# Feasibility of Obtaining Two Crops of Sweet Sorghum for Ethanol, MAC, 2006

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## Abstract

*Sweet sorghum has potential as an energy crop in the Southwest since, compared to corn, it requires less fertilizer and water, is cheaper to grow, and requires less energy to process into ethanol. The purpose of this study is to determine the feasibility of obtaining two crops of sweet sorghum from a single seeding. Two cultivars of sweet sorghum were seeded at early and late dates at the Maricopa Agricultural Center in 2006. Two crops of sweet sorghum were obtained in our study with a short season cultivar Bundle King, but not with the longer season cultivar MMR 327/36. The ethanol yield of Bundle King of 213 gal/acre from two crops planted on April 7 was not significantly greater statistically than the ethanol yield of 162 gal/acre from a single crop planted on June 1. Bundle King is an inherently low yielding variety, as are most short season sweet sorghum cultivars that may be used for double cropping. Thus, the problem with double cropping is identifying a suitable cultivar along with increased harvest costs, despite the advantage of providing a more even supply of feedstock to an ethanol plant.*

## Introduction

Sweet sorghum is a potential crop for producing ethanol in the Southwest. The advantage of sweet sorghum compared with corn is that it requires less fertilizer, water, and pesticides and is cheaper to grow. It also does not have the aflatoxin problem that corn for grain does. The juice pressed from the stem contains fermentable sugars and thus, the step of breaking down the starch to sugar required in corn and other grains is bypassed.

The purpose of this study is to determine the feasibility of obtaining two crops of sweet sorghum from a single seeding.

## Materials and Methods

The experiment was conducted on a Casa Grande sandy clay loam soil during the 2006 growing season. Sweet sorghum varieties Bundle King (Browning Seed) and MMR 327/36 (Richardson Seed) were planted on April 7, 2006 and June 1, 2006 at the Maricopa Agricultural Center, Field 17, Borders 1-6. A second cutting was planned for the April 7 planting date and the sum of the two cuttings at this date compared to a single cutting from June 1 planting date. Seed was planted 3.125 inches apart in 40-inch rows for a rate of 50,181 seeds/A (or about 2.5 lbs seed/A) using a Monosem air planter. Plots were 4 rows wide and 600 feet long. The experimental design was a split plot with 2 planting dates as main plots, 2 varieties as subplots, and 3 replications.

The seed was planted dry on flat ground and irrigated using the border flood method. Subsequent irrigations were on about a 2-week schedule once the crop was well-established. Urea (46-0-0) was applied at a rate of 46 lbs N/acre at planting and at the 1$^{st}$ and 2$^{nd}$ or 2$^{nd}$ and 3$^{rd}$ irrigations after emergence. The plots were harvested about 30 days after anthesis. We were not able to obtain two cuttings from the April 7 planting date for MMR 327/36 since it was too late-maturing to fit into a two-cut regime. The irrigation, fertilization, and harvest schedule for each planting date is presented in Table 1.

We hand-harvested 5 ft of the two center rows of each plot in four different areas for a total of 40 ft of row harvested per plot. The plants were harvested by cutting the stalks about 2 inches above ground with a machete. The entire plants were weighed, and moisture estimated from a sample of five plants that was shredded and oven-dried. A sub-sample of 10 plants had the head removed, leaves stripped, and juice squeezed from the stalks. The juice was weighed and sugar content estimated from the BRIX reading. The heads, leaves, and bagasse (remainder of stalks after juicing) were oven-dried for estimation of dry weight. Potential ethanol yield was estimated by assuming that the BRIX reading represents total fermentable sugars, the maximum theoretical conversion of 0.5 pound of ethanol per pound of sugar would be achieved, and a specific gravity of 6.59 lbs/gal of ethanol. The feeding potential of the by-products from the first harvest was evaluated by measuring acid detergent fiber (ADF), neutral detergent fiber (NDF), and crude protein. In the two-cutting regime, the plants remaining after the hand-harvest were cut with a forage swather (with the crimpers removed) to a height of 6 inches. The stalks were then picked up and removed with a side-mount forage chopper that blew the forage into a wagon.

## Results and Discussion

Two crops of sweet sorghum were obtained in our study with a short season cultivar Bundle King, but not with the longer season cultivar MMR 327/36 (Table 2). The first cutting of Bundle King was earlier than optimum, about 21 days after flowering instead of the recommended 30 days, in order to insure a viable second crop. However, in retrospect, it probably was not necessary to cut this early since the second cutting was obtained on October 21, well ahead of the average date of the first frost. So, the yield from the first cutting was probably lower than could be expected from a later cutting time.

At harvest, the dry weight of the plant is composed of about 78% stalk, 16% leaves, and 6% heads (Table 3). The crop moisture content is about 67 to 74%, which is a good range for making silage. The bagasse contained about 70% moisture, so there is potential for higher ethanol yields if more juice can be extracted from the stalk. The feeding quality of the sweet sorghum plant at harvest is relatively poor (Table 4), but it could be used as a source of roughage.

If two crops of sweet sorghum are to be obtained, it is important to plant as early as possible and use a cultivar of the appropriate maturity. The early planting may not be optimum for a single crop, but necessary in a double cropping system. In our study, ethanol yield for Bundle King was statistically similar for the early and later planting dates. The later maturing variety, MMR 327/36, was too late maturing for the later planting date where the crop was killed by frost before maturing.

Tthe ethanol yield from two crops planted on April 7 was not significantly greater than the ethanol yield from a single crop planted on June 1. The disadvantage of two crops is greater growing and harvest costs, but the advantage is a more even supply of feedstock for an ethanol plant.

A potential problem in the double cropping system is identifying a high yielding, early season cultivar. In a sweet sorghum variety trial conducted in Tucson, Bundle King ranked in the bottom 6$^{th}$ of all 30 varieties tested and yielded about 179 gallons of ethanol per acre, similar to the 162 gallons per acre obtained in this study at a June 1 planting date (Wittenberg, 2007). Short season varieties are inherently low-yielding, and are usually forage types, which were not bred for sugar yield per se and do not have much potential for producing ethanol.

In summary, it is possible to obtain two crops of sweet sorghum in a single season from one seeding of a short season cultivar, but there may not be a yield advantage compared to a single cutting of a longer season cultivar.

## References

Wittenberg, E. 2007. Preliminary evaluation of sweet sorghum (*Sorghum bicolor* (L.) Moench) as a feedstock for ethanol production in Arizona. MS Thesis. Plant Sciences Department, University of Arizona, Tucson.

Table 1. Irrigation and fertilization dates and amounts for the single and double crop harvest systems and early and late planting dates.

| Harvest system | Planting date | Variety | Cutting date | Irrigation dates | Irrigation amounts | Fertilizer dates | Fertilizer amounts |
|---|---|---|---|---|---|---|---|
| | | | | | inches | | lbs N/A |
| | | | | | | | |
| Double crop | April 7 | Bundle King | July 26 | 4/7, 4/14, 5/12, 6/1, 6/16, 6/30, 7/14 | 42 | 4/7, 6/1, 6/16 | 138 |
| | | | Oct 24 | 7/28, 8/11, 8/25, 9/22, 10/13 | 30 | 7/28, 8/25, 9/22 | 138 |
| | | | Total or Avg | --- | 72 | --- | 276 |
| | | MMR 327/36 | Too late maturing | --- | --- | --- | --- |
| | | | | | | | |
| Single Crop | April 7 | Bundle King | July 26 | 4/7, 4/14,5/12, 6/1, 6/16, 6/30, 7/14 | 42 | 4/7, 6/1, 6/16 | 138 |
| | | MMR 327/36 | July 26 | 4/7, 4/14,5/12, 6/1, 6/16, 6/30, 7/14 | 72 | 7/28, 8/25, 9/22 | 276 |
| | | MMR 327/36 | Oct 24 | 4/7, 4/14,5/12, 6/1, 6/16, 6/30, 7/14, 7/28, 8/11, 8/25, 9/22, 10/13 | 72 | 4/7, 6/1, 6/16, 7/28, 8/25, 9/22 | 276 |
| | | | | | | | |
| Single Crop | June 1 | Bundle King | Sept 18 | 6/1, 6/16, 6/30, 7/14, 7/28, 8/11, 8/25, | 42 | 4/7, 6/30, 7/14 | 138 |
| | | MMR 327/36 | Dec 12 | 6/1, 6/16, 6/30, 7/14, 7/28, 8/11, 8/25, 9/22, 10/13, 11/3 | 60 | 4/7, 6/30, 7/14 | 138 |

Table 2. Yield of forage, sugar, and ethanol calculated from juice extraction from sweet sorghum stalks grown in a single or double crop system.

| Harvest system | Planting date | Variety | Cutting date | Flowering date | Forage yield | Stalks | Juice* | Juice | Juice | Brix | Sugar yield | Estimated ethanol yield |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | T/acre | % of total | lbs/A | % of total | % of stalks | % | lbs/A | gal/A |
| | | | | | | | | | | | | |
| Double crop | April 7 | Bundle King | July 26 | July 5 | 18.4 | 76 | 12,756 | 30 | 48 | 12.2 | 1552 | 118 |
| | | | Oct 24 | Sep 20 | 15.9 | 77 | 7,968 | 24 | 40 | 15.7 | 1247 | 95 |
| | | | Total or Avg | --- | 34.3 | 77 | 20,724 | 27 | 44 | 13.9 | 2799 | 213 |
| | | | | | | | | | | | | |
| Single Crop | April 7 | Bundle King | Jul 26 | July 5 | 18.4 | 76 | 12,756 | 30 | 48 | 12.2 | 1552 | 118 |
| | | MMR 327/36 | Jul 26 | Sep 18 | 13.4 | 69 | 8,407 | 20 | 34 | 7.1 | 596 | 45 |
| | | MMR 327/36 | Oct 24 | Sep 18 | 35.1 | 76 | 12,655 | 20 | 38 | 15.6 | 1979 | 150 |
| | | | | | | | | | | | | |
| Single Crop | June 1 | Bundle King | Sep 18 | Aug 19 | 24.0 | 79 | 14,700 | 29 | 46 | 14.6 | 2137 | 162 |
| | | MMR 327/36 | Dec 12 | Oct 11 | 24.8 | 89 | 3,261 | 8 | 14 | 15.7 | 504 | 38 |
| | | | | | | | | | | | | |
| | | | LSD.10 | --- | 11.1 | 3.6 | 4,286 | 2.8 | 5.2 | 2.3 | 764 | 58 |

* The specific weight of the juice for sweet sorghum planted on April 7 and harvested on July 26 was 8.695 lbs/gallon for Bundle King (not presented above) and 8.658 lbs/gallon for MMR 327/36.

Table 3. Relative contribution of various plant parts to the total plant composition and moisture content of these plant parts as affected by a single or double crop system.

| | | | | Plant Composition* | | | | | Moisture Content | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Harvest system | Planting date | Variety | Cutting date | Leaf | Head | Stalk | Bagasse | Juice | Leaf | Head | Bagasse | Entire Plant |
| | | | | ---------- % ---------- | | | | | | | | |
| Double crop | April 7 | Bundle King | Jul 26 | 18.3 | 4.0 | 77.6 | 45.1 | 30.3 | 70.4 | 57.1 | 72.8 | 73.9 |
| | | | Oct 24 | 14.9 | 7.0 | 78.1 | 51.7 | 24.1 | 70.8 | 64.1 | 67.9 | 71.0 |
| | | | Avg | 16.6 | 5.5 | 77.9 | 48.4 | 27.2 | 70.6 | 60.6 | 70.3 | 72.5 |
| Single Crop | April 7 | Bundle King | Jul 26 | 18.3 | 4.0 | 77.6 | 45.1 | 30.3 | 70.4 | 57.1 | 72.8 | 71.0 |
| | | MMR 327/36 | Jul 26 | 27.9 | 0.5 | 71.5 | 49.0 | 20.3 | 70.8 | 54.4 | 80.3 | 80.5 |
| | | MMR 327/36 | Oct 24 | 19.4 | 2.5 | 78.1 | 40.3 | 19.8 | 60.8 | 49.7 | 58.8 | 67.0 |
| Single Crop | June 1 | Bundle King | Sept 18 | 14.4 | 5.8 | 79.8 | 41.3 | 28.6 | 69.1 | 61.8 | 67.7 | 72.0 |
| | | MMR 327/36 | Dec 12 | 0.2 | 0.2 | 99.5 | 84.7 | 8.5 | 2.1 | 8.0 | 63.8 | 59.6 |
| | | | LSD.10 | 2.8 | 1.0 | 3.0 | 10.2 | 2.8 | 5.3 | 6.8 | 7.6 | 4.7 |

* Plant composition is expressed as a percent of dry weight, except for juice which is expressed as a percent of fresh weight.

Table 4. Feeding quality, moisture content, and relative composition of various parts of the sweet sorghum plant. These samples were taken from the April 7 planting of Bundle King at harvest.

| Plant part | NDF* | ADF | Protein | Moisture | Relative composition in plant |
|---|---|---|---|---|---|
| | ---------- % ---------- | | | | |
| Leaf | 49.7 | 34.5 | 9.6 | 70.4 | 18.3 |
| Head | 52.6 | 34.4 | 9.4 | 57.1 | 4.0 |
| Bagasse | 56.4 | 36.7 | 3.8 | 72.8 | 45.1 |
| Mixture of above | 54.4 | 36.0 | 5.7 | 66.8 | 67.4 |
| Entire plant | 46.5 | 30.0 | 5.0 | 73.9 | 100 |

* NDF, ADF, and protein are expressed on a 12% moisture basis.