Extension Agronomy

eUpdate

08/03/2023

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. Nitrate toxicity in drought-stressed corn and sorghum

Drought-stressed crops such as corn and sorghum tend to accumulate high nitrate levels in the lower leaves and stalk of the plant (Figure 1). Nitrates accumulate in the lower portion of these plants when stresses reduce crop yields to less than expected, based on the supplied nitrogen fertility level. Nitrate toxicity in livestock is because of its absorption into the bloodstream and binding to hemoglobin, rendering it unable to carry oxygen throughout the body. The result is eventual asphyxiation and death.

Figure 1. Drought-stressed corn plants (top photo) and forage sorghum (bottom photo). Photos by Dorivar Ruiz Diaz and John Holman, K-State Research and Extension.

Forage testing

It is wise for producers to test their drought-stricken forage prior to harvest. Levels of nitrates can increase in drought-stressed plants after a rain and delaying harvest may be beneficial. Nitrate testing can be done through several labs, including the K-State Soil Testing Laboratory. Harvesting the forage 6-to-12 inches above the ground to avoid the highest concentrations of nitrate in the plant is a good practice. Producers should collect a good representative forage sample above this cutting height to get an accurate determination of the nitrate concentration. Factors to consider in setting the harvest height would include actual nitrate concentration, storing and feeding methods, and forage availability, Toxicity is related to the total amount of nitrate in the diet (including water) and how quickly it is eaten, but, generally, if forages contain more than 6,000 ppm nitrate, they should be considered potentially toxic (Table 1). Animals under physiological stress (sick, hungry, lactating, or pregnant) are more susceptible to nitrate toxicity than healthy animals.

Table 1. Level of forage nitrate (dry matter basis) and the potential effect on animals.

ppm Nitrate (NO_3)	Effect on Animals
0-3,000	Virtually safe
3,000-6,000	Moderately safe in most situations; limit use for stressed animals to

	50% of total ration.
6,000-9,000	Potentially toxic to cattle depending on the situation; should not be the only feed source.
9,000 and above	Dangerous to cattle and often will cause death.

Management options

Depending on the planned feeding method, a producer may wish to harvest different parts of the plant. If wrapping the forage into a bale and feeding it directly to livestock, a producer may want to test the lowest part of the stalk to determine the greatest risk of nitrate forage that the animal could ingest. If a producer was planning on grinding the bale, a whole-plant sample above what will be left in the field might be a more accurate representation of what will be eaten. If a harvested forage is high in nitrate, grinding and mixing the feed with another forage such as prairie hay or brome will dilute the total nitrates in the animal's diet and could potentially reduce the risk of poisoning.

If parts of the field show more stress and potentially differ in nitrate concentration, baled forage from those areas can be segregated. Mark bales and retain their identity in storage. Resample and test for nitrates and forage quality in each field and subgroup separately to determine safe and cost-effective feeding options. While the nitrate concentration does not change after hay harvest, the variability of nitrates across a field and the challenge of collecting a truly representative sample pre-harvest make a thorough post-harvest sample imperative.

High-nitrate forages chopped for silage and properly ensiled are a safer option for livestock feeding. During the ensiling process, potentially 50 percent of the nitrates in the forage will be metabolized by the microbes and can vastly reduce the risk of poisoning. Leaving 6 inches of stubble in the field is still not a bad idea. That is the portion of the stem with the highest concentration of nitrates.

Grazing high nitrate forages can be a dangerous practice. Grazing pressure should be limited so that animals do not consume the parts of the plant forage testing shown to be dangerous. Although animals tend to consume the leaves and the top portions of the plant, which contain less nitrates, the risk of consuming a high-nitrate portion of the plant still exists. In addition, the longer the animal is left on a field and the more that animal is forced to eat the remaining forage at the lower portions of the plant, the greater risk of nitrate poisoning.

For more information, see K-State Research and Extension publication MF3029, "Nitrate Toxicity", at your local county Extension office, or at https://bookstore.ksre.ksu.edu/pubs/MF3029.pdf

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2. Biomass production and nutrient uptake of drought-damaged corn

A number of farmers are asking some pretty difficult questions on the value of drought-damaged corn for various uses, including as feed and for soil protection. There are a number of variables that go into that answer, some of which include:

- Does the farmer have a need or market for the corn as hay or silage, which will also be influenced by plant nitrate content? (Nitrate toxicity is discussed in more detail in a companion article in this eUpdate issue.)
- The plant nutrient content of the crop and what portion of those nutrients would be available to future crops.
- The need for residue cover to prevent wind or water erosion.
- The value of additional soil moisture for future crops from maintaining residue cover.

Range of vegetative growth and grain yields

Previous data collected in Kansas on drought-affected corn used measurements of the plant stand, height, dry matter, and moisture content to estimate biomass production and nutrient uptake/value of the biomass.

Forage yield. A general rule of thumb is that corn with <20-bushel yield potential is best used as forage, while corn with > 50 bushels per acre yield should be harvested for grain. What do these different yield levels look like? Figure 1 gives the dry matter content found in corn standing in the field versus plant height (from the ground to the base on the tassel).

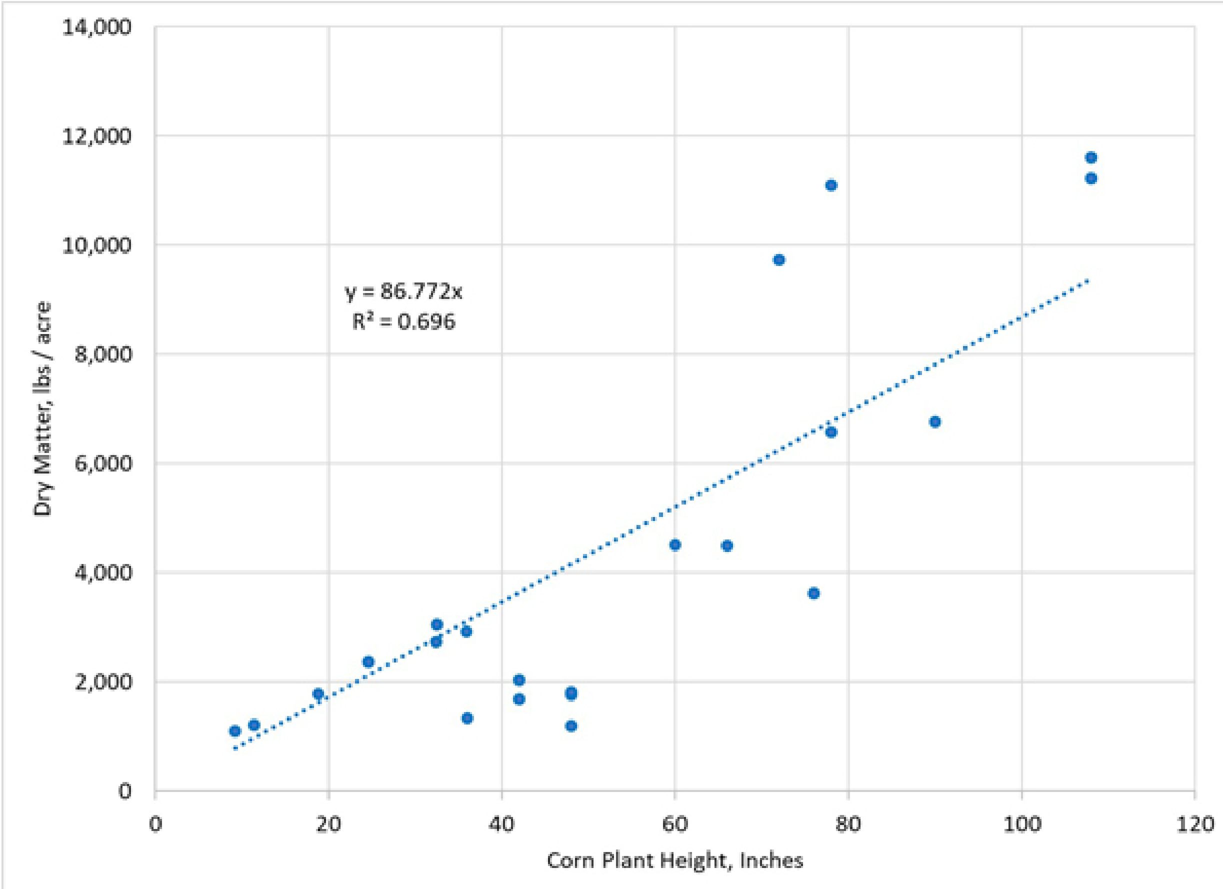

Figure 1. Dry biomass production vs. corn plant height of drought-affected corn collected in Kansas.

Nutrient content of the vegetation. What is the potential value of the crop left in the field for residue cover? There are several benefits that have to be considered in making that decision. The nutrient content of the plants and subsequent effects on soil test levels and fertilizer rates for next year's crop is one factor to consider. The nutrient content of the plant material harvested in July 2011 is given in Figure 2. The nutrient content of the material is relatively high at these stages of growth and increases on an acre basis with dry matter yield. But, how do these numbers relate to future fertilizer needs?

The majority of the nitrogen (N), phosphorus (P), and sulfur (S) in plant material are generally present as protein and other organic compounds. For these nutrients to become available to plants, these compounds must be broken down and the N and P mineralized. This process will normally take 3 or more years to complete, with the C:N ratio being the primary factor controlling the release rate. Corn stalks are normally a very high C:N material, with a C:N ratio of around 60 to 1. In high C:N materials, very little net N mineralization will occur until the organisms utilizing this material as a foodstuff reduce the carbon content of the residue to a C:N ratio of roughly 25:1. In these severely drought-damaged crops, the N content is much higher than normal, since there is little or no grain present. The C:N ratio in many of these severely damaged crops is less than 35:1. Thus, net mineralization will occur much quicker, in a matter of months rather than years. In very severely damaged corn where N content is around 2% or more, roughly 50% of this N, P, and S is likely to be available for a summer crop planted next spring.

Corn silage with much more stalk and grain contains about 25 pounds of K_2O per dry ton. When the biomass is removed, the amount of K_2O removed from the field is usually much higher than nitrogen. Potassium can leach from the residue and back to the soil in a few months and is K that will be likely available for the next crop.

Unfortunately, wheat planted this fall into these residues will not benefit nearly as much from the N, P, and S present in the vegetation as there will not be as much time for soil organisms to break the residues down and mineralize these nutrients. Winter wheat planted in October will essentially be done taking up nutrients by the end of May when soil organisms will be getting into high gear!

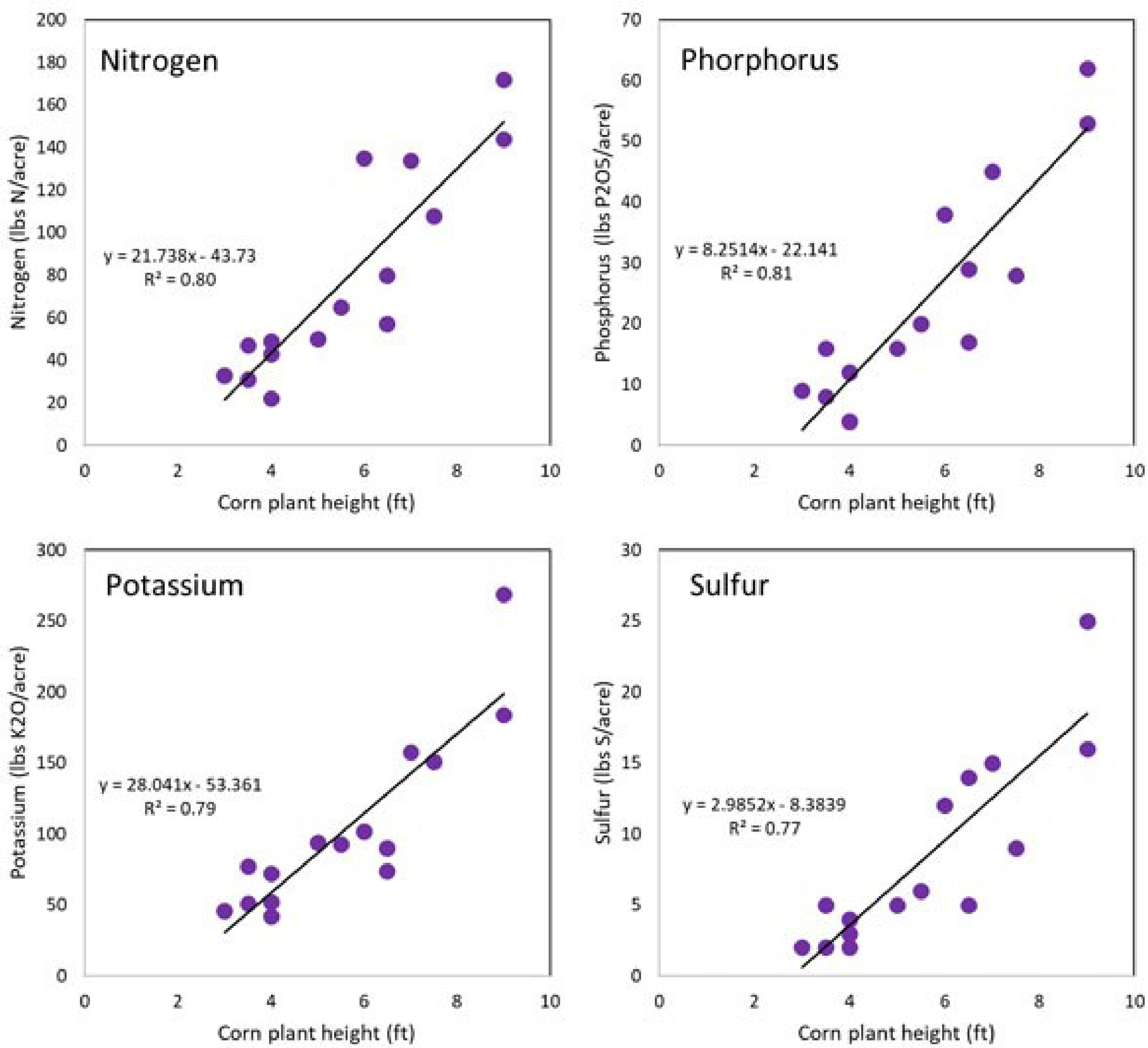

Figure 2. Nutrient uptake (N, P, K, and S) vs corn plant height from drought-affected corn collected in Kansas.

Summary

A number of factors should be considered when assigning a value to drought-damaged corn. Nutrient removal from the field is one key aspect since biomass can export significant amounts of nutrients. Some nutrients like K can are primarily present in the plant biomass, and in a typical grain production system, most of the K stays in the field/crop residue and is available for the subsequent crops. Other nutrients such as N, P, and S will become available after residue decomposition and mineralization, which will require time and maybe only be partially available in the short term.

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3. Allow time for lime applications when planting alfalfa this fall

Correcting acidic soil conditions through the application of lime can have a significant impact on crop yields, especially for alfalfa. Acidic soils can significantly reduce nodule establishment and activity in alfalfa, affecting nitrogen status and overall nutrient and water uptake (Figure 1). Since seeding alfalfa is expensive and a stand is expected to last for several years, getting lime applied and acidity corrected before seeding is critical. Liming is one of the most essential, but often overlooked, management decisions a producer can make for alfalfa production.

Unfortunately, lime is not always available in close proximity to where it may be needed. In many cases, trucking and spreading costs may be more than the cost of the lime itself. Lime quality can also vary widely and no one wants to apply more than is necessary. It is useful to know how lime recommendations are made to make the best decisions on how much and what kind of lime to apply.

Tissue N=2.59% (pH=5.2)   Tissue N=3.92% (pH=6.1)

Figure 1. Soil pH affects nodule formation and activity for N fixation in alfalfa, in addition to nutrient availability and uptake. Photo by Dorivar Ruiz Diaz, K-State Research and Extension.

K-State lime recommendations

A routine soil test will measure the pH of the soil, and this will determine whether lime is needed on the field. Generally, east of the Flint Hills, lime is recommended for alfalfa if the pH drops below 6.4, with a target pH for liming of 6.8. In the Flint Hills and west, lime is recommended for alfalfa and all other crops when the pH drops below 5.8, with a target pH of 6.0. The target pH is simply the pH goal once the lime reacts with the soil.

Why is the target pH different for the two areas of Kansas?

The target pH values differ because of the pH of the subsoil. East of the Flint Hills, especially south of the Kansas River, the subsoil tends to be more acidic. A higher target pH is used to assure adequate pH conditions in the root zone and provide sufficient amounts of calcium and magnesium. Most soils from the Flint Hills and west have high pH (basic) subsoils that can provide calcium and magnesium to meet crop needs.

Determining the soil pH is the first step in determining if lime is needed. However, it does not tell you the amount of lime you need to apply. Soils with more clay and organic matter will have more acidity at a given pH and will require more lime/ECC (effective calcium carbonate) to reach a target soil pH than will sandy soil. This is why two soils may have the same soil pH but have different lime requirements.

Calculating lime rates

Lime rates are given in pounds of effective calcium carbonate (ECC) per acre. How does that relate to agricultural lime and how much lime to apply? Lime materials can vary widely in their neutralizing power. All lime materials sold in Kansas must guarantee their ECC content and dealers are subject to inspection by the Kansas Department of Agriculture.

The two factors that influence the neutralizing value of aglime are the chemical neutralizing value of the lime material relative to pure calcium carbonate, and the fineness of crushing, or particle size, of the product. The finer the lime is ground, the greater the surface area of the product, the faster it will react, and the faster the acid neutralization will occur. These two factors are used in the determination of ECC. Expressing recommendations as pounds of ECC allows fine-tuning of rates for variation in lime sources, and avoids under- or over-applying lime products.

Lime sources

Research has clearly shown that a pound of ECC from agricultural lime, pelletized lime, water treatment plant sludge, fluid lime, or other sources are equal in neutralizing soil acidity. Therefore, under most circumstances, the cost per pound of ECC applied to your field should be a primary factor in source selection. Other factors such as rate of reaction (fineness), uniformity of spreading, and availability should be considered, but the final pH change, and subsequent alfalfa growth, will depend on the amount of ECC applied.

Application methods

All lime sources have very limited solubility. When planting alfalfa, the best performance occurs when lime is incorporated and given time to react with and neutralize the acidity in the soil. When surface-applied and not incorporated, as in no-till systems, the reaction of lime is generally limited to only neutralizing the acidity and raising the pH in the top 2 to 3 inches of soil. Surface applications are sufficient in slightly acidic soils, but may not provide as good a soil environment for nodulation and nitrogen fixation in extremely acid soils.

In no-till or reduced-till systems, where no incorporation of lime is planned, lower rates of lime application are normally recommended to avoid over-liming and raising the pH higher than needed in the surface 2-3 inches of soil. Over-liming can also reduce the availability of micronutrients such as zinc, iron, and manganese, and trigger deficiencies in some soils. Current K-State lime recommendations suggest that "traditional" rates designed for incorporation and mixing with the top 6 inches of soil should be reduced by 50 percent when surface-applied in no-till systems, or when applied to existing grass or alfalfa stands.

What about the calcium and magnesium contents?

Most agricultural limes found in Kansas contain both calcium and magnesium, with calcium exceeding magnesium. The exact ratio of these two essential plant nutrients will vary widely. Dolomitic lime (magnesium-containing) and calcitic lime (low-magnesium, high-calcium) provide similar benefits for most Kansas soils.

For more information, see the K-State publication *Soil Test Interpretations and Fertilizer Recommendations*, MF-2586: http://www.bookstore.ksre.ksu.edu/pubs/MF2586.pdf

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4. Southern rust is in Kansas and spreading quickly

Just in the last couple of days, southern rust has been detected in six central Kansas counties – Ellsworth, Reno, Rice, Saline, McPherson, and Sedgwick (Figure 1). Unlike some other corn diseases, such as gray leaf spot, southern rust does not survive in Kansas during winter months and blows in annually from more tropical regions. The severity is dependent on the weather and southern rust likes 90-degree days, warm nights, and high humidity.

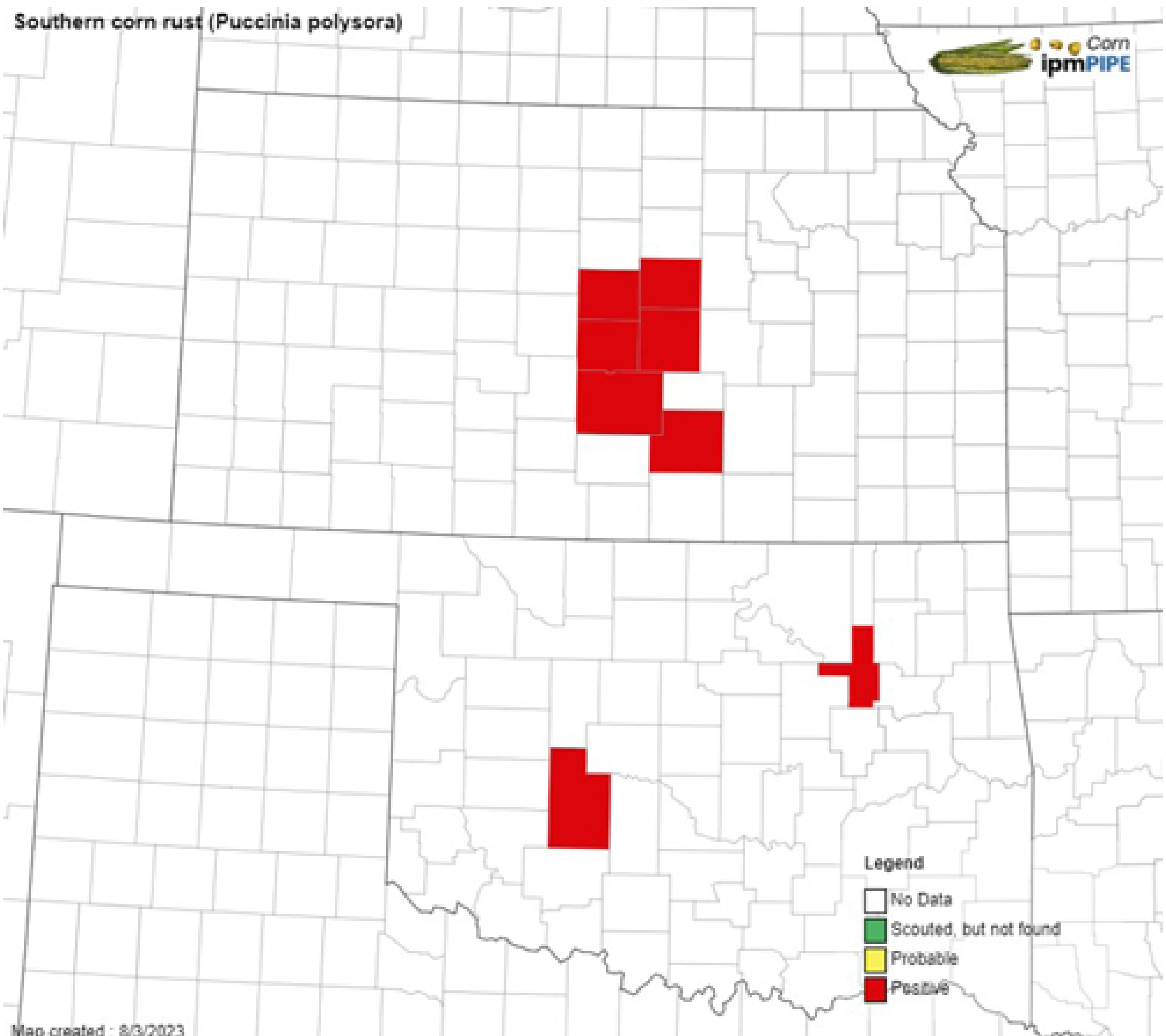

Figure 1. Southern corn rust (Puccinia polyspora**) in Kansas as of August 3, 2023.**
Source: https://corn.ipmpipe.org/southerncornrust/

Here are some frequent questions related to managing southern rust in Kansas.

Q1. Should I apply a fungicide <u>prior to observing</u> southern rust?

A1. It is not recommended to apply a fungicide to control southern rust unless the disease has been observed in the canopy. Now that southern rust has been reported in Kansas, it is time to be out scouting corn fields. Once pustules are observed, the pathogen can reproduce rapidly if temperatures and humidity are high.

Q2. What factors should I consider when making the decision to spray for southern rust?

A2. It is important to consider hybrid susceptibility, disease incidence (how many plants are affected), and the growth stage of the crop. Infection early in the season on a susceptible hybrid, coupled with conducive weather conditions, pose the highest risk for yield loss.

Q3. If I apply a foliar fungicide at tasseling (VT) or silking (R1) to control gray leaf spot, will this application have efficacy against southern rust?

A3. Yes. Most fungicides that are labeled for gray leaf spot are also effective for southern rust and will have residual activity for approximately three weeks after application, depending on the product. Fields should be carefully monitored for disease development. Research has suggested that applications can be effective at preserving yield up until dent (R5) when dealing with a susceptible hybrid and high disease pressure.

Q4. What fungicides are best to control southern rust?

A4. Efficacy ratings for corn fungicide management of southern rust have been compiled by a working group of corn researchers and can be found here:

https://crop-protection-network.s3.amazonaws.com/publications/fungicide-efficacy-for-control-of-corn-diseases-filename-2021-03-09-163332.pdf

Q5. How do I know if what I'm seeing is southern rust?

A5. Southern rust produces characteristic orange pustules of spores, primarily on the upper side of the leaf (Figure 2). If you run your finger across the pustules, the orange spores will be visible on your hand. The Kansas State Plant Diagnostic Lab can also confirm southern rust by observing spores under the microscope. Additional information about sending in a sample can be found here: https://www.plantpath.k-state.edu/extension/diagnostic-lab/.

Figure 2. Southern rust on corn. Photo courtesy of Rodrigo Borba Onofre, K-State Plant Pathology.

For more information on identifying corn rusts, see K-State Research and Extension Bulletin MF3016, [Corn Rust Identification and Management in Kansas].

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5. Tar Spot of corn is confirmed in five counties in Kansas

Tar spot of corn, a disease caused by the fungus *Phyllachora maydis*, has now been confirmed in Doniphan (6/26), Atchison (6/30), Jefferson (6/30), Brown (7/05), and Nemaha (7/28) counties, Kansas (Figure 1).

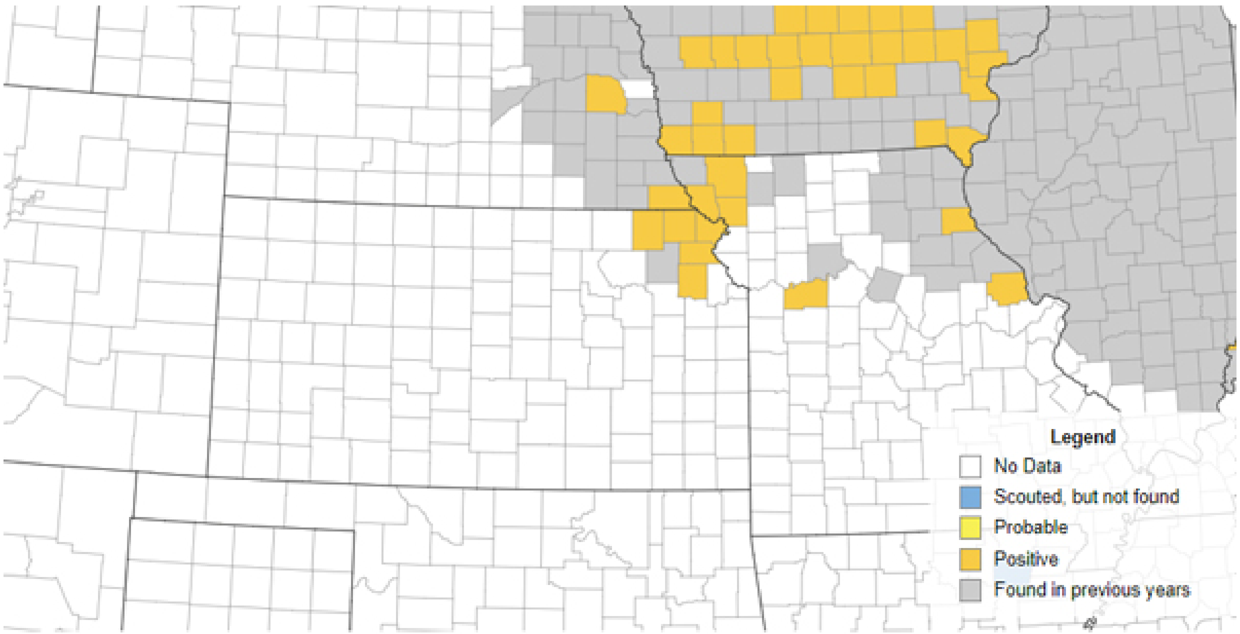

Figure 1. Tar Spot of Corn (Phyllachora maydis**) in Kansas and surrounding states in 2023.**
Source: https://corn.ipmpipe.org/tarspot/

What am I scouting for?

Tar spot develops as small, black, raised spots (circular or oval) that develop on infected plants, and may appear on one or both sides of the leaves, leaf sheaths, and husks. Spots may be found on both healthy (green) and dying (brown) tissue. Tar spot can be easily confused with insect poop, which can appear as black spots on the surface of the leaf **(**Figure 2**)**. For assistance in confirming tar spot, please contact your local county extension office or the K-State plant diagnostic clinic at https://www.plantpath.k-state.edu/extension/plant-disease-diagnostic-lab/.

Figure 2. **Tar Spot of Corn. Purple arrows are indicating a few of the tar spot lesions. Photos courtesy of Rodrigo Onofre, Department of Plant Pathology, K-State Research and Extension.**

Is there a history of disease in this field or neighboring fields?

Tar spot overwinters on infested corn residue on the soil surface, which serves as a source of inoculum for the subsequent growing season. Spores can be dispersed by wind and rain splash and can move to nearby fields if conditions are favorable.

What growth stage is the field?

Research has shown that making an application just after first detection and at or after VT is effective if lesions are detected early. If you wait until there is significant disease in the upper canopy, then a fungicide application may be too late. Here you can find a guide for growth stages in corn: https://bookstore.ksre.ksu.edu/pubs/MF3305.pdf.

How does moisture influence disease development?

The recent rains likely helped to promote tar spot development. Additionally, irrigated corn may be at particularly high risk for yield or silage loss. Forecasted rainfall and high humidity will favor tar spot development and spread.

Should I apply a fungicide?

Fungicides are an effective tool for controlling tar spot if they are timed well. Research has shown the best return on investment from a fungicide application on corn occurs when **fungal diseases are active** in the corn canopy. A **well-timed, informed fungicide application** will be important to reduce disease severity when it is needed, and we recommend holding off until the disease is active in your field and corn is at least nearing VT/R1 (tassel/silk) or even R2 (blister). Scouting will be especially important if wet weather continues. There are several fungicides that are highly effective at controlling tar spot when applied from tassel (VT) to R2 (blister). I would recommend picking a product with multiple modes of action. The National Corn Disease Working Group has put together efficacy ratings for fungicides labeled for the control of tar spot can be found at the Crop Protection Network website, link: https://cropprotectionnetwork.org/publications/fungicide-efficacy-for-control-of-corn-diseases.

If there is high disease pressure early in the season, a second application may be warranted. Fields should be scouted 14-21 days after the first application to see if tar spot has become active again. Fungicides will not provide benefits after R5. Always consult fungicide labels for any use restrictions prior to application.

Please help us track tar spot, you can contact me (785-477-0171) directly if you suspect a field has tar spot and/or submit a sample to the K-State Plant Disease Diagnostic Lab at https://www.plantpath.k-state.edu/extension/diagnostic-lab/documents/2021_PP_DiseaseLabChecksheet.pdf.pdf. This will help us monitor the situation in the state.

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6. Extreme heat and Kansas farm income

Moderate or severe drought is prevailing through much of the Corn Belt and many areas of Kansas, Missouri, and Nebraska are experiencing extreme drought. Although the degree to which drought will affect 2023 crop prices is still uncertain, research on historical impacts of extreme heat[1] on farm profitability provides evidence that Kansas farms could be impacted by increasing frequency and extremity of severe weather in the future.

While Kansas farmers are no strangers to adverse weather, extreme heat has been increasing in Kansas over the last few decades. Figure 1 shows that extreme degree-days, henceforth referred to as EDD (a measure used by researchers to account for both the duration and intensity of temperatures above a threshold, defined as 32°C or 89.6°F in our study)[2], have increased over the past 4 decades across Kansas. Kansas had an average of 54 EDDs per year in the growing season (April-Sept) from 1981-1990, which increased to 57 EDDs during 2011-2020. Meanwhile, USDA reports total net cash income for Kansas farms has ranged from $1.5 billion to nearly $6 billion since 2000, which reflects both price and yield volatility. Given that weather volatility and droughts are expected to increase (Masson-Delmotte, 2021), we have sought to quantify the historic relationship between farm income and extreme heat, as well as factors that have historically mitigated the impacts of extreme heat. Our research shows Kansas farm income is very sensitive to extreme heat. However, both (1) farm practices and (2) crop insurance have partially mitigated the impacts of extreme heat historically.

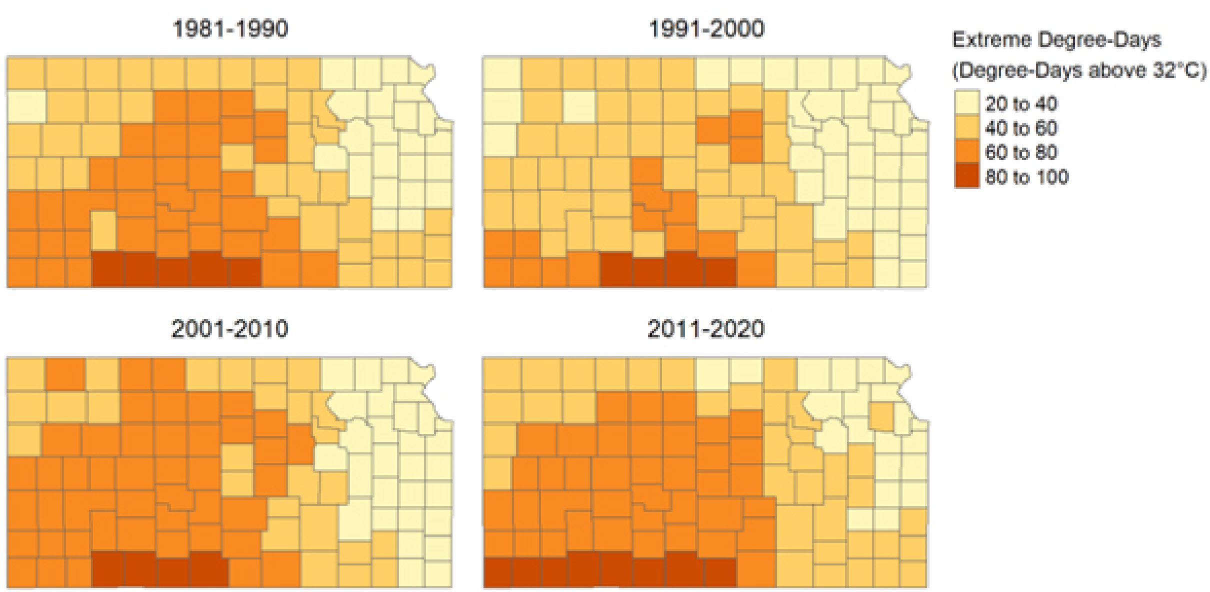

Figure 1. Extreme degree-days have been increasing in Kansas.

Note: 32 degrees Celsius is equivalent to 89.6 degrees Fahrenheit; this study uses a measure of extreme degree-days that accounts for both the period of time over this threshold and level above this threshold.

Summary of data and methods

Our study uses a farm-level panel dataset from the Kansas Farm Management Association (KFMA), which spans four decades (1981-2020) and covers thousands of farms. The KFMA offers accounting and financial analysis services for farmers. KFMA's affiliation with Kansas State University has led to a partnership for the provision of farm-level data for research and outreach purposes, including tracking farm financial health across the state.

We use panel econometric methods to analyze the impact of extreme heat (EDD) on different measures of farm income[3]. This analysis controls for farm-specific factors and characteristics, as well as local precipitation (rain) and year, which accounts for changes in commodity markets, policies, etc. that are common across all farms. To understand the degree to which farm practices and policies play a role in mitigating extreme heat, we use the same modeling approach to analyze the impact of extreme heat on inventories, government payments, and crop insurance. We also quantified the role of irrigation access in buffering extreme heat. More details on our methodology can be found here.

Findings

While our analysis was conducted with EDD, we convert our primary findings to increases in temperature for ease of interpretation.[4] We find that during our study period, 1°C (1.8°F) of additional warming decreased gross income by 7% and net farm income by 66%. Comparing the monetary value of temperature-driven losses of the two income measures reveal that for an average farm, net income loss is roughly 1.6 times the size of gross income loss --- a 1°C warming leads to $34,650 and $54,119 decline in gross income and net income, respectively. The disparity between the percentage effect of warming can be partially explained by tight profit margins experienced by farm operations, as a small share of gross farm income is typically a large share of profit (net farm income). The average real gross and net farm income during the study period is $**494,955** and $**82,005**, respectively. Likewise, the higher dollar value effect of extreme heat on net farm income partially reflects increasing expenses.

Table 1 – Kansas farm profits take a large hit in years with more extreme heat

	Gross Farm Income	**Net Farm Income**
Impact of 1°C (1.8°F) warming	-7%	-66%
Impact of 1°C (1.8°F) warming	-$34,650	-$54,119
Note. Impact in dollars relates to the average farm in our sample (having average real gross and net farm income of $**494,955** and $**82,005**, respectively. During the 2012 Midwestern drought, temperatures were approximately 1.6C (2.9F) warmer than the average of our study period.		

Table 2 – Net income losses would be much larger without crop insurance and farm-level practices

	Policies and farm practices		
	Crop Insurance	Adjustment in crop inventory	Irrigation use
Proportion of net income loss from extreme heat prevented	51%	16%	37%
Note. Irrigation use is defined as farms with a greater than average proportion of cropland as irrigated. The numbers in the table should not be added together, because the effect associated			

with irrigation use is estimated separately from the other two and can change depending on how we define 'irrigation use'.

Farm practices that can mitigate extreme heat include drawing down inventories. We find that the value of crop inventory stock declines after farms experience extreme weather, which likely reflects farms selling off inventory from the previous marketing year to make up for low yields. This form of inventory adjustment shields 16% of the net income loss due to extreme heat. Government payments don't have any relationship with extreme heat in the current year but do have a strong relationship with government payments two years prior. This is consistent with Title 1 (ARC and PLC, currently) and disaster payments often being authorized or paid out well after the year that they are incurred. On the other hand, crop insurance payouts have a strong relationship with extreme heat in the current year, buffering approximately 51% of the net income loss as a result of extreme heat. This is consistent with crop insurance indemnities typically being paid out in the year a loss is incurred, or immediately in the subsequent year.

Farms that have access to irrigation may be less affected by extreme heat. A significant portion of western Kansas overlaps with the High Plains Aquifer (Figure 2), allowing us to examine the buffering impacts of irrigation on net income loss under extreme heat conditions. We found that highly irrigated farms experience approximately 37% less net income loss compared to other farms. Kansas is currently facing declining groundwater availability and biophysical and regulatory limitations on water availability are likely to restrict irrigation in the future.

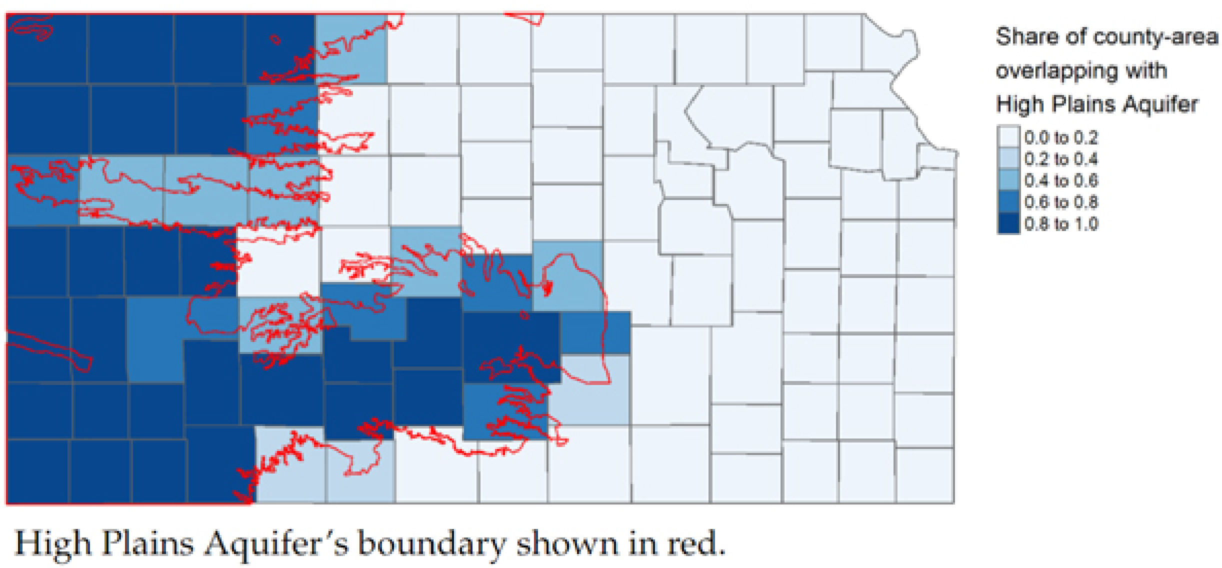

Figure 2. Many Kansas counties have access to the High Plains Aquifer.

Discussion

Our findings are consistent with the experience of Kansas farmers, many of whom experienced extreme drought in 2022. Average 2022 farm income, as reported by the Kansas Farm Management Association (KFMA), was near the 5-year average and higher than 2018 and 2019. This was partially due to crop insurance and government payments accounting for 72% of accrual net farm income for KFMA farms. However, substantial regional variation occurred across the state: net insurance payouts were negative[5] for the average KFMA farm in northeast Kansas, which was much less affected by drought. On the other hand, crop insurance payouts made up nearly all of net farm income for KFMA farms in northwest and southeast Kansas, which experienced extreme drought.

Kansas farm income is highly sensitive to extreme heat. This impact is partially mitigated by both farm practices and crop insurance. From a policy perspective, crop insurance is working as designed and shields producers from some of the effects of extreme heat or extreme weather more generally. However, as with any policy intervention, there may be positive or negative unintended consequences. Whether government policy impedes the long-term adaptation of U.S. agriculture to extreme weather is an ongoing debate.

Our research shows that the financial impact of extreme heat is high, suggesting that projected increases in extreme heat could pose risks to gross and net farm income. Further, the financial impact of weather shocks on farm operations is transmitted to lenders, insurance companies, the Federal Crop Insurance Program, agribusiness, and rural communities. How producer, industry, and government actions play a role in facilitating adaptation to extreme weather is an important topic for future research and policy design.

Reference: Masson-Delmotte, V. P. (2021). Climate change 2021: the physical science. *Contribution of working group I to the sixth assessment report of the intergovernmental*.

Acknowledgements: We are grateful for the cooperation of KFMA membership and staff and the Environmental Defense Fund for supporting this research. This research was also supported in part by the USDA National Institute for Food and Agriculture Award number 2021-67023-33816.

Editor's note: This article originally was published online at https://farmdocdaily.illinois.edu/2023/07/extreme-heat-and-kansas-farm-income.html.

Sajid, O., J. Ifft, A. Ortiz-Bobea and V. Gauthier. "Extreme Heat and Kansas Farm Income." *farmdoc daily* (13):138, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, July 26, 2023.

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[1] Extreme heat and drought are not the same thing but are correlated. We use “extreme heat” in our research because it is a consistent measure of extreme weather that is more appropriate for statistical analysis.

[2] EDD is a two-dimensional measure of thermal time, computed as the product of temperature (in 1° C increments) above 32° C and the exposure (in days) at each of those temperature points. EDD is similar in construction to ‘growing degree days’. EDD is considered a more accurate measure of extreme heat than just duration of higher temperatures (the number of days above 32°C), because it also accounts for intensity, or gives higher weight to higher temperatures --- the farther the temperature is from 32° C, the larger is the value of EDD. The full impact of extreme heat cannot be captured without accounting for both duration and temperature.

[3] Gross farm income captures all sources of farm income in a year and net farm income is gross farm income less expenses. These are accrual measures of income and include government payments, crop insurance payments, and any income earned (or lost) through inventory adjustment.

[4] We calculate this through a recomputed measure of EDD by using a reconstructed dataset where we increased the temperature by 1˚ C at all times.

[5] Negative net payouts means that premiums were higher than indemnities.

7. July weather summary for Kansas - A cool start, a hot finish

In an eUpdate article last month, we examined the counts of 90-degree days across Kansas this summer. At that time, every location had fewer such days than in 2022. Just two weeks ago, it appeared that July 2023 would be one of the cooler Julys on record. Through the first 21 days of July, the statewide average temperature was 76.1°F or 3.0 degrees below normal. Had that been the average temperature for the entire month, it would have ranked in the top 20 coldest Julys on record. Mother Nature turned up the heat starting on July 22 though, and Kansas' average temperature for the last 10 days of July was 82.8°F. This late-month heat nearly erased the negative departure of the first three weeks of July; the preliminary average temperature for the entire month of July is 78.3°F, or just 0.5°F below normal. In this report, we take a closer look at the means and extremes of this recent heat wave.

Over three-quarters of the Kansas Mesonet sites reached 100°F at least once during the last 10 days of the month. Around one-quarter of the sites reached 100°F on at least half of those days, with Ness City and WaKeeney leading with eight days. On three of the ten days, the average high temperature across all stations in the Kansas Mesonet was over 100°F (Table 1), with the 25th (100.4°F) narrowly edging out the 26th (100.3°F) and 28th (100.2°F) for the warmest average. The highest reading on all three days was the Gypsum site in Saline County at 107.9°F on the 26th.

Morning lows were also unseasonably warm. July 26 had the warmest average minimum temperature at 73.3°F. Five stations had lows in the 80s that morning, with Overbrook in Osage County the warmest at 81.5°F. At a few Mesonet sites, the extreme heat set all-time station records for both warmest high and low temperatures. Four Kansas Mesonet sites in service for 5 or more years recorded new all-time record highs (Table 2), two each on the 26th and 28th. On July 26, seven locations set new all-time record warm minimums (Table 3). Both the Gypsum and Overbrook extremes mentioned earlier were new records. For those locations not setting all-time station records, it had been a few years since temperatures were this hot. At ten Mesonet locations, the highest temperature reached during the last 10 days of July was the hottest reading in over 5 years, and for four of the ten, their highest was the hottest in over 10 years (Table 4).

Table 1. Warmest average high temperatures across the Kansas Mesonet during July 2023.

Date	Average high temperature (°F)	Number of sites with highs ≥ 100°F	Highest temp. (°F)	Location/County
July 25	100.4	48	107.3	WaKeeney/Trego
July 26	100.3	39	107.9	Gypsum/Saline
July 28	100.2	38	107.6	Clay/Clay

Table 2. Kansas Mesonet sites setting all-time station records for high temperature during the

last ten days of July 2023. Only stations in service for more than 5 years are listed.

Location	County	Highest temp. (°F) / date recorded	Length of record (years)
Ashland Bottoms	Riley	106.9 / July 28	9.7
Gypsum	Saline	107.9 / July 26	8.4
Overbrook	Osage	104.7 / July 28	6.3
Elmdale 1SE	Chase	102.5 / July 26	5.1

Table 3. Kansas Mesonet sites that set all-time station records for the warmest minimum temperature on July 26, 2023. Only stations in service for more than 5 years are listed.

Location	County	July 26, 2023 low temperature (°F)	Length of record (years)
Miami	Miami	80.5	14.4
Jewell	Jewell	79.3	12.5
Rock Springs	Dickinson	78.7	9.6
Olathe	Johnson	80.3	9.3
Gypsum	Saline	80.8	8.4
Oskaloosa 1SE	Jefferson	79.9	7.7
Overbrook	Osage	81.5	6.3

Table 4. Kansas Mesonet sites where the hottest reading during the last 10 days of July 2023 was the warmest temperature in over five years.

Location	County	Highest temp. (°F) / date recorded	Last time this temperature was exceeded
Scandia	Republic	105.5 / July 28	June 27, 2012
Clay	Clay	107.6 / July 28	July 25, 2012
Washington	Washington	104.9 / July 28	July 25, 2012
Osborne	Osborne	107.1 / July 28	July 13, 2013
Rock Springs	Dickinson	106.4 / July 26	July 28, 2015
Jewell	Jewell	107.2 / July 28	July 21, 2017
Mitchell	Mitchell	107.0 / July 28	July 21, 2017
Ottawa 2SE	Ottawa	102.3 / July 28	July 22, 2017
Rossville 2SE	Shawnee	99.8 / July 26	July 22, 2017
Manhattan	Riley	104.9 / July 28	June 28, 2018

There were even higher temperatures recorded at cooperative sites. Minneapolis, in Ottawa County, reached 111°F on July 28, Kansas' highest reading so far this year. Wilson Lake in Russell County and

Courtland in Republic County both hit 110°F. There were multiple sites that reached 109°, including at both the Concordia and Manhattan Airports. This was the hottest reading in Concordia in 17 years; it last reached 109°F on July 19, 2006. Had it been just one degree warmer, it would have been the first 110°F in Concordia since 1954. Minneapolis' 111°F is a few degrees shy of their July record high of 117°F set on July 24, 1936, but it was their warmest July reading since 2011. Lawrence had the warmest minimum temperature in the state on July 26 at 84°, closely followed by Concordia at 83° and a few 82° readings, including at both Topeka and Olathe-Johnson County Executive Airports. Lawrence's 84° was their warmest daily minimum since September 4, 1947, while Concordia's 83° was the warmest since July 19, 1954. At both locations, the all-time warmest daily minimum is 86°, set in 1933 at Lawrence and 1936 in Concordia.

Stress Degree Days

The very high temperatures led to stress on Kansas' corn crop. The amount of stress can be quantified by calculating corn stress degree days. When a daily maximum temperature exceeds 86°F, one corn stress degree day is earned for each degree the high is above 86°F (e.g., Mitchell's high of 107° on July 28th resulted in 21 corn stress degree days). When 140 or more corn stress degree days are recorded in a growing season, there is a potential for yield loss. Nine Kansas Mesonet sites accumulated 140 or more corn stress degree days in the last 10 days of July (Table 5). When added to the corn stress degree days accumulated prior to July 22, growing season totals are running well above normal in all of these locations.

Evapotranspiration (ET) for the last 10 days of July was also higher than normal (Table 6). Areas in the southwest were closer to normal than in northern Kansas.

Table 5. The highest number of accumulated corn stress degree days during July 22-31, 2023 across the Kansas Mesonet, along with these stations' totals for the growing season and departures from 30-year normal counts.

Location	County	Corn Stress Degree Days		
		July 22-31, 2023	Growing season April 1-July 31, 2023	Growing season Departure from normal
Ness City	Ness	165	416	+115
Gypsum	Saline	164	427	+149
WaKeeney	Trego	162	305	+32
Hays	Ellis	158	337	+72
La Crosse	Rush	152	347	+93
Osborne	Osborne	149	318	+98
Gove 5SE	Gove	143	283	+143
McPherson 1S	McPherson	141	343	+64
Hodgeman	Hodgeman	140	406	+105

Table 6. Total evapotranspiration (ET) at select Kansas Mesonet sites for the period July 22-31, 2023, and 10-year normals for the same 10-day period, based on 2013-2022 data.

Location	County	July 22-31, 2023 ET (inches)	Normal July 22-31 ET (inches)
Manhattan	Riley	2.21	1.98
Miami	Miami	2.10	1.73
Parsons	Labette	2.24	1.93
Hutchinson 10 SW	Reno	2.65	2.21
Scandia	Republic	2.13	1.89
Hays	Ellis	2.83	2.35
Colby	Thomas	2.58	2.28
Tribune	Greeley	2.38	2.27
Garden City	Finney	2.37	2.29
Meade	Meade	2.26	2.21

Weather outlook for August 6-10

The heat of late July has lingered into early August, but a cooling trend looks to be on the way. The Climate Prediction Center's 6 to 10-day outlook, valid for the period August 6-10 (Figure 1), calls for an increased likelihood of below-normal temperatures statewide. In addition, there are elevated chances for above-normal precipitation during the same period (Figure 2). This is good news for those areas of the state where precipitation has been lacking this growing season.

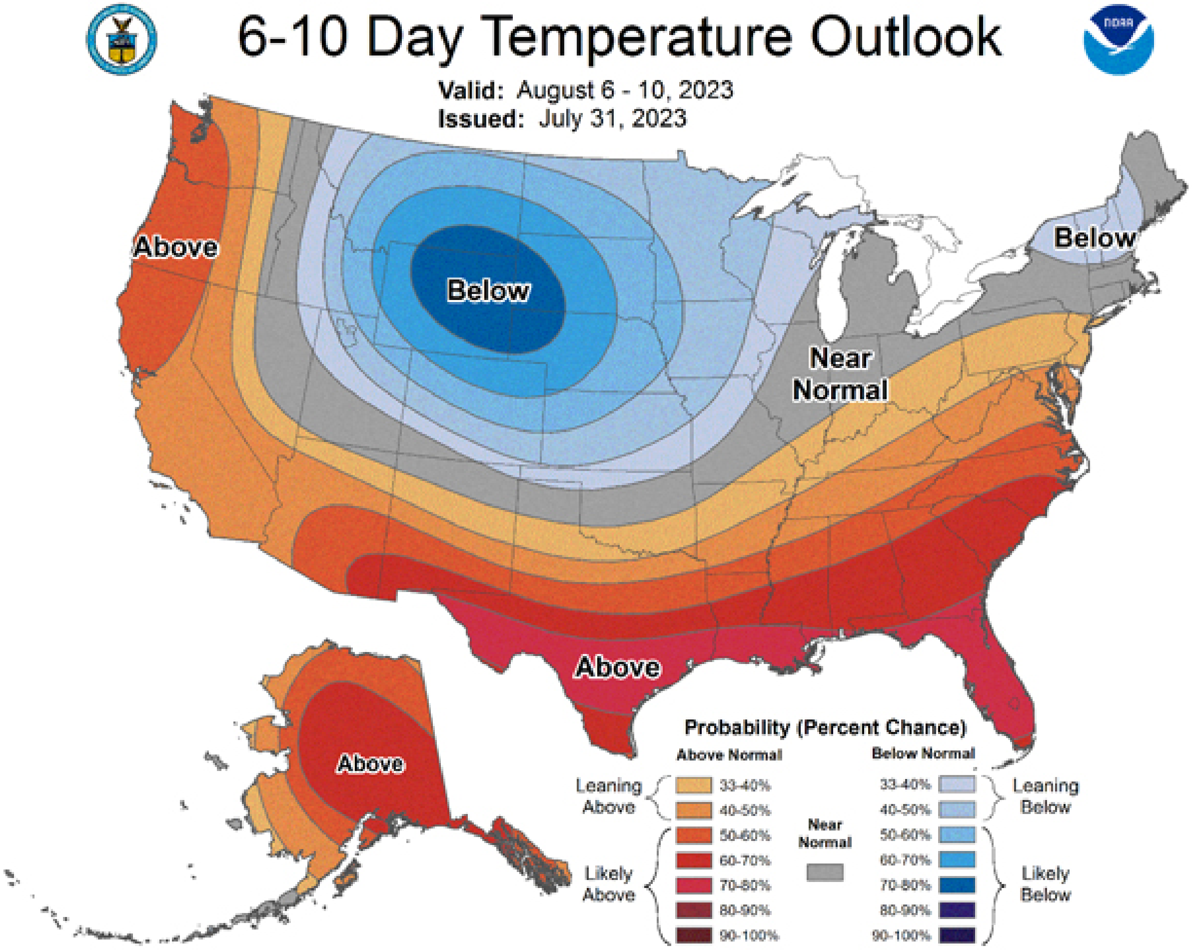

Figure 1. The Climate Prediction Center's 6 to 10-day temperature outlook for the period August 6-10, 2023.

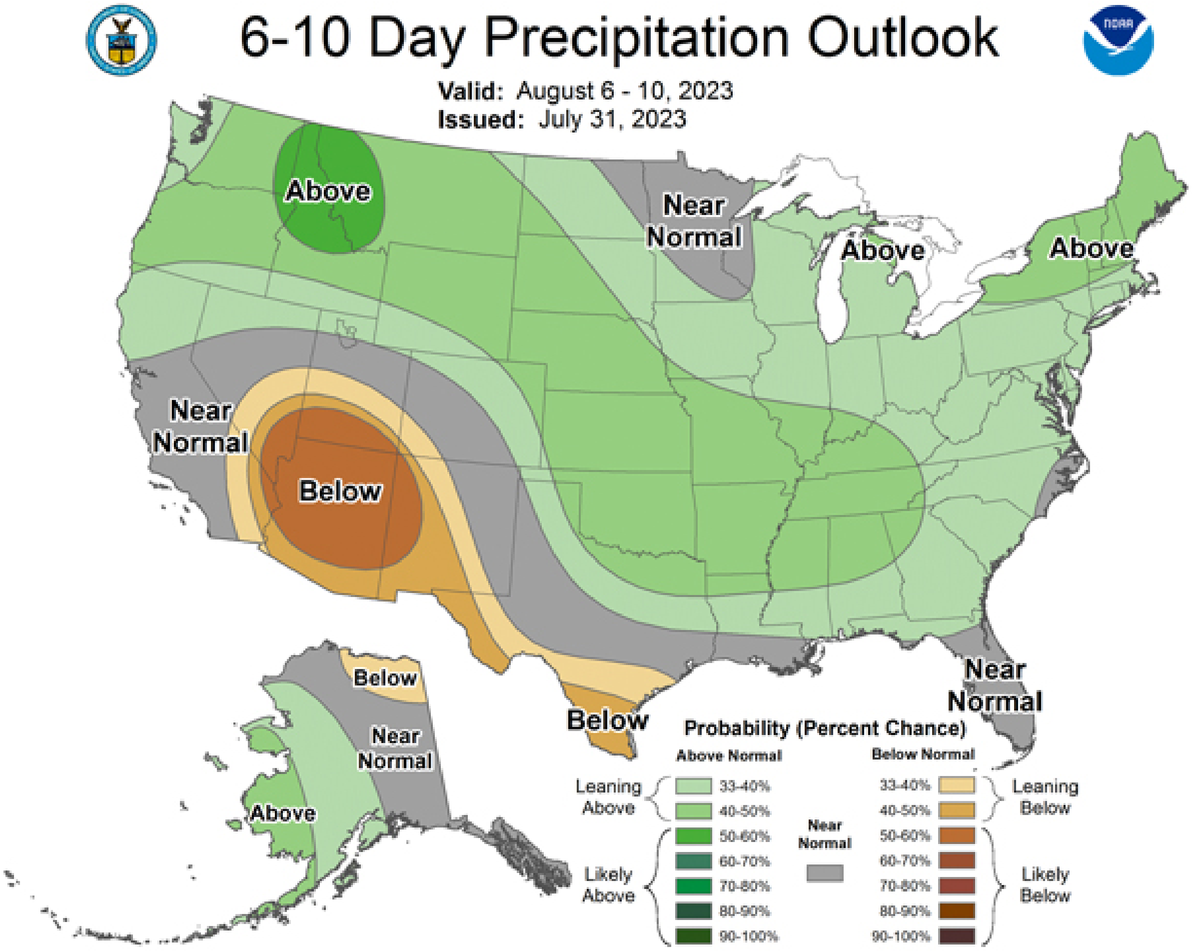

Figure 2. The Climate Prediction Center's 6 to 10-day precipitation outlook for the period August 6-10, 2023.

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8. Western Kansas Fall Field Days set for three locations in late August

Join K-State agronomists and extension specialists at one or more of the Western Kansas Fall Field Days. A series of three programs will take place in late August in Tribune (Aug. 22), Hays (Aug. 23), and Garden City (Aug. 24). These events are open to the public and are free to attend with a meal provided at each location.

Registration is requested to have an accurate meal count. Please register at https://kstate.qualtrics.com/jfe/form/SV_3y11xSdN4deXK2G.

Tribune – August 22, 8:30 a.m. (MT)

- Lunch will be provided
- Nitrogen management for dryland and irrigated row crops
- Management of limited irrigation corn

Directions: 4 miles east of Tribune on Hwy 96 (to Whitelaw), then 4.5 miles north and ¾ mile east

Hays – August 23, 2:30 - 6:30 p.m. (CT)

- Dinner will be provided
- Sorghum hybrids for early planting
- Occasional tillage in wheat-sorghum-fallow rotation

Location: 1232 240th Ave, Hays

Garden City – August 24, 8:30 a.m. – 2:00 p.m. (CT)

- Lunch will be provided
- Crop water use
- Weed management

For questions, contact:

Tribune: Lucas Haag – lhaag@ksu.edu

Hays: Augustine Obour – aobour@ksu.edu

Garden City: Jonathan Aguilar - jaguilar@ksu.edu

K·STATE
Research and Extension

KSU FIELD DAYS

WHEN

August 22-24, 2023

WHERE

KSU Western Kansas Research-Extension Centers

Tribune · 4 mile east of Tribune on Highway 96 (to Whitelaw), then 4.5 mile north and ¾ mile east
Hays · 1232 240th Ave
Garden City · 4500 E Mary St

For Any Questions Contact:
Tribune: Lucas Haag – lhaag@ksu.edu
Hays: Augustine Obour – aobour@ksu.edu
Garden City: Jonathan Aguilar: jaguilar@ksu.edu

TRIBUNE: AUGUST 22 8:30 AM MT

- Lunch will be Provided.
- Nitrogen Mgmt for Dryland & Irrigated Row-Crop
- Management of Limited Irrigation Corn

HAYS: AUGUST 23 2:30-6:30 PM CT

- Dinner will be Provided.
- Sorghum hybrids for early planting
- Occasional Tillage in Wheat-Sorghum-Fallow Rotation

GARDEN CITY: AUGUST 24 8:30AM-2PM CT

- Lunch will be Provided.
- Crop Water Use
- Weed Management

K-State Research and Extension is committed to providing equal opportunity for participation in all programs, services and activities. Program information may be available in languages other than English. Reasonable accommodations for persons with disabilities, including alternative means for communication (e.g., Braille, large print, audio tape, and American Sign Language) may be requested by contacting the event contact KSU Field Days two weeks prior to the start of the event ***August 22, 2023*** *at* ***monica94@ksu.edu.*** *Requests received after this date will be honored when it is feasible to do so. Language access services, such as interpretation or translation of vital information will be provided free of charge to limited English proficient individuals upon request.*
Kansas State University Agricultural Experiment Station and Cooperative Extension Service
K-State Research and Extension is an equal opportunity provider and employer

9. Flickner Innovation Farm Field Day - August 10

The Flickner Innovation Farm will host a field day on Aug. 10 to highlight current work by local producers, national and state industry members, and Kansas State University researchers to effectively manage weeds through technology and precision ag management strategies.

The event will take place at different venues in the Moundridge area and will feature technology demonstrations and experts speaking on soil health, cover crops, weed suppression, and weed management.

The program begins at 8:30 a.m. and ends at 2 p.m. The event is free and lunch will be provided. More information, including registration, is available online from the Kansas Center for Agricultural Resources and the Environment.

“In the last few years, there have been some pretty big advances when it comes to tackling weeds on the farm,” said Ray Flickner, owner and operator of the Flickner Innovation Farm. “We’re looking forward to sharing these technologies so people can see first-hand how these things can perform in the field.”

Participants will be able to observe such systems as a John Deere See and Spray Ultimate and a Redekop Harvest Weed Seed Control. In addition to these technologies, two Kansas-based companies will be on hand to exhibit their products. Greenfield Robotics will demonstrate the use of its Weedbot system, and RowShaver will have its product on site (Figure 1).

Figure 1. Greenfield Robotics operates two of its fleet of Weedbots at the Flickner Innovation

Farm in Moundridge, Kansas. Photo by K-State Research and Extension.

Weeds use valuable resources that row crops need to thrive. Climate, chemical resistance, and other factors can lead to problems for farmers who try to manage the problem. According to K-State researchers, there are no “one-and-done” solutions for weeds.

“Weed management is an ongoing challenge that requires a range of tactics to support traditional broadcast herbicide applications. The Flickner field day will give farmers an opportunity to learn about many strategies to diversity their weed management tools,” said Sarah Lancaster, a K-State Research and Extension weed science specialist.

The Flickner Innovation Farm is a partnership between the Flickner family, university agronomists, commodity groups, and industry leaders. Together, they are conducting studies in a large-farm setting to identify the most efficient technologies and techniques for Kansas producers to use on their own farms.

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