THE PRODUCTION OF SORGHUM IN WATER-RESTRICTED CROP SYSTEMS IN THE USA

Brent Bean, Director of Agronomy, USA Sorghum Checkoff
OUTLINE OF PRESENTATION

- Why Sorghum
- Sorghum Yield Components
- Local Climate and Crop Water Use
- Sorghum Water Use
- Sorghum in Cropping Systems
WHY SORGHUM?

- Drought tolerant crop, but responds well to additional water
- Long planting window
- Uses the same farming equipment as maize and other crops
- Rotational benefits with other crops
  - Yield increase to proceeding broadleaf crops (soybean)
  - Disease, insect and nematode reduction
- Can plant in narrow rows for weed suppression
CONTRIBUTION TO YIELD

Limited Water:
• Seeds per panicle – 63%
• Panicles per ha – 30%
• Seed mass – 7%

Plenty of Water:
• Seeds per panicle – 40%
• Panicles per ha – 32%
• Seed mass – 23%
Harvest Index is the ratio of grain produced VS total above ground plant mass

Range: 0.35 to 0.55
## SEEDING RATE

### TWO YEAR AVERAGE YIELD AT THREE PLANT POPULATIONS

<table>
<thead>
<tr>
<th>Plant Population</th>
<th>Beltsville, KS</th>
<th>Manhattan, KS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants ha⁻¹</td>
<td>Grain Yield, t ha⁻¹</td>
<td></td>
</tr>
<tr>
<td>75,000</td>
<td>6.33</td>
<td>6.55</td>
</tr>
<tr>
<td>150,000</td>
<td>6.65</td>
<td>6.83</td>
</tr>
<tr>
<td>225,000</td>
<td>6.71</td>
<td>6.72</td>
</tr>
</tbody>
</table>
## SEEDING RATE BASED ON YIELD POTENTIAL

<table>
<thead>
<tr>
<th>Seeding Rate per hectare</th>
<th>Yield Potential or Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>75,000</td>
<td>3,000 – 4,750 lb/ac</td>
</tr>
<tr>
<td></td>
<td>3.4 – 5.3 t ha(^{-1})</td>
</tr>
<tr>
<td>125,000</td>
<td>4,750 – 7,550 lb/ac</td>
</tr>
<tr>
<td></td>
<td>5.3 – 8.5 t ha(^{-1})</td>
</tr>
<tr>
<td>175,000</td>
<td>7,550 - 10,000 lb/ac</td>
</tr>
<tr>
<td></td>
<td>8.5 – 11.2 t ha(^{-1})</td>
</tr>
<tr>
<td>225,000</td>
<td>Greater than 10,000 lb/ac</td>
</tr>
<tr>
<td></td>
<td>Greater than 11.2 t ha(^{-1})</td>
</tr>
</tbody>
</table>
Sorghum Growing Areas in USA

Sorghum 2015
Planted Acres by County
for Selected States

U.S. Department of Agriculture, National Agricultural Statistics Service
PRECIPITATION MAP OF USA
**SORGHUM WATER USE**

**DEPENDS ON LOCAL CLIMATE**

<table>
<thead>
<tr>
<th>Climate Factor</th>
<th>Crop Water Need (ET-Evapotranspiration)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>HIGH</strong></td>
</tr>
<tr>
<td>Temperature</td>
<td>Hot</td>
</tr>
<tr>
<td>Humidity</td>
<td>Low (dry)</td>
</tr>
<tr>
<td>Wind speed</td>
<td>Windy</td>
</tr>
<tr>
<td>Sunshine</td>
<td>Sunny</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Climate Factor (July)</th>
<th><strong>Amarillo, Texas, USA</strong></th>
<th><strong>Bucharest, RO</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (c)</td>
<td>32.7</td>
<td>29</td>
</tr>
<tr>
<td>Humidity (AVG Daily)</td>
<td>78% High, 32% Low</td>
<td>96% High, 42% Low</td>
</tr>
<tr>
<td>Wind speed Avg (m/s)</td>
<td>6 m/s</td>
<td>2 m/s</td>
</tr>
<tr>
<td>% Median Cloud Cover</td>
<td>25%</td>
<td>35%</td>
</tr>
<tr>
<td>% AVG Sunlight hr/Day</td>
<td>11.03</td>
<td>10.5</td>
</tr>
</tbody>
</table>
SORGHUM WATER USE EFFICIENCY AT DIFFERENT RAINFALL OR IRRIGATION LEVELS

<table>
<thead>
<tr>
<th>Irrigation Amount (% of ET)</th>
<th>Water Use Efficiency kg m(^{-3})</th>
<th>Water Use Efficiency lb ac-in(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.45</td>
<td>102</td>
</tr>
<tr>
<td>25</td>
<td>1.23</td>
<td>279</td>
</tr>
<tr>
<td>50</td>
<td>1.85</td>
<td>420</td>
</tr>
<tr>
<td>75</td>
<td>1.86</td>
<td>422</td>
</tr>
<tr>
<td>100</td>
<td>1.70</td>
<td>385</td>
</tr>
</tbody>
</table>
• **Growing Point Differentiation**: ~ 30 days past emergence. Panicle size begins to be determined.

• **Boot**: Rapid growth and nutrient uptake. Panicle enclosed in flag leaf.

• **Half Bloom**: 50% of plants in a field are blooming.
Sorghum Daily Water Use and Key Growth Stages

- Days After Planting:
  - 0: Panicle Initiation
  - 30: Rapid Growth
  - 60: Seed Number Determined
  - 90: Flowering
  - 120: Grain Fill

- Stages:
  - Mature
  - Grain Drying
  - Grain Filling
  - Boot
  - Flowering
  - Rapid Growth
  - Seed Number Determined
  - Panicle Initiation

DAILY WATER USE
DAILY WATER USE OF MAIZE AND SORGHUM
20 YEAR AVERAGE 1991-2010, AMARILLO, TX

Total Seasonal Water Use
- Maize – 875 mm
- Sorghum – 680 mm

Daily Water Use, mm

2-May 2-Jun 2-Jul 2-Aug 2-Sep 2-Oct

DAILY WATER USE
SORGHUM AND MAIZE RESPONSE TO WATER

![Graph showing yield vs. total water for sorghum and maize.]

- **Maize**:
  - Yield: 2.65 kg/m³
  - Yield at 10 t/ha (160 bu/ac): 10 t/ha
  - Yield at 6.67 t/ha (106 bu/ac): 6.67 t/ha

- **Sorghum**:
  - Yield: 2.12 kg/m³
  - Yield at 10 t/ha (160 bu/ac): 9 t/ha
  - Yield at 6.67 t/ha (106 bu/ac): 5.8 t/ha

- **Yield in t/ha**: 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20
- **Total Water in mm**: 25, 127, 229, 330, 432, 533, 635, 737, 838, 940
## YIELD VS ET RELATIONSHIP FOR CROPS IN KANSAS, USA

<table>
<thead>
<tr>
<th>Crop</th>
<th>Max. ET</th>
<th>Threshold ET</th>
<th>Slope of Yield vs ET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>635</td>
<td>275</td>
<td>3.29</td>
</tr>
<tr>
<td>Grain Sorghum</td>
<td>535</td>
<td>175</td>
<td>2.32</td>
</tr>
<tr>
<td>Sunflower</td>
<td>560</td>
<td>140</td>
<td>0.66</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>610</td>
<td>255</td>
<td>1.22</td>
</tr>
<tr>
<td>Soybean</td>
<td>610</td>
<td>200</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Dryland or low rainfall
- Rotation with wheat
  - 11 month fallow between crops
- Rotation with cotton or soybeans
  - Reduction in disease, weeds and nematodes

Limited Irrigated or regions with moderate rainfall
- Rotation with soybean
- Double crop with sorghum planted after wheat harvest
- Split irrigation circle
  - Maize/Sorghum
  - Cotton/Sorghum

Fully Irrigated or regions with high rainfall
- Rotation with soybean or cotton
Sorghum Evapotranspiration
Long-term Average
(1997–2011)

Day of Year

mm day


1-5 May
15-5 May
1-Jun
15-Jun

(Rajan and Maas)
USE IN OPTIMIZING IRRIGATION CAPACITY

- Utilize planting dates to apply irrigation during key growth stages
- Since sorghum will tolerate short periods of drought, more water can be applied to the maize if needed
DAILY WATER USE

MAIZE VS SORGHUM

mm day$^{-1}$

15-Apr
29-Apr
13-May
27-May
10-Jun
24-Jun
8-Jul
22-Jul
5-Aug
19-Aug
2-Sep
16-Sep
30-Sep
14-Oct

Maize
Sorghum
Sorghum water use efficiency is improved by using a seeding rate that matches the environment’s yield potential.

Sorghum water use depends on local climate.

Sorghum has a maximum water use of approximately 75% of maize.

Sorghum yields better than maize in low rainfall environments.

Sorghum benefits the yield of broadleaf crops in a rotation.

Sorghum can be planted with other crops to maximize water use efficiency in fields with limited irrigation water capacity.