Issue 844

K-STATE
Research and Extension

Extension Agronomy

eUpdate

03/18/2021

These e-Updates are a regular weekly item from K-State Extension Agronomy and Kathy Gehl, Agronomy eUpdate 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 Kathy Gehl, 785-532-3354 kgehl@ksu.edu, or Dalas Peterson, Extension Agronomy State Leader and Weed Management Specialist 785-532-0405 dpeterso@ksu.edu.

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1. Residual herbicides for corn

Residual herbicides that kill weed seeds/seedlings as they germinate or emerge are an important component of herbicide applications at or before the time of corn planting. These herbicides can control weeds for several weeks, which prevents yield loss due to early-season weed competition and can greatly improve the effectiveness of a post-emergence herbicide application and give more flexibility for post-application timing. Residual herbicides are also an important component of sequential herbicide applications later in the growing season. In general, preventing the emergence of weeds, especially herbicide resistant weeds, is preferable to controlling them after they emerge (Figure 1).

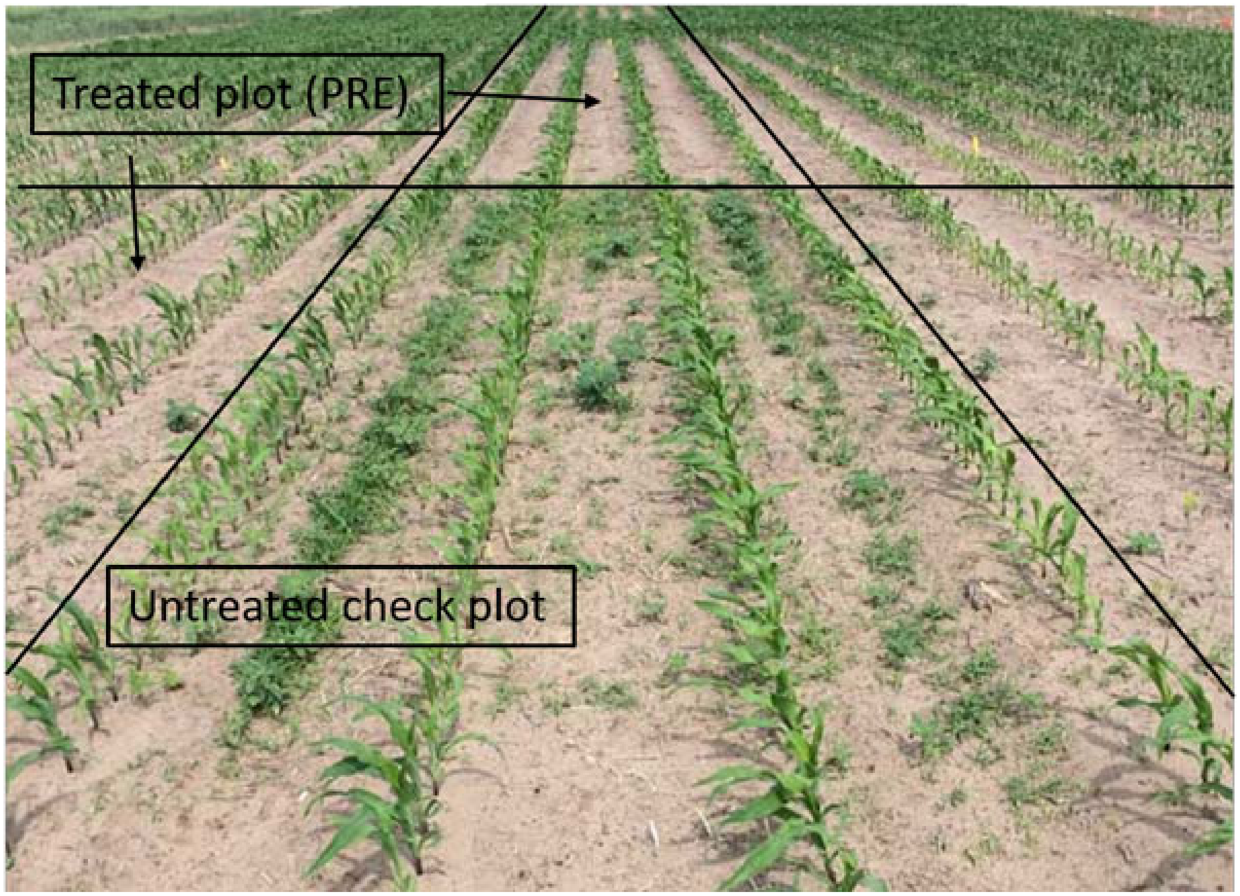

Figure 1. The corn plot in the foreground received no pre-emergence herbicide. The plots adjacent to the untreated check received an application of pre-emergence herbicide. The photo was taken just prior to the prescribed post-emergence treatment in May 2018 at the Kansas River Valley Experiment Field in Rossville. Photo by Stu Duncan, K-State Research and Extension.

Many cases of herbicide-resistant weeds have resulted from over-reliance on post-emergence herbicide applications, thus it is essential to include one or more residual herbicides available for corn. However, it is also important to remember to change residual herbicides to prevent selection of tolerant or resistant weeds. The importance of this is reflected in the recent confirmation of waterhemp and Palmer amaranth that are resistant to *S*-metolachlor (Dual).

The specific herbicide you use is important, but it is usually less important than making the decision to use a residual herbicide. But, it is important to know the strengths and weaknesses of each product in terms of the spectrum of weeds controlled. A table summarizing weed species response to various corn herbicides can be found on pages 24-26 of *2021 Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland* (SRP 1162) at: https://bookstore.ksre.ksu.edu/pubs/SRP1162.pdf

Categories of residual herbicides for corn

Triazines (Group 5). Atrazine is the most widely used triazine in corn. It is a common component of many preplant and pre-emergence herbicide premixes for corn. It controls a wide variety of broadleaf weeds, including pigweeds, ragweeds, morningglories, and mustards, as well as some grass species. However, atrazine resistance has been reported for many weed species. Atrazine use rates are influenced by soil type, soil pH, and organic matter, and use is prohibited in instances where water contamination is likely. Unless your situation prohibits atrazine use, it is recommended to include atrazine when you apply HPPD-inhibitor and acetamide herbicides.

Acetamides and pyrazole (Group 15). The main acetamide (15) products used in corn include acetochlor, *S*-metolachlor, metolachlor, dimethamid-P, and many premix products containing one of these active ingredients. Pyroxasulfone is a pyrazole herbicide, but has the same site of action as the acetamides. In general, these products are very effective in controlling most annual grasses (except shattercane) and small-seeded broadleaf weeds such as pigweeds. They are much less effective in controlling small-seeded kochia or large-seeded broadleaf weeds such as cocklebur, devilsclaw, morningglory, sunflower, and velvetleaf. An exception are those products containing pyroxasulfone, such as Zidua, Anthem, and Anthem ATZ, Fierce and Fierce MTZ. Engenia Pro and Purpetuo are two other pyroxasulfone-containing products that are awaiting approval Though resistance to Group 15 herbicides have been reported in corn/soybean rotations in Illinois, there have been no cases of weed populations in Kansas developing resistance to the group 15 herbicides to date.

The acetamide and pyrazole products are most effective when applied with atrazine. Several such premixes are available and should be used instead of acetamides or pyrazole alone, unless atrazine is not allowed. These premixes generally fit into two groups: products with a reduced atrazine rate (1 lb or less/acre) and products with a full atrazine rate (1 to 2 lb/acre). Soil characteristics determine whether the reduced- or full-rate atrazine product is used. In past years, often because of cost, reduced rates of these products were applied to help manage heavy summer annual grass pressure, then followed up with a good post-emergence herbicide program. With the increased occurrence of glyphosate- and other herbicide-resistant weeds, it is essential to use the full rates of these products in conjunction with a POST program.

HPPD-inhibitors (Group 27). Examples of HPPD-inhibitors are isoxaflutole (e.g. Balance Flexx) and mesotrione (e.g. Callisto and many generics). These products should be applied with atrazine, which is often included in premixes with Group 27 herbicides (e.g. Acuron, Callisto Xtra, Lexar EZ, Lumax EZ). HPPD-inhibitors provide excellent for control of kochia, pigweeds, velvetleaf, and many other broadleaf weeds, as well as grasses. Corvus (thiencarbazone + isoxaflutole) will control shattercane and common sunflower better than Balance Flexx, provided the sunflower is not ALS-resistant. Prequel has a low rate of Balance mixed with Resolve and will not provide the same level of residual weed control as Acuron, Resicore, Lexar EZ, Lumax EZ, Balance Flexx, or Corvus used at full rates.

Keep in mind, products containing Balance should not be applied to coarse-textured soils when the water table is less than 25 feet below the soil surface. Balance Flexx does not provide adequate control of sunflower.

PPO-inhibitors (Group 14). Examples of PPO-inhibitors include flumioxazin (e.g. Valor) and saflufenacil (Sharpen (14). Herbicides containing flumiozaxin must be applied 7 to 30 days before corn planting. These herbicides provide excellent control of pigweeds; however, they are marginal on kochia. Fierce (flumioxazin + pyroxasulfone) will provide improved control of velvetleaf and kochia compared to Valor. The addition of atrazine will enhance kochia, pigweed, velvetleaf, and morningglory control, provided the populations are not triazine-resistant. Sharpen and Verdict (saflufenacil + dimethenamid-P) have excellent activity on pigweeds, kochia, and large-seeded broadleaf weeds. However, the length of residual activity can be shorter than other pre-emergence products when all are compared at full rates. Approximately 7 to 10 days of residual can be expected per 1 oz of Sharpen and 5 oz of Verdict.

ALS-inhibitors (Group 2). One example of a pre-emergence ALS-inhibitor used in corn is flumetsulam (Python), which only has broadleaf activity and provides good control of large-seeded broadleaf weeds such as cocklebur, sunflower, and velvetleaf, or the small-seeded common lambsquarters. Flumetsulam is also a component of Hornet, Stanza, SureStart II, and TripleFlex II. These products are especially effective for control of sunflower, along with cocklebur and velvetleaf, but less effective for morningglory control.

Rimsulfuron is another ALS-inhibiting herbicide that is a component of Basis Blend, Instigate, Prequel, Realm Q and Steadfast Q. Products with rimsulfuron will provide short residual control of grass and broadleaf weeds and should be used as a setup herbicide with a good post-emergence weed control program. If ALS-resistant broadleaf weeds are present, these ALS-containing herbicides often will be less effective.

Sarah Lancaster, Extension Weed Science Specialist
slancaster@ksu.edu

2. First hollow stem update: March 18, 2021

Cattle should be removed from wheat pastures when the crop reaches first hollow stem (FHS). Grazing past this stage can severely affect wheat yields (for a full explanation, please refer to the eUpdate article "Optimal time to remove cattle from wheat pastures: First hollow stem").

First hollow stem update

In order to screen for FHS during this important time in the growing season, the K-State Extension Wheat and Forages crew measures FHS on a weekly basis in 34 different commonly grown wheat varieties in Kansas. The varieties are in a September-sown replicated trial at the South Central Experiment Field near Hutchinson.

Ten stems are split open per variety per replication (Figure 1), for a total of 30 stems monitored per variety. The average length of hollow stem is reported for each variety in Table 1. As of March 18, 2021, only one variety (Buckhorn AX) had reached first hollow stem but most varieties had started to show minor stem elongation.

Figure 1. Ten main wheat stems were split open per replication per variety to estimate first hollow stem for this report, for a total of 30 stems split per variety. Photo by Romulo Lollato, K-State Research and Extension.

Table 1. Length of hollow stem measured on March 3, 8, and 16th of 34 wheat varieties sown mid-September 2020 at the South Central Experiment Field near Hutchinson. The critical FHS length is 1.5 cm (about a half-inch or the diameter of a dime). Value(s) in bold indicate the highest FHS group. Variety name(s) in bold indicate varieties that have reached FHS.

	First hollow stem		
Variety	**3/3/2021**	**3/8/2021**	**3/16/2021**
		(cm)	
10BC329-17-5	0	0.01	0.03
AP EverRock	0	0	0.46
AP Roadrunner	0	0.13	0.21
Buckhorn AX	0.01	**1.16**	**2.76**
Canvas	0	0	0.07
Crescent AX	0	0	0.14
High Country	0	0.01	0.03
KS12DH0156-88	0	0	0.02
KS13DH0041-35	0.01	0	0
KS Dallas	0	0	0.12
KS Hamilton	0	0	0.01
KS Hatchett	0	0	0.10
KS Silverado	0.01	0	0.01
KS Western Star	0	0.01	0.13
LCS Atomic AX	0	0	0
LCS Helix AX	0	0	0.06
LCS Julep	0	0	0.03
LCS Photon AX	0	0	0.34
LCS Revere	0	0	0.19
Long Branch	0	0.03	0.54
MS Maverick	0	0	0.12
NUSAKA15-3	0	0.03	0.19
OCW04S717T-6W	0	0.01	0.13
OK12912C-138407-2	0	0	0
OK16D101089	0	0.01	0.26
OK Corral	0	0.02	0.08
Paradise	0	0.01	0.02
Rock Star	0	0	0.04
Showdown	0	0	0.07
Smith's Gold	0	0.11	0.14
WB4269	0	0.06	0.18
WB4401	0	0.09	0.38
WB4699	0	0.03	0.03
Zenda	0	0.02	0.31
Variety effect	ns	<0.01	<0.01

While only one variety (Buckhorn AX) had reached first hollow stem as of March 16, 2021, all varieties had started to elongate the stem at different rates and there were statistical differences among the varieties evaluated. These differences tend to increase over time. Thus, we will report first hollow stem during the next few weeks again until all varieties are past this stage. Additionally, first hollow stem is generally achieved within a few days from when the stem starts to elongate, so we advise producers to closely monitor their wheat pastures at this time.

The intention of this report is to provide producers an update on the progress of first hollow stem development in different wheat varieties. Producers should use this information as a guide, but it is extremely important to monitor FHS from an ungrazed portion of each individual wheat pasture to take the decision of removing cattle from wheat pastures.

Contact author:

Romulo Lollato, Wheat and Forages Specialist
lollato@ksu.edu

Co-authors:

Nicolas Giordano, M.S. student

Luiz Pradella, Visiting Assistant Scientist

Brahian Dávila Díaz, Visiting Assistant Scientist

3. New Kansas Mesonet tool for estimating wheat growth stage

Winter wheat is beginning to break dormancy and the Kansas Mesonet has introduced a new tool to help track the crop development. The Wheat Growth Stage page tracks wheat growing degree days (GDD), which are highly correlated with wheat growth stage. This tool employs a wheat growth model developed by Kansas State University based on field observations collected throughout the state between 2015-2019. The output of the model provides an estimate of the current (and historical) growth stage of the crop in Kansas.

Wheat growth stages

There are multiple scales used to describe wheat growth. Perhaps the most common example used by Kansas farmers is the Feekes growth stage scale, which was developed in the 1950's (Figure 1). This scale describes wheat development with respect to visual characteristics of the plants and assigns a numerical code to facilitate note taking and communication among growers. This growth stage information is often incorporated into wheat management decisions regarding fertilizer and pesticide application timing. In fact, many product labels contain specific application guidelines and/or restrictions based on wheat growth stage. Knowledge of the crop's growth stage also allows the ability to gauge for potential impacts of environmental events such as spring freeze.

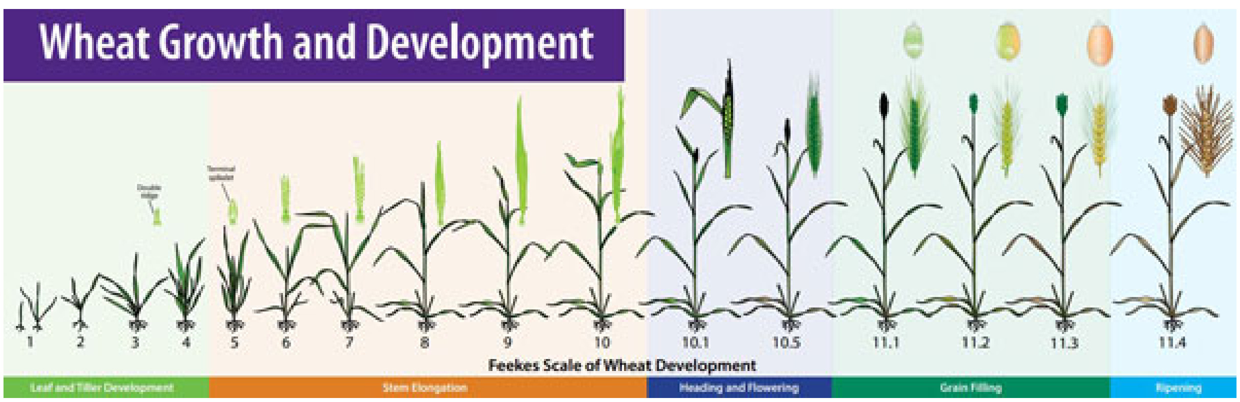

Figure 1. Feekes scale of wheat development provides a visual representation, text description of wheat growth, and assigns a numerical value to each category.
(https://bookstore.ksre.ksu.edu/pubs/MF3300.pdf).

Calculation of wheat GDD and estimated growth stages

Wheat growth stage is estimated for each location-year based on a simple empirical estimate of growing degree days (Equation 1) accumulation since January 1st. The wheat growth model deployed here translates the GDD into general categories of wheat growth (Figure 2). These general categories help the model account for differences in crop development among different fields due to contrasting wheat varieties or sowing dates, which are not integrated directly into the wheat growth model.

Accumulated GDD were calculated based on Equation 1:

$$GDD\ (^{\circ}C) = \sum_{i=1}^{n} \frac{(Tmax_i + Tmin_i)}{2} - Tbase,\ GDD \geq 0$$

where Tmax and Tmin are maximum and minimum daily temperatures (°C) for day of year, and Tbase is the crop's base temperature which was assumed to be a constant 0°C (McMaster & Wilhelm, 1997).

Color	GDD °F	Estimated Wheat Growth Stage
	0 to 600	Seedling growth or tillering
	600 to 800	Tillering or strongly upright tillers
	800 to 1000	Strongly upright tillers or jointing (first node)
	1000 to 1200	Jointing (first node) or approaching flag leaf emergence
	1200 to 1400	Flag leaf emergence or boot
	1400 to 1600	Boot or heading
	1600 to 1800	Heading to flowering
	1800 to 2000	Heading or flowering
	2000 to 2200	Flowering or watery ripe
	2200 to 2400	Watery ripe or milk
	2400 to 2600	Milk or dough
	2600 to 2800	Dough or kernels maturing
	2800 to 3000	Dough or kernels maturing
	More than 3000	Physiologically mature or approaching harvest

Figure 2. The wheat growth stage model translates growing degree days (GDD) values into general categories of wheat development. Note: a general category is provided to help account for differences in growth that often result for different sowing dates and cultivar maturities.

How might you benefit from the Kansas Mesonet Wheat GDD page?

Here are a few examples:

- **Compare previous years with a chart**. Select the "Chart" tab within the wheat growth tools (Figure 3). By selecting specific years of interest, it is possible to compare the current year to other recent years and the long-term normal for a given location. Current data supports comparisons between 2016-present year. The example below illustrates a comparison made for Harper KS. Note how the years of 2017 and 2019 were contrasting (warmer vs. cooler), which directly impacts crop development.

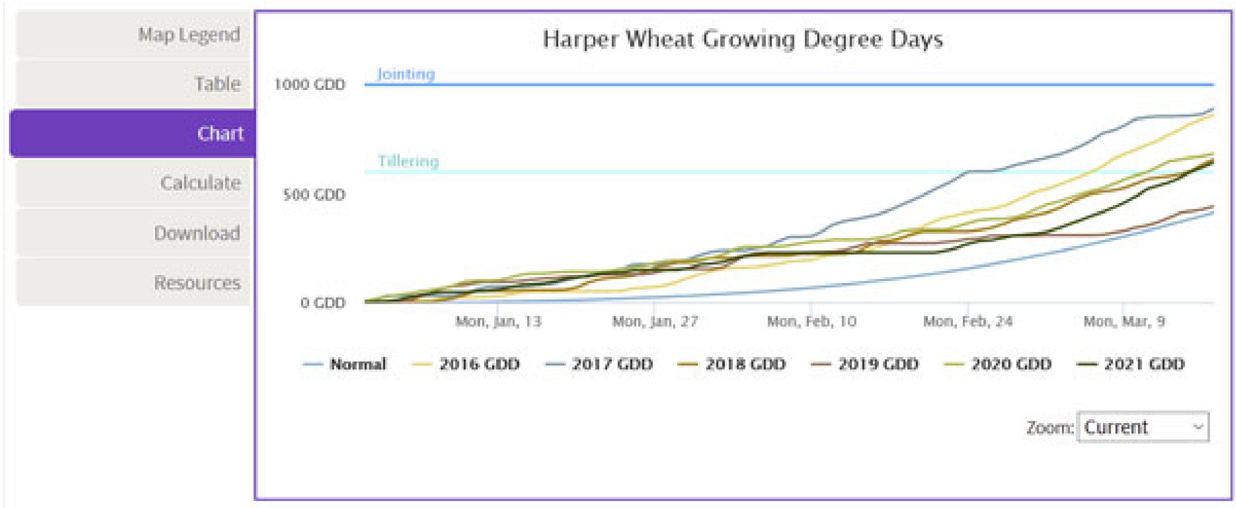

Figure 3. Screenshot of the "Chart" feature using the Wheat GDD tool.

- **Calculate historical GDD values for a given date or range of dates**. Select the "Calculate" tab and specify a date range of interest (Figure 4). This tool allows specific comparisons of the observed GDD from the current growing season and historical normal within a given timeframe.

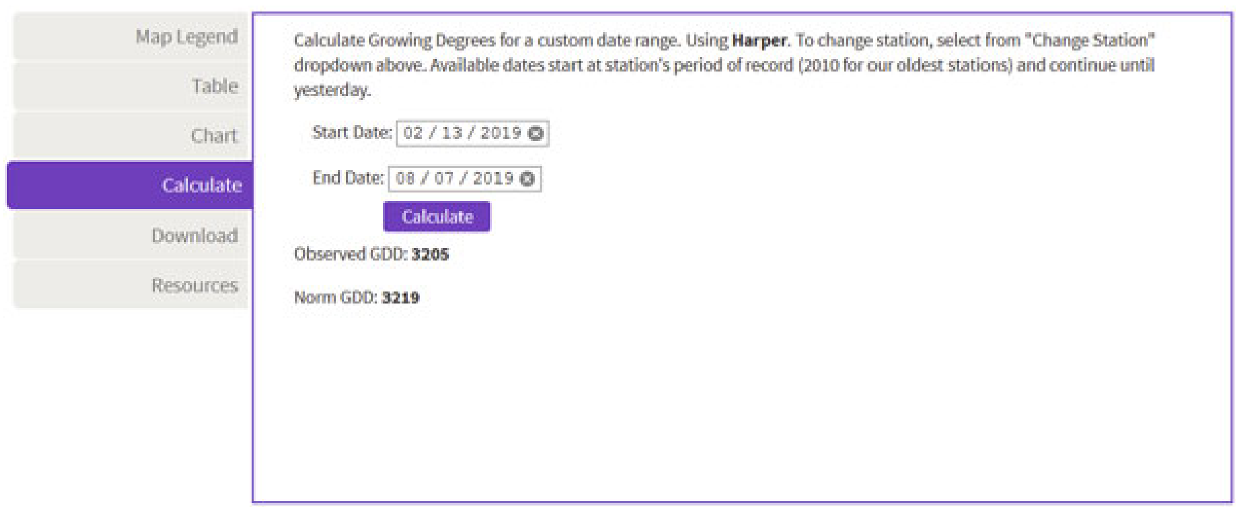

Figure 4. Screenshot of the "Calculate" feature using the Wheat GDD tool.

- **Statewide statistics**: The table lets you quickly view and sort data from across the state. You can also download data to perform your own analysis (see the Download tab).

- **Graphics and social media**: Download any of the maps in .PNG format for easy sharing.

Chip Redmond, Mesonet Manager
christopherredmond@ksu.edu

Mary Knapp, Assistant State Climatologist
mknapp@ksu.edu

Erick DeWolf, Wheat Pathologist
dewolf1@ksu.edu

Romulo Lollato, Wheat and Forages Specialist
lollato@ksu.edu

4. Optimal corn seeding rate recommendations

The optimal corn seeding rate depends on the hybrid (genotype, G) and the interaction with the environment (E), researchers termed this as the G x E interaction. Producers can look back to their corn crop from the previous growing season, or wait until the current growing season is nearly complete, and evaluate whether the plant population they used was adequate. Another factor that sometimes we neglect to mention is the effect of management practices (M). Planting date, row spacing, and crop rotations can also exert some influence on the yield response to the plant population factor.

Individual hybrids can respond differently, but the following guidelines may help in deciding if current seeding rates need to be adjusted.

- If more than about 5% of the plants are barren or if most ears have fewer than 250 kernels per ear, the plant population may be too high.
- If there are consistently more than 600 kernels per ear or if most plants have a second ear contributing significantly to grain yield, the plant population may be too low. Of course the growing conditions will influence ear number and ear size as well, so it is important to factor in the growing conditions for that season when interpreting these plant responses.
- In addition to the growing conditions, nutrient status can also influence the final number of grains per ear. For example, severe nitrogen (N) deficiency will have a high impact on the final number of grains, ear size and ear number.

Don't be too concerned if a half-inch or so of the ear tip has no kernels. If kernels have formed to the tip of the ear, there may have been room in that field for more plants contributing to grain yield. Again, "tipping back" will vary with the G x E x M interaction. Potential ear size and potential number of kernel (1,000-1,200 per ear) are set before silking, but the actual final number of kernels is not determined until after pollination and early grain fill due to relative success of fertilization and degree of early abortion.

Always keep the long-term weather conditions in mind. In a drought year, almost any population is too high for the available moisture in some areas. Although it's not a good idea to make significant changes to seeding rates based only on what has happened recently, it is worthwhile taking into consideration how much moisture there is currently in the soil profile and the long-term forecasts for the upcoming growing season.

Making a decision on whether to keep seeding rates at your usual level, or increase somewhat this year if the soil profile is wetter-than-normal is a little like the famous line in the movie Dirty Harry: "Do I feel lucky?" If you think weather conditions will be more favorable for corn this year than the past years, stay about in the middle to upper part of the range of seeding rates in the table below. If you do not think growing conditions will improve enough to make up for dry subsoils, you might want to consider going toward the lower end of the range of recommended seeding rates, with the warning that if growing conditions improve, you will have limited your top-end yield potential.

Optimal seeding rates may need to be adjusted for irrigated corn if fertilizer or irrigation rates are sharply increased or decreased. For example, research at the Irrigation Experiment Field near Scandia has shown that if fertilizer rates are increased, seeding rates also have to be increased to realize the maximum yield benefit. Consult seed company recommendations to determine if seeding rates for specific hybrids should be at the lower or upper end of the recommended ranges for a given environment.

The recommended planting rates in the following tables attempt to factor in these types of questions for the typical corn growing environments found in Kansas. Adjust within the recommended ranges depending on the specific conditions you expect to face and the hybrid you plan to use.

Table 1. Suggested dryland corn final populations and seeding rates

Area	Environment	Final Plant Population (plants per acre)	Seeding Rate* (seeds per acre)
Northeast	100-150 bu/a potential	22,000-25,000	26,000-29,500
	150+ potential	24,000-28,000	28,000-33,000
Southeast	Short-season, upland, shallow soils	20,000-22,000	23,500-26,000
	Full-season bottom ground	24,000-26,000	28,000-30,500
North Central	All dryland environments	20,000-22,500	23,500-26,500
South Central	All dryland environments	18,000-22,000	21,000-26,000
Northwest	All dryland environments	16,000-20,000	19,000-23,500
Southwest	All dryland environments	14,000-20,000	16,500-23,500

Table 2. Suggested irrigated corn final populations and seeding rates

Environment	Hybrid Maturity	Final Plant Population (plants per acre)	Seeding Rate* (seeds per acre)
Full irrigation	Full-season	28,000-34,000	33,000-40,000
	Shorter-season	30,000-36,000	35,000-42,500
Limited irrigation	All	24,000-28,000	28,000-33,000

* Assumes high germination and that 85 percent of seeds produce plants. Seeding rates can be reduced if field germination is expected to be more than 85%.

New research on corn seeding rates

An intensive review of a large database from Corteva Agriscience (2000-2014 period) was utilized to synthesize yield response to plant population under varying yield environments (<100 bu/acre to >200 bu/acre). Overall, yield response to plant population depended on the final yield environment (Figure 1). In yield environments below 100 bu/acre, yield response to plant population was slightly negative. Yield response to plant population tended to be flat when yield environment ranged from 100 to 150 bu/acre; positive and quadratic with the yield environment improving from 150 to 180 bu/acre; and lastly, increasing almost linearly with increasing plant populations when the yield environment was more than 200 bu/acre (Figure 1).

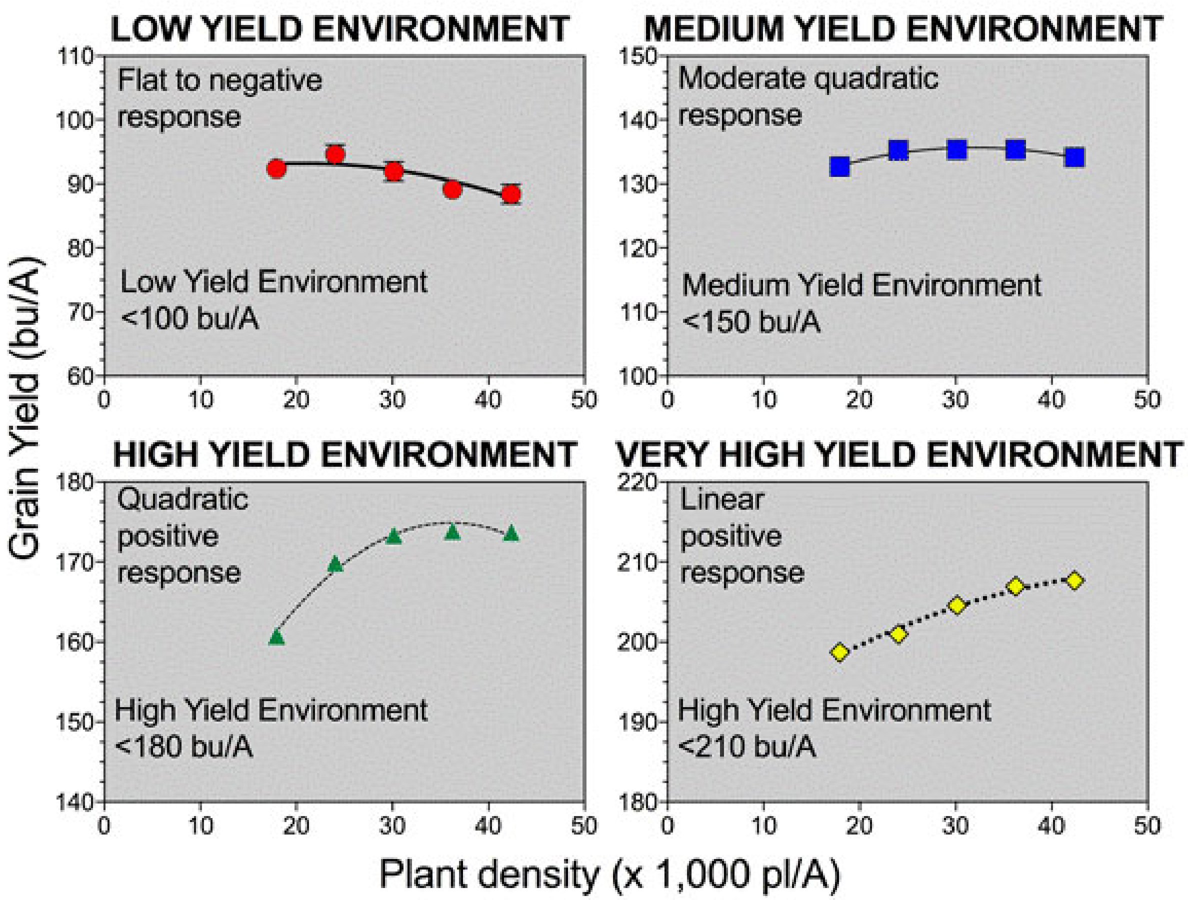

Figure 1. Corn grain yield response to plant density in four yield environments, a) <100; b) 100-150; c) 150-180; and d) > 180-210 bu/acre (Assefa, Ciampitti et al., 2016, Crop Science Journal).

As a disclaimer, "agronomically" optimum plant population does not always coincide with the "economically" optimal plant population. Lastly, final seeding rate depends on the environment, hybrid, and production practices (e.g., planting date, rotation, tillage).

The next step in our research study on yield response to plant density is to increase the level of prediction of agronomically and economically optimum plant density, based not only on the yield environment (or an average of past yield data), but also considering the available water at planting and the weather forecast for the growing season. Lastly, the corn yield response to plant density curves (solid lines) also present an uncertainty level (error, shaded areas) based on those main factors affecting yields (Figure 2). Including the risk level taking by farmers when selecting plant density is a relevant point of investigation in our future studies.

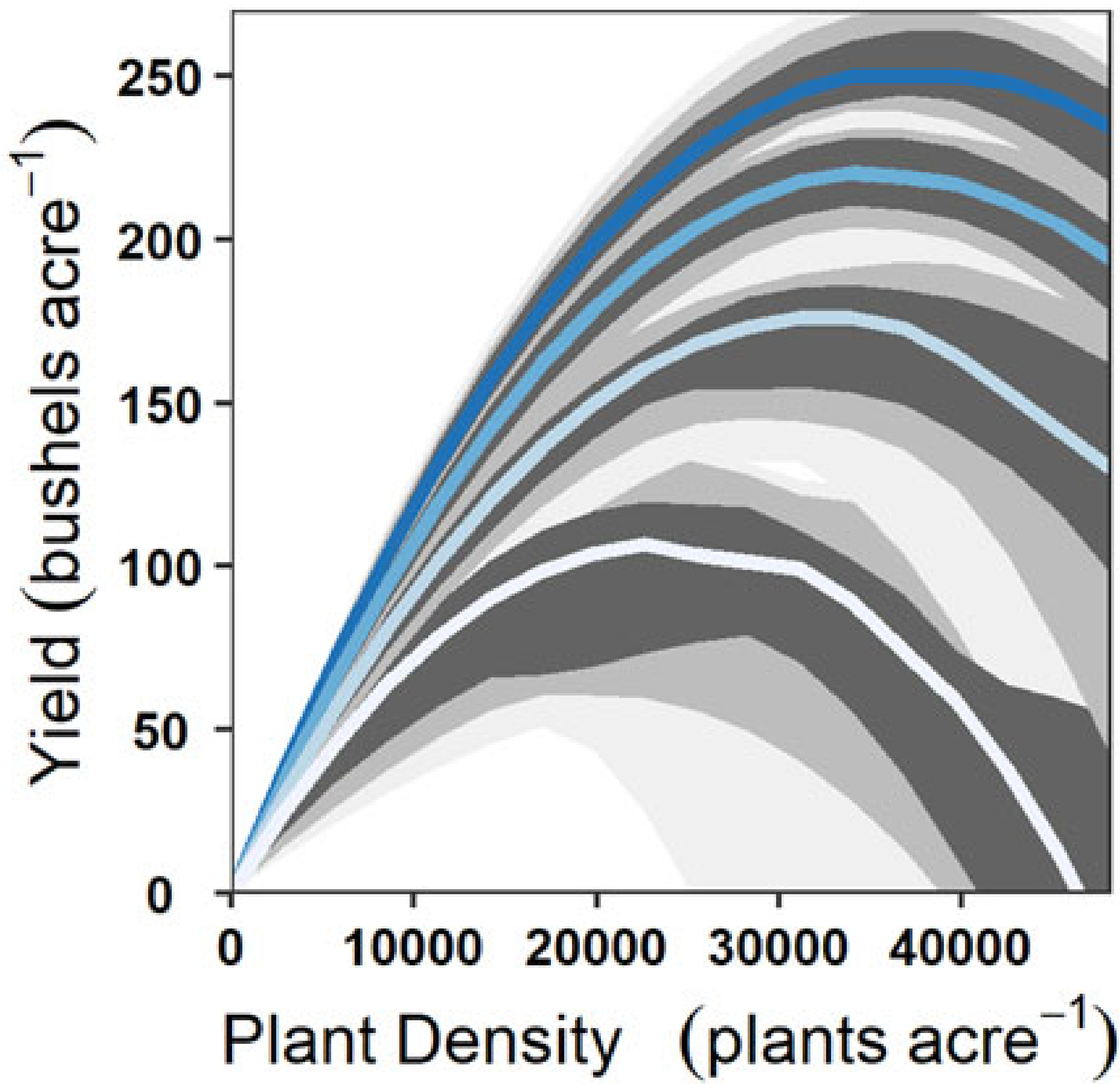

Figure 2. Corn grain yield response to plant density in four target yield environments (Lacasa, Ciampitti et al., 2020, Scientific Reports, https://www.nature.com/articles/s41598-020-72693-1). Solid lines are the main yield-to-plant density response curves for each yield environment and shaded grey areas represent the level of uncertainty on the predictions for each response model.

Stay tuned to future eUpdate articles related to this and other relevant topics from the Cropping Systems lab - https://ciampittilab.wixsite.com/ciampitti-lab

Ignacio Ciampitti, Farming Systems

ciampitti@ksu.edu

5. 2021 Grain sorghum management publication now available

A newly revised K-State Research and Extension publication, *Kansas Grain Sorghum Management 2021*, is now available and can be accessed online at: https://bookstore.ksre.ksu.edu/pubs/MF3046.pdf

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Kansas Sorghum Management 2021

MF3046 Crop Production

This publication offers advice to producers, crop consultants, and agronomists to manage their sorghum crop as efficiently and profitably as possible. Recommendations should be considered as guidelines and must be tailored to situations based on the cropping system, soils, and weed populations encountered in that field.

This comprehensive guide is written specifically for Kansas and includes valuable, up-to-date information on:

- Tillage and rotations
- Hybrid selection
- Planting practices
- Rate of dry down before harvest
- Weed management
- Irrigation management
- Fertilizer requirements
- Diseases
- Insects
- Pre-harvest desiccants

Contributors to the 2021 version of this publication include:

Ignacio Ciampitti, Crop Production and Cropping Systems
Sarah Lancaster, Weed Management
Dorivar Ruiz Diaz, Soil Fertility and Nutrient Management
Jonathan Aguilar, Bio and Ag Engineering – Irrigation
Rodrigo Onofre, Plant Pathology
Doug Jardine, Plant Pathology (Emeritus)
Jeff Whitworth, Entomology