1. Sorghum populations and row spacing

Sorghum responds to environmental conditions and available resources by adjusting tillering, head size, and seed weight. Seed weight has less room for adjustment than the other yield components, so the number of seeds harvested per acre is the critical factor determining yield. Assuming fertility needs are met, seeding rate and plant population can influence the number of seeds harvested per acre. Usually, it is desirable to have populations that result in one head per plant to allow for uniform grain filling and maturation.

**Populations**

Sorghum population recommendations range from a desired stand of 24,000 to 100,000 plants per acre depending on annual rainfall:

<table>
<thead>
<tr>
<th>Average Annual Rainfall (inches)</th>
<th>Recommended Plant Population (plants/acre)</th>
<th>Within-row Seed Spacing (at 65% emergence)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10-inch rows</td>
</tr>
<tr>
<td>Less than 20</td>
<td>24,000</td>
<td>16.5</td>
</tr>
<tr>
<td>20 to 26</td>
<td>35,000</td>
<td>12.0</td>
</tr>
<tr>
<td>26 to 32</td>
<td>45,000</td>
<td>9.0</td>
</tr>
<tr>
<td>More than 32</td>
<td>70,000</td>
<td>6.0</td>
</tr>
<tr>
<td>Irrigated</td>
<td>100,000</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Because of sorghum’s ability to respond to the environment, final stands can vary at least 25% from the values listed above depending on expected growing conditions without significantly affecting yields. Lower seeding rates minimize risk of crop failure in dry environments. Sorghum can compensate to good growing conditions by adding tillers and adjusting head size, but yields can be reduced in a dry year if populations are too high.

Recent research has confirmed these long-term recommendations. In these studies, sorghum yields were maximized at 25,000 plants per acre in western Kansas (17 inches annual precipitation); 40,000 in central Kansas (30 inches annual precipitation); and 50,000 in eastern
Kansas (32 inches annual precipitation). Studies in Missouri, with substantially more than 32 inches of annual precipitation, maximized yield with about 60,000 plants per acre. Having more than the recommended number of plants per acre will reduce yield in the drier environments.

**Planting date**

Planting date has some effect on seeding rates. Sorghum tillers more readily in cool temperatures and less readily under warm conditions. As a result, later plantings in warmer weather should be on the high side of the recommended range of seeding rates for each environment since there will be less tillering. Potential for greater tillering with earlier planting dates makes sorghum yields generally more stable when planted in May and early June compared to late June or July plantings.

**Row spacing**

The other factor that can influence yield is row spacing. The last three columns in the table above show that plant spacing within the row becomes greater as row spacing decreases. This greater intra-row plant spacing reduces plant-plant competition early in the growing season when many of the yield components are being determined (head number and head size).

Another potential benefit of narrower row spacing is faster canopy closure. Research at the North Central Experiment Field near Belleville has documented that the sorghum canopy closed 19 days sooner when planted in 10-inch rows compared to 30-inch rows, and sorghum planted in 7-inch rows closed another 5 days sooner than that. Quicker canopy closure has the potential to improve suppression of late-emerging weeds, a major concern for many sorghum producers.

The influence of row spacing on sorghum yield has not been entirely consistent. In 21 experiments that compared different combinations of 10-, 15-, 20-, and 30-inch row spacings, ten demonstrated a yield advantage for narrower row spacing, eight showed no yield response to row spacing, and three had a yield reduction with narrow rows. The experiments that had greater yields with 30-inch rows had yields of 90 bushels/acre and less. Where there was no difference due to row spacing, yields ranged from 78 to 148 bushels per acre. Where narrow rows had an advantage, the yield range was 84 to 173 bushels per acre. Potential for a positive yield response to narrow rows is greatest in high-yielding environments, but response is not always evident.

Should populations be adjusted with narrow rows? Results indicate that the population producing the greatest yield doesn’t change with different row spacings, but the magnitude of response to population potentially can be greater with narrower row spacings in high-yielding environments.

Plating date seems to have an interaction with row spacing. Over three years at the North Central Experiment Field, there was essentially no difference in yield between 15 and 30-inch rows for late May plantings, but there was a 10-bushel yield advantage for 15-inch rows for late June plantings. A similar response was observed at Manhattan in 2009 when no difference in row spacing was observed for the May planting, but 10-inch rows had an 11 bushel/acre yield advantage over 30-inch rows with the June planting. The opposite response was seen at Hutchinson in 2009 where narrow rows had a 6 bushel/acre yield advantage with a May planting date, but wide rows had a 6 bushel/acre yield advantage with a June planting date. In all cases, yields were less with the June planting, but the June plantings at Belleville and Manhattan averaged more than 115 bushels/acre, while yields at Hutchinson were less than 92 bushels/acre.
Summary

* Determine your desired population based on average rainfall and expected growing conditions – no need to go overboard.
* Make sure you plant enough seed for your desired plant population (65% field germination is a good general rule).
* Think about using narrower row spacings to close the canopy sooner and potentially capture greater yields in yield environments of 90 bushels per acre or more.

-- Kraig Roozeboom, Cropping Systems and Crop Production Specialist
kraig@ksu.edu

-- Stu Duncan, Northeast Area Crops and Soils Specialist
sduncan@ksu.edu

-- Kent Martin, Southwest Area Crops and Soils Specialist
kentlm@ksu.edu

-- Brian Olson, Northwest Area Crops and Soils Specialist
bolson@ksu.edu

-- Doug Shoup, Southeast Area Crops and Soils Specialist
dshoup@ksu.edu

2. Wheat flowering and early kernel development

About 3 to 5 days after the head is fully emerged, flowering begins in wheat.
Feekes 10.5.2. Flowering complete to top of spike. Flowering generally starts in the middle spikelets (or slightly above the middle) of the head. Flowering continues in the upper and lower spikelets over the next few days. This head has been flowering for at least a day. Photos by Jim Shroyer, K-State Research and Extension.

Wheat is self-pollinating. Most florets are pollinated before anthers are extruded. As flowering begins, the stamen filaments grow rapidly. At the tip of each anther two pores appear through which the pollen will be shed. At the base of each floret, the stamens emerge and dangle freely from the floret. The pollen from the anthers falls onto the receptive feathery stigmas of the stamen parts which have unfolded to receive it, and pollination is complete.
This is inside a floret before pollination. There are three lime-green, tri-lobed structures. These are the anthers and the pollen is inside them. The white, fuzzy structure is the stigma. The round, greenish-white object with a greenish crease is the ovule. When the pollen from the anthers is released and the pollen grains attach to the stigma pollination has occurred. Then the pollen moves from the stigma through the style to the ovule where it is fertilized. At that point, a kernel will form.

On the left, you can see this floret has immature floral parts, because the stigma has not fully expanded. In the middle, the anthers have turned yellow, the filaments (the threadlike structures attached to each anther) have elongated (the anthers will soon be visible outside the floret), the stigma has expanded and is ready for pollen. Also, you can see pollen grains everywhere. On the right, you can see the fertilized embryo, which will soon develop into a recognizable kernel. The anthers are gone and the stigma is drying up.
Bloom in a given wheat plant is usually all over four to five days after heading. After successful pollination, grain fill begins. The length of grain fill will depend on the environmental conditions. Under stress, grain fill will be rapid. Under typical Kansas conditions, grain fill may continue for up to 20 days or more (that’s after the first 10 days that were spent forming the kernel).
Pulling back the lemma and palea, the early stage of the kernel can be seen. It still has that whitish-green color.
Two kernels that about 7 days old and 5 mm long.

Two kernels that are 10 days old, about 7 mm long.

These two kernels are about 12 days old, and they are noticeably plumper than the kernels above that were 10 days old. This is called the watery-ripe stage and it lasts several days. A wheat kernel takes about 10 days to reach full size and then the starch and proteins can start moving in. That’s when it starts getting plump.
From this point on, the wheat will be in the grain-filling period. This is a very important time because this is when grain yield is determined and any stresses, such as, diseases, heat, or drought, could cause yield losses.

In two weeks, we will discuss grain fill in detail.

-- Jim Shroyer, Extension Agronomy State Leader
jshroyer@ksu.edu

3. Symptoms of freeze damage to wheat heads

Recent freezing temperatures in parts of Kansas have damaged the flowers and heads in some wheat. Wheat is particularly vulnerable to damage from freezing weather from the late boot stage, as the head starts to emerge, through the flowering stage.

The photos below show partial white heads caused by freeze injury this year to wheat in the boot stage. Freeze injury at the boot stage causes a number of symptoms when the heads are enclosed in the sheaths of the flag leaves. Freezing may trap the spikes inside the boots so that they cannot emerge normally. When this happens, the spikes will remain in the boots, split out the sides of the boots, or emerge base-first from the boots.

Sometimes heads emerge normally from the boots after freezing, but remain yellow or even white instead of their usual green color. When this happens, all or part of the heads have been killed. Frequently, only the male parts (anthers) of the flowers die because they are more sensitive to low temperatures than the female parts. Since wheat is self-pollinated, sterility caused by freeze injury results in poor kernel set and low grain yield.

Freeze damage to tips of heads in Barton County, May 13, 2010.
Photos by Jim Shroyer, K-State Research and Extension.
If you are unsure whether there has been freeze damage to the flowers, wait several days and determine whether kernels are developing normally. A week after flowering, kernels should be well-formed up and down the head.

If flowering has already occurred and kernels were forming at the time of the freeze, there still could be damage. Generally, it takes colder temperatures to cause damage to kernel development than to floral structures.

Healthy, developing kernels shortly after flowering are greenish-white and as they grow, they turn more greenish. But if they are damaged, they will turn grayish-white, shriveled and rough and will not continue to enlarge. Producers might need to check heads several times to determine the amount of damage.

**Summary**

If the primary tillers were in the early heading stage at the time of the hard freeze, then it is very likely that most of the heads were killed. However, some spikelets or entire heads may have survived. If a spikelet flowers and the kernels start to develop, then that spikelet is fine. About 5 days after flowering, a tiny developing kernel should become visible if the spikelet is alive and developing normally. By 10 days after flowering, the kernel length should be fully developed.

For more information about spring freeze damage to wheat, see K-State publication C-646, "Spring Freeze Injury to Kansas Wheat," or check the Web at [http://www.oznet.ksu.edu/library/crpsl2/C646.pdf](http://www.oznet.ksu.edu/library/crpsl2/C646.pdf).

-- Jim Shroyer, Extension Agronomy State Leader
ejshroyer@ksu.edu

These e-Updates are a regular weekly item from K-State Extension Agronomy and Steve Watson, Agronomy e-Update Editor. All of the Research and Extension faculty in Agronomy will be involved as sources from time to time. If you have any questions or suggestions for topics you'd like to have us address in this weekly update, contact Steve Watson, 785-532-7105 swatson@ksu.edu, or Jim Shroyer, Research and Extension Crop Production Specialist and State Extension Agronomy Leader 785-532-0397 jshroyer@ksu.edu