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Extension Agronomy

eUpdate

08/24/2023

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. Drought and heat stress impacts on soybeans in Kansas

Over the last week, impressive heat has taken hold of the region with absolutely no precipitation statewide (Figures 1 & 2). Like corn fields, dryland soybean fields have started to experience significant heat stress. Despite many areas of the state seeing drought improvement over the last month, the duration of record-breaking heat has exacerbated in-field moisture stress.

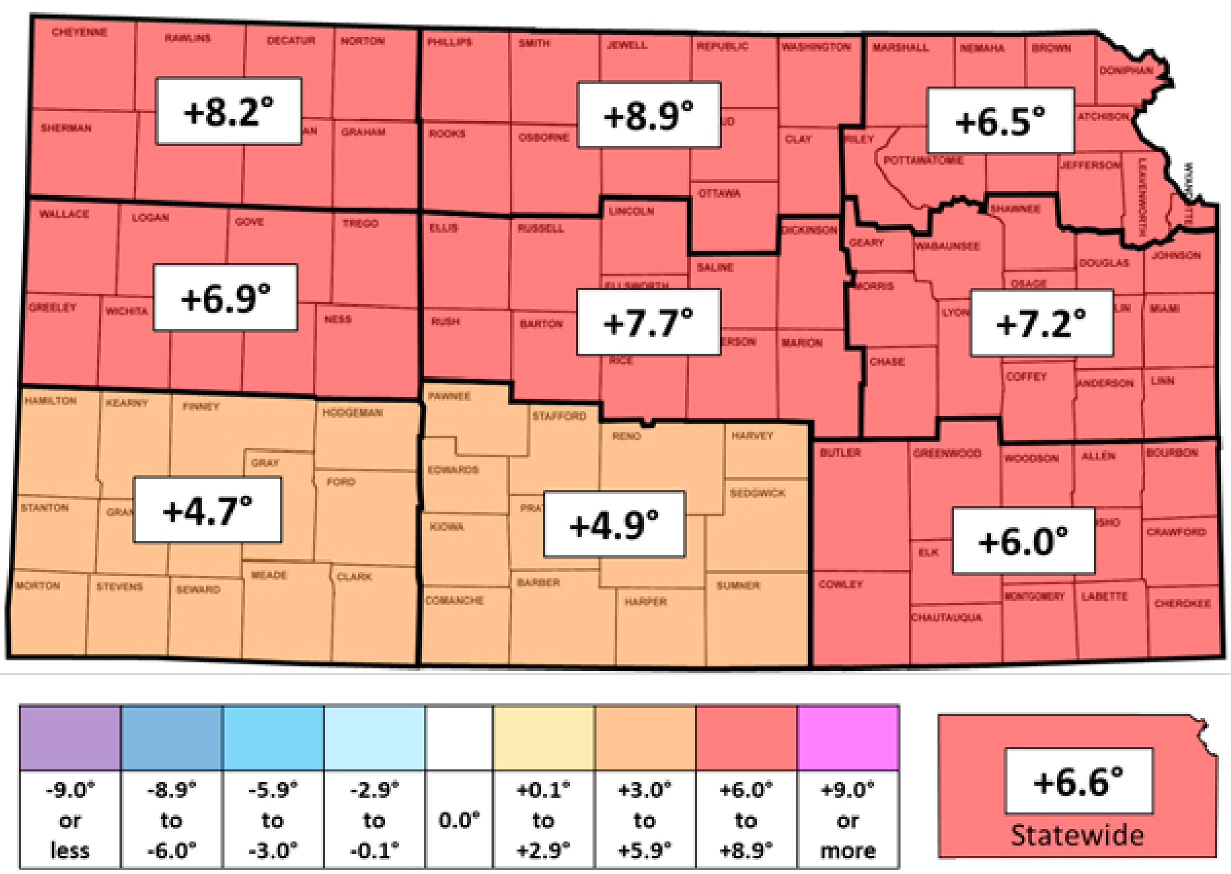

Figure 1. Temperature anomalies by division for the period August 18-24, 2023. All divisions were above normal. Source: Kansas Weather Data Library.

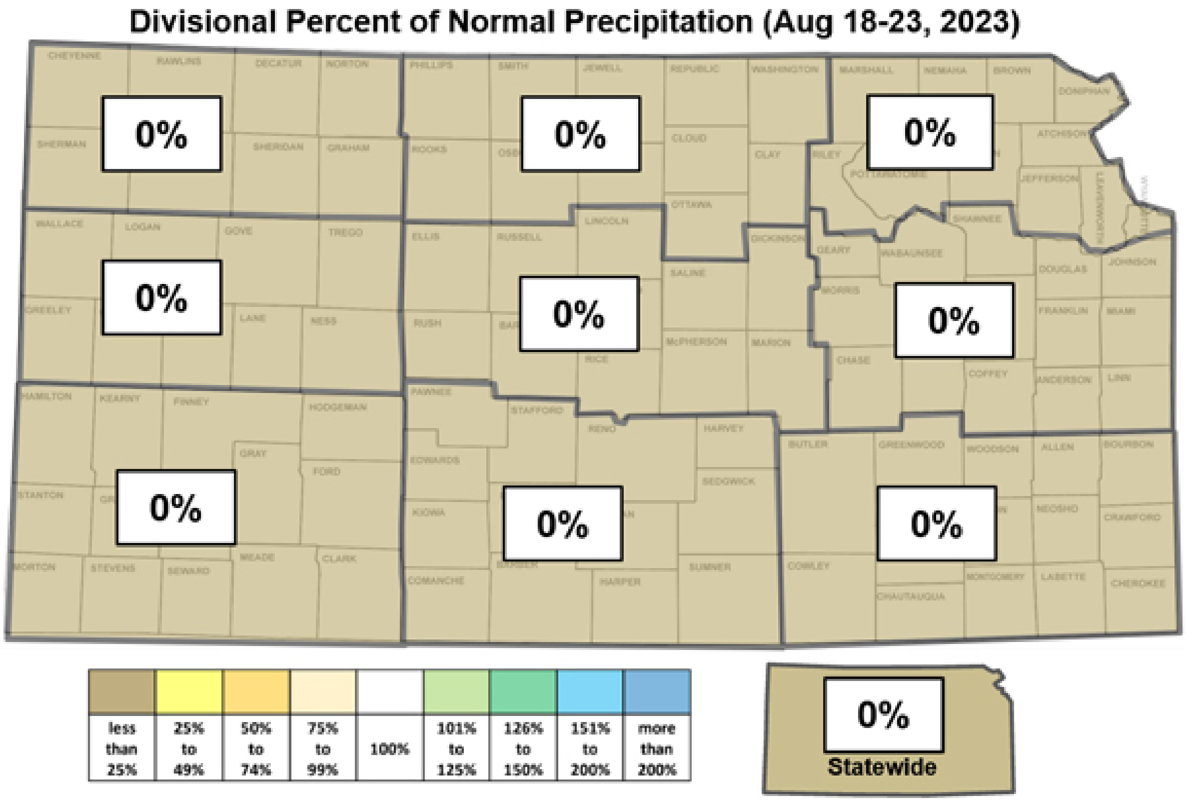

Figure 2. Percent of normal precipitation by division for the time period August 18-23, 2023. All divisions recorded negligible precipitation. Source: Kansas Weather Data Library.

The latest USDA Kansas Crop Progress Report and Condition (August 21, 2023) rated the soybean crop condition as 26% poor or very poor, 34% fair, 34% good, and only 6% as excellent. This report came out during the onset of the heat wave with worse conditions expected next week. In parallel, soils have rapidly dried out at the surface over the last week (Figure 3), with both topsoil and subsoil moisture reported as >19% very short, ~37% short, with only about 42% as adequate, and 2% under a water surplus per the USDA.

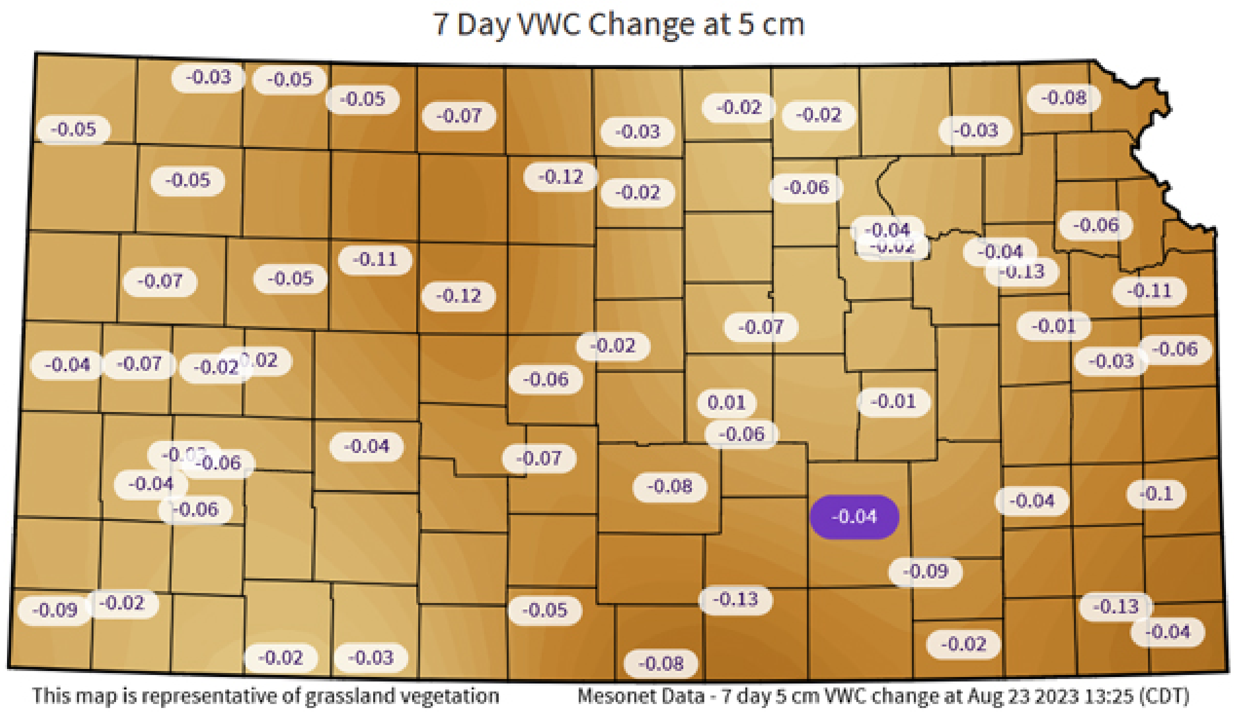

Figure 3. Weekly decrease in volumetric water content at the 2-inch depth. Source: Kansas Mesonet.

Entering the second half of August, most soybean fields have entered into the reproductive period (~94% flowering), with already more than half (~76%) of fields setting pods. The lack of moisture combined with warmer-than-normal temperatures will likely accelerate the growing season, moving crop phenology along much faster than the overall plant growth.

The remainder of this article reviews potential symptoms of drought and heat stress on soybeans.

Common drought and heat stress symptoms

Typically, soybeans can withstand drought stress reasonably well during the vegetative phases and are normally less sensitive than corn until late reproductive stages (e.g., pod formation). However, the combined effect of water shortage and heat stress has been extreme in many parts of the state, especially towards the Central and East regions, with soybean leaves starting to flip, curl, or even drop, increasing the abortion of flowers and pods.

Leaf flipping is one of the first symptoms that occurs when soybean plants are experiencing drought stress. Leaves flip over, exposing their undersides (Figure 4). This defense mechanism will help reduce transpiration but ultimately reduce crop growth and productivity.

Leaf curling/clamping is a second mechanism to conserve water for soybean plants. This stress response reduces the leaf area exposed, thus compromising crop productivity.

Figure 4. Leaf flipping. Photo by Ignacio Ciampitti, K-State Research and Extension.

Leaf sunscald is more evident in the leaves exposed to the sun, resulting in loss of leaves (Figure 5).

Figure 5. Leaf sunscald. Photo by Christopher "Chip" Redmond, K-State Research and Extension.

Leaf drop is a third, and more extreme, mechanism involving leaves that wilt and drop, especially during very intense and prolonged periods of water stress. Soybeans that were planted in June or early July are probably still young enough to withstand drought stress for several more weeks without dropping leaves. Soybeans planted in May or early June (and with much larger plant size) will be more vulnerable to rapid leaf loss at this time of year.

Flower and pod abortion - When the crop is already at reproductive stages, a classic symptom is an increase in aborted flowers and small pods. Since indeterminate soybeans may produce flowers for about a month, the crop may be able to recover depending on the duration and intensity of the stress. The priority of the plants will be to provide resources to older pods, which may in turn increase the number of seeds per pod partially compensating for the flower and small pods abortion. If the drought and/or heat stress is intense, both the blooming and pod-setting periods could be shortened and compromise yields (Figure 6).

Figure 6. Flower and pod abortion. Photo by Ignacio Ciampitti, K-State Research and Extension.

Impact on yield components

During reproductive stages, the effects of prolonged heat and drought are critical. As mentioned above, under drought conditions, soybeans in early reproductive stages will have increased flower and pod abortion. Soybeans can tolerate short periods of heat and drought at this time by aborting flowers and forming more later. But the crop will not bloom indefinitely and under prolonged heat and drought may be unable to recover. If no pods are set after the normal blooming period of three to six weeks, it is possible that the crop will not set any pods or make any seed yield. Determinate varieties have shorter blooming periods than indeterminate varieties.

Because of extremely high July and August temperatures, irrigated fields are not immune to the effects of drought stress. With numerous days over 100 degrees, even irrigated plants can fail to set or fill pods. If stress continues during seed filling, the crop will have fewer possibilities to compensate for yield reduction, with major impacts on final seed weight. Pod setting marks the beginning of the most critical period of the crop when the main yield component is determined: the seed number. Any stress-reducing biomass accumulation during this critical period will impact the number of seeds, and thus yield.

Management considerations

Harvest - Soybeans with 50 to 90 percent leaves and a good number of pods at the R6 stage have a good chance of producing a decent crop if allowed to mature -- especially if timely rains occur. In that case, it would probably be best to harvest the crop as normal, even though some of the leaves and flowers have dropped due to stress. Good yields are not guaranteed even if the plants are in good shape at R6.

Cutting for hay - Prolonged heat and drought stress can cause considerable leaf area loss and soybean yield reduction. If the crop is so drought-stressed that it's losing leaves or not setting pods, it may be time to cut it for hay. This might appeal to livestock producers who are facing dry pastures and supplemental feed costs. The decision depends on the stage of growth and condition of the plants. If possible, it's best to hold off on making any decisions about cutting soybeans for hay until the plants are moving into seed fill (the optimal time to cut beans for hay to retain digestible nutrients).

However, holding off until this stage of growth may not be possible if plants in the vegetative stage are dropping half or more of their leaves already. If too many leaves have dropped, the crop has a reduced value as a hay crop. Producers may need to make the decision to cut for hay while the plants are still in the vegetative stage, before the beginning seed fill stage, and before the soybeans lose too many leaves. Soybean plants that still have 30 percent of their leaves can produce 0.75 to 1.25 tons dry matter of hay per acre, with about 13 percent protein and 48 percent in-vitro dry matter digestibility. The more leaves a plant has, the more hay tonnage it will produce.

The "grey area" is where there are plants with 30 to 50 percent of leaves remaining since those leaves have the capability of filling pods if it rains and of making a soybean harvest that is worth more than the price of the hay.

Please remember - many herbicide labels do restrict the use of soybeans as a forage. It will be critical to know the waiting period that must be followed between the application of a given herbicide and the grazing or harvesting of the soybeans for use as a forage. A companion article in this eUpdate summarizes the rules for several herbicides when feeding soybeans.

Final considerations

Scout your acres for drought and heat stress so you can make timely decisions. Beyond yield reductions due to pod abortion, further yield impact can be expected also due to poor seed-filling conditions that may reduce the seed weight.

Finally, if you would like to report drought impacts to your region, anyone can submit Condition Monitoring Observer Reports (CMOR). You can submit reports here: http://go.unl.edu/CMOR and view other's reports here: http://go.unl.edu/CMORMAP. To learn more about the Drought Monitor process, please visit https://bit.ly/3Q2UUke.

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2. Soybean yield potential estimation

With most Kansas soybean fields already in reproductive stages, it is time to start assessing the yield potential. The latest USDA-NASS Kansas Crop Progress and Condition report (Aug 21) estimates that 94% of soybeans in Kansas are blooming, near 90% from last year. Around 76% of the soybeans in the state are setting pods, which is also ahead compared to 66% from last year (5-year average = 72%).

Soybean plants can more easily compensate for stress (relative to corn), more so if the timing of the stress is before seed filling. One of the key factors in the crop's ability to compensate for stress situations is the significant overlapping of vegetative and reproductive stages that indeterminate soybeans express, allowing them to keep producing new leaves even toward the reproductive period. On the other hand, the production of flowers could normally last between 4-6 weeks, which potentially allows to replace flowers and small pods abortion.

Since the final number of pods is not determined until reaching the beginning of seed filling, when estimating soybean yield potential, we must keep in mind that the estimate could change based on the timing of this estimation and weather conditions. For example, wet periods toward the end of the reproductive period can extend the seed-set period, promoting greater pod production and retention, with heavier seed weight.

Estimating the final yield before harvest can be a very tedious task, but a simplified method using yield components can be applied to start setting yield expectations.

From a physiological perspective, the main yield components to consider are:

- plants per acre,
- pods per area,
- seeds per pod, and
- seed size.

When can I start making soybean yield estimates?

There is no precise time, but we can start making soybean yield estimates as soon as the end of the R4 stage, full pod (pods are ¾-inch long on one of the top four nodes), or at the onset of the R5 stage, beginning seed (seeds are 1/8-inch long on one of the top four nodes). Keep in mind that yield prediction is less precise at these early reproductive stages since the seed number per area, as well as the seed weight, are not yet completely defined. At this early stage of seed development, it is important to only consider the pods that are at least ¾-inch long to avoid over-optimistic estimations since smaller pods can still abort under stress conditions.

As we move into the R6 stage (full seed), the seed number (main yield component) is majorly defined, yet the conditions during seed filling will determine the final seed number as well as the size and weight of the seed. The closest to maturity (R7 stage) that we move the estimation, the most accurate the expectation and overall yield prediction.

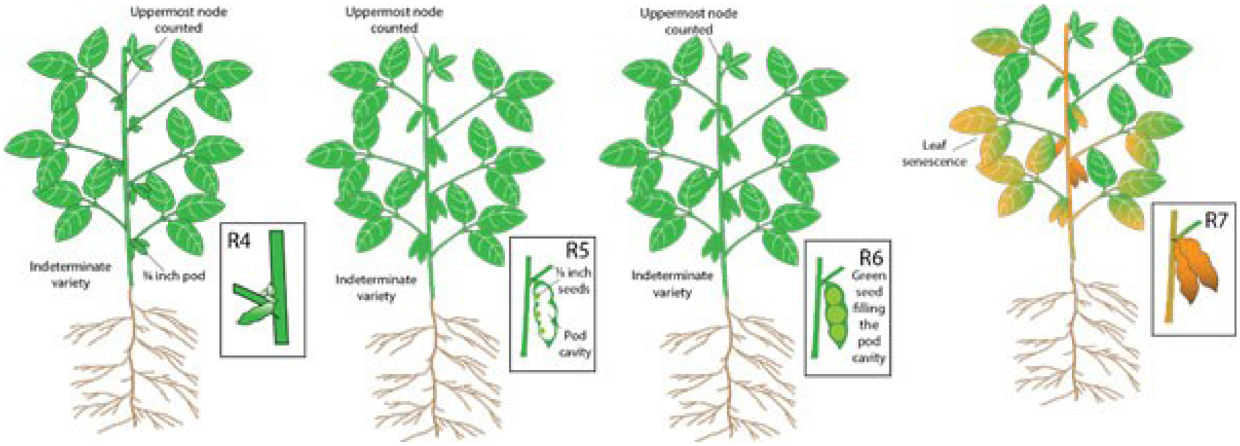

Figure 1. Soybean phenological stages to start yield prediction using the yield components method.

How many samples are needed to account for field variation?

We should make yield estimations in about 10 (at least 6, ideally 12) different areas of the field. Of course, properly recognizing and identifying the variation within the field is important, and then taking enough samples from the different areas to fairly represent the entire field. Within each sample section, take consecutive plants within the row to have a good representation. The variability between plants in terms of the number of pods and seed size needs to be considered when trying to get an estimation of soybean yield. Variability between areas within the same field needs also to be properly accounted for (e.g. low vs. high areas in the field). The more variability to represent, the more samples we would need for a proper estimation.

The yield components equation

Soybean yield estimates following the conventional approach are based on the following components (**Eq. 1**):

Eq. 1

$$\left[\left(\frac{plants}{ac.}\right) x \left(\frac{pods}{plant}\right) x \left(\frac{seeds}{pod}\right)\right] \div \left[\left(\frac{seeds}{lbs.}\right) x \left(\frac{lbs.}{bu}\right)\right]$$

where,

1. **Plants/ac.** A simplified approach can be applied by using samples covering 1/10,000th of an acre with sections of 30 inches width by 21 inches length (**Figure 2, step 1.**). Thus, the average of plants on several sections multiplied by 10,000 will give us an estimation of the number of plants per acre. Following this simplified approach, if the soybean plants are arranged in 30-inch rows we just need to sample a single row; 2 rows if the row spacing is 15 inches; and 4 rows if the row spacing is 7.5 inches.
2. **Pods/plant.** Once the samples have been obtained, we proceed to count and later average the number of pods per plant (**Figure 2, step 2.**).

3. **Seeds/pod.** Then, we proceed to count and later average the number of seeds per pod (**Figure 2, step 3.**). Soybean plants will have, on average, 2.5 seeds per pod (ranging from 1 to 4 seeds per pod), primarily regulated by the interaction between the environment and the genotypes. Under severe drought and heat stress, a pessimistic expectation would be an average of 1-1.5 seeds per pod.
4. **Seeds/acre.** A calculation of the total number of plants/ac (1)., pods/plant (2), and seeds/pod (3), obtaining the total number of seeds per unit area (**Figure 2, step 4.**).
5. **lbs/bu.** For this estimation, the "test weight" for soybean could be considered here as a constant number at 60 lbs./bu.
6. **Seeds/lbs.** The number of seeds per pound will vary depending on the seed filling conditions, which will determine the seed size. Normally, this number could range somewhere between 2,500 (bigger seeds) to 3,500 (smaller seeds) seeds per pound, for optimal to unfavorable seed filling conditions. Combined with a constant test weight of 60 lbs./bu, this will lead to a range of expectation of seeds per bushel between 150,000 seeds per bushel to 210,000 seeds per bushel, respectively (**Figure 2, step 5**).

The final step to get the estimation is dividing seeds/acre by seeds/bu to obtain the yield estimation in bushels per acre (**Eq. 2**).

Eq. 2

$$\left(\frac{seeds}{ac.}\right) \div \left(\frac{seeds}{bu}\right) = {}^{bu}/_{ac.}$$

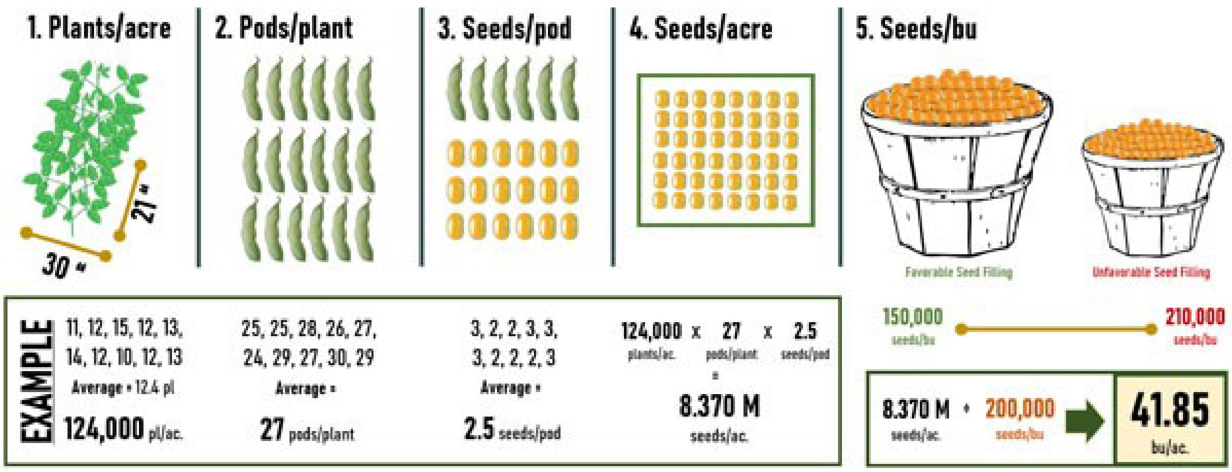

Figure 2. Example of yield estimation method using samples of 1/10,000th of an acre (21-inch x 30-inch sections) for a regular yield until seed filling, where the seed size is expected to be reduced compared to favorable seed filling conditions, increasing the #seeds/bu component.

Example representing average conditions

In Figure 2, we have taken 10 samples of 30x21 inches sections, leading to an average number of 12.4 plants. Since these sections are 1/10,000th of an acre, our first component, the plant density is 124,000 plants/acre. Then, in those 12 plants, we measured on average 27 pods per plant. If we assume a "normal" growing season condition, then we could expect to count around 2.5 seeds per pod. Combining these components, we obtained an expectation of 8.370 M seeds per acre. Finally, we had to assume (if the estimation is early) or represent (if close to maturity) the seed-filling conditions. In this case, we have used regular-to-poor seed filling due to the lack of precipitation combined with heat, thus we divided the seeds per acre by an expectation of 200,000 seeds per bu (small seed size), giving us an estimate of roughly 42 bu/a.

Adjusting for 2023 expectations

For this season, soybeans have shown a good start during May and June. However, challenging conditions have arisen from drought and heat experienced during July and August (mainly during this current week). Thus, even if the pod number is the same as in a normal season, for a "droughty" and mainly hot (from R2 to R6 stages) growing season such as the present one, the final seed number will be negatively impacted. Therefore, a yield calculation for unfavorable conditions while defining the number of seeds per pod component could be as follows:

$$(124{,}000 \ \frac{plants}{ac.} \ x \ 27 \ \frac{pods}{plant} \ x \ 1.5 \ \frac{seeds}{pod}) \div 200{,}000 \ \frac{seeds}{bu} = \mathbf{25.11} \ {}^{\boldsymbol{bu}}/_{\boldsymbol{ac.}}$$

If the stress conditions started earlier in the reproductive period, the situation could be worse impacting the final number of pods, and if the stress conditions are not alleviated soon, we may expect a considerable reduction in the final seed weight. Still, this week of above-normal temperatures will produce a significant impact on yields (via pod or seed abortion) and rush to final maturity for a very short seed-filling period, with a reduction in final seed weight.

The practice of estimating seed yield in soybeans will provide an opportunity for farmers and agronomists not only to obtain a more reliable prediction of yields but also to scout fields for associated issues before harvest, such as insects, diseases, and other potential production problems. The effects of the current weather conditions can be assessed in the coming week in order to obtain a more precise estimate of the final yield expected on this crop.

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3. Check herbicide labels before using soybeans for livestock feed

Drought conditions and extreme heat throughout Kansas are forcing farmers to consider harvesting soybeans for forage, rather than grain. Many factors should be considered when making this decision and some are discussed in a companion article in this Agronomy eUpdate, *Drought and heat stress in Kansas soybean fields*.

Herbicide applications made during the growing season are an additional concern that has been raised by farmers. The herbicide label is the law, and many herbicide labels do restrict the use of soybeans as a forage. It will be critical to know the waiting period that must be followed between the application of a given herbicide and the grazing or harvesting of the soybeans for use as a forage. Table 1 summarizes statements related to feeding soybeans.

Table 1. Summary of restrictions for grazing/haying soybeans treated with various herbicides.

Herbicide	**Comments related to haying and/or grazing**
Anthem Maxx	DO NOT graze or feed treated soybean forage or hay to livestock.
Assure II	Do not feed forage, hay, or straw from treated areas to livestock unless stated otherwise under the specific crop use directions.
Classic	**Do not** graze treated fields or harvest for hay within 14 days after application.
Cobra	Do not graze animals on green forage or stubble. Do not feed treated soybean silage (ensiled soybeans) to cattle. Do not utilize hay or straw for animal feed or bedding.
Dual Magnum	DO NOT graze or feed treated forage, hay, or straw from soybeans to livestock for 30 days following a preplant surface, preplant incorporated, or preemergence application. DO NOT graze or feed treated forage or hay from soybeans to livestock following a postemergence application.
Engenia	Allow at least 14 days between final application and harvest or feeding of soybean hay.
Enlist Duo	Do not graze treated soybean. Do not harvest for forage or hay.
Enlist One	Do not graze treated soybean. Do not harvest for forage or hay.
FirstRate	Forage or Hay: Do not apply within 25 days before harvest. Soybeans: Do not apply within 70 days before harvest.
Flexstar/Reflex	Do not graze treated areas or harvest for forage or hay.
Flexstar GT 3.5	Do not graze treated areas or harvest for forage or hay.
Fusilade DX	Do not harvest soybeans for 60 days following the last application.
Fusion	Do not graze or harvest for forage or hay.
Harmony GT XP	Do not allow livestock to graze on, or feed forage, hay or straw from treated soybean fields.
Intermoc	DO NOT graze or feed treated forage, hay, or straw.

	DO NOT graze or feed treated forage or hay from soybeans to livestock after a post-emergent application.
Liberty 280 SL	DO NOT graze the treated crop or cut for hay
Marvel	Do not graze or feed treated soybean forage or hay to livestock.
Outlook	DO NOT graze or feed forage, hay, or straw to livestock
Perpetuo	DO NOT graze treated fields or harvest for forage or hay
Poast Plus	Only processed meal from seed or hay may be fed to animals.
Prefix	Do not graze or feed treated forage or hay from soybeans to livestock following a postemergence application of Prefix Herbicide.
Pursuit	DO NOT graze or feed treated soybean forage, hay, or straw to livestock.
Raptor	No comments on label
Resource	Do not graze treated fields or harvest for forage or hay.
RoundUp PowerMax3	Allow a minimum of 14 days between application and harvest of soybean grain or feeding of soybean grain, forage or hay.
SelectMax	DO NOT graze treated fields or feed treated forage or hay to livestock
Sequence	DO NOT graze or feed treated forage or hay to livestock following a postemergence application.
Synchrony	DO NOT graze or feed treated forage or hay to livestock following a postemergence application
Tavium	DO NOT graze or feed treated forage or hay to livestock following a postemergence application.
Thunder Master	DO NOT graze or feed treated soybean forage, hay or straw to livestock.
Torment	Do not graze treated areas or harvest for forage or hay.
Ultra Blazer	Do not use treated plants for feed or forage.
Warrant	DO NOT graze treated area or feed treated soybean forage to livestock following the application of this product.
Warrant Ultra	DO NOT graze treated area or feed treated forage to livestock following application of this product.
XtendiMax	Livestock Grazing or Feeding Permitted.
Zidua SC	No comments on label

The use of trade names is for clarity to readers and does not imply endorsement of a particular product, nor does exclusion imply non-approval. Always consult the herbicide label for the most current use requirements.

For more information, see 2023 Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland, K-State publication SRP-1176.

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4. Final irrigation of the growing season - Timing is everything

This year has been especially challenging for irrigators as we started the year with extremely low levels of soil profile water in most places followed by above-normal precipitation then returning to hot and dry conditions. As we look towards the end of the irrigation season, producers have an opportunity to improve their water productivity by properly timing their final irrigation application. This is an important decision as an early termination of irrigation can result in reductions in grain yield, primarily through reductions in the kernel weight yield component. Conversely, a late termination of irrigation results in unnecessary pumping, and energy consumption, increases the risk of soil compaction at harvest due to increased soil water, and increases the risk of water loss overwinter through drainage.

With the goal of matching available water to crop needs while avoiding excess, it is important to understand crop water use requirements late in the growing season. Anticipated water use from various growth stages until physiological maturity for corn, grain sorghum, and soybeans is shown in Table 1.

Table 1. Anticipated water use for corn, grain sorghum, and soybeans at various growth stages.

Stage of Growth	Approximate number of days to maturity	Water use to maturity (inches)
Corn		
Blister	45	10.5
Dough	34	7.5
Beginning dent	24	5
Full dent	13	2.5
Black layer	0	0
Grain Sorghum		
Mid bloom	34	9
Soft dough	23	5
Hard dough	12	2
Black layer	0	0
Soybeans		
Full pod	37	9
Beginning seed	29	6.5
Full seed	17	3.5
Full maturity	0	0

Adapted from K-State MF2174, Rogers and Sothers.

Research in western Kansas has shown the importance of keeping the management allowable depletion limited to 45% during the post-tassel period. In other words, maintaining available soil water contents above 55%. By knowing anticipated water use from a given growth stage and the remaining soil water in the profile, producers can add just enough irrigation water to meet that demand and maintain profile available soil water content above 55%.

By closely following the growth and development of the crop, one can know when physiological maturity, i.e. black layer in corn, has been reached and at that point, water use for the production of grain yield has ceased and additional irrigation is certainly unnecessary.

Termination based on calendar dates

Traditionally many producers have used a fixed calendar date to determine their final irrigation. Long-term studies conducted by Freddie Lamm at the Northwest Research-Extension Center at Colby show the potential problems in this approach. Table 2 shows silking, maturity, and irrigation termination dates for a long-term study in corn. Over the course of this study, the irrigation termination date for maximum grain yield varied from August 12 to September 21. This is a significant departure from a general rule of thumb using Labor Day as a termination date. As shown, the use of a fixed date on the calendar without regard to crop progress, soil water status, or ET demand would have resulted in both forfeited yield and wasteful pumping across this timeframe.

Table 2. Silking, maturity, and irrigation termination dates for a long-term study in corn.

Year	Date of Anthesis	Date of Maturity	Irrigation Season Termination Date For		
			80% Max Yield	90% Max Yield	MaxYield
1993	20-Jul	30-Sep	5-Aug	5-Aug	15-Aug
1994	20-Jul	15-Sep	5-Aug	15-Aug	15-Aug
1995	20-Jul	29-Sep	5-Aug	13-Aug	18-Aug
1996	20-Jul	3-Oct	17-Jul	17-Jul	29-Aug
1997	23-Jul	1-Oct	23-Jul	23-Jul	27-Aug
1998	20-Jul	28-Sep	20-Jul	20-Jul	24-Aug
1999	23-Jul	6-Oct	24-Jul	13-Aug	20-Sep
2000	12-Jul	20-Sep	14-Sep	20-Sep	20-Sep
2001	16-Jul	29-Sep	30-Jul	22-Sep	22-Sep
2002	22-Jul	30-Sep	4-Aug	30-Aug	7-Sep
2003	22-Jul	23-Sep	3-Aug	3-Aug	18-Aug
2004	19-Jul	28-Sep	8-Aug	21-Aug	27-Aug
2005	20-Jul	28-Sep	2-Aug	9-Aug	29-Aug
2006	17-Jul	25-Sep	30-Jul	13-Aug	13-Aug
2007	18-Jul	19-Sep	14-Aug	21-Aug	28-Aug
2008	24-Jul	10-Oct	31-Jul	6-Aug	27-Aug
Average	**19-Jul**	**27-Sep**	**2-Aug**	**13-Aug**	**28-Aug**
Standard Dev.	**3 days**	**6 days**	**13 days**	**19 days**	**13 days**
Earliest	**12-Jul**	**14-Sep**	**17-Jul**	**17-Jul**	**12-Aug**
Latest	**24-Jul**	**10-Oct**	**14-Sep**	**21-Sep**	**21-Sep**

* *Estimated dates are based on the individual irrigation treatment dates from each of the different studies when the specified percentage of yield was exceeded.*

Consequences of excess late-season irrigation

In the silt-loam soils common in western Kansas, water drainage out of the soil profile starts to occur when the profile water content rises above 60% available soil water. The rate of drainage loss increases rapidly with increasing water content. Late-season irrigation in excess of crop water use results in increased accumulation of water in the profile, which is subject to drainage losses. A survey of irrigated corn fields was conducted in 2010 and 2011 (Figure 1). Fields were surveyed after corn harvest across three east-west transects in western Kansas.

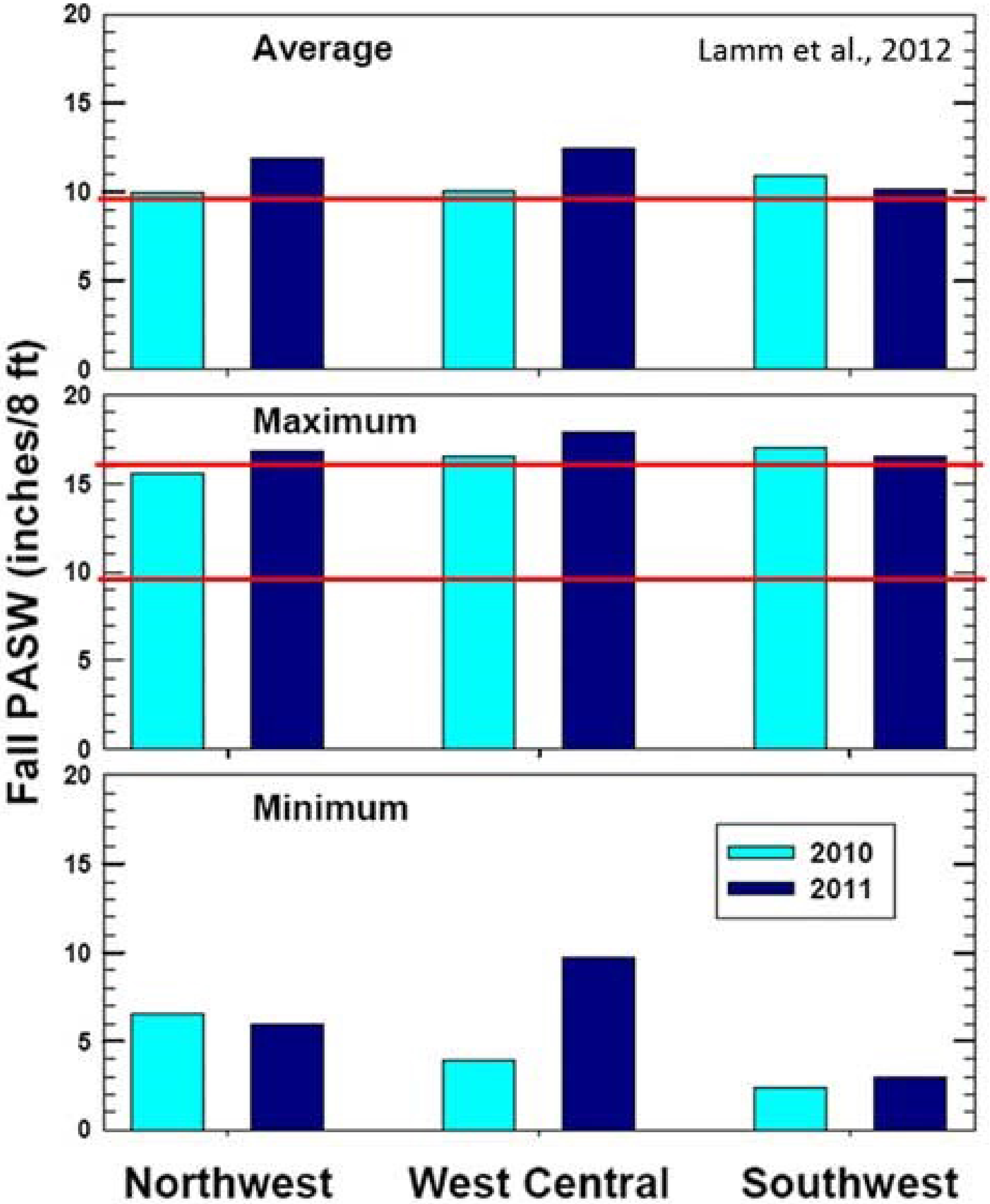

Figure 1. Results from a 2-year survey of irrigated corn fields. Fields were surveyed after harvest across three east-west transects in western KS.

The line at 9.6 inches of plant-available soil water (PASW) denotes the approximate water content where drainage losses would start to occur. On average, most producer fields were near this level of soil water storage indicating a good management strategy as drainage losses had been minimized while yet maintaining adequate soil water to complete grain fill.

Producer fields near the minimum observed values likely did not have adequate soil water to ensure maximum grain yields. The most concerning scenario, however, is the fields at the upper end of soil water values such as the maximum observation. The red line at 16 inches PASW represents field capacity, the point at which free drainage and significant water losses from the profile would occur. In the wettest producer fields, in all three regions, significant amounts of free drainage and water loss would have been occurring at the time of crop maturation and harvest.

Timing of the final irrigation:

1. Determine crop growth stage and anticipated remaining water use
2. Determine soil water status in the field by probe or calibrated soil sensor technology
3. Determine the irrigation strategy necessary to meet remaining crop water use while maintaining soil water content at or above 55% (limit depletion to 45%).
4. Be ready to make adjustments based on changes in ET demand, precipitation, etc. Historical weather and ET data can be accessed on the Mesonet with a new ET product found here: http://mesonet.k-state.edu/agriculture/et/.

Additional information, including a step-by-step procedure, can be found in the publication **MF2174**: "**Predicting the final irrigation for corn, grain sorghum, and soybeans**" - http://www.bookstore.ksre.ksu.edu/pubs/MF2174.pdf

Special Note: Much of the data in this article was collected by Freddie Lamm, Irrigation Engineer at the Northwest Research-Extension Center at Colby. Freddie passed away in May 2022, just months short of completing his 43rd year of irrigation research at the NWREC. A tribute to Freddie's career can be found at: https://newprairiepress.org/cgi/viewcontent.cgi?article=8336&context=kaesrr

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5. Sample handling practices affect the accuracy of plant tissue nitrate tests

Plant tissue analysis is a valuable tool for many applications, including evaluating fertilizer management practices, identifying nutrient deficiencies, and determining hay and forage crops' safety and nutritional value. However, the accuracy of these tests is often limited by the quality of the sample that the laboratory receives.

Much like the soil that plants grow in, many microorganisms exist on the stems and leaves of plants. Many of these microbes actively decompose plant tissue after the growing season. These processes are beneficial for crop production as they drive the nutrient cycling in our fields, but can also lead to skewed test results if they occur in our samples.

A recent study at the KSRE Soil Testing Lab helps to illustrate what can happen if sample submission is delayed. This study compares the effects of storing fresh plant-tissue samples in paper or ziptop-style plastic bags for varying amounts of time (up to 7 days) in the cab of a pickup truck.

Breathable paper bags are usually recommended over plastic bags as they prevent condensation in the samples. However, airflow is also needed to dry fresh plant samples quickly, even if they are stored in paper bags, as can be seen in Figure 1.

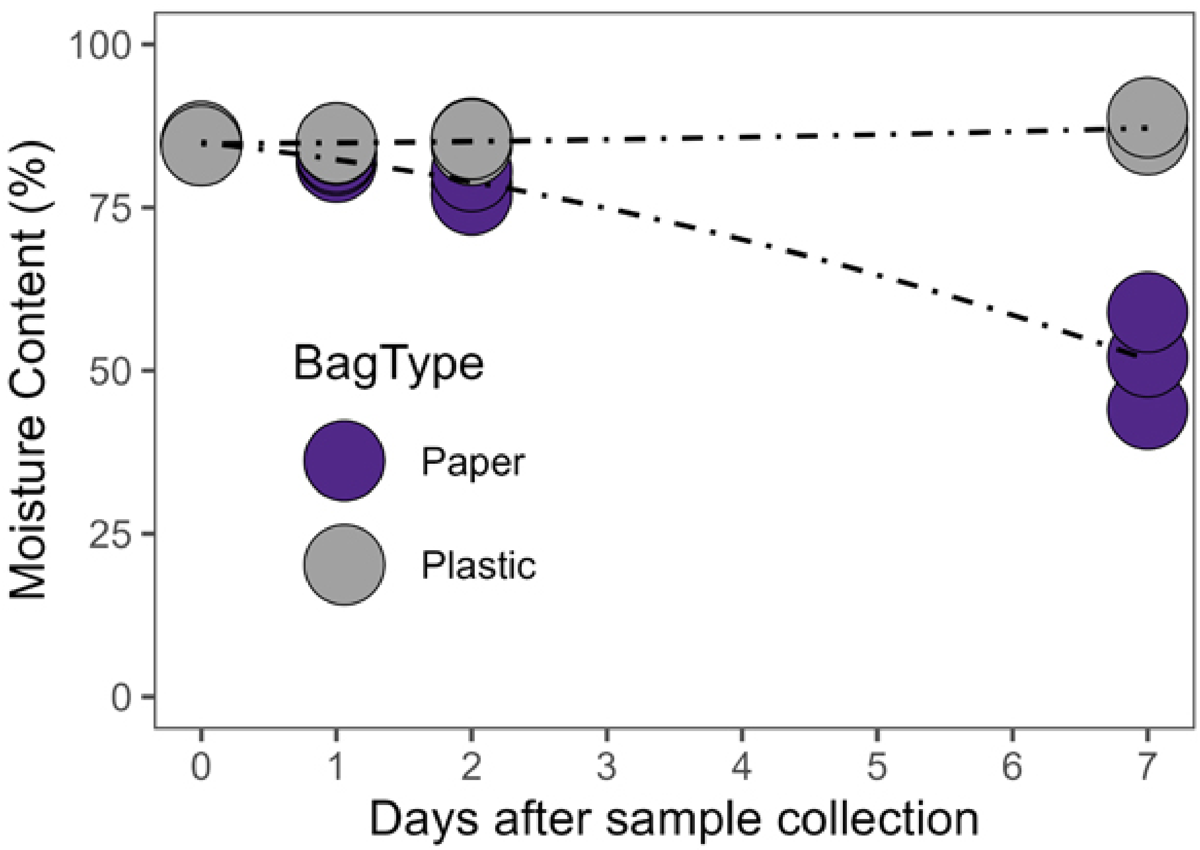

Figure 1. Moisture content of plant-tissue samples that were stored in the cab of a pickup truck over 7 days. Purple points indicate paper bags and plastic ziptop-style bags are indicated by

grey points. Data and graph by Bryan Rutter, K-State Research and Extension.

Microbial activity affected the results of various tests when samples were not allowed to dry on the same day they were collected. These effects were most notable for the nitrate, protein, acid detergent fiber (ADF), and neutral detergent fiber (NDF) tests (Figure 2). Nitrate contents were reduced rapidly after field collection in undried samples, especially when ziptop plastic bags were used (Figure 3). This can have significant implications for high nitrate forage and potential safety for cattle feeding. When samples are dry, they become stable and can be tested later, showing the same results (Figure 4)

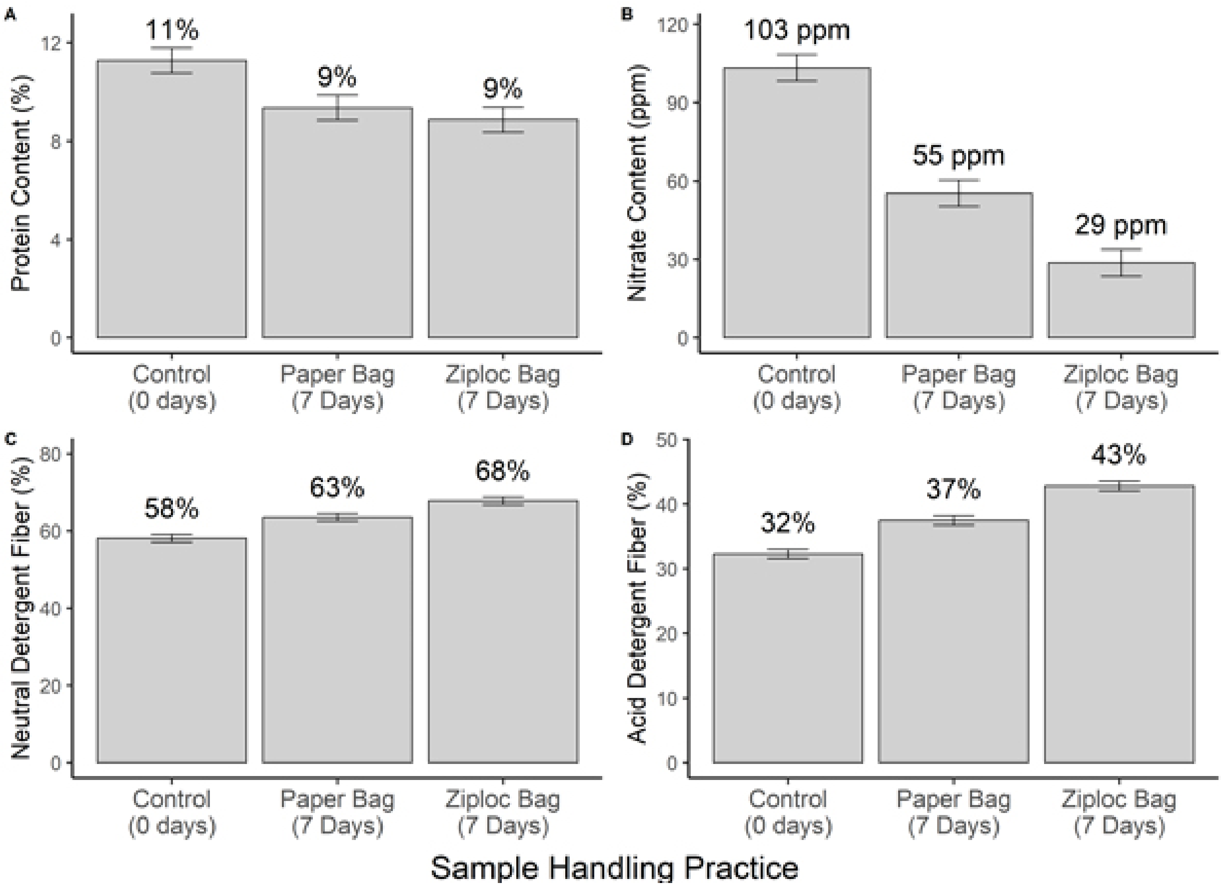

Figure 2. Changes in crude protein (Panel A), nitrate content (Panel B), neutral detergent fiber (Panel C), and Acid Detergent Fiber (Panel D) in whole plant rye samples that were stored in either paper or ziploc-style bags in the cab of a pickup truck for up to seven days after collection. Data and graphs by Bryan Rutter, K-State Research and Extension.

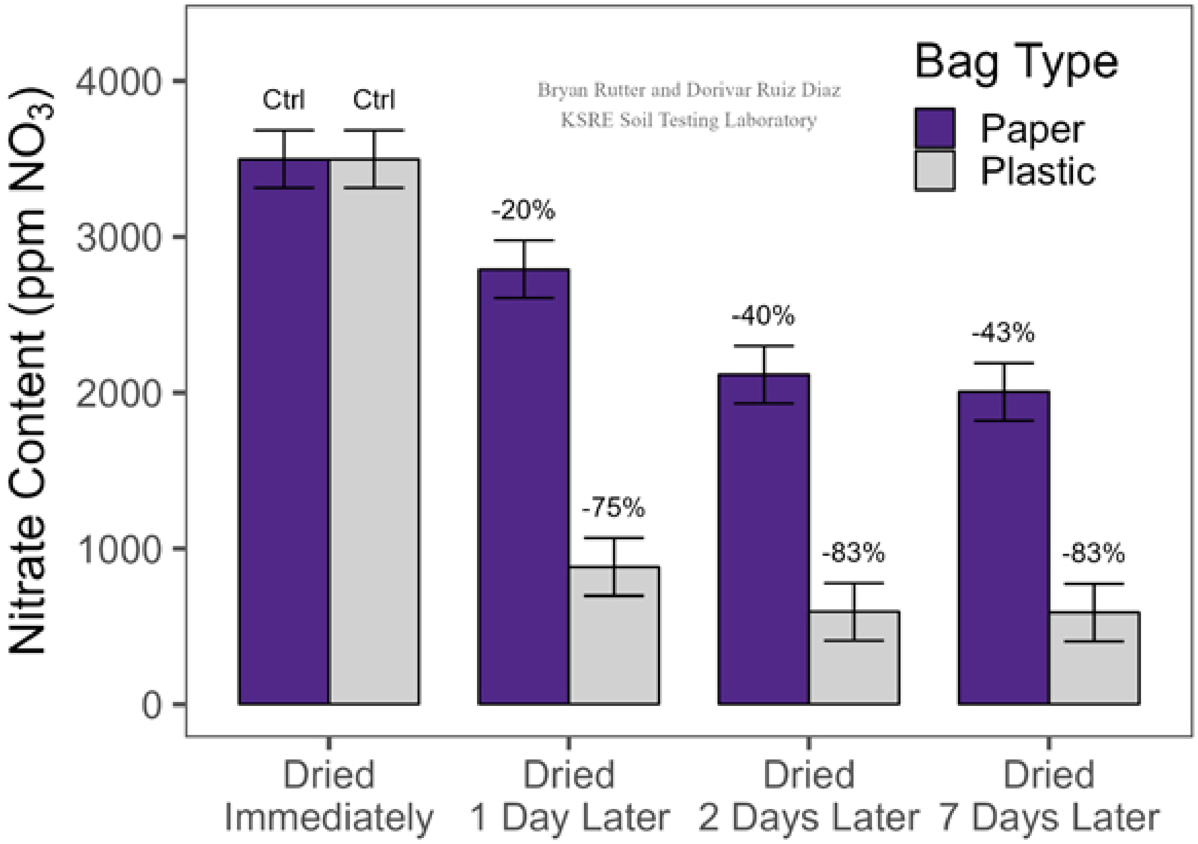

Figure 3. Nitrate content of fresh corn plant samples stored in the cab of a pickup truck for up to seven days. Paper sample bags are indicated by the purple bars, and ziploc-style plastic bags are indicated by the grey bars. The percent difference from the control ("Dried Immediately") is also indicated. Data and graph by Bryan Rutter, K-State Research and Extension.

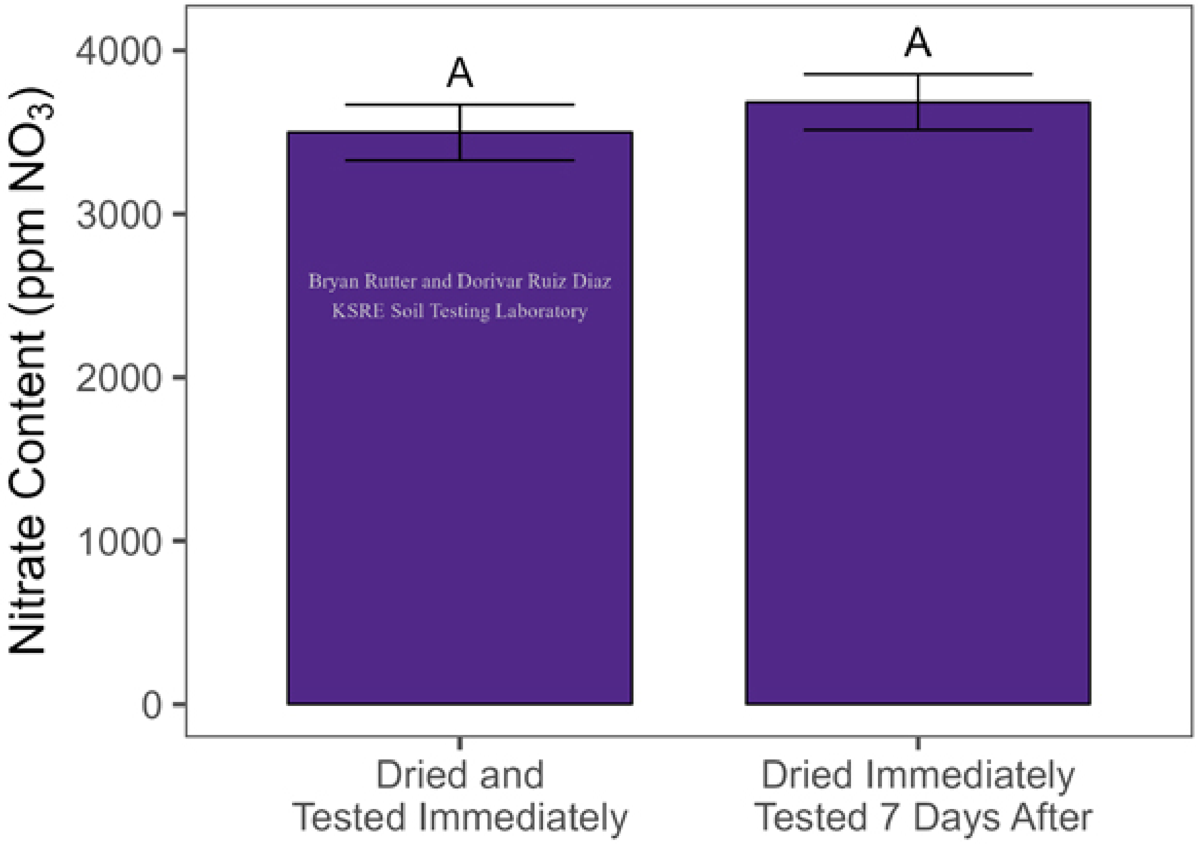

Figure 4. Comparison of nitrate content in corn plant samples that were either dried and tested immediately or dried immediately and tested seven days later. Significance letters are also shown indicating no statistical difference between the two groups. This illustrates the stability of nitrate content in plant samples when they are allowed to dry the same day they are collected. Data and graph by Bryan Rutter, K-State Research and Extension.

Take home message

- Sample handling practices can greatly impact the accuracy of test results. This can have significant implications for high nitrate forages and potential safety for cattle feeding.
- Have a plan in place to get samples submitted to the lab as soon as possible, especially when nitrate tests are needed in fresh/actively growing plants.
- If samples cannot be submitted to a lab the same day they are collected, they should be allowed to wilt and air-dry immediately.
- Place undried samples in an open area with good air movement to speed up the drying process.

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6. Liming soils for optimum wheat production

Problems of low soil pH are common throughout central and south-central Kansas. Well-drained, productive soils under good management usually become acidic over time as a natural result of high crop production. This problem typically starts in sandier soils and is exacerbated by high rates of nitrogen (N) fertilizer application over the years; making long-term continuous wheat production in central and south central Kansas especially vulnerable to this problem. However, long-term application of N also generated acid soils in other regions of the state with different soil types.

Strongly acidic soils may present several problems for wheat production. These include aluminum toxicity and in some cases manganese toxicity, as well as deficiencies of phosphorus, calcium, magnesium, and molybdenum. These problems caused by acid soils are difficult to separate one from another and are often related to root damage due to Al toxicity (Figure 1).

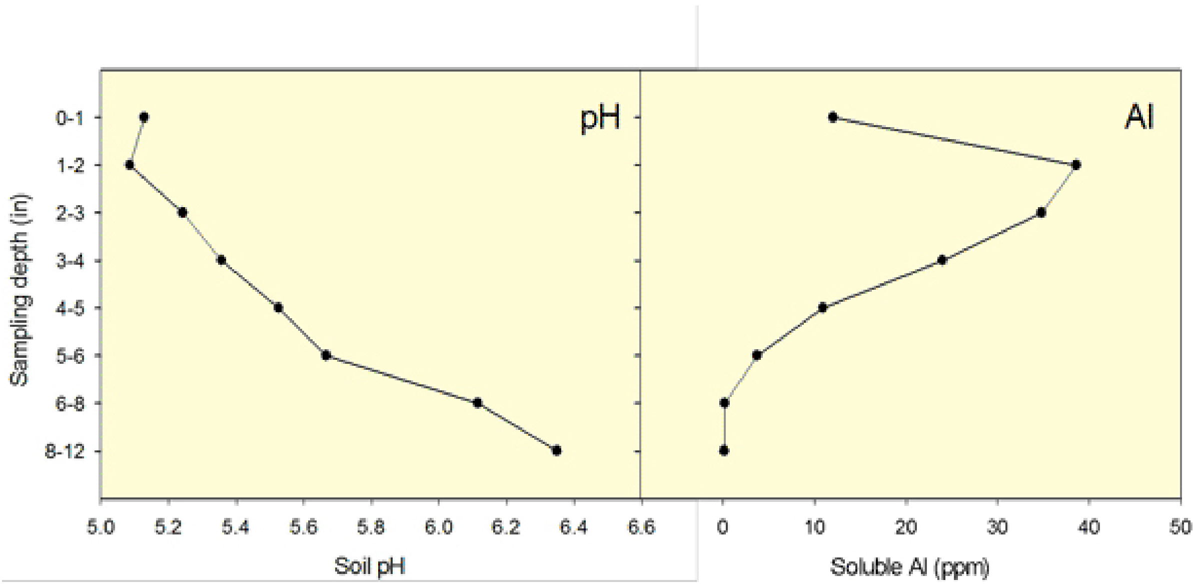

Figure 1. Soil pH stratification after long-term surface nitrogen application. Aluminum concentration in solution increases with a decrease in soil pH. Data from Dorivar Ruiz Diaz, K-State Research and Extension.

Typical symptoms of aluminum toxicity include thin stands, poor plant vigor, and purpling (Figure 2). High concentrations of aluminum will reduce root development, giving them a short stubby appearance. The roots will often have a brownish color.

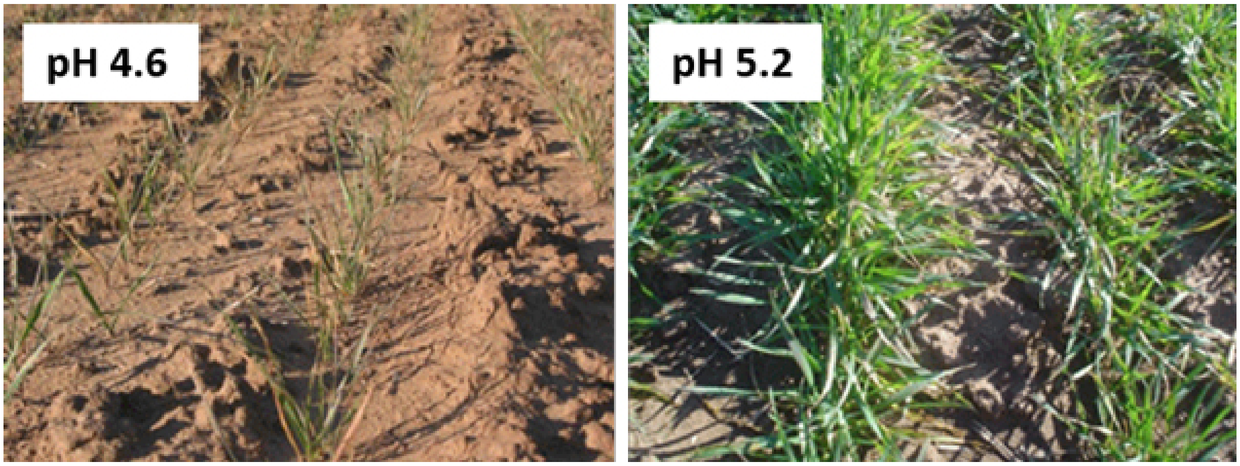

Figure 2. Wheat growing on very acidic soils, such as this soil in Harper County with a pH of 4.6, is often spindly and has poor vigor. Photos by K-State Research and Extension.

In general terms, aluminum toxicity will reduce the grain yield potential of wheat when soil pH levels are below 5.5 and KCl-extractable (free aluminum) levels are greater than 25 parts per million (ppm). If aluminum levels are not high, pH levels in this range are not as much of a problem for wheat. When soil pH levels are 5.0 or less, yields start dropping off rapidly in most cases. A minimum soil pH of approximately 6.0 is needed to maximize wheat fall forage production for most wheat varieties.

Where acid soils are causing a reduction in wheat production, plant growth, and yield can be significantly improved by liming the soils and raising the pH to an optimum range.

Common questions about lime applications for wheat

- **If a half-rate of lime is applied now, or in late August, will that give it enough time to benefit wheat planted in early to mid-October this year?**
- **Is incorporation needed to allow enough time to be effective in that situation?**

Lime application may require time to react and increase soil pH. However, most of the change in pH will occur in the first 4-6 weeks after lime application. If the lime is incorporated, the effect in the upper soil profile will be relatively quick. With a lower application rate to the surface (no-till), the effect on pH would be limited to the upper 2-3 inches and would require more time to have a significant effect depending on factors such as soil texture and moisture.

- **What kind of yield increases can you expect?**

Several studies in Kansas have shown a significant increase in yield as well as test weight when liming acid soils (Figure 3 and Table 1). In some cases yield can easily double depending on the severity of the problem.

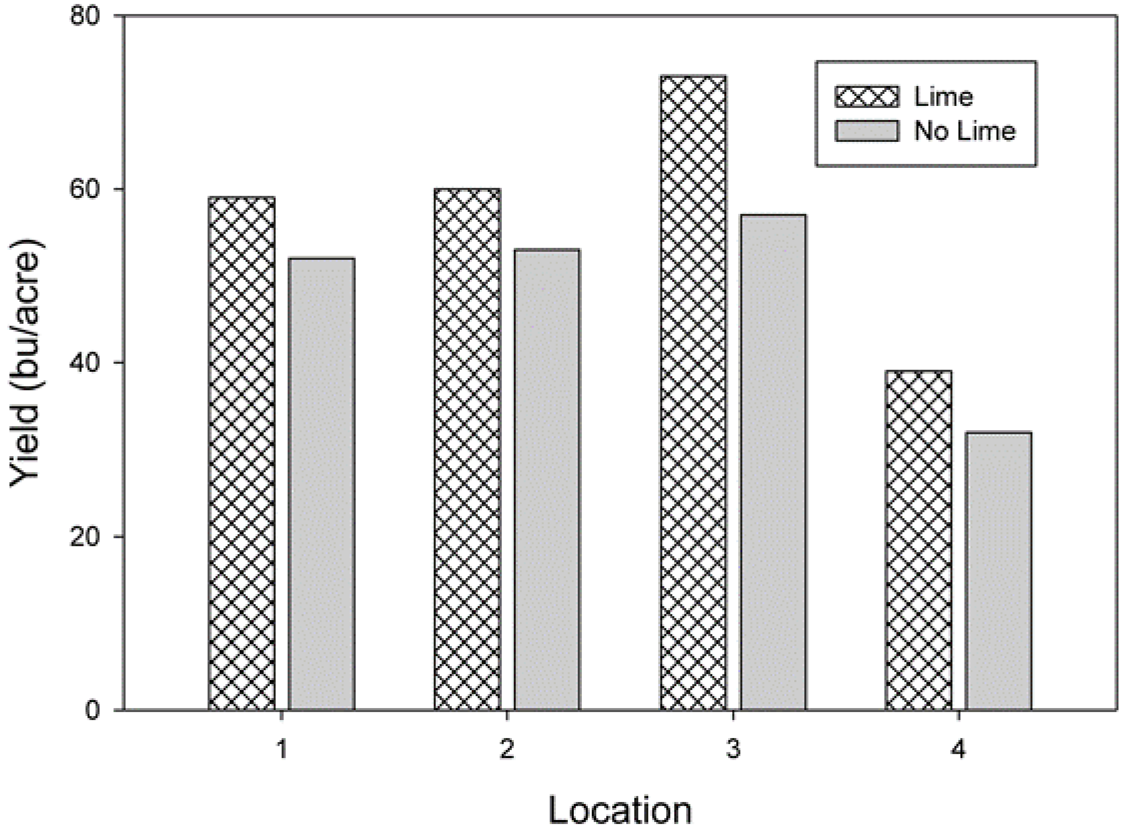

Figure 3. Effect of lime on wheat yields at four locations in Reno and Rice Counties. Yields averaged over two varieties – one susceptible and one tolerant to acid soils. Initial soil pH varied from 4.8 to 5.1 and lime application rates varied from 5,000 to 11,000 lbs/acre ECC. Source: Olsen, C.J. et al. Kansas Fertilizer Research 1999, SRP847.

- **Should producers consider applying a lower rate of lime than what is recommended by the K-State soil testing laboratory?**

It can be expensive to apply the full recommended rate of lime to soils. The yield increases from an application of the full rate of lime are likely to hold up for up to 8 years or more. But the initial cost can be quite high. Lime is a long-term investment that many producers are reluctant to make for several reasons.

If the cropping system consists of some combination of wheat, grain sorghum, corn, or sunflowers, without a legume in the rotation, then it's not critical to use the full recommended rate of lime, particularly during years of lower grain prices. With these crops, which can tolerate somewhat lower pH levels than soybeans and alfalfa, producers may realize some benefit by applying less-than-recommended rates of lime as long as they are willing to make more frequent applications. If soybeans or alfalfa will be grown on the field in question, and if the pH level is less than 6.0, then the full rate of lime should be applied.

Table 1 below shows the effect of a lower-than-recommended rate on wheat yield and test weight. The half-rate increased yield and test weight nearly as much as the full rate in this case. However, producers should be aware that if they use lower-than-recommended rates of lime, they will need to make more frequent applications. The current crop prices require efficient and cost-effective lime application which can be achieved with the use of technology such as variable application. Soil pH can vary significantly in the field, making lime one of the inputs with the highest return to variable rate application.

Table 1. Effect of lime rate on wheat yield and test weight, Sedgwick County.

Lime rate (lb ECC/acre)	Yield (bu/acre)	Test weight (lb/bu)
0	23	46
3750 (half rate)	42	60
7500 (full rate)	46	61

Variety: Karl (susceptible to acid soils). Initial soil pH: 4.7. Lime recommendation: 7500 lb ECC/acre (full rate). Source: Suderman, A.J., et al. Kansas Fertilizer Research 1994, SRP719.

- **What type of lime is best to apply?**

All lime materials must guarantee their ECC content and are subject to inspection by the Kansas Department of Agriculture. The purity of the lime material relative to pure calcium carbonate and the fineness of crushing are the two factors used in the determination of the Effective Calcium Carbonate (ECC) content. Lime can be from various sources and with different qualities. To ensure a standardized unit of soil-acidity neutralizing potential, we use units of ECC.

Research has clearly shown that a pound of ECC from ag lime, pelletized lime, water treatment plant sludge, fluid lime, or other sources is equal in neutralizing soil acidity. All lime sources have very limited solubility and must be incorporated and given time to react with the acidity in the soil to effect neutralization.

Therefore, when selecting a lime source the cost per pound of ECC should be a primary factor in source selection. Such factors as rate of reaction, uniformity of spreading, and availability should be considered, but the final pH change will hinge on the amount of ECC applied.

Other recommendations to increase yields in acid soils include the use of aluminum-tolerant wheat varieties and applying phosphate fertilizer with the seed to tie up aluminum and reduce toxicity. These management practices can certainly help to maintain yields and may be the best alternatives for some producers. However, there is only one long-term solution to low soil pH levels: liming.

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7. 2023 Kansas Performance Tests with Winter Wheat Varieties report available online

The 2023 Kansas Performance Tests with Winter Wheat Varieties report is now online. The Kansas Agricultural Experiment Station annually compares both new and currently grown varieties in the state's major crop-producing areas. These performance tests generate unbiased performance information designed to help Kansas growers select wheat varieties suited for their area and conditions.

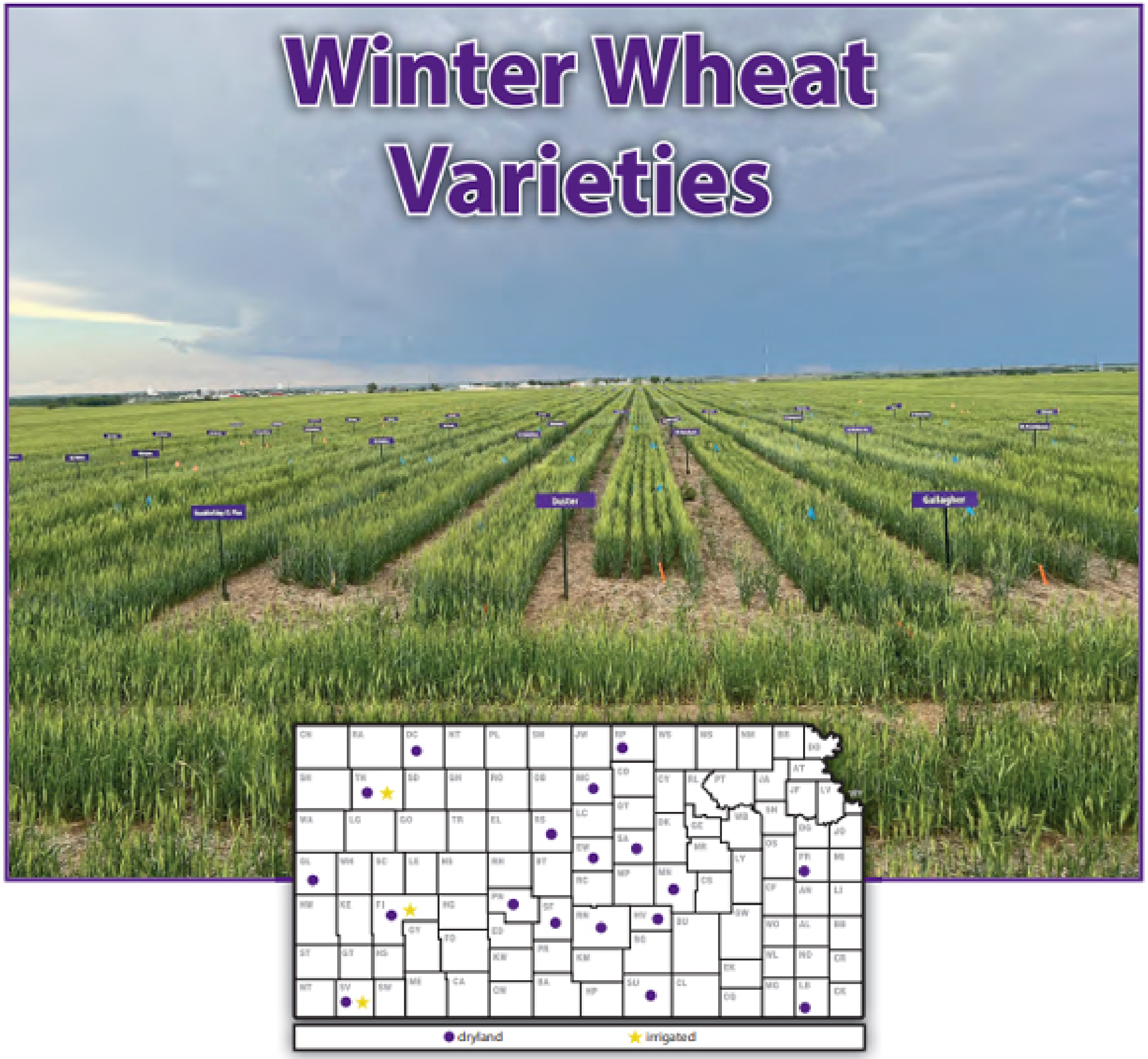
In this report, you will find a recap of the 2022-23 wheat crop, with a detailed discussion of weather conditions from planting through grain filling. The 2023 winter wheat crop in Kansas had a rough start to the season due to a number of factors. During an entire week in late December, temperatures dropped well into negative values, which, combined with the drought, led to widespread winterkill damage in north central Kansas. From a regional perspective, the worst crop conditions occurred in far southwest Kansas, where many times the wheat did not emerge until sometime in May and led to crop termination. From a cropping systems perspective, the extreme drought caused large differences in the yield potential of the wheat crop as a function of the previous crop and the presence of a fallow period. A summary of insect pressure and diseases is also included.

Producers and crop consultants can use this resource to help select wheat varieties for their operation by checking for varieties that show consistently good performance in their region. One-year or one-location results can be misleading because of the possibility of unusual weather or pest conditions. Be sure to keep extenuating environmental conditions in mind when examining test results.

The online version of the 2023 variety performance report is available here: https://bookstore.ksre.ksu.edu/pubs/SRP1179.pdf

Performance test results from previous years are available at https://www.agronomy.k-state.edu/outreach-and-services/crop-performance-tests/wheat/

2023 Kansas Performance Tests with Winter Wheat Varieties



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8. A hot day for the record books in Kansas - August 19, 2023

Less than a month after a late July heat wave brought the hottest temperatures in years to parts of Kansas, another heat wave arrived on Saturday, August 19, and brought even hotter temperatures than those experienced just a few weeks ago. This second round of heat is still in progress at the time this article is being written, and will be summarized in a forthcoming article next week once the heat has (hopefully) diminished. For now, let's take a look at some of the superlatives surrounding August 19 across Kansas.

The average high temperature across the Kansas Mesonet on the 19th was 105.3°F. In terms of average high, this was the hottest day in over 11 years; back on June 27, 2012, the statewide average high was 106.5°F. That day still holds the record for the warmest average high temperature in the 38-year history of the Kansas Mesonet. The average high for August 19 ranks as the 6th warmest on record (Table 1). Only six Mesonet sites failed to reach 100°F, and eight of them recorded highs at or above 110°F (Figure 1). It had been exactly 13 months since at least one Kansas Mesonet site hit 110°F or more. Since 1985, there are only 39 dates on which at least one Kansas Mesonet site has reached 110°F. On August 19, eight sites reached that number. That's the third-highest count on record. Only August 2, 2011, and June 27, 2012, had more; 11 stations reached 110°F on each of those days.

Table 1. The 10 hottest days in Kansas Mesonet history, as ranked by average high temperature for all stations on the given day.

Rank	Date	Average Maximum Temperature (°F)	Number of Mesonet Stations	Warmest Maximum Temperature (°F)
1	Jun. 27, 2012	106.5	44	114.9
2	Sep. 1, 2000	105.9	14	110.1
	Jul. 10, 1995	105.9	14	112.0
4	Aug. 1, 2011	105.6	34	110.1
5	Jul. 29, 2012	105.5	46	110.2
6	Aug. 19, 2023	105.3	79	113.6
7	Jul. 27, 2011	105.0	34	112.7
	Jun. 28, 2012	105.0	44	111.5
9	Jul. 11, 1995	104.8	14	110.2
	Aug. 27, 2000	104.8	14	109.7

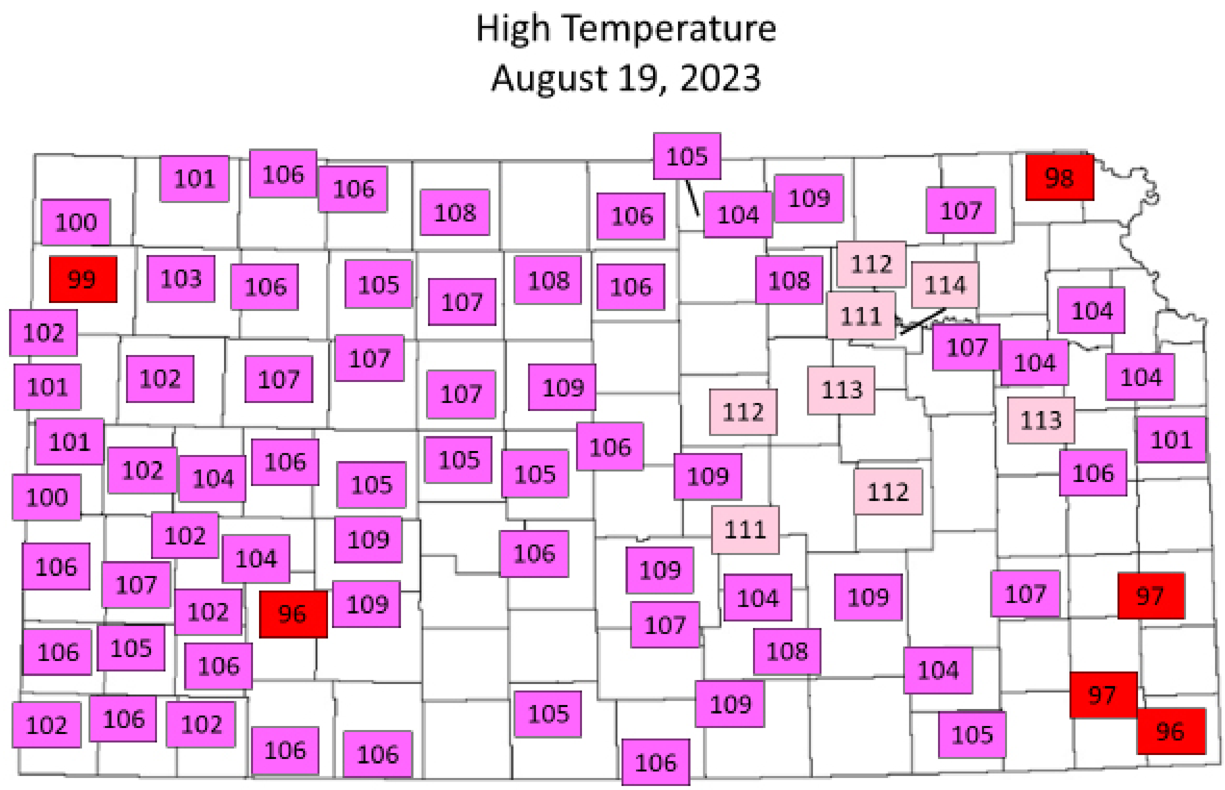

Figure 1. High temperatures measured at Kansas Mesonet stations on August 19, 2023. Source: Kansas Mesonet https://mesonet.k-state.edu/

The hottest Kansas Mesonet reading on the 19th was a scorching 113.6° at the Ashland Bottoms site in southern Riley County. While 113.6°F wasn't the hottest ever recorded by a Kansas Mesonet site, it wasn't far off. The hottest on record is 114.9°, recorded at the Mitchell County site on June 27, 2012. Ashland Bottoms' high ranks as the 4th hottest reading ever in the history of the Kansas Mesonet and the warmest reading at any location since 2012 (Table 2). Rock Springs' and Overbrook's highs on the 19th also rank in the top 10 hottest.

Table 2. The ten hottest high temperatures ever recorded at a Kansas Mesonet site.

Rank	Temperature (°F)	Location	County	Date
1	114.9	Mitchell	Mitchell	Jun. 27, 2012
2	114.2	Meade	Meade	Jun. 26, 2011
3	113.7	Hays	Ellis	Jun. 27, 2012
4	113.6	Ashland Bottoms	Riley	Aug. 19, 2023
5	113.2	Rock Springs	Dickinson	Aug. 19, 2023
6	112.9	Hays	Ellis	Jun. 26, 2012
7	112.9	Osborne	Osborne	Jun. 27, 2012
8	112.9	Overbrook	Osage	Aug. 19, 2023
9	112.7	St. John 1NW	Stafford	Jul. 27, 2011
10	112.5	Butler	Butler	Aug. 2, 2011

Seventeen Mesonet sites recorded their hottest temperature on record on the 19th. Eleven have been in service for five or more years (Table 3). Of these, the Manhattan site has the longest period of record at over 38 years. Four sites bested their all-time high that was set less than a month ago in late July: Ashland Bottoms, Elmdale 1SE, Gypsum, and Overbrook. It was a close call for the site in Clay County; their high of 108.0° tied their all-time record set on June 30, 2011. Clay was one of seven locations that, while not setting an all-time high, recorded its warmest reading in over a decade (Table 4).

Table 3. Kansas Mesonet sites that set all-time station records on August 19, 2023. Only stations in service for more than 5 years are listed.

Location	County	Maximum Temperature (°F)	Length of Record (years)
Manhattan	Riley	111.4	38.7
Washington	Washington	109.2	13.4
Ashland Bottoms	Riley	113.6	9.8
Rock Springs	Dickinson	113.2	9.7
Rocky Ford	Riley	112.0	9.4
Haysville 3SE	Sedgwick	108.4	9.4
Olathe	Johnson	104.4	9.4
Gypsum	Saline	112.4	8.5
Overbrook	Osage	112.9	6.4
McPherson 1S	McPherson	109.1	6.2
Elmdale 1SE	Chase	111.6	5.1

Table 4. Kansas Mesonet sites where the high on August 19, 2023, was the warmest temperature in over ten years.

Location	County	Maximum Temperature (°F)	Last time this temperature was exceeded
Clay	Clay	108.0	Jun. 30, 2011
Butler	Butler	109.3	Jul. 29, 2012
Hutchinson 10SW	Reno	108.5	Jul. 29, 2012
Woodson	Yates	106.6	Jul. 29, 2012
Ottawa 2SE	Franklin	106.4	Jul. 29, 2012
Silver Lake 4E	Shawnee	103.6	Jul. 29, 2012
Osborne	Osborne	107.5	Jul. 13, 2013

Outside of the Mesonet, there were additional superlatives recorded. The hottest temperature in the state on the 19th was just a few miles from Ashland Bottoms: 115°F at the Manhattan Airport. This is the hottest on record at that site, dating back to their start of records in 1960. In addition, this was the highest temperature in all of the lower 48 states on August 19! The Salina Airport tied its all-time high on the 19th with a high of 113°. Records at that location date back to 1949. Co-operative observers setting their all-time record high on the 19th include Milford Lake (Geary County; 112°, records began in 1965) and Melvern Lake (Osage County; 112°, 1973). Ties of the all-time high were notched at Tuttle Creek Lake (Riley County; 111°, 1959) and Pomona Lake (Osage County; 112°, 1963).

Could there be more records set in this heat wave? Stay tuned for a full recap next week!

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9. Free Extension webinar on new spray technologies - September 6

Novel technologies with real-time camera-based weed detection systems for site-specific weed management (aka spot spraying) such as the Blue River Technology John Deere See & Spray Ultimate, One Smart Spray (Bosch-BASF joint venture), and the Greeneye technology. Each technology accounts for spatial variation in weed density by spraying foliar herbicides only on areas with weed infestation ("green-on-brown" for burndown PRE-emergence applications and "green-on-green" for foliar POST-emergence applications).

The goal of this Extension webinar is to generate awareness and address agricultural stakeholder questions regarding these novel technologies. This FREE technical webinar is being organized by Rodrigo Werle and Glenn Nice, University of Wisconsin-Madison; Chris Proctor, University of Nebraska-Lincoln; and Anita Dille, Kansas State University as part of a research and education grant funded by the National Corn Growers Association and the North Central Soybean Research Program. All are welcome to register and attend this event!

Presenters and topics

- **Rodrigo Werle, University of Wisconsin-Madison** - *Welcome to our Extension Webinar* and *Stakeholder Perception on Targeted Spraying Technologies: Survey Results*
- **William Patzoldt, Blue River Technology John Deere** - *See & Spray™ Ultimate – A New Tool for Weed Management*
- **Matt Leininger, One Smart Spray** - *The ONE Integrated Reliable Solution for Smart Weed Control*
- **Nadav Bocher, Greeneye Technology** - *Precision spraying – How to Maximize Savings and Efficacy Through an Aftermarket Approach*
- **Tom Wolf, Agrimetrix Research & Training and Sprayers 101** - *What Does Spot Spray Success Look Like?*

This program has been approved to provide 2 CCA CEUs in Integrated Pest Management.

You can register by scanning the QR Code or by clicking this link:
https://uwmadison.co1.qualtrics.com/jfe/form/SV_0diRuadNM1E6xBs

For questions, please contact Rodrigo Werle at rwerle@wisc.edu

Spot Spray Technologies Extension Zoom Webinar

September 6th, 2023
Noon to 2 pm CST

Register:

Questions? rwerle@wisc.edu

Speakers:

Rodrigo Werle, University of Wisconsin-Madison;

William Patzoldt, Blue River Technology, John Deere;

Matt Leininger, One Smart Spray;

Nadav Bocher, Greeneye Technology; and

Tom Wolf, Agrimetrix Research & Training and Sprayers 101.

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Cropping Systems Weed Science, University of Wisconsin-Madison
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