were measured. Gypsum block were install and soil moisture readings were recorded every week. To derive a formula to estimate *in situ* ethanol yield of these sweet and forage sorghums, we made forage yield estimates and stalk sugar content readings. For the forage yield estimates, we measured plant density, plant height, total nodes, and plant weight. To determine the internode that corresponds to percent sugar of entire stalk, we measured the 2nd, 4th, 6th, and 8th internodes for stalk diameter with a digital caliper and percent sugar with a hand refractometer at boot, flowering, early milk, and late milk. Plants were milled with a manual cane press to extract total stalk juice. This juice was weighed, volume determined, and refractometer readings taken for each hybrid/variety at all four developmental stages. When the seed of the forage sorghums reached early dough, plants were counted and harvested from 21.75 ft of one row and total stalk juice was hand milled from the plants. Plant density, plant weight, percent sugar, juice volume and weight were recorded. The same forage harvest was performed on the sweet sorghums; however, none of the sweet sorghum reached early dough development. Forage harvest for stalk juice extraction was performed on the sweet sorghums just before the site was harvested for silage. This entire dryland forage study was harvested with a silage chopper on October 2, 2007. The silage from each plot was weighed and a representative sample of each hybrid/variety was oven-dried for moisture content and silage yields recorded at 70% moisture content.

To determine the ethanol production of the stalk juice pressed at early dough (or just before silage harvest for sweet sorghums), the juice was lowered to pH 4.8, yeast added and fermented for 5 days in an air locked container. We had planned to distill these wines and record volume and proof of the distilled alcohol; however, these musts did not completely ferment. We tried to restart these stalled fermentations by adding additional yeast and yeast nutrients (a mix of DAP and other nutrients), but they still did not complete their fermentations. We did not distill these sweet wines; therefore, the ethanol yields we used were potential and not actual ethanol yields.

Procedure: Forage and Sweet Sorghums, Second Year, 2008

Four sweet sorghum varieties and four forage sorghum hybrids were planted into a dryland no-till system on June 30, 2008. The site was pre-irrigated because there was insufficient winter and spring moisture for seed germination and growth. Early in the season, notes were taken at emergence and plant densities were measured. Gypsum block were install and soil moisture readings were recorded every week. To derive a formula to estimate *in situ* ethanol yield of these sweet and forage sorghums, we made forage yield estimates and stalk sugar content readings. For the forage yield estimates, we measured plant density, plant height, stalk diameter, and plant weight. The parameters we used to estimate forage yields were: 1) the average stalk diameter of the 6th internode (in.) for 2007 or the average of the 5th and 7th internodes (in.) for 2008, 2) stalk count from 11ft. of one row (2.5ft. x 11ft.), and 3) plant height (in.). We multiplied these measurements by their specified units of measure to produce the parameter products, i.e., stalk diameter (inches) x stalk count (number of stalks) x plant height (inches) = parameter product. To derive constants for estimated silage yields based on these parameters, we used plant weights (silage yields, tons/a) divided by the parameter products calculated at each developmental stage. To determine the internode that corresponds to percent sugar of entire stalk, we measured the 3nd, 5th, 7th, and 9th internodes for stalk diameter with a digital caliper and percent sugar with a hand refractometer at boot, flowering, milk, and dough (only one hybrid, Sorghum Partners Sordan 79, reached the dough stage). Plants were milled with a manual cane press to extract overall stalk juice. This juice was measured with refractometer to determine sugar percentage of overall stalk juice for each hybrid/variety at all four developmental stages, or the most advanced development stage at first freeze. Two plants were harvested at each developmental stage: the stalk of one plant was pressed for overall percent sugar, and the second plant was deconstructed and the leaves, head, and stalk were weighed and oven-dried to determine dry weight and plant moisture of leaves, head, and stalk. This entire dryland forage study was harvested with a silage chopper on October 27, 2008. The silage from each plot was weighed and a representative sample of each hybrid/variety was oven-dried for moisture content and silage yields were adjusted to 70% moisture content.

Last year, we found that our manual cane press would only expel an average of 17% of the theoretical stalk juice, and this varied greatly with stalk diameter. Our manual cane press was good for determining the overall Brix readings for the entire stalk, but not for total juice yields. We were unable to find a small-scale, commercially available hydraulic press that would produce commercially acceptable extraction levels of stalk juice. However, we did determine that total stalk sugar could be extracted by finely chopping the stalks, adding water, and heating the mixture to 80°C for 30 minutes, then pressing the mixture with a fruit press to extract the juice (Larson, 2008). By repeating the above procedure on the same chopped stalks, we obtained stalk sugar amounts similar to theoretical stalk sugar amounts derived by Brix readings at the 6th internode and measuring stalk water (water loss from drying wet stalks). Stalk water divided by 100-Brix/100 is stalk juice. Stalk juice minus stalk water is stalk sugar.

To derive potential ethanol production of the sweet and forage sorghum hybrids, we first had to determine stalk juice yield. For example, the conversional steps from silage yield to stalk juice yield of Theis at flowering (Table 9) were: 14.14 x 600 = 8484 (silage yield tons/a at 70% moisture x wet silage to dry silage conversion = dry silage yield, lb/a); 8484 ÷ 0.2597 = 32694 (dry silage, lb/a ÷ 1 - whole plant moisture ratio = wet silage yield, lb/a); 32694 x 0.8127 = 26570 (wet silage yield, lb/a x wet stalk to plant ratio = wet stalk yield, lb/a); 26570 x 0.7543 = 20042 (wet stalk yield, lb/a x stalk moisture ratio = stalk water, lb/a); 20042 ÷0.858 = 23359 (stalk water, lb/a ÷ 1 - stalk brix reading ratio = stalk juice yield, lb/a); 23359 ÷ 8.8007 = 2654 (stalk juice yield, lb/a ÷ stalk juice conversion, lb/gal (0.335(Brix) + 8.325) = stalk juice yield, gal/a). The final conversion of stalk juice yield to potential ethanol production of Theis at flowering (final harvest) required one further step (Table 7): 2654 x 0.0752 = 199.6 (stalk juice yield, gal/a x potential ethanol (Brix(0.6)-1) = potential ethanol yield, gal/a).

Procedure: Grain Sorghum, First and Second Years, 2007 and 2008

The first year, we planted five high starch and seven conventional starch grain sorghums into a dryland no-till system on June 5, 2007. The second year, we planted five high starch and six conventional starch grain sorghums into a no-till dryland system on June 10, 2008. In 2008, the site was pre-irrigated because there was insufficient winter and spring moisture for seed germination and growth. Early in the season, notes were taken at emergence and plant densities were measured. Gypsum blocks were installed and soil moisture readings were recorded every week. For each hybrid, we recorded the date when 50% of the stalks flowered and the date when 50% of the stalk had mature seeds. At grain harvests (first year, October 29, 2007; second year, November 25, 2008), we measured plant height, plant lodging, and grain yield. We took grain samples from each hybrid and measured grain moisture and test weight. Grain yields are adjusted to 14% seed moisture content. From these grain samples, we determined ethanol yield by milling the grain, adding water and enzymes and heating the mash to convert the starch into sugar, pitching in the yeast and fermenting the mash, pressing the beer from the mash, distilling the beer, and measuring the volume, weight and proof of the distill ethanol.

Results and Discussion

Forage and Sweet Sorghums

In 2007, refractometer readings of stalk juice were taken at the 2nd, 4th, 6th, and 8th internodes at boot, flowering, early milk, and late milk to determine which internode readings most closely corresponded to the percent sugar of the overall stalk juice. The percent sugar for total stalk juice for forage and sweet sorghums were best represented by the refractometer readings from the 6th and 8th internodes at all four developmental stages (Table 1). Although no measurements were taken from the 7th internode, linear analysis suggests that readings of the 7th internode provided the best representation of percent sugar for the whole stalk (Fig. 1).

In 2008, to better target the best corresponding internode, we took stalk readings at the 3rd, 5th, 7th and 9th internodes. The percent sugar for the overall stalk juice for forage and sweet sorghums was best represented by the refractometer readings from the 5th internode at all four developmental stages (Table 2). Reviewing the internode refractometer readings for the past two seasons indicated that the 6th internode provided the best representation of percent sugar for the whole stalk, 7th internode for 2007 and 5th internode for 2008, (Fig. 2).

For the forage yield estimates, we measured plant density, plant height, stalk diameter, and plant weight. We multiplied the parameters: stalk diameter of the 6th internode (inches) x stalk count from 11 ft. of one row (number of stalks) x plant height (inches) = parameter product. To derive constants for estimated silage yields based on these parameters, we used silage yields divided by the parameter products calculated at each developmental stage. For both years, we found that developmental stages differentiated less than sorghum class (SS, Sorghum x Sudan; FS, Forage Sorghum; and SW, Sweet Sorghum). In 2007, the constants we derived for the sorghum classes from boot through late milk were 0.007838 for SS, 0.01054 for FS, and 0.006231 for SW (Table 3). In 2008, the constants we obtained for the sorghum classes from boot through soft dough were 0.004402 for SS, 0.005384 for FS, and 0.006262 for SW (Table 4). For each individual year, these constants times the parameter products provided good estimates of silage yields ($F(10,10) = 0.8529$, $P = 0.8063$ for 2007; $F(8,8) = 2.3496$, $P = 0.2483$ for 2008). However, the class constants that we calculated in 2008 were much lower than the constants obtained in 2007, except for the class constant for sweet sorghums (0.006262 in 2008, and 0.006231 in 2007). With the exception of the class constants for sweet sorghum, the class constants are too variable between years to provide reasonable estimates of silage yields.

Our stalk juice extraction rates were negligible and labor intensive with the manual cane press. Our average extraction rate was only 17% of the theoretical total stalk juice, i.e., the oven-dried water weight of the stalk, plus the stalk sugar weight (calculated from the Brix reading of the sixth internode) (Table 5). We were unsuccessful in acquiring a motorized hydraulic press, therefore, we could not simulate field juice extraction by swather pressing. Because of our low stalk juice extractions and incomplete fermentations, we reported potential ethanol production and not actual ethanol production.

In a related study, we obtained high stalk juice extraction rates by finely chopping the stalks, adding water, heating the chopped stalks and water mix at 80^{o}C for 30 minutes, and pressing the liquid out with a fruit press (Larson, 2008). By repeating this procedure on the same chopped stalk sample, we were able to reach the theoretical stalk sugar yield.

The final harvest juice constant for all the hybrids/varieties tested provided acceptable estimates of the potential ethanol yield for each individual year ($F(7,7) = 1.1535$, $P = 0.8554$ for 2007; $F(7,7) = 0.7334$, $P = 0.6928$ for 2008) (Tables 6 and 7). However, the large disparity we found between years for silage constants were also found for juice constants. In 2008, the juice constants were much larger than the juice constants obtained in 2007; for example, the average juice constants for sweet sorghums at final harvest were 193.2 for 2008 and 124.5 for 2007. The juice constants were too variable between years to provide reasonable estimates of juice yields and resultant ethanol yields.

The problems of predicting ethanol production were further compounded by our model's inability to predict silage yield and juice constants, since these were integral factors in the equation for estimating ethanol production. Our silage, juice, and ethanol production models, which we derived from plant height, plant density, stalk diameter, and stalk Brix measurements, did not provide adequate yield constants to make them suitable predictive tools between years.

In 2008, stalk juice yield for forage sorghums peaked at flowering with an average of 3106 gal/a, whereas stalk juice yield averaged similar amounts for boot and milk stages (Tables 8, 9, and 10).

Despite the curvilinear change in stalk juice yield with advancing developmental stages, ethanol production for forage sorghums increased linearly with later developmental stages. Highest ethanol production occurred at final harvest, even with lower stalk juice yield, because sugar levels increased with later development stages (Tables 11, 12, and 13). At final harvest in 2008, the average potential ethanol production was 220.8 gal/a for the forage sorghums, and 218.3 gal/a for the sweet sorghums (Table 7). At final harvest, all the sweet sorghums were in flowering and the average developmental stage for the forage sorghums was mid-milk. Tracking the ethanol production of Sorghum Partners Sordan 79, the only hybrid to reach all four developmental stages, we found that potential ethanol production increased with each progressive developmental stage sampled: boot (21.0 gal/a), flowering (56.3 gal/a), mid-milk (137.1 gal/a), and soft dough (146.7 gal/a) ($y = -56.3 + 77.9x – 6.4x^2$, $R^2 = 0.940$). Ethanol production increased nearly exponentially for the first three developmental stages, but was quite flat between mid-milk and soft dough. This indicates that the soft dough stage is near the optimum harvest stage for ethanol production.

Although we were unable to develop reasonable predictive tools for silage and ethanol yield, we were able to identify adapted sweet and forage sorghums with high ethanol production. At final harvest for both years, the top potential ethanol producing forage sorghum hybrid was NB 305F with an average of 222.0 gal/a. Of the sweet sorghums tested, Topper 76-6 had the highest average potential ethanol production, 229.7 gal/a (Tables 6 and 7). In 2007, there was less than 2 gal/a in potential ethanol production between the best forage sorghum hybrid, NB 305F, and the second best hybrid, Sorghum Partners HiKane II, and less than 1 gal/a of potential ethanol production separated the two best sweet sorghum varieties, Theis and Topper 76-6. In 2008, the differences in potential ethanol production among the forage sorghum hybrids and among the sweet sorghum varieties were much larger than we found the previous year. The difference between first and second in potential ethanol production was 45.3 gal/a for forage sorghums and 23.6 gal/a for sweet sorghums.

At final harvest in 2008, the average developmental stage of the forage sorghums was one full sample stage later than the developmental stage of the sweet sorghums (Table 7). The earlier developmental stage of the sweet sorghums may have contributed to the lack of ethanol production difference between the sweet sorghums and the forage sorghums at final harvest.

The earlier developmental stage at final harvest does not explain the results in 2007, where the potential ethanol production of sweet sorghums at final harvest averaged 59 gal/a more than the forage sorghums, even though their average developmental stage was earlier than the forage sorghums (Table 6). Late season dry weather in 2007 arrested the development of the sweet sorghum variety M81-E. The silage and ethanol productions of M81-E were still quite good despite its slowed development. Of the four sweet sorghums tested, M81-E appeared to be the least adapted to our dry conditions.

High Starch and Conventional Starch Grain Sorghums

The five high starch grain sorghums are designated by their NC+ brand. The high starch grain sorghums produced equivalent grain yields in 2007 and were within 5 bu/a in 2008 of the conventional starch grain sorghums (Tables 14 and 15). There was no difference in overall ethanol yield between high starch and conventional starch grain sorghum hybrids in 2007. Ethanol yield per bushel averaged identical yields of 2.42 gal/bu for both high starch and conventional starch grain sorghum hybrids in 2007, and only 0.01 gal/bu separated the average of the high starch and conventional starch hybrids in 2008. There were only minor differences in average total ethanol production, 0.1 gal/a in 2007 and 10 gal/a in 2008, between high starch and conventional starch grain sorghums. A comparison of the high starch to conventional-starch grain sorghums revealed that there were minimal differences between the average grain yield, ethanol yield (gal/bu), and total ethanol production (gal/a) for the two years of this study. There appears to be no ethanol production advantage with high starch grain sorghums compared to conventional starch grain sorghums, and therefore, high starch grain sorghums do not warrant price premiums.

As part of our study, we planned to compare a high starch grain sorghum to a conventional starch grain sorghum under commercial ethanol production conditions in a nearby ethanol facility. Conditions were extremely dry at planting in 2008; therefore, we chose NC+ 5B89 for this farm scale, high starch grain sorghum comparison. We selected NC+ 5B89 because it was the highest yielding, early maturing, high starch grain sorghum hybrid tested in 2007. Unfortunately, the ethanol plant at Walsh ceased operations before we could compare high starch and conventional starch grain under commercial ethanol production conditions.

Ethanol production from sweet sorghums averaged 34% more ethanol per acre than ethanol produced from grain sorghum (Tables 6, 7, 14, and 15). Despite its higher ethanol production, the utilization of sweet sorghum would be slowed by transportation problems resulting from its bulky feedstock, its narrow harvest window, and the conversion of ethanol facilities to handle stalk juice extraction.

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Tables and Figures

Table 1.-Internode Brix Reading Compared to Whole Stalk Juice Brix Reading, Walsh, 2007.

	Internode				**Whole**	internode			
Hybrid	2	4	6	8	**Stalk**	2	4	6	8
	%sugar					difference from actual			
Boot									
Sordan 79	7.6	8.0	6.4	7.8	**8.0**	-0.4	0.0	-1.6	-0.2
HiKane II	7.2	7.6	6.0	6.2	**7.2**	0.0	0.4	-1.2	-1.0
NB 305F	5.2	6.6	7.8	9.0	**10.2**	-5.0	-3.6	-2.4	-1.2
NK 300	8.0	8.8	9.8	10.6	**11.0**	-3.0	-2.2	-1.2	-0.4
Average	7.0	7.8	7.5	**8.4**	**9.1**	-2.1	-1.4	-1.6	**-0.7**
Flowering									
Sordan 79	8.8	10.0	10.0	12.0	**11.6**	-2.8	-1.6	-1.6	0.4
HiKane II	9.8	10.2	10.6	12.4	**11.6**	-1.8	-1.4	-1.0	0.8
NB 305F	10.2	11.0	13.4	13.6	**11.8**	-1.6	-0.8	1.6	1.8
NK 300	9.8	11.0	11.4	13.2	**12.2**	-2.4	-1.2	-0.8	1.0
Average	7.2	7.8	**8.5**	9.5	**8.8**	-1.6	-1.0	**-0.3**	0.8
Early Milk									
Sordan 79	10.8	10.8	12.6	14.2	**13.0**	-2.2	-2.2	-0.4	1.2
HiKane II	12.6	11.8	12.0	13.0	**13.0**	-0.4	-1.2	-1.0	0.0
NB 305F	16.4	15.6	19.2	20.8	**19.2**	-2.8	-3.6	0.0	1.6
NK 300	12.2	12.6	15.2	15.0	**15.8**	-3.6	-3.2	-0.6	-0.8
Average	13.0	12.7	**14.8**	**15.8**	**15.3**	-2.3	-2.6	**-0.5**	**0.5**
Late Milk									
Sordan 79	9.2	10.4	11.8	16.4	**13.8**	-4.6	-3.4	-2.0	2.6
HiKane II	8.6	9.0	11.8	12.2	**11.8**	-3.2	-2.8	0.0	0.4
NB 305F	7.0	7.4	10.0	10.4	**10.2**	-3.2	-2.8	-0.2	0.2
NK 300	12.8	13.4	15.2	15.4	**15.4**	-2.6	-2.0	-0.2	0.0
Average	9.4	10.1	**12.2**	13.6	**12.8**	-3.4	-2.8	**-0.6**	0.8
Boot									
Theis	11.2	11.2	11.8	14.8	**13.0**	-1.8	-1.8	-1.2	1.8
Dale	11.4	13.8	16.8	17.2	**15.0**	-3.6	-1.2	1.8	2.2
Topper 76	16.8	19.0	19.2	15.0	**18.4**	-1.6	0.6	0.8	-3.4
M81E	13.8	14.8	15.0	15.2	**16.2**	-2.4	-1.4	-1.2	-1.0
Average	13.3	14.7	**15.7**	15.6	**15.7**	-2.4	-0.9	**0.0**	-0.1
Flowering									
Theis	11.8	13.2	15.0	17.0	**15.0**	-3.2	-1.8	0.0	2.0
Dale	14.4	17.6	20.8	20.4	**19.0**	-4.6	-1.4	1.8	1.4
Average	13.1	15.4	**17.9**	18.7	**17.0**	-3.9	-1.6	**0.9**	1.7
Early Milk									
Theis	12.8	14.2	15.4	17.2	**15.8**	-3.0	-1.6	**-0.4**	1.4
Average	10.8	11.8	**13.1**	14.1	**13.5**	-2.7	-1.7	**-0.4**	0.6

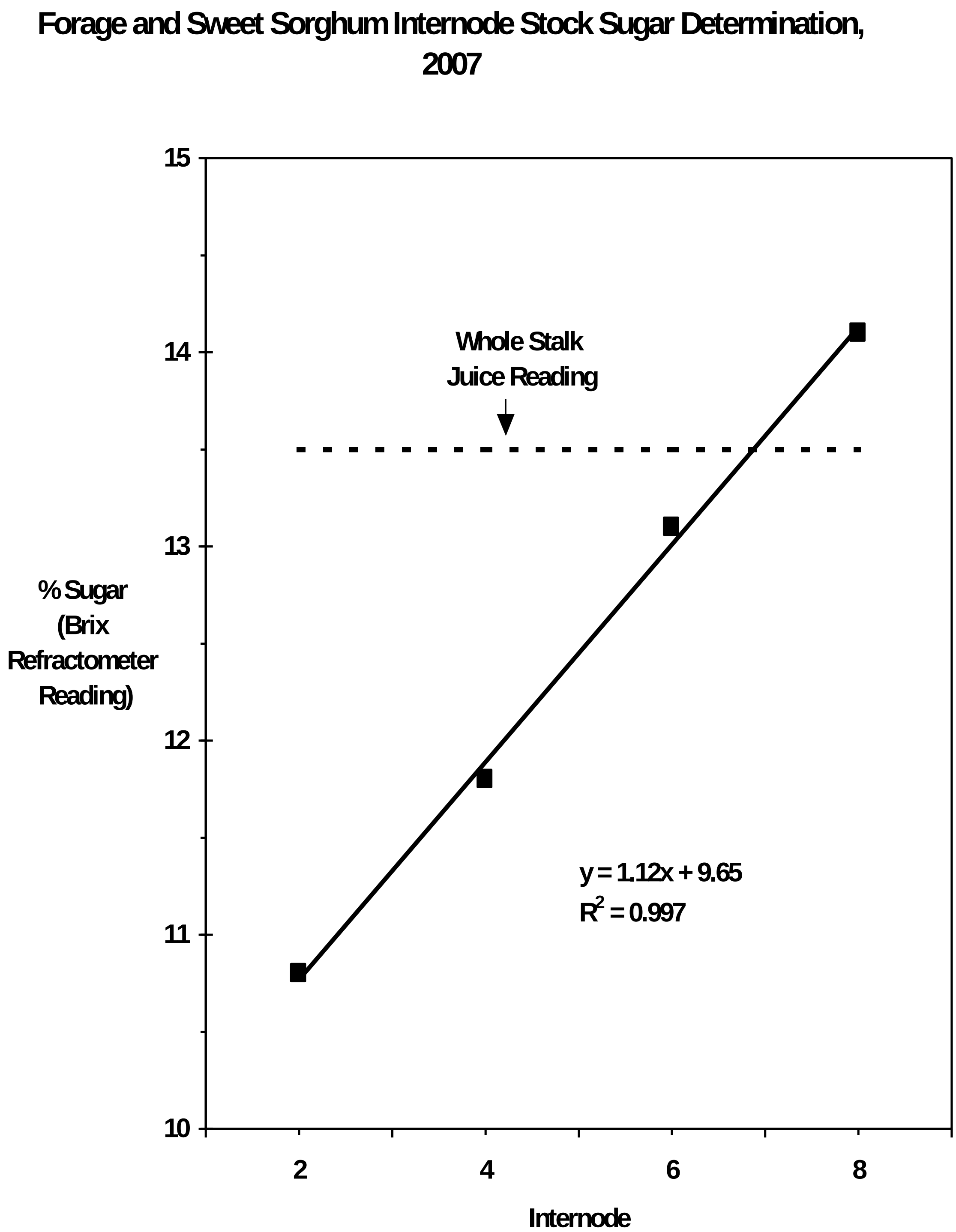

Fig. 1. Forage and sweet sorghum internode stalk sugar determination, 2007. Average Brix readings (% sugar) of stalk juice from four forage and four sweet sorghum hybrids were taken from boot to late milk at 2, 4, 6, and 8 internodes and compared to whole stalk juice readings.

Table 2.-Internode Brix Reading Compared to Whole Stalk Juice Brix Reading, Walsh, 2008.

Hybrid	Internode 3	Internode 5	Internode 7	Internode 9	**Whole Stalk**	internode 3	internode 5	internode 7	internode 9
	%sugar					difference from actual			
Boot									
Sordan 79	2.8	3.9	4.3	6.0	**4.4**	-1.6	-0.5	-0.1	1.6
HiKane II	3.6	3.9	4.9	6.9	**4.6**	-1.0	-0.7	0.3	2.3
NB 305F	7.3	8.4	7.1	6.3	**6.7**	0.6	1.7	0.4	-0.4
NK 300	6.9	7.6	8.7	7.1	**7.8**	-0.9	-0.2	0.9	-0.7
Average	5.2	**6.0**	6.3	6.6	**5.9**	-0.7	**0.1**	0.4	**0.7**
Flowering									
Sordan 79	4.4	5.5	5.8	6.4	**5.3**	-0.9	0.2	0.5	1.1
HiKane II	5.8	7.2	8.3	8.6	**8.4**	-2.6	-1.2	-0.1	0.2
NB 305F	11.2	13.9	14.2	10.5	**12.5**	-1.3	1.4	1.7	-2.0
NK 300	10.3	11.5	12.0	10.5	**12.0**	-1.7	-0.5	0.0	-1.5
Average	7.9	**9.5**	10.1	9.0	**9.6**	-1.6	**0.0**	0.5	-0.6
Milk									
Sordan 79	8.4	11.5	13.8	15.1	**12.1**	-3.7	-0.6	1.7	3.0
HiKane II	14.5	15.4	14.8	16.9	**16.5**	-2.0	-1.1	-1.7	0.4
NB 305F	15.0	16.9	18.7	18.9	**18.8**	-3.8	-1.9	-0.1	0.1
Average	12.6	14.6	**15.8**	17.0	**15.8**	-3.2	-1.2	**0.0**	1.2
Soft Dough									
Sordan 79	9.0	9.8	**11.6**	13.6	**11.5**	-2.5	-1.7	**0.1**	2.1
Boot									
Theis	8.5	9.9	8.8	8.7	**9.4**	-0.9	0.5	-0.6	-0.7
Dale	9.4	11.5	10.6	8.3	**8.3**	1.1	3.2	2.3	0.0
Topper 76	10.0	12.0	8.8	7.3	**10.2**	-0.2	1.8	-1.4	-2.9
M81E	6.6	8.8	7.1	7.5	**8.5**	-1.9	0.3	-1.4	-1.0
Average	8.6	10.6	**8.8**	8.0	**9.1**	-0.5	1.5	**-0.3**	-1.2
Flowering									
Theis	10.8	12.9	15.5	15.5	**13.8**	-3.0	-0.9	1.7	1.7
Dale	11.0	12.8	14.9	14.2	**13.1**	-2.1	-0.3	1.8	1.1
Topper 76	13.4	16.0	16.9	17.0	**15.4**	-2.0	0.6	1.5	1.6
M81E	8.4	10.2	11.0	11.3	**10.2**	-1.8	0.0	0.8	1.1
Average	10.9	**13.0**	14.6	14.5	**13.1**	-2.2	**-0.2**	1.5	1.4
Average	**9.0**	**10.6**	**11.2**	**11.4**	**10.8**	**-1.8**	**-0.3**	**0.4**	**0.6**

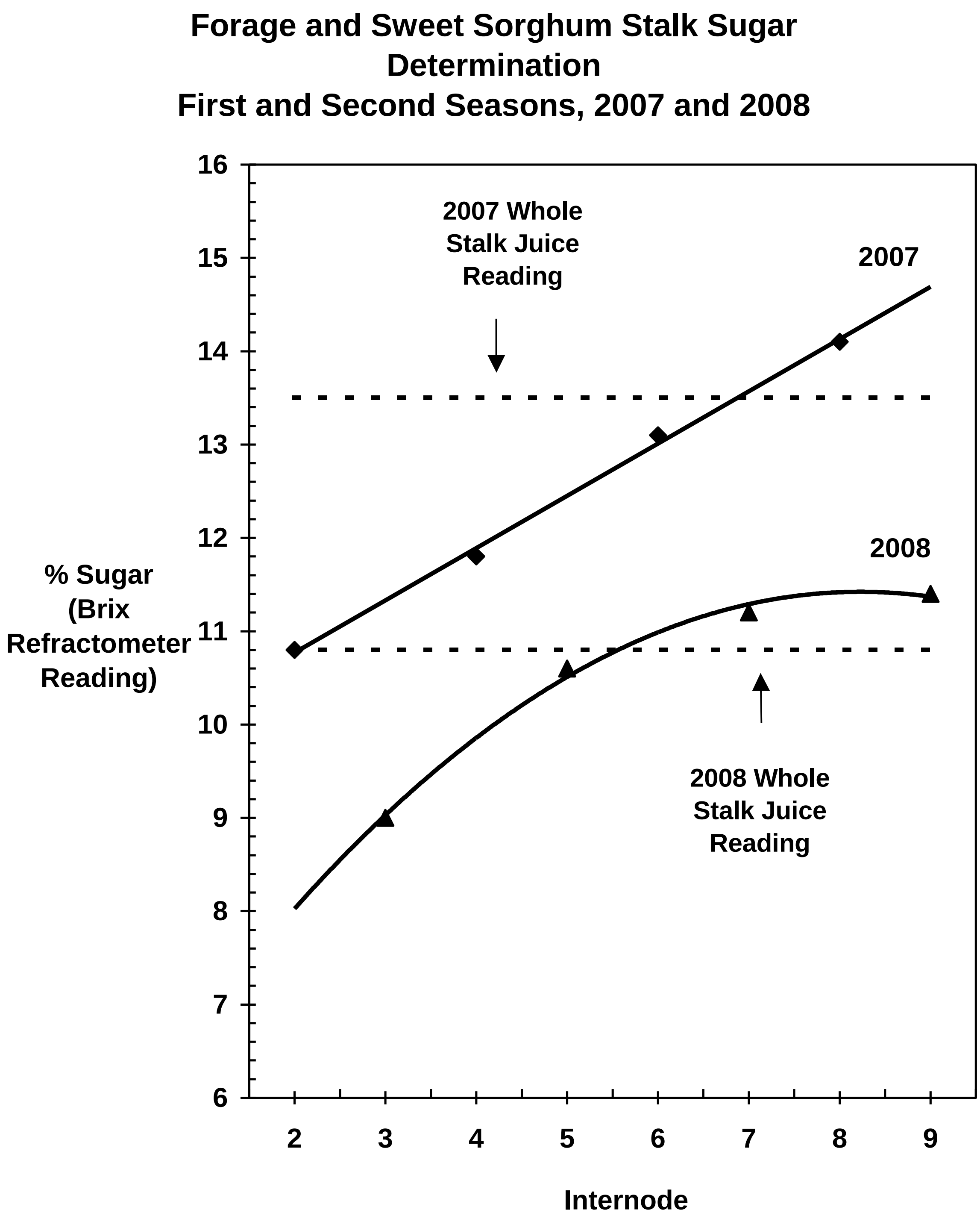

Fig. 2. Forage and sweet sorghum internode stalk sugar determination. Average Brix readings (% sugar) of stalk juice from four forage and four sweet sorghum hybrids were taken from boot to soft dough at 2, 4, 6, and 8 internodes for 2007 and 3, 5, 7, and 9 internodes for 2008 and compared to whole stalk juice readings.

Table 3.-Dryland Forage and Sweet Sorghums, Parameters and Constants for Silage Estimate, 2007.

Sorghum Class	Developmental Stage	Measured Parameters Product	Measured Silage Yield	Developmental Stage Constant	Measured Parameters Product	Class Constant	Estimated Silage Yield
			tons/a				tons/a
SS	Boot	1427.3	11.74	0.008225	1427.3	0.007721	11.02
SS	Flower	1676.1	10.08	0.006014	1676.1	0.007721	12.94
SS	Early Milk	1297.6	10.88	0.008385	1297.6	0.007721	10.02
SS	Late Milk	1261.6	11.01	0.008727	1261.6	0.007721	9.74
Average SS		**1415.7**	**10.93**	**0.007721**	**1415.7**	**0.007721**	**10.93**
FS	Boot	1187.4	11.86	0.01042	1187.4	0.01039	12.34
FS	Flower	1475.9	14.09	0.00967	1475.9	0.01039	15.33
FS	Early Milk	1310.7	13.66	0.01042	1310.7	0.01039	13.62
FS	Late Milk	1341.2	15.63	0.01178	1341.2	0.01039	13.94
Average FS		**1328.8**	**13.81**	**0.01039**	**1328.8**	**0.01039**	**13.81**
SW	Boot	1663.4	11.49	0.007013	1663.4	0.006168	10.26
SW	Flower	1883.5	10.6	0.005611	1883.5	0.006168	11.62
SW	Early Milk	2061.4	12.51	0.006069	2061.4	0.006168	12.71
Average SW		**1869.4**	**11.53**	**0.006168**	**1869.4**	**0.006168**	**11.53**

Sorghum Class: SS, Sorghum X Sudan Grass; FS, Forage Sorghum; SW, Sweet Sorghum.
Measured Parameters: sixth internode diameter (in.) x stalk count (11ft of one row, 2.5ft. x 11ft.); x plant height (in.).
Silage Yield: tons/a at 70% moisture content based on oven-dried sample.

Table 4.-Dryland Forage and Sweet Sorghums, Parameters and Constants for Silage Estimate, 2008.

Sorghum Class	Developmental Stage	Measured Parameters Product	Measured Silage Yield	Developmental Stage Constant	Measured Parameters Product	Class Constant	Estimated Silage Yield
			tons/a				tons/a
SS	Boot	1562.4	4.26	0.002727	1562.4	0.004402	6.88
SS	Flower	2049.0	7.94	0.003875	2049.0	0.004402	9.02
SS	Milk	2726.5	12.98	0.004761	2726.5	0.004402	12.00
SS	Soft Dough	2821.5	15.13	0.005362	2821.5	0.004402	12.42
Average SS		**2289.9**	**10.08**	**0.004402**	**2289.9**	**0.004402**	**10.08**
FS	Boot	1765.9	8.44	0.004778	1765.9	0.005384	9.51
FS	Flower	2293.3	12.75	0.005544	2293.3	0.005384	12.35
FS	Milk	2822.0	15.86	0.005620	2822.0	0.005384	15.19
Average FS		**2293.7**	**12.35**	**0.005384**	**2293.7**	**0.005384**	**12.35**
SW	Boot	1867.1	10.28	0.005541	1867.1	0.006262	11.69
SW	Flower	2310.6	15.87	0.006945	2310.6	0.006262	14.47
Average SW		**2088.9**	**13.08**	**0.006262**	**2088.9**	**0.006262**	**13.08**

Sorghum Class: SS, Sorghum X Sudan Grass; FS, Forage Sorghum; SW, Sweet Sorghum.
Measured Parameters: average of fifth and seventh internode diameters (in.) x stalk count (11ft of one row, 2.5ft. x 11ft.) x plant height (in.).
Silage Yield: tons/a at 70% moisture content based on oven-dried sample.

Table 5.-Dryland Forage and Sweet Sorghums, Single Plant Stalk Juice Yield, Walsh, 2007.

Brand	Hybrid/ Variety	Stage	Plant Density	Single Plant Stalk Juice	Stalk Sugar	Actual Stalk Juice Yield	Ethanol Prod.	Potent. Stalk Juice Yield	Potential Ethanol Production
			plants/a X1000	ml	%	gal/a	gal/a	gal/a	gal/a
	Corn								
Mycogen	2T801	Tassel	28.5	13	11	98	5.9	1178	71.3
	Forage Sorghum								
Sorghum Partners	Sordan 79	Boot	74.5	15	8	295	13.0	1696	74.6
Sorghum Partners	HiKane II	Boot	74.5	23	7.2	453	17.9	1396	55.3
(Check)	NB 305F	Boot	60.2	29	10.2	462	25.9	3065	172.0
Sorghum Partners	NK300	Boot	63.4	16	11	268	16.2	2629	159.1
	Sweet Sorghum								
Miss. State Univ.	Theis	Boot	44.4	60	13	704	50.3	3294	235.5
Miss. State Univ.	Dale	Boot	57.0	81	15	1222	100.8	4603	379.8
Miss. State Univ.	Topper 76-6	Boot	50.7	44	18.4	590	59.7	4228	427.9
Miss. State Univ.	M81-E	Pre Boot	44.4	31	16.2	364	32.4	3718	331.3
	Corn								
Mycogen	2T801	Silk	31.7	19	11	159	9.6	2693	162.9
	Forage Sorghum								
Sorghum Partners	Sordan 79	Flower	61.8	15	11.6	245	15.6	1435	91.5
Sorghum Partners	HiKane II	Flower	58.6	19	11.6	295	18.8	1918	122.4
(Check)	NB 305F	Flower	55.4	66	11.8	968	62.8	3428	222.5
Sorghum Partners	NK300	Flower	64.9	39	12.2	670	45.0	3739	250.9
	Sweet Sorghum								
Miss. State Univ.	Theis	Flower	44.4	65	15	763	62.9	3529	291.2
Miss. State Univ.	Dale	Flower	53.9	63	19	898	93.8	4557	476.2
	Corn								
Mycogen	2T801	Early Milk	25.3	19	12.2	127	8.6	2147	144.1
	Forage Sorghum								
Sorghum Partners	Sordan 79	Early Milk	57.0	19	13	287	20.5	1505	107.6
Sorghum Partners	HiKane II	Early Milk	53.9	32	13	456	35.6	2447	174.9
(Check)	NB 305F	Early Milk	47.5	63	19.2	792	83.6	3221	340.2
Sorghum Partners	NK300	Early Milk	50.7	18	15.8	241	21.0	2083	181.0
	Sweet Sorghum								
Miss. State Univ.	Theis	Early Milk	41.2	55	15.8	599	52.1	4276	371.6
	Corn								
Mycogen	2T801	Late Milk	23.8	33	11.2	207	12.8	2695	166.0
	Forage Sorghum								
Sorghum Partners	Sordan 79	Late Milk	50.7	18	13.8	241	18.3	1240	94.1
Sorghum Partners	HiKane II	Late Milk	53.9	24	11.8	342	22.2	2532	164.3
(Check)	NB 305F	Late Milk	55.4	41	10.2	601	33.7	2936	164.7
Sorghum Partners	NK300	Late Milk	53.9	24	15.4	342	29.0	3179	269.3
Average			51.2	35	13	470	35.9	2791	211.2

Table 6.-Dryland Forage and Sweet Sorghums, Final Harvest Silage, Stalk Juice Production, and Ethanol Production, Walsh, 2007.

Brand	Hybrid/ Variety	Stage	Stalk Sugar	Silage Yield	Actual Stalk Juice Yield	Ethanol Prod.	Juice Factor	Potential Stalk Juice Yield	Potential Ethanol Prod.	Final Harvest Juice Factor	Estimated Juice Yield	Estimated Ethanol Production
			%	ton/a	gal/a	gal/a		gal/a	gal/a		gal/a	gal/a
Forage Sorghum												
Sorghum Partners	Sordan 79	ED	12.9	15.1	154.3	10.9	128.1	1935	137.3	115.3	1742	123.6
Sorghum Partners	HiKane II	ED	14.0	18.8	348.8	26.9	113.0	2119	163.2	115.3	2162	166.5
(Check)	NB 305F	ED	15.7	20.9	364.7	31.5	91.7	1912	165.1	115.3	2405	207.7
Sorghum Partners	NK300	ED	14.0	16.0	121.6	9.4	91.5	1464	112.7	115.3	1845	142.0
Forage Sorghum Average		**ED**	**14.2**	**17.7**	**247.4**	**19.7**	**106.1**	**1858**	**144.6**	**115.3**	**2039**	**160.0**
Sweet Sorghum												
Miss. State Univ.	Theis	EM	16.0	17.2	289.9	25.5	141.2	2432	214.0	115.3	1985	174.7
Miss. State Univ.	Dale	FL	17.3	19.2	371.5	35.3	104.1	1995	189.8	115.3	2210	210.3
Miss. State Univ.	Topper 76-6	BT	20.8	16.4	166.7	19.1	113.4	1865	213.3	115.3	1896	216.8
Miss. State Univ.	M81-E	Pre BT	15.2	16.9	173.4	14.5	139.2	2358	197.1	115.3	1953	163.3
Sweet Sorghum Average		**FL**	**17.3**	**17.4**	**250.4**	**23.6**	**124.5**	**2162**	**203.6**	**115.3**	**2011**	**191.3**
Average			15.7	17.6	248.9	21.6	115.3	2010	174.1	115.3	2025	175.6
LSD 0.20			0.84	2.82	66.4							

Planted: June 5 at 69.7 seeds/a x 1000. Harvest Area: 21.75 ft. x 2.5 ft.
Stage: Pre BT, pre boot; BT, boot; FL, flowering; EM, early milk; LM, late milk; ED, early dough.
Silage Yield was adjusted to 70% moisture content based on oven-dried sample.
Juice Factor is the product of all the conversions from Silage Yield (tons/a @ 70% MC) to Potential Juice Yield (gal/a).
Ethanol Production is Brix(0.55)/100 times Juice Yield.

Table 7.-Dryland Forage and Sweet Sorghums, Final Harvest Silage and Potential Ethanol Production, Walsh, 2008.

Brand	Hybrid/ Variety	Harvest Stage	Silage Yield	Juice Factor	Juice Yield	Stalk Brix Reading	Potential Alcohol	Potential Ethanol Prod.	Final Harvest Juice Factor	Estimated Juice Yield	Estimated Ethanol Production
			tons/a 70% MC		gal/a	%	% v/v	gal/a		gal/a	gal/a
Forage Sorghum											
Sorghum Partners	Sordan 79	SD	15.13	178.9	2707	10.7	5.42	146.7	188.8	2857	154.8
Sorghum Partners	HiKane II	MM	15.48	179.4	2778	15.1	8.06	223.9	188.8	2923	235.6
(Check)	NB 305F	MM	16.24	177.4	2881	17.8	9.68	278.9	188.8	3066	296.8
Sorghum Partners	NK300	FL	18.99	202.3	3841	11.8	6.08	233.6	188.8	3585	218.0
Forage Sorghum Average		**MM**	**16.46**	**184.5**	**3052**	**13.9**	**7.31**	**220.8**	**188.8**	**3108**	**226.3**
Sweet Sorghum											
Miss. State Univ.	Theis	FL	14.14	187.7	2654	14.2	7.52	199.6	188.8	2670	200.8
Miss. State Univ.	Dale	FL	15.03	185.9	2794	13.9	7.34	205.1	188.8	2838	208.3
Miss. State Univ.	Topper 76-6	FL	15.85	174.4	2765	16.5	8.90	246.1	188.8	2992	266.3
Miss. State Univ.	M81-E	FL	18.47	224.7	4150	10.6	5.36	222.5	188.8	3487	186.9
Sweet Sorghum Averge		**FL**	**15.87**	**193.2**	**3091**	**13.8**	**7.28**	**218.3**	**188.8**	**2997**	**215.6**
Overall Average			16.17	188.8	3071	13.8	7.30	219.6	188.8	3052	220.9
LSD 0.20			2.87								

Planted: June 30 at 69.7 seeds/a x 1000; Silage Harvested: October 27.
Harvest Stage: BT, boot; FL, flowering; PM, pre-milk; EM, early milk; MM, mid milk; LM, late milk; ED, early dough; SD, soft dough; HD, hard dough.
Juice Factor is the product of all the conversions from Silage Yield (tons/a @ 70% MC) to Juice Yield (gal/a).
Stock Brix Reading is the average refractometer juice reading from the 5th and 7th internodes.
Potential Ethanol Production is Juice Yield times potential alcohol % v/v, Brix(0.6) - 1.

Table 8.-Forage and Sweet Sorghums: Silage, Plant Measurements, and Juice Factor Determinations at Boot, 2008.

Hybrid/ Variety	Silage Yield	Dry Silage Yield	Whole Plant Moist.	Wet Silage Yield	Wet Stalk to Plant	Wet Stalk Yield	Stalk Moist.	Stalk Water	Stalk Brix Reading	Stalk Sugar Yield	Stalk Juice Yield	Stalk Juice Conver.	Stalk Juice Yield	Juice Factor
	tons/a (70% MC)	lb/a	ratio	lb/a	ratio	lb/a	ratio	lb/a	%	lb/a	lb/a	lb/gal	gal/a	
Sordan 79	4.26	2556	0.8531	17400	0.7638	13290	0.8791	11683	4.1	500	12183	8.4624	1440	338.0
HiKane II	7.38	4428	0.8618	32041	0.7646	24499	0.8914	21838	4.4	1005	22843	8.4724	2696	365.2
NB 305F	8.69	5214	0.8529	35445	0.7209	25553	0.8662	22134	7.8	1872	24006	8.5863	2797	321.8
NK 300	9.24	5544	0.8397	34585	0.6236	21567	0.8684	18729	8.2	1673	20402	8.5997	2373	256.8
FS Average	**7.39**	**4436**	**0.8519**	**29868**	**0.7182**	**21227**	**0.8763**	**18596**	**6.1**	**1263**	**19859**	**8.5302**	**2327**	**320.5**
Theis	10.62	6372	0.8101	33554	0.7870	26407	0.8299	21915	9.4	2275	24190	8.6399	2799	263.5
Dale	8.85	5310	0.8127	28350	0.7524	21331	0.8363	17838	11.1	2229	20067	8.6969	2308	260.8
Topper 76-6	11.3	6780	0.8150	36649	0.7281	26684	0.8342	22260	10.4	2584	24844	8.6734	2865	253.5
M81-E	10.35	6210	0.8264	35772	0.7729	27648	0.8441	23338	8.0	2030	25368	8.5930	2953	285.3
SW Average	**10.28**	**6168**	**0.8161**	**33581**	**0.7601**	**25518**	**0.8361**	**21338**	**9.7**	**2280**	**23617**	**8.6508**	**2731**	**265.8**
BT Average	8.84	5302	0.8340	31725	0.7392	23372	0.8562	19967	7.9	1771	21738	8.5905	2529	293.1

Whole Plant Moisture and Stalk Moisture are from oven-dried deconstructed plant sample.
Wet Stalk to Plant ratio is from deconstructed plant sample.
Stalk Juice Yield (lb/a) is Stalk Water divide by 100-Brix/100.
Stalk Juice Conversion (lb/gal) is Stalk Juice Yield (lb/a) divided by lb/gal at various Brix readings, 0.335(Brix) + 8.325 lb/gal, i.e., stalk sugar + stalk water in lb/gal.
Stalk Juice Yield (gal/a) is Stalk Juice Yield (lb/a) divided by Stalk Juice Conversion (lb/gal).
Juice Factor is Stalk Juice Yield (gal/a) divided by Silage Yield (tons/a @ 70% MC).

Table 9.-Forage and Sweet Sorghums: Silage, Plant Measurements, and Juice Factor Determinations at Flowering, 2008.

Hybrid/ Variety	Silage Yield	Dry Silage Yield	Whole Plant Moist.	Wet Silage Yield	Wet Stalk to Plant	Wet Stalk Yield	Stalk Moist.	Stalk Water	Stalk Brix Reading	Stalk Sugar Yield	Stalk Juice Yield	Stalk Juice Conver.	Stalk Juice Yield	Juice Factor
	tons/a (70% MC)	lb/a	ratio	lb/a	ratio	lb/a	ratio	lb/a	%	lb/a	lb/a	lb/gal	gal/a	
Sordan 79	7.94	4764	0.8369	29209	0.7324	21393	0.8735	18687	5.7	1128	19815	8.5160	2326	293.0
HiKane II	10.85	6510	0.8296	38204	0.7784	29738	0.8567	25477	7.8	2155	27632	8.5863	3219	296.7
NB 305F	13.68	8208	0.7833	37878	0.7533	28533	0.8038	22935	14.1	3764	26699	8.7974	3036	221.9
NK 300	18.99	11394	0.7861	53268	0.6751	35961	0.8214	29539	11.8	3952	33491	8.7203	3841	202.3
FS Average	**12.87**	**7719**	**0.8090**	**39640**	**0.7348**	**28906**	**0.8389**	**24160**	**9.9**	**2750**	**26909**	**8.6550**	**3106**	**253.5**
Theis	14.14	8484	0.7405	32694	0.8127	26570	0.7543	20042	14.2	3317	23359	8.8007	2654	187.7
Dale	15.03	9018	0.7510	36217	0.7720	27960	0.7561	21140	13.9	3412	24552	8.7907	2794	185.9
Topper 76-6	15.85	9510	0.7399	36563	0.7497	27411	0.7480	20504	16.5	4051	24555	8.8778	2765	174.4
M81-E	18.47	11082	0.7799	50350	0.7999	40275	0.7997	32208	10.6	3820	36028	8.6801	4150	224.7
SW Average	**15.87**	**9524**	**0.7528**	**38956**	**0.7836**	**30554**	**0.7645**	**23474**	**13.8**	**3650**	**27124**	**8.7873**	**3091**	**193.2**
FL Average	14.37	8621	0.7809	39298	0.7592	29730	0.8017	23817	11.8	3200	27016	8.7212	3098	223.3

Whole Plant Moisture and Stalk Moisture are from oven-dried deconstructed plant sample.
Wet Stalk to Plant ratio is from deconstructed plant sample.
Stalk Juice Yield (lb/a) is Stalk Water divide by 100-Brix/100.
Stalk Juice Conversion (lb/gal) is Stalk Juice Yield (lb/a) divided by lb/gal at various Brix readings, 0.335(Brix) + 8.325 lb/gal, i.e., stalk sugar + stalk water in lb/gal.
Stalk Juice Yield (gal/a) is Stalk Juice Yield (lb/a) divided by Stalk Juice Conversion (lb/gal).
Juice Factor is Stalk Juice Yield (gal/a) divided by Silage Yield (tons/a @ 70% MC).

Table 10.-Forage and Sweet Sorghums: Silage, Plant Measurements, and Juice Factor Determinations at Milk and Dough, 2008.

Hybrid/ Variety	Silage Yield	Dry Silage Yield	Whole Plant Moist.	Wet Silage Yield	Wet Stalk to Plant	Wet Stalk Yield	Stalk Moist.	Stalk Water	Stalk Brix Reading	Stalk Sugar Yield	Stalk Juice Yield	Stalk Juice Conver.	Stalk Juice Yield	Juice Factor
	tons/a (70% MC)	lb/a	ratio	lb/a	ratio	lb/a	ratio	lb/a	%	lb/a	lb/a	lb/gal	gal/a	
Stage at Harvest: Milk														
Sordan 79	12.98	7788	0.7135	27183	0.7649	20793	0.7609	15821	12.7	2302	18123	8.7505	2071	159.6
HiKane II	15.48	9288	0.7333	34825	0.7968	27748	0.7507	20831	15.1	3706	24537	8.8309	2778	179.4
NB 305F	16.24	9744	0.7402	37506	0.7479	28051	0.7532	21128	17.8	4576	25704	8.9213	2881	177.4
Milk Average	**14.90**	**8940**	**0.7290**	**33171**	**0.7699**	**25531**	**0.7549**	**19260**	**15.2**	**3528**	**22788**	**8.8342**	**2577**	**172.1**
Stage at Harvest: Soft Dough														
Sordan 79	15.13	9078	0.7421	35200	0.7597	26741	0.7846	20981	10.7	2514	23495	8.6835	2707	178.9
FS Average	14.96	8975	0.7323	33679	0.7673	25833	0.7624	19690	14.1	3275	22965	8.7966	2609	173.8

Whole Plant Moisture and Stalk Moisture are from oven-dried deconstructed plant sample.
Wet Stalk to Plant ratio is from deconstructed plant sample.
Stalk Juice Yield (lb/a) is Stalk Water divide by 100-Brix/100.
Stalk Juice Conversion (lb/gal) is Stalk Juice Yield (lb/a) divided by lb/gal at various Brix readings, 0.335(Brix) + 8.325 lb/gal, i.e., stalk sugar + stalk water in lb/gal.
Stalk Juice Yield (gal/a) is Stalk Juice Yield (lb/a) divided by Stalk Juice Conversion (lb/gal).
Juice Factor is Stalk Juice Yield (gal/a) divided by Silage Yield (tons/a @ 70% MC).

Table 11.-Dryland Forage and Sweet Sorghums, Silage and Potential Ethanol Production at Boot, Walsh, 2008.

Brand	Hybrid/ Variety	Stage	Silage Yield	Juice Factor	Juice Yield	Stalk Brix Reading	Potential Alcohol	Potential Ethanol Prod.	Class Juice Factor	Estimated Juice Yield	Estimated Ethanol Production
			tons/a 70% MC		gal/a	%	% v/v	gal/a		gal/a	gal/a
Forage Sorghum											
Sorghum Partners	Sordan 79	BT	4.26	338.0	1440	4.1	1.46	21.0	320.5	1365	19.9
Sorghum Partners	HiKane II	BT	7.38	365.2	2695	4.4	1.64	44.2	320.5	2365	38.8
(Check)	NB 305F	BT	8.69	321.8	2796	7.8	3.68	102.9	320.5	2785	102.5
Sorghum Partners	NK300	BT	9.24	256.8	2373	8.2	3.92	93.0	320.5	2961	116.1
Forage Sorghum Average		**BT**	**7.39**	**320.5**	**2326**	**6.1**	**2.68**	**65.3**	**320.5**	**2369**	**69.3**
Sweet Sorghum											
Miss. State Univ.	Theis	BT	10.62	263.5	2798	9.4	4.64	129.8	265.8	2823	131.0
Miss. State Univ.	Dale	BT	8.85	260.8	2308	11.1	5.66	130.6	265.8	2352	133.1
Miss. State Univ.	Topper 76-6	BT	11.3	253.5	2865	10.4	5.24	150.1	265.8	3004	157.4
Miss. State Univ.	M81-E	BT	10.35	285.3	2953	8.0	3.80	112.2	265.8	2751	104.5
Sweet Sorghum Average		**BT**	**10.28**	**265.8**	**2731**	**9.7**	**4.84**	**130.7**	**265.8**	**2732**	**131.5**
Boot Average			8.84	293.1	2529	7.9	3.76	98.0	293.2	2551	100.4

Planted: June 30 at 69.7 seeds/a x 1000.

Harvest Stage: BT, boot; FL, flowering; PM, pre-milk; EM, early milk; MM, mid milk; LM, late milk; ED, early dough; SD, soft dough; HD, hard dough.

Juice Factor is the product of all the conversions from Silage Yield (tons/a @ 70% MC) to Juice Yield (gal/a).

Stalk Brix Reading is the average refractometer juice reading from the 5th and 7th internodes.

Potential Ethanol Production is Juice Yield times potential alcohol % v/v, Brix(0.6) - 1.

Table 12.-Dryland Forage and Sweet Sorghums, Silage and Potential Ethanol Production at Flowering, Walsh, 2008.

Brand	Hybrid/ Variety	Stage	Silage Yield	Juice Factor	Juice Yield	Stalk Brix Reading	Potential Alcohol	Potential Ethanol Prod.	Class Juice Factor	Estimated Juice Yield	Estimated Ethanol Production
			tons/a 70% MC		gal/a	%	% v/v	gal/a		gal/a	gal/a
Forage Sorghum											
Sorghum Partners	Sordan 79	FL	7.94	293.0	2326	5.7	2.42	56.3	253.5	2013	48.7
Sorghum Partners	HiKane II	FL	10.85	296.7	3219	7.8	3.68	118.5	253.5	2750	101.2
(Check)	NB 305F	FL	13.68	221.9	3036	14.1	7.46	226.5	253.5	3468	258.7
Sorghum Partners	NK300	FL	18.99	202.3	3842	11.8	6.08	233.6	253.5	4814	292.7
Forage Sorghum Average		**FL**	**12.87**	**253.5**	**3106**	**9.9**	**4.91**	**158.7**	**253.5**	**3261**	**175.3**
Sweet Sorghum											
Miss. State Univ.	Theis	FL	14.14	187.7	2654	14.2	7.52	199.6	193.2	2732	205.4
Miss. State Univ.	Dale	FL	15.03	185.9	2794	13.9	7.34	205.1	193.2	2904	213.1
Miss. State Univ.	Topper 76-6	FL	15.85	174.4	2764	16.5	8.90	246.0	193.2	3062	272.5
Miss. State Univ.	M81-E	FL	18.47	224.7	4150	10.6	5.36	222.5	193.2	3568	191.3
Sweet Sorghum Average		**FL**	**15.87**	**193.2**	**3091**	**13.8**	**7.28**	**218.3**	**193.2**	**3067**	**220.6**
Flowering Average			14.37	223.3	3098	11.8	6.10	188.5	223.4	3164	198.0

Planted: June 30 at 69.7 seeds/a x 1000.
Harvest Stage: BT, boot; FL, flowering; PM, pre-milk; EM, early milk; MM, mid milk; LM, late milk; ED, early dough; SD, soft dough; HD, hard dough.
Juice Factor is the product of all the conversions from Silage Yield (tons/a @ 70% MC) to Juice Yield (gal/a).
Stalk Brix Reading is the average refractometer juice reading from the 5th and 7th internodes.
Potential Ethanol Production is Juice Yield times potential alcohol % v/v, Brix(0.6) - 1.

Table 13.-Dryland Forage and Sweet Sorghums, Silage and Potential Ethanol Production at Milk and Dough, Walsh, 2008.

Brand	Hybrid/ Variety	Stage	Silage Yield	Juice Factor	Juice Yield	Stalk Brix Reading	Potential Alcohol	Potential Ethanol Prod.	Class Juice Factor	Estimated Juice Yield	Estimated Ethanol Production
			tons/a 70% MC		gal/a	%	% v/v	gal/a		gal/a	gal/a
Forage Sorghum											
Sorghum Partners	Sordan 79	MM	12.98	159.6	2072	12.7	6.62	137.1	172.1	2234	147.9
Sorghum Partners	HiKane II	MM	15.48	179.4	2777	15.1	8.06	223.8	172.1	2664	214.7
(Check)	NB 305F	MM	16.24	177.4	2881	17.8	9.68	278.9	172.1	2795	270.5
FS at Mid-Milk Average		**MM**	**14.90**	**172.1**	**2577**	**15.2**	**8.12**	**213.3**	**172.1**	**2564**	**211.1**
Forage Sorghum											
Sorghum Partners	Sordan 79	SD	15.13	178.9	2707	10.7	5.42	146.7	173.8	2630	142.5
Average			14.96	173.8	2609	14.1	7.45	196.6	172.5	2581	193.9

Planted: June 30 at 69.7 seeds/a x 1000.
Harvest Stage: BT, boot; FL, flowering; PM, pre-milk; EM, early milk; MM, mid milk; LM, late milk; ED, early dough;
SD, soft dough; HD, hard dough.
Juice Factor is the product of all the conversions from Silage Yield (tons/a @ 70% MC) to Juice Yield (gal/a).
Stalk Brix Reading is the average refractometer juice reading from the 5th and 7th internodes.
Potential Ethanol Production is Juice Yield times potential alcohol % v/v, Brix(0.6) - 1.

Table 14.--Dryland Grain Sorghum Hybrid Performance and Ethanol Production Trial at Walsh, 2007. \1

Brand	Hybrid	Days to Emerge	50% Bloom DAP	50% Bloom GDD	50% Mature DAP	50% Mature Group	Plant Ht.	Harvest Density	Test Wt.	Grain Yield	Ethanol Yield	Total Ethanol Prod.
							in	plants/a (1000 X)	lb/bu	bu/a	gal/bu	gal/a
High Starch Hybrids												
NC+	NC+ 7C22	8	70	1879	109	ME	43	29.4	62	66	2.46	161.1
NC+	NC+ 5B89	8	65	1712	103	E	41	27.1	62	62	2.41	149.2
NC+	NC+ Y363	8	69	1845	107	ME	42	25.2	61	60	2.47	148.7
NC+	NC+ 6B50	9	80	2191	122	M	42	27.9	60	61	2.37	144.8
NC+	NC+ 5C35	7	61	1592	98	E	38	22.5	60	55	2.37	129.4
Average High Starch Hybrids		**8**	**69**	**1844**	**108**	**ME**	**41**	**26.4**	**61**	**61**	**2.42**	**146.6**
Standard Starch Hybrids												
SORGHUM PARTNERS	NK5418	8	69	1845	107	ME/M	38	26.3	61	72	2.43	175.9
ASGROW	Pulsar	9	64	1683	105	E	41	24.4	61	63	2.42	153.4
DEKALB	DKS29-28	9	62	1624	100	E	38	27.9	61	61	2.50	152.5
SORGHUM PARTNERS	NK4420	9	72	1944	112	ME	38	27.9	62	61	2.50	151.8
DEKALB	DKS37-07	9	72	1944	112	ME	41	24.4	62	62	2.35	145.0
SORGHUM PARTNERS	KS310	7	66	1743	104	E	39	29.0	61	54	2.41	130.1
SORGHUM PARTNERS	251	8	54	1401	92	E	35	30.2	60	50	2.32	116.7
Average Standard Starch Hybrids		**8**	**66**	**1741**	**105**	**E**	**39**	**27.2**	**61**	**61**	**2.42**	**146.5**
Overall Average		8	67	1784	106	ME	40	26.9	61	61	2.4	146.6
LSD 0.20										4.1		

\1 Planted: June 5; Harvested: October 29, 2007.
Yields are adjusted to 14.0% seed moisture content.
DAP: Days After Planting or maturation of seed at first freeze.
Seed Maturation: EM, early milk; MM, mid milk; LM, late milk; ED, early dough; SD, soft dough; HD, hard dough; mature (DAP).
GDD: Growing Degree Days for sorghum.
Maturity Group: E, early; ME, medium early; M, medium; ML, medium late; L, late.
Ethanol Yield was derived from 7 lb grain samples that was milled, cooked, malted, fermented, and distilled.

Table 15.--Dryland Grain Sorghum Hybrid Performance and Ethanol Production Trial at Walsh, 2008. \1

Brand	Hybrid	Days to Emerge	50% Bloom DAP	50% Bloom GDD	50% Mature DAP	50% Mature Group	Plant Ht.	Harvest Density	Test Wt.	Grain Yield	Ethanol Yield	Total Ethanol Prod.
							in	plants/a (1000 X)	lb/bu	bu/a	gal/bu	gal/a
High Starch Hybrids												
NC+	NC+ 6B50	7	73	1894	118	M	42	24.6	58	75	2.54	190.0
NC+	NC+ Y363	8	72	1870	117	M/ME	44	21.7	59	73	2.41	176.4
NC+	NC+ 7C22	8	71	1854	117	M	42	24.0	60	71	2.42	172.1
NC+	NC+ 5C35	8	58	1607	106	E	37	23.8	61	71	2.31	163.5
NC+	NC+ 5B89	8	67	1806	115	ME	39	22.5	58	69	2.47	171.4
Average High Starch Hybrids		**8**	**68**	**1806**	**115**	**ME**	**41**	**23.3**	**59**	**72**	**2.43**	**174.7**
Standard Starch Hybrids												
SORGHUM PARTNERS	NK5418	7	70	1840	117	M	40	23.5	59	77	2.63	202.0
ASGROW	Pulsar	7	62	1698	112	E	44	26.9	60	75	2.43	181.0
DEKALB	DKS37-07	8	69	1830	115	ME	42	25.4	59	75	2.55	190.0
DEKALB	DKS29-28	8	61	1678	113	E	33	24.2	60	65	2.39	156.3
SORGHUM PARTNERS	KS310	8	64	1747	114	ME/E	42	23.1	59	63	2.36	149.2
SORGHUM PARTNERS	251	8	55	1514	102	E	33	23.7	60	49	2.28	111.7
Average Standard Starch Hybrids		**8**	**64**	**1718**	**112**	**E**	**39**	**24.5**	**60**	**67**	**2.44**	**165.0**
Average		8	66	1758	113	ME	40	23.9	59	69	2.44	169.4
LSD 0.20										6.6		

\1 Planted: June 10; Harvested: November 25, 2008.

Yields are corrected to 14.0% seed moisture content.

DAP: Days After Planting or maturation of seed at first freeze.

Seed Maturation: EM, early milk; MM, mid milk; LM, late milk; ED, early dough; SD, soft dough; HD, hard dough; mature (DAP).

GDD: Growing Degree Days for sorghum.

Maturity Group: E, early; ME, medium early; M, medium; ML, medium late; L, late.

This study was pre-irrigated with about 8 in./a of furrow irrigation to ensure stand establishment.

Ethanol Yield was derived from 7 lb grain samples that was milled, cooked, malted, fermented, and distilled.

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