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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. Plan now for volunteer corn control

We can debate whether or not volunteer corn is truly a "weed," but it is definitely a problem for some farmers (Figure 1). According to research conducted in South Dakota, soybean yield loss was 8 to 9% when volunteer corn density was about one plant per ten square feet. Yield loss increased to 71% at volunteer corn densities of about one plant per square foot. Conversely, other scientists concluded that corn grain yield is not reduced by volunteer corn – so long as the volunteer corn was harvested along with the hybrid corn. However, the authors also noted negative impacts such as harvest inefficiency, disease occurrences, and poor stewardship of insect-resistant traits.

One of the factors that makes volunteer corn management difficult is the prevalence of glyphosate- and/or glufosinate-resistant varieties and hybrids. In addition, tank mixes with dicamba or 2,4-D to control broadleaf weeds may reduce the effectiveness of glyphosate and Group 2 herbicides like clethodim (Select Max, others) or quizalofop (Assure II, others). However, there are some steps farmers can take early in the growing season to manage volunteer corn.

Figure 1. Volunteer corn emerging with soybeans. Photo by Sarah Lancaster, K-State Research and Extension.

Burndown options

As mentioned above, glyphosate will not control glyphosate-resistant volunteer corn. However, paraquat (Gramoxone, others) will control volunteer corn that has emerged prior to soybean planting. Glufosinate (Liberty, others) will also control volunteer corn -- as long as the corn is not glufosinate-resistant (LibertyLink).

One thing to remember with burndown herbicide applications is that they must come in contact with the growing point to ensure the corn plant will not regrow, which means contact herbicides will be ineffective if applied to volunteer corn smaller than V6. In some cases, tillage may be the most effective option to avoid regrowth.

At planting options - soybeans

In research conducted at the University of Nebraska, pre-emergence applications of sulfentrazone in combination with imazethapyr, cloransulam, metribuzin, or chlorimuron (Authority Assist, Authority First, Authority MTZ, or Authority XL) reduced volunteer corn growth compared to non-treated controls. Other treatments, including flumioxazin (Valor, others) alone or in combination with chlorimuron (Valor XLT) or cloransulam (FirstRate), or fomesafen + metolachlor (Prefix) or saflufenacil + imazethapyr (Optill) did not reduce volunteer corn growth. There are no residual herbicide options to control volunteer corn at the time of field corn planting.

Over-the-top options

Group 2 herbicides (Select Max, Assure II, Fusilade, Poast, and others) are typically very effective over-the-top options for volunteer corn control in soybean. However, research from Indiana and Canada suggests that volunteer corn control by clethodim formulations without "fully loaded" surfactants can be reduced up to about 60% when applied with glyphosate or glyphosate plus 2,4-D and up to about 75% when applied with glyphosate plus dicamba. The reduction in control can be minimized by increasing the rate of the Group 2 herbicide to the maximum labeled rate or by using a more aggressive adjuvant. Research from North Dakota suggests that adding a high surfactant oil concentrate (HSOC) can improve volunteer corn control by tank mixtures of clethodim plus glyphosate, but neither NIS nor AMS improves control.

One potential option to control volunteer corn in emerged corn is to use an Enlist® corn hybrid. Enlist corn hybrids can be sprayed with Assure II herbicide, which would control glyphosate and/or glufosinate-resistant volunteers. However, there are very few varieties that are well-suited for Kansas.

For more detailed information, the "2023 Chemical Weed Control for Field Crops, Pastures, and Noncropland" guide is available online at https://www.bookstore.ksre.ksu.edu/pubs/CHEMWEEDGUIDE.pdf or check with your local K-State Research and Extension office for a paper copy.

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.

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2. Effects of high temperatures on wheat

Both daytime high and nighttime low temperatures were extremely high across parts of Kansas during a few days in the second week of May, with as many as 12 hours above 82°F accumulated on May 8 alone (Figure 1). The daytime high temperatures during this period sometimes exceeded 96°F. These temperatures occurred when much of the state's wheat crop was either in the heading or flowering stages, which was concerning and unfortunately is resulting in many symptoms of heat stress (Figure 2).

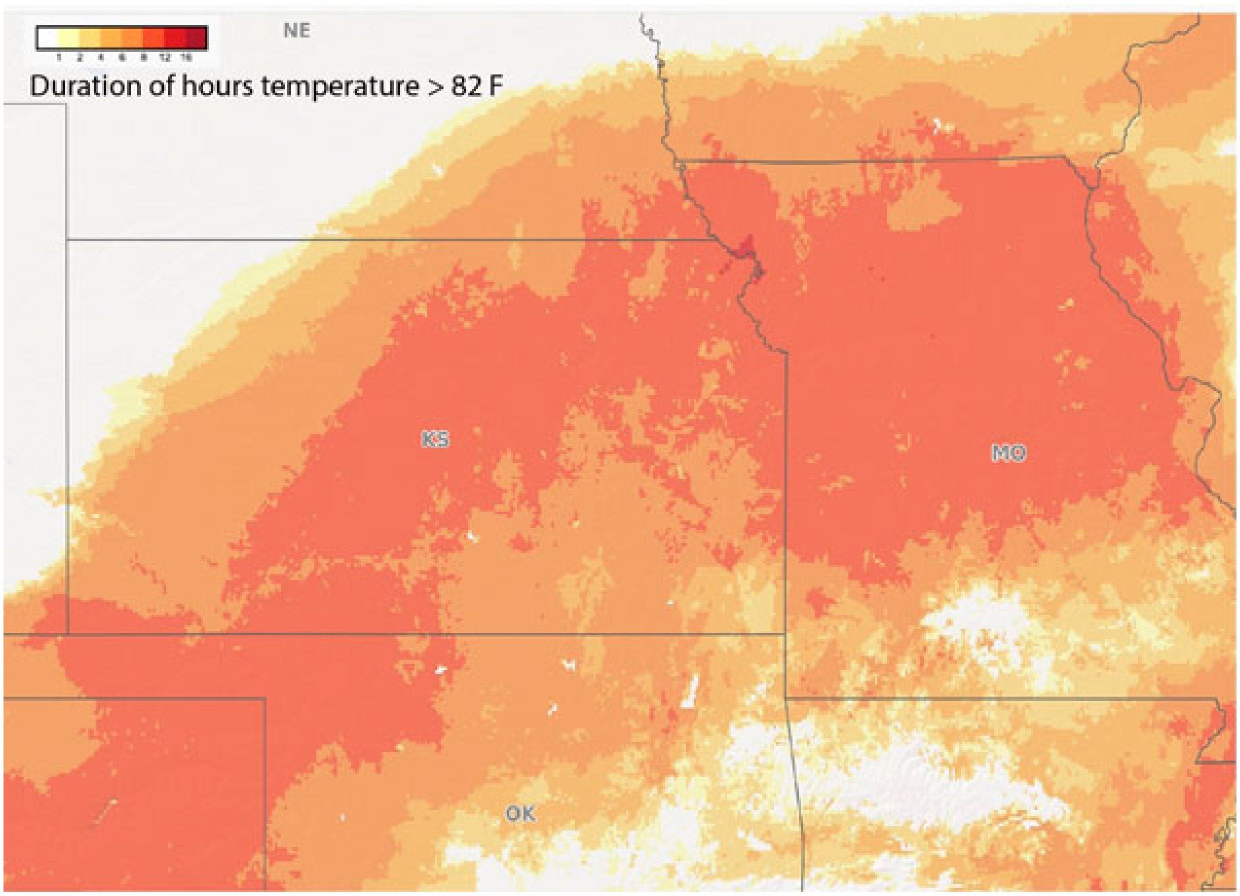

Figure 1. The number of hours of temperatures greater than 82°F on May 8, 2023. Darker colors indicate the largest duration of high temperatures. Source: Erick DeWolf, K-State Research and Extension.

Figure 2. Field in Saline County, Kansas, showing signs of head scorching likely due to heat stress. Photo taken by Jay Wisbey, K-State Research and Extension.

Wheat is generally sensitive to unusually high temperatures at nearly every stage of growth, being more sensitive in the reproductive stages than in the vegetative stages, and becoming less sensitive as it progresses from flowering to late grain fill (after soft dough stage of development) and physiological maturity.

One of wheat's most sensitive stages to heat is anthesis (flowering). The optimum temperature for wheat from flowering to grain fill is about 54 to 72°F. The longer the period of high temperatures and the higher the temperatures during reproductive stages, the more serious the potential yield loss. Temperatures above 82°F immediately prior to anthesis can greatly reduce pollen viability, thus reducing grain number and consequently grain yield.

Another unfortunate factor worsening wheat's response to heat stress this year was soil moisture. Air temperatures do not necessarily correspond to temperatures within the wheat canopy. Plants can cool themselves by about 2 to 3°F when soils are moist. On the other hand, heat stress is often worsened by drought stress (Figure 3). We might expect the impact of the heat stress will be worse in areas where there is little or no soil moisture, which was the majority of the state's conditions during May 8, 2023

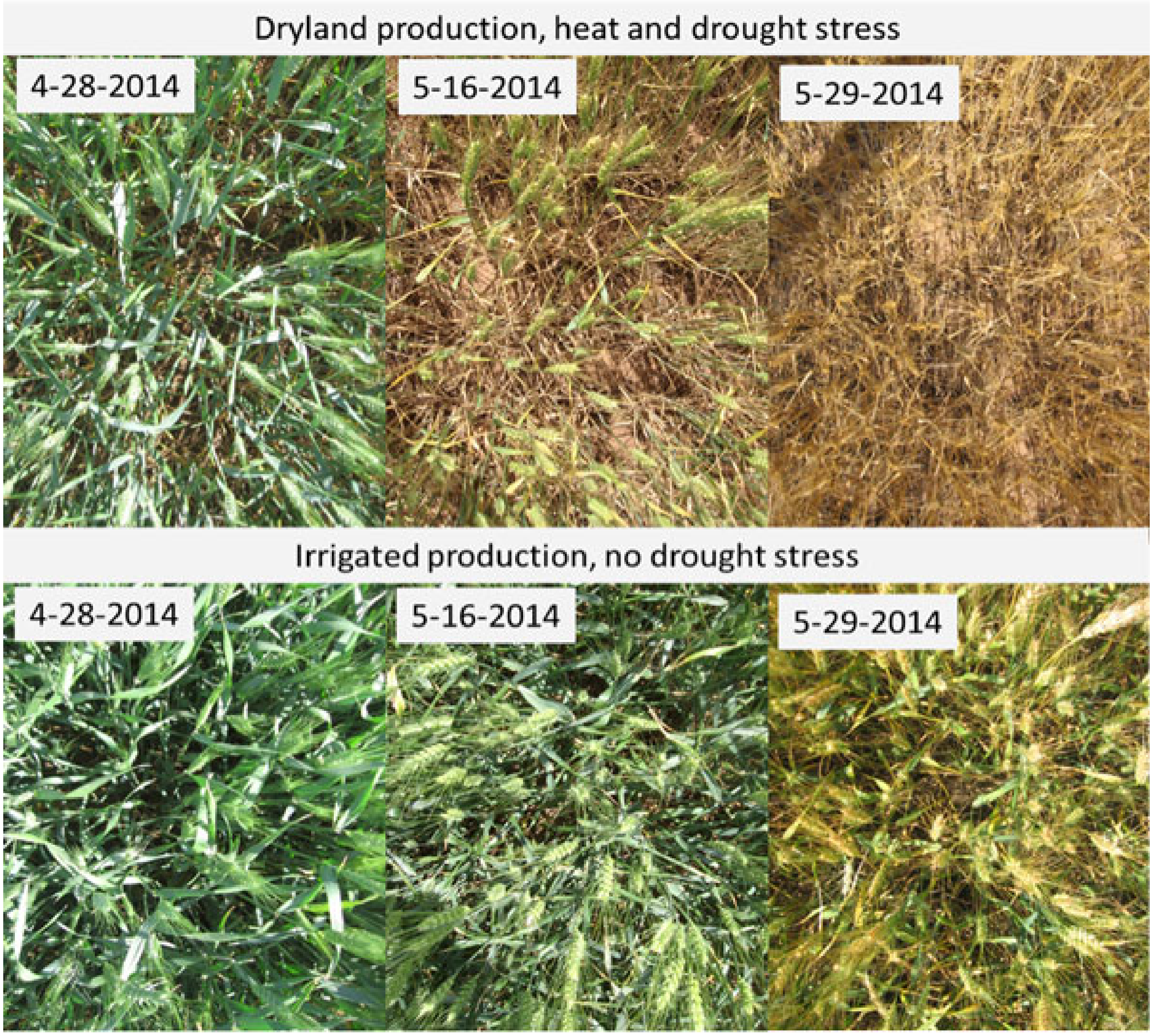

Figure 3. Interaction of heat and drought stress on wheat canopy coverage and leaf area progression between late April and late May (heading through grain filling and maturity stages). Photos were taken from neighboring fields conducted under the exact same management except that the field in the upper row was dryland and the field in the lower row was irrigated. Photos by Romulo Lollato, K-State Research and Extension.

Heat stress during pollen formation

Pollen forms in the developing head about 5 to 7 days before flowering. It's during this period, in addition to about 3 days following flowering, that the wheat is the most sensitive to heat stress. If temperatures in the canopy get above about 88°F during pollen formation, there can be significant pollination problems.

If the wheat is actively pollinating during the time of extreme heat, this can reduce fertilization, cause kernel abortion and a reduction in the number of seeds per spike, and ultimately reduce grain yield. In general, the more advanced the wheat stage of growth when this period of extreme heat began, the less severe the potential damage might be.

Where wheat development is the furthest along, such as where wheat flowered somewhere in the first week of May or earlier when temperatures were cooler, the current period of high heat should have no effect on the development of viable pollen and little effect on pollination success. There's a good chance this wheat had already successfully pollinated before the period of extreme heat began. Indeed, we are seeing fewer symptoms of heat stress in far south central Kansas (i.e., Sedgwick and Sumner counties) as opposed to central Kansas (i.e., McPherson and Saline counties). But that's not to say the wheat in this stage of development would not be affected at all by the heat. That wheat would probably have been at the kernel elongation stage during the period of maximum heat stress. Short-but-early heat stress during grain filling can reduce grain growth, sometimes to a greater extent than longer periods of moderately high temperatures.

Where wheat had just headed or begun flowering during the period of May 7-8, there may be pollen sterility and/or problems with normal self-fertilization processes. Either way, seed set may be reduced, possibly severely in the worst-case scenarios.

Where wheat was still in the flag leaf or early boot stage of growth, heat stress could still reduce grain yield mostly due to a reduction in the length of what we call the "critical period." The critical period for yield determination is the period most related to grain number determination, and in wheat, it starts about 20 days before flowering and ends around 10 days after flowering under normal temperature conditions. Because crop development is driven by temperature accumulation, this period can be as long as 45-50 days in a cool and moist year, to as short as 15-20 days in a hot and dry year. By accelerating crop development, heat stress shortens the duration of this period and negatively impacts yield.

Summary

It is hard to put a number of the potential yield damage due to heat stress, as it depends on many factors such as the stage of crop development during heat stress (different tillers and different kernels within a head will be at different stages of development), actual temperatures within the wheat canopy, and especially on grain-filling conditions following this heat wave.

If the period of high heat damaged pollen viability, disrupted pollination or caused kernel abortion, the effect on grain yields can be significant and irreversible, especially if grain fill conditions continue warm. Cool temperatures, especially nighttime temperatures, for the upcoming 3 to 4 weeks would normally help the crop compensate by lengthening the grain fill period, kernel weight, and the number of kernels per spikelet – if the heads were successfully pollinated. If the extreme heat occurred before pollen formation, pollen viability should be unaffected but shortening of the critical period could reduce yield. If the wheat had already successfully been fertilized at the time of the heat stress, grain yield could be reduced by reduced grain growth, but the actual effect on grain yield will depend greatly on whether the remainder of the spring is cool and moist.

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3. Check wheat heads for pollination problems

Many environmental conditions can cause pollination problems in wheat, such as freeze damage, drought, or heat stress. This year, the most concerning factor as it relates to a potential for unsuccessful pollination is heat stress, in particular that experienced during the second week of May 2023 (for more details, please see the accompanying eUpdate article).

About 4 to 5 days after flowering, producers can begin checking their fields to see if their wheat successfully pollinated. To check for successful pollination, producers can collect some heads from the field, pull the flower parts back and look to see if there is a small developing wheat kernel in the ovary (Figure 1). If there is, fertilization was successful.

Because different tillers go through development at slightly different timings, and kernels in the middle section of the head initiate pollination before those at the top and bottom of the head, heat stress is context-specific. It may damage kernel fertility in various tillers or spikelets within a head differently depending on the susceptibility of the particular stage of pollination during the heat event. Thus, growers are encouraged to check for kernel development in as many tillers and portions of the head within a tiller as possible.

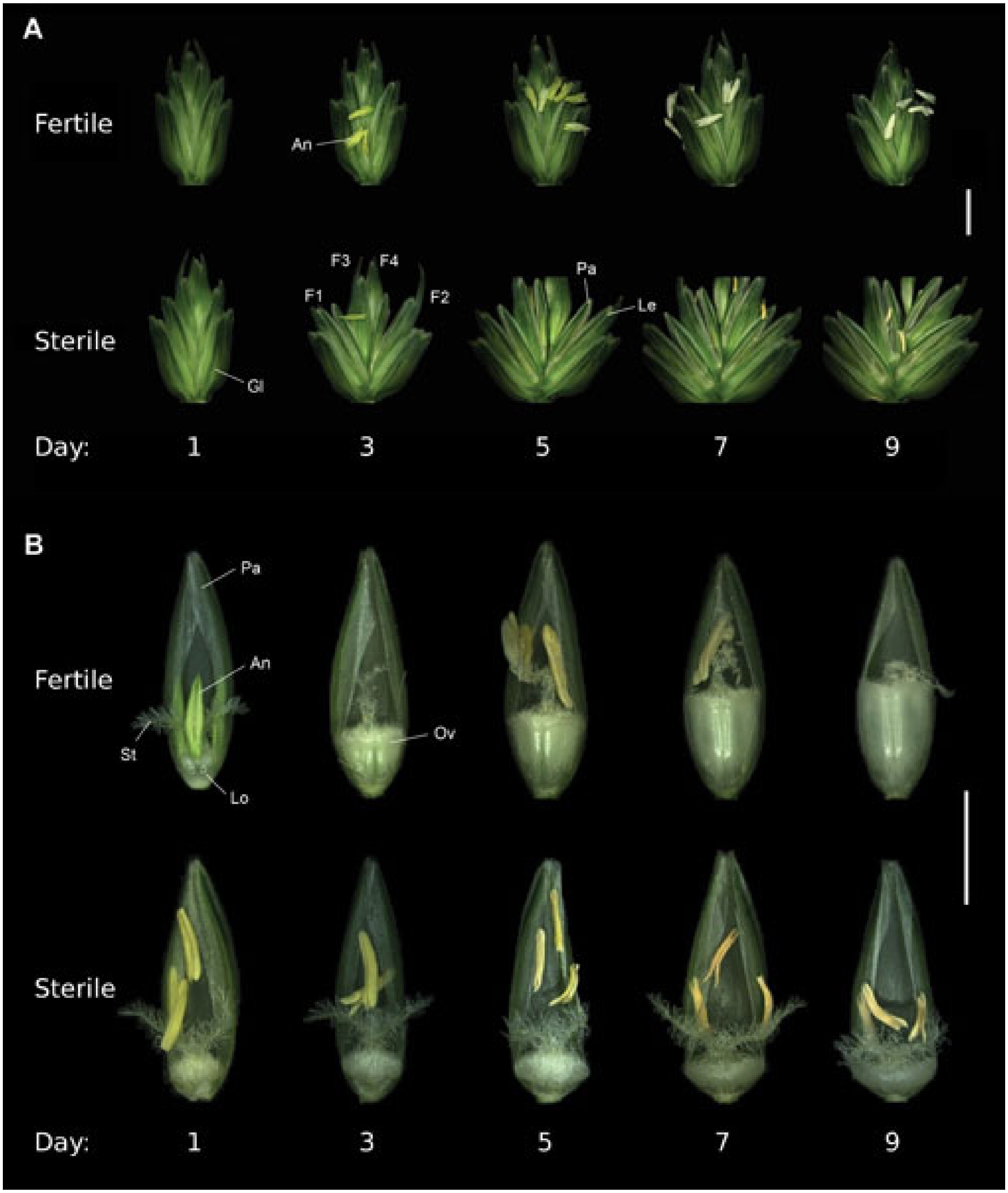

Figure 1. Floret images of male-fertile (upper row) and male-sterile (lower row) plants during the flowering time and early seed development with days counted from full heading. Abbreviations: An, anther; Lo, lodicule; Pa, palea; Ov, ovary; St, stigma. Scale bar is 2 mm. Photo adapted from Okada et al (2017), available at: https://academic.oup.com/jxb/article/69/3/399/4676045

If normal self-fertilization was unsuccessful, the florets will flare open. These flowers can still be cross-pollinated by nearby wheat plants with viable pollen, but the odds of that occurring are low.

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4. Possible causes for white heads in wheat

White heads have been appearing in many wheat fields around Kansas. Sometimes the white heads are just single tillers scattered throughout part or all of a field, and sometimes they occur in small-to-large patches. Heads might be completely white starting from the stem or have just partial bleaching showing a few spikelets with discoloration.

There are many causes of white heads. Here are some of the most common causes and their diagnosis.

Freeze injury to stem or crown. Depending on the stage of growth at the time of a late spring freeze, parts of the head or all of the heads may die and turn white (Figure 1).

In years when the freeze occurs about the boot stage or a little earlier, there can be injury to the lower stem, which then cuts off water and nutrients to the developing head, and that stem simply does not develop. In years when the wheat is in the early heading stage at the time of the freeze, the freeze can damage the heads directly. This year, a hard freeze with temperatures down to 24 degrees F occurred in late April, while a light freeze with temperatures down to 28 degrees F occurred in early May. Symptoms of freeze damage are occurring across fields for most of the state.

Often, wheat on north-facing slopes, on ridge tops, or in low-lying areas will be most affected by freeze injury. But freeze injury can also be so severe that it occurs in no particular pattern throughout the fields. Crown rot is another potential problem that can be traced back to freeze injury.

When the crown is damaged by cold temperatures or a freeze, part or all of the tillers can die. If the tiller from a damaged crown forms a head, this head will almost always be white. The crown will have internal browning, and stands will usually be thinner than normal.

Figure 1. Freeze-damaged wheat heads. Photos by Romulo Lollato, K-State Research and Extension.

Hail. Hail can cause a white head to appear when it breaks the connection between the stem and the head (Figure 2). Occasionally, hail can also damage just a portion of a head, and cause that damaged portion to turn white. The hail impact on the heads may also remove spikelets and expose the rachis (Figure 3). This year, a severe hailstorm occurred in the region between Rozel and Great Bend, damaging and many times completely eradicating wheat fields in that region.

Figure 2. Wheat field in Sumner County showing a high incidence of white heads due to hail damage. Photo taken May 22, 2019, by Romulo Lollato, K-State Research and Extension.

Figure 3. The heads in this photo have had a few spikelets removed due to hail impact and have their rachis exposed. Photo by Romulo Lollato, K-State Research and Extension.

Heat stress. Heat stress can scorch wheat heads and make them turn white, usually starting from the top and moving downwards (Figure 4). Depending on the level of heat stress, entire tillers may be scorched in a given plant. During this growing season, severe heat stress occurred in parts of central, south central, and southwest Kansas on May 7 and 8. Partial discoloration of the top third of wheat heads is occurring in this region.

Figure 4. White wheat heads caused by heat stress. Notice the scorched appearance starting from the top of the head and moving downwards. Photo by Romulo Lollato, K-State Research and Extension.

Dryland root rot (also known as dryland foot rot). This disease, caused by the *Fusarium* fungus, causes white heads and often turns the base of the plants pinkish (Figure 5). As with take-all, dryland root rot causes all the tillers on an infected plant to have white heads. This disease is usually most common under drought stress conditions and is often mistaken for either drought stress or take-all.

Figure 5. White wheat head caused by Fusarium root rot. Detail on the right shows pink discoloration inside the stem typical of the Fusarium pathogen. Photo by Romulo Lollato, K-State Research and Extension.

Head scab. When there are periods of rainy weather while the wheat is flowering, as seen across North Central and Northwest Kansas this growing season, some heads may become infected with Fusarium head blight and turn white. The heads of some red-chaffed varieties turn a darker red when infected with scab, but the heads of most varieties turn white. Symptoms can be restricted to one or few spikelets in the head, but often times the upper half or the entire head might be affected (Figure 6). Head scab is most common where wheat is grown after corn, or after a wheat crop that had head scab the previous year. Head scab can be identified by looking for pink spores of the Fusarium fungi and a darker discoloration to the rachis of the wheat head. During the current growing season, head scab has been observed at low levels in south-central and southeast Kansas, but it is probably still early to see symptoms in north-central and northwest Kansas as it takes approximately three weeks from flowering for the first symptoms to appear.

Figure 6. Wheat heads affected by head scab or Fusarium head blight. Symptoms range from one or few spikelets that turned white, to the upper half or entirety of the head. Photo by Romulo Lollato, K-State Research and Extension.

Take-all. This disease often causes patches of white heads scattered throughout the field. It occurs most frequently in continuous wheat, and where there is a moderate to high level of surface residue. Take-all is also favored by high pH soils, so a recently limed field might also show symptoms. To diagnose take-all, pull up a plant and scrape back the leaf sheaths at the base of a tiller. If the base of the tiller is shiny and either black or dark brown, it is take-all. All tillers on a plant infected with take-all will have white heads. Plants will pull up easily.

Sharp eyespot. This disease is common in Kansas but rarely causes significant yield loss. Sharp eyespot causes lesions with light tan centers and dark brown margins on the lower stems. The ends of the lesions are typically pointed. If the stems are girdled by the fungus, the tiller may be stunted with a white head. Each tiller on a plant may be affected differently.

Wheat stem maggot. Wheat stem maggot damage is common every year in Kansas, but rarely results in significant yield loss. It usually causes a single white head on a tiller, scattered more or less randomly through part or all of a field. One typical symptom of white heads caused by wheat stem maggot is that the flag leaf and lower stem are often green, and only the last internode (peduncle) and head are white. If you can grab the head and pull the stem up easily just above the uppermost node, the tiller has probably been infested with wheat stem maggot. Scout for symptoms of chewing close to the base of the plants, which could indicate that the head has died as a function of wheat stem maggot (Figure 7).

Figure 7. White wheat head due to wheat stem maggot, characterized by a white head and peduncle but with a healthy and green lower stem. Detail on the right shows chewing of the base of the peduncle by the maggot. Photo by Romulo Lollato, K-State Research and Extension.

Premature death. As wheat begins to mature, plants in some areas of the field may have an off-white color similar to take-all (Figure 8). This premature death could be due to drowning, hot dry winds, or other stress. The pattern of discolored heads will often follow soil types or topography and may occur in large patches. The grain will be shriveled and have a low test weight.

Figure 8. Large patches of drowned wheat in central Kansas (upper photo) and south central Kansas (lower photo). Photos were taken May 16 and 17, 2017, by Romulo Lollato, K-State Research and Extension.

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5. Crop options after early terminated wheat

Cropping options to follow an early terminated wheat crop could be similar to those for full-season crops. At this point in the season, viable crop options are still corn, soybeans, and sorghum.

Regardless of which crop you choose to plant, weed control will likely be needed. Despite insufficient precipitation to produce a crop, many fields will still have emerged weeds and all fields will have a weed seed bank likely to emerge and compete with the summer crop. In addition, any remaining wheat will need to be terminated. Burndown of summer annual weeds present at planting is essential for successful double-cropping. Glyphosate will be effective for terminating wheat, but if glyphosate-resistant kochia and/or pigweeds are present, alternative treatments such as paraquat may be required.

General agronomic considerations, herbicide carryover, and weed management will be addressed for each crop in the following sections.

Corn

In some regions, planting corn later can move critical corn growth stages around pollination to later in the growing season, after the most intense heat. This strategy has been adopted by some growers in areas that often encounter heat and moisture stress during the growing season, even though crop insurance cutoff dates for planting corn may be too early for this practice. However, in many dryland conditions, planting date is not a very good predictor of corn yield in fields with lower yield potential (<200 bu/a).

Hybrid relative maturity and target seeding rate can be like earlier planting dates until the month of June. Fertilization focusing on nitrogen (and other nutrients as needed based on soil testing) is still a critical practice to increase the likelihood of high attainable yields. If planting is delayed, longer maturity hybrids will be a good option to produce biomass for silage and grain, if they can reach maturity before a hard freeze.

Depending on application date, herbicide rate, and soil and environmental conditions, carryover of Group 2 herbicides such as chlorsulfuron (Glean, others), metsulfuron (Ally), sulfosulfuron (Outrider, others), triasulfuron (Amber, others) will be a concern. If Beyond was used in Clearfield wheat, Clearfield corn hybrids will allow replanting at any time, otherwise, the rotation interval is 8.5 months. If Aggressor was used in CoAxium wheat, the interval is 120 days.

If grassy weeds such as downy brome have become established in wheat, control prior to planting will be very important. However, they will likely be controlled by glyphosate or atrazine used to terminate wheat. Using a Group 1 herbicide such as clethodim (Select, others) or quizalofop (Assure, others) to terminate wheat will prevent corn planting, as these products have rotation restrictions, as mentioned for Aggressor. In addition to atrazine, residual herbicides such as mesotrione (Callisto, others) and Group 15 products (S-metolachlor, Dual; acetochlor, Harness; dimethenamid-P, Outlook; or pyroxasulfone, Zidua) should be used and can be included in the burndown application.

Soybean

Soybean is a very good alternative crop. A dense soybean canopy may reduce herbicide costs compared to leaving the field fallow. Still, a residual herbicide should be applied at or before, or at planting time.

From a variety selection, planting a variety with the same or perhaps even slightly later maturity rating (compared to a typical planting date) will allow the crop to develop a larger canopy before flowering. Planting a variety that is too much later in maturity, however, increases the risk that the seeds may not mature before frost, especially if long periods of drought slow growth. The goal is to maximize the length of the crop's growing season. The earlier you can plant, the higher the yield potential of the crop if moisture is not a limiting factor. From a fertilization standpoint, a soil test before wheat termination is recommended. Seeding rate can be similar to that for early planting dates, and row spacing could be narrower (15-inch or less), if this is an option with the available planting equipment. Narrow rows also offer the benefits of increasing early-season light capture, suppressing weeds, and reducing erosion.

If Group 2 herbicides are in the sulfonyl urea family and have the potential to remain in the soil after harvest. If an herbicide such as chlorsulfuron (Glean, Finesse, others) or metsulfuron (Ally) has been used, the most tolerant double crop will be sulfonylurea-resistant varieties of soybean (STS, SR, Bolt)

Chemical control of pigweeds at or before plating is especially important for soybeans. Dicamba (XtendiMax, Engenia, or Tavium) or 2,4-D (Enlist) can be used to control emerged pigweeds if soybean varieties with corresponding herbicide resistance traits are planted. Dicamba may also provide a bit of residual activity for pigweeds and kochia. However, a residual herbicide program that includes multiple effective active ingredients is important. Herbicides to consider include metribuzin, Group 14 herbicides (flumioxazin, Valor; sulfentrazone), and Group 15 herbicides listed previously.

Sorghum

Sorghum is another crop option with optimal planting time usually around late May and early June for late-maturing hybrids. Seeding rate and row spacing are similar to those recommended in normal planting dates (see recent Sorghum management eUpdate article). For N fertilization, a key component for the estimation of N application rates is the yield potential. It is also important to consider potential residual N from the wheat crop, mainly under the current conditions of very low production for wheat.

Sorghum will also have rotation restrictions to Group 2 herbicides. Igrowth hybrids are tolerant of imazamox (Beyond); however, current herbicide labels do not address rotation restrictions for these hybrids. Similarly, the Aggressor herbicide label does not address rotation restrictions for Double Team hybrids, which are tolerant of quizalofop.

Weed control before planting is critical for successful grain sorghum production. Both a thorough burndown program and an effective residual herbicide program is needed for both grasses and pigweeds to preserve double-crop sorghum yields. Using atrazine and a Group 15 herbicide product at planting is highly recommended for successful double crop sorghum production. One important difference from other crops discussed is that pyroxaulfone (Zidua, others) is not labeled for use in grain sorghum. Herbicide-tolerant grain or forage sorghum hybrids will allow the use of additional herbicides (imazamox, Imiflex; quizalofop, First Act; nicosulfuron, Zest) that are effective on summer annual grasses, but have little to no activity on pigweeds.

Cover Crops

Less information is available regarding the herbicide carryover potential of wheat herbicides to cover crops. There is little or no mention of rotational restrictions for specific cover crops on the labels of most herbicides. However, this does not mean there are no restrictions. Generally, there will be a statement indicating "no other crops" should be planted for a specified amount of time, or that a bioassay must be conducted before planting the crop.

For more detailed information about herbicides, see the "2023 Chemical Weed Control for Field Crops, Pastures, and Noncropland" guide available online at https://www.bookstore.ksre.ksu.edu/pubs/CHEMWEEDGUIDE.pdf or check with your local K-State Research and Extension office for a paper copy.

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6. Kansas Wheat Crop Conditions: Summary of the 2023 Wheat Quality Tour

The 2023 Wheat Quality Tour took place May 15 - 18, 2023. About 106 people actively scouted hundreds of Kansas wheat fields in 27 groups spread across six routes (Figure 1). The groups left Manhattan and headed to Colby on day 1, from Colby to Wichita on day 2, and finally from Wichita to Manhattan on day 3.

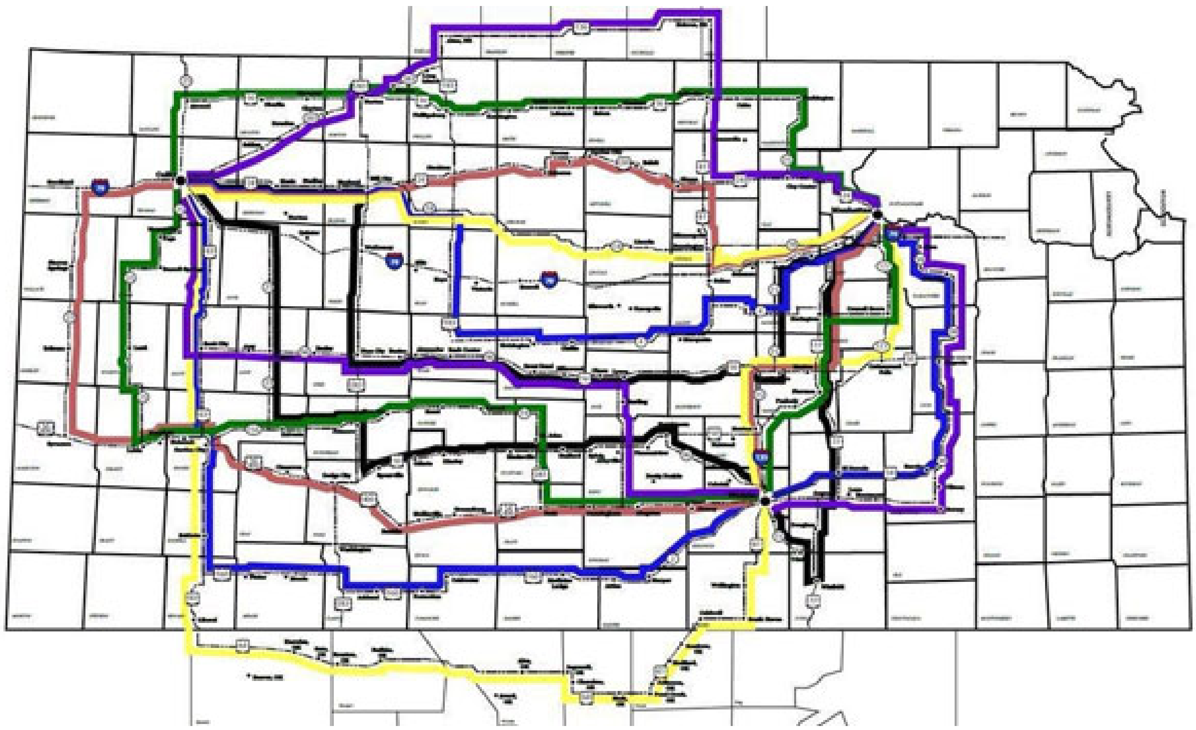

Figure 1. Representation of the six routes (purple, green, pink, yellow, blue, and black) explored during the wheat quality tour. Image courtesy of Wheat Quality Council.

The Kansas wheat crop is currently facing many challenges. After three days and 652 yield estimates from commercial fields – excluding those that looked like they would be terminated with less than 5 bushels/acre potential, the overall 2023 production estimate for Kansas resulting from the tour was 178 million bushels of wheat, compared to 261 and 364 million bushels estimated by the tour in 2022 and 2021, respectively. This is the first time in many years that the estimate is below 200 million bushels, reflecting the widespread drought, heat, freeze, and hail conditions that impacted the Kansas wheat crop in 2023. Weather conditions during the next 2-3 weeks will be crucial in determining where the final grain production will actually land.

Drought stress

The entirety of the state's wheat crop has suffered from drought stress during the 2022-23 growing season, with levels of drought differing among subregions. Symptoms of drought stress were milder in the eastern portion of the state (younger leaves curled, abortion of older leaves, and yellowing of lower canopy), and got progressively worst towards the western region (extremely reduced plant height and biomass, and delayed development). Many of the sampled fields were well into the reproductive stages of development, such as flowering and grain elongation, and were only 9-12 inches tall due to the prolonged stress (Figure 2). For fields under these conditions, yield estimates of 8-15 bushels per acre were common. The lack of growth will reduce the crop's yield potential, create difficulties during harvest, and leave virtually no residue behind that could benefit next season's summer crop.

Figure 2. Drought-stressed wheat fields got progressively worse as the group moved from central to western Kansas. Symptoms included decreased crop biomass production and height, curled leaves, abortion of older leaves, and yellowing of lower canopy. Photos taken by Romulo Lollato, K-State Research and Extension.

Conditions deteriorated as the group moved from northwest to southwest Kansas, where drought stress has been more severe (Figure 3). A very large area, spanning as far north as southern Wichita County to the KS-OK border, and from the KS-CO border to as far east as around Barber/Pratt counties, has been severely affected by drought and will have a large abandonment. Many of the producers around the state have already taken the decision to terminate their wheat crop. Visiting with growers in different regions, the average crop abandoned reported in the southwest part of the state ranged from about 25% to as much as 90%. For the crop that remains with some potential, precipitation within the next few days is essential to improve crop conditions and ensure some harvestable grain yield. If no rain occurs in the next few days, producers will have to face the decision of whether to harvest a crop with extremely limited yield potential or terminate the crop and switch to a summer crop (should moisture conditions improve for planting).

Figure 3. A vast majority of wheat planted in the southwest part of Kansas and northwest Oklahoma will be abandoned due to severe and prolonged drought stress. Photo by Romulo Lollato, K-State Research and Extension.

Heat stress

The second largest concern affecting the 2023 winter wheat crop in Kansas is heat stress. Many fields in the central portion of the state, with an area spanning from Saline County and south down to Sumner County, are showing signs of heat stress, such as scorched white heads (Figure 4). Heat stress interacts with drought stress and thus the symptoms tended to be worse than usual this year.

Figure 4. Wheat field in Saline County, Kansas, showing signs of head scorching likely due to heat stress. Photo taken by Jay Wisbey, K-State Research and Extension.

Freeze damage

Most of the state is showing symptoms of freeze damage, not only in the leaves but also in the heads (Figure 5). Burnback of leaf tissue resulting from a freeze should be mostly cosmetic and not result in yield reduction, but damage to the heads can reduce yield potential. Freeze injury seems to be widespread across the state but with a fairly low within-field incidence of damaged heads. If the crop has enough moisture from here onwards, it should help compensate for the lost tillers, and yield reductions from this problem might be minimal. If the crop has been severely damaged by a freeze, yield losses might be severe enough to justify no further investment in the crop.

Figure 5. White heads showing symptoms of freeze damage to a wheat field in Reno County, Kansas. Photo by Romulo Lollato, K-State Research and Extension.

Summary

The above factors are a few of the major challenges that the 2023 Kansas wheat crop is currently facing. While each of those factors could restrict wheat yields to a certain extent, the largest uncertainty when estimating wheat production at the state level at this time of year is the percent area abandonment (which may be historically high due to the severe prolonged drought), as well as weather remaining to occur during grain filling. Because the crop has been severely drought-stressed for the majority of the growing season in western and parts of central Kansas, the recent cool and moist conditions during grain fill should help ensure that the current potential of the crop is attained.

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7. Corn rootworm egg hatch has begun in Kansas

To date, corn rootworm degree day accumulation for the northern half of Kansas is similar to the same time last year and egg hatching should begin in one to two weeks in most locations. In the southern portion of the state, egg hatching is well underway, and scouting for root damage should begin in south central Kansas in the coming week as degree day accumulation indicates peak egg hatch is approaching (Table 1).

Table 1. 2023 corn rootworm degree day accumulation compared to 2022 during the same time period. Calculated using 10 cm max/min ground temperatures provided by KSU Mesonet.

CRW Degree Day Accumulation as of May 23			
Location	**2022**	**2023**	**Difference**
Colby	244	228	-16
Hays	323	337	+14
Manhattan	333	345	+12
Garden City	529	495	-34
Meade	517	619	+102
Parsons	458	482	+24

Calculating Corn Rootworm Degree Days

As with all degree-day models, the base temperature, or developmental threshold, will be important for predicting rootworm hatch and emergence. Western corn rootworm eggs are laid in summer and overwinter in the soil. The following spring, a threshold soil temperature of 52°F or higher will trigger eggs to begin developing. This base temperature along with daily 10cm high and low soil temperatures are used to monitor egg hatch using the formula below. It is important to note that degree day calculations for egg hatch should begin starting January 1 of the current year.

Calculating growing degree days for western corn rootworm egg hatch:

$$\left(\frac{\text{(Max. Daily 10cm Soil Temp. + Min. Daily 10cm Soil Temp)}}{2}\right) - 52°F$$

For example:

$$\frac{(58°F + 54°F)}{2} = \frac{112}{2} = 56 - 52 = 4 \text{ degree days accumulated that day}$$

Eggs should begin hatching after approximately 380-degree days have accumulated. Peak egg hatch occurs between 684-767 accumulated degree days. Examining corn roots for damage 10 to 14 days following peak hatch is recommended since feeding damage will be fresh and easier to detect.

Why it is important to scout for root damage

Western corn rootworm resistance to Bt corn continues to be an issue in continuous corn in the United States. Field evolved resistance was first detected in 2009 and, to date, resistance to every commercially available Bt trait package has been detected in corn-producing areas of the country. However, resistance is not uniform across all corn-growing regions, so check local conditions when making planting decisions. Given this, evaluating corn roots for rootworm damage during the growing season is highly recommended. Doing so allows you to get an idea of how well your rootworm management practices are working and provides a way to detect rootworm problems in first-year corn as well as the potential development of resistance to the Bt hybrid planted.

Details for the process of evaluating corn root damage can be found in the KSRE publication MF 845 Corn Rootworm Management in Kansas Field Corn. In short, several plants should be dug up throughout the field and their roots washed well for subsequent evaluation using the Iowa State University 1-3 Node Injury Scale. Digging roots will need to be timed after peak damage from rootworm larvae occurs but before roots begin to regrow, typically late June to early July. Corn rootworm resistance to a Bt protein should be considered if the node injury rating is 1.0 in a field with at least 2 consecutive years of use of the same single corn rootworm Bt toxin or if the node injury rating is greater than .5 in a field with at least 2 consecutive years use of the same pyramided corn rootworm Bt toxins.

It is important to remember that the best management tool for western corn rootworm is rotation. In continuous corn production, this includes rotating Bt traits annually to help slow the evolution of resistance. Rotation to a non-Bt hybrid combined with soil-applied insecticides would be another option for continuous corn. Both of these practices will be useful for prolonging the efficacy of currently available Bt traits.

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8. Growing season precipitation for Kansas - A dry start

Kansas' growing season began on April 1. The first month of this season was a dry one across most of the state (Table 1). The April statewide average precipitation of 1.32" was just 49% of normal. This ranked as the 17th driest April on record out of 129 years, dating back to 1895. All but one of Kansas' nine climate divisions averaged below normal. Northwest Kansas was driest; their 0.42" was just 21% of normal and ranked as the 7th driest on record. Southeast Kansas' total was higher, 1.26", but was only 30% of normal, and also ranked as 7th driest. The only division to finish April above normal was southwest Kansas, where an average of 1.92" of precipitation fell; this total ranked as the 46th wettest April on record in that division. Southwest Kansas would have finished the month below normal had it not been for a late-month precipitation event that brought 2 to 3" over a large part of that division between the 25th and 28th. The heavy rain led to a 1-category improvement in the US Drought Monitor in the May 2nd update, placing parts of southwest Kansas back in D3 after a 6 to 9-month period of being in D4, the most severe drought category. Unfortunately, parts of northwest, central, and south central Kansas had worsening drought conditions in April and were moved from D3 down to D4.

Table 1. Total precipitation (inches) by Kansas climate division for the month of April 2023 and estimated total precipitation for May 1-22, 2023. Numbers in parentheses are the departures from the 30-year normal)

Division	Precipitation		
	April (Departure)	May 1-22 (Departure)	Total (Departure)
Northwest	0.42" (-1.56")	3.64" (+1.33")	4.06" (-0.23")
North Central	0.91" (-1.55")	2.91" (-0.52")	3.82" (-2.07")
Northeast	2.51" (-0.97")	3.18" (-0.16")	5.69" (-1.13")
West Central	0.85" (-0.91")	2.63" (+0.54")	3.48" (-0.37")
Central	0.99" (-1.48")	2.60" (-0.19")	3.59" (-1.67")
East Central	1.60" (-2.15")	2.83" (-0.66")	4.43" (-2.81")
Southwest	1.92" (+0.25")	2.59" (+0.61")	4.51" (+0.97")
South Central	1.38"	2.34"	3.72"

	(-1.24")	(-0.33")	(-1.57")

Southeast	1.26″ (-2.88″)	3.33″ (-0.24″)	4.59″ (-3.12″)
STATE	**1.32″** **(-1.36″)**	**2.79″** **(+0.03″)**	**4.11″** **(-1.33″)**

Starting to improve

May is typically one of the wetter months of the year, and while all divisions have had more precipitation so far in May than they did in April, only the three western Kansas climate divisions are averaging above normal for the month as of May 22. The remainder of the state is below normal, but departures from normal in these areas are two-thirds of an inch or less. Northwest Kansas, often one of the driest divisions of the state, is currently averaging the highest precipitation in the state. This is due mainly to a heavy rain event that brought 3 to 5″ of rain to much of the area between May 10-12. Statewide, precipitation over the last 14 days (Figure 1) has been heaviest in the northwest and southeast corners of the state. Parts of north central Kansas have missed out on the higher rainfall totals, and recent US Drought Monitor updates have continued to show worsening conditions in this division (Figure 2).

The 7-day precipitation forecast for the last week in May (Figure 3) suggests western Kansas should finish the month above normal, while eastern and central Kansas are likely to finish below normal. At this time of year, any extended period without rain can rapidly increase precipitation deficits. For the last 7 days of May, precipitation averages around 0.80″ in the western third of the state, 1.10″ in the central third, and 1.25″ in the eastern third. For the eastern two-thirds of Kansas, where deficits for the growing season currently range from 1.1″ to 3.1″, another week with below normal precipitation, as is currently forecast, is not welcome news.

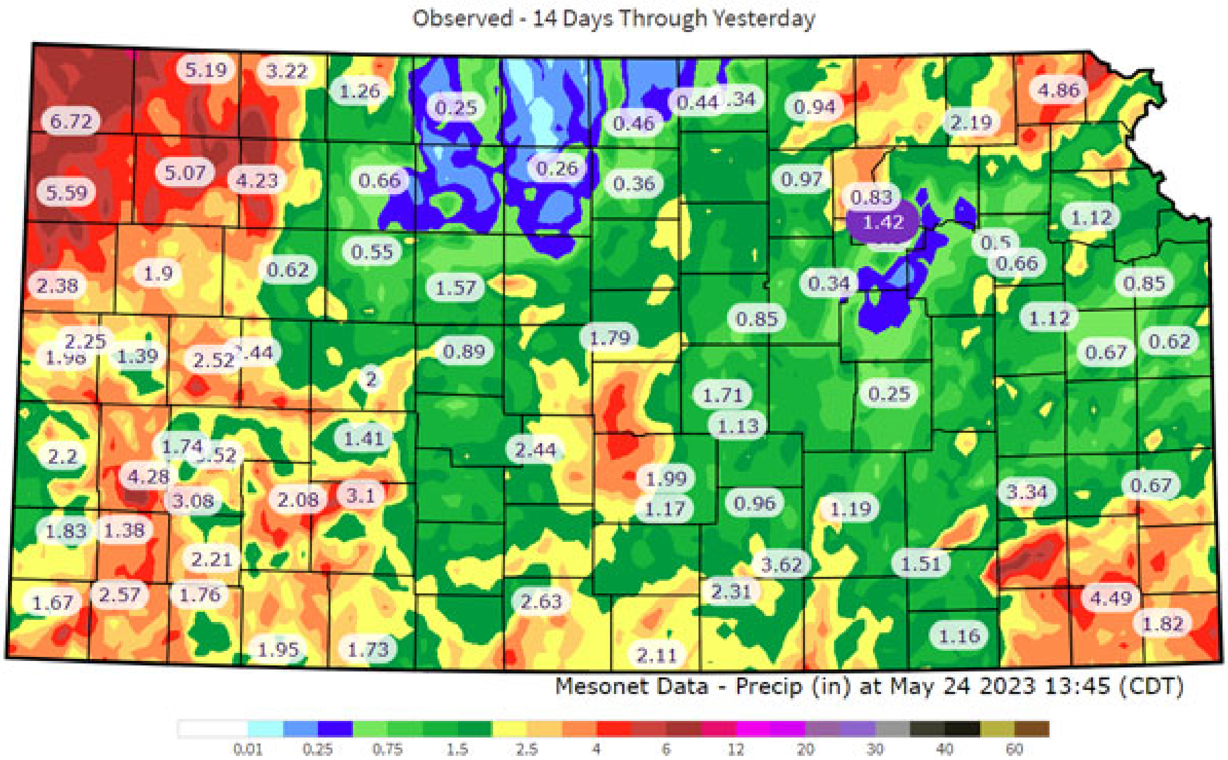

Figure 1. 14-day precipitation totals as of 11 AM CDT on May 23, 2023 across the Kansas Mesonet network.

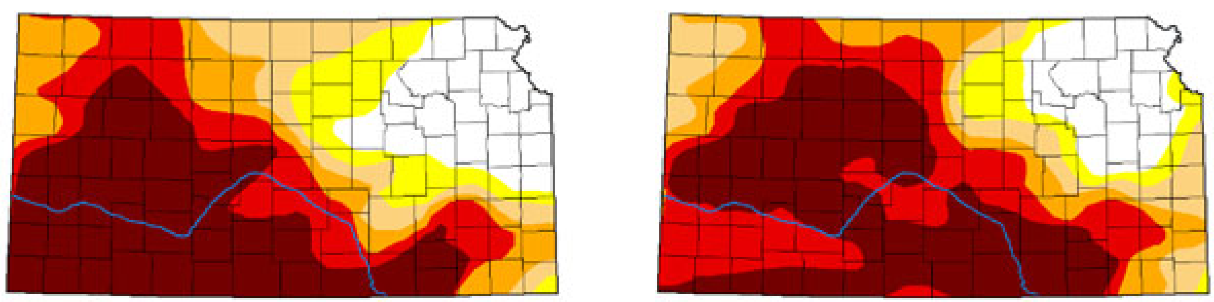

Figure 2. US Drought Monitor map for Kansas on March 28, 2023 (left) and May 16, 2023 (right).

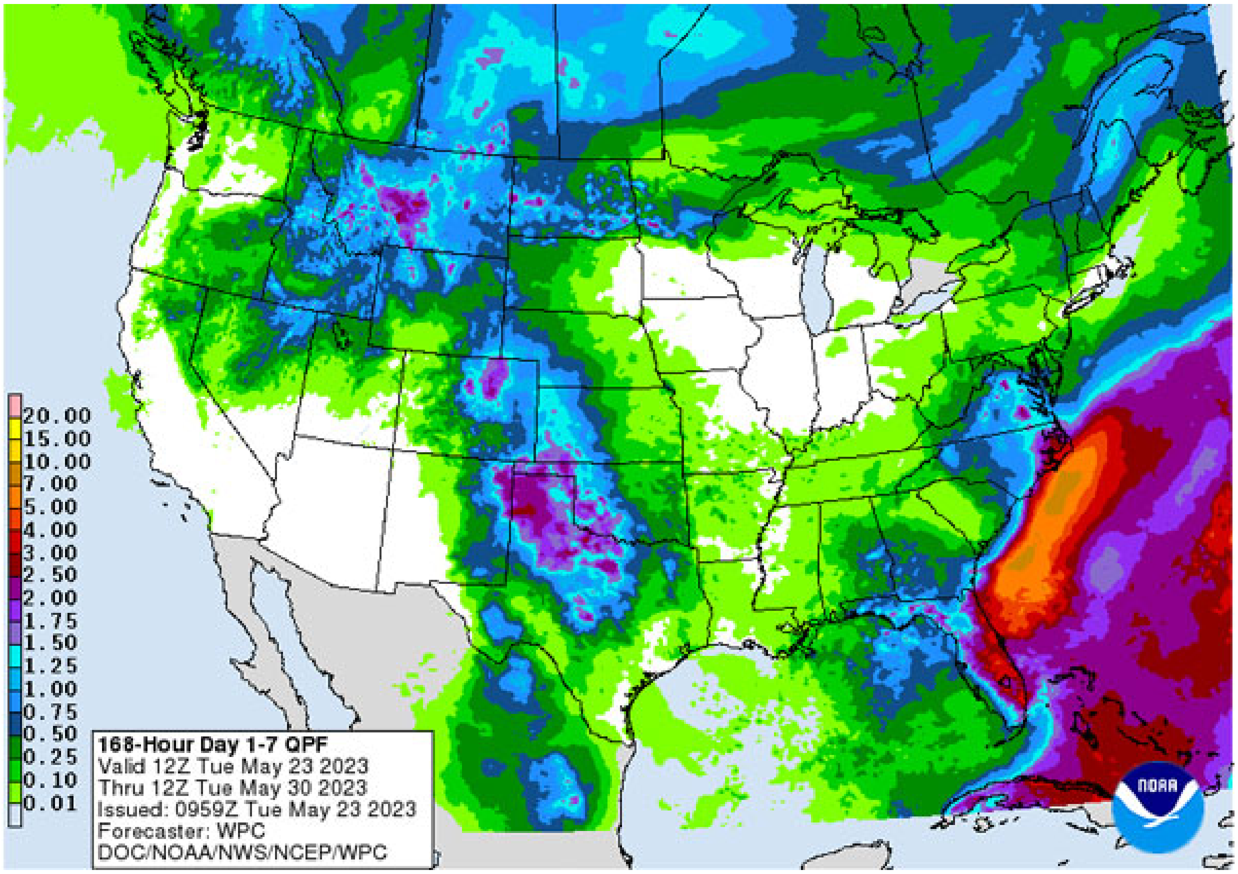

Figure 3. The Weather Prediction Center's 7-day total precipitation forecast for May 23-30, 2023.

Looking to the future

The current configuration of the upper atmosphere is stuck in what we meteorologists call a "blocking pattern." While this has resulted in moisture in the west, it isn't spreading the moisture statewide. This "omega block" as we call the current configuration (Figure 4), is notoriously difficult to forecast/model. In fact, the current depiction of the pattern (Wed, 5/24/23; Figure 4 top) is extremely similar to the pattern modeled over a week out (Sun, 6/4/23; Figure 4 bottom). Therefore, the pattern is expected to remain incredibly consistent into June. Even the current June Climate Prediction Center outlooks favor similar conditions to the last week through the month (Figure 5).

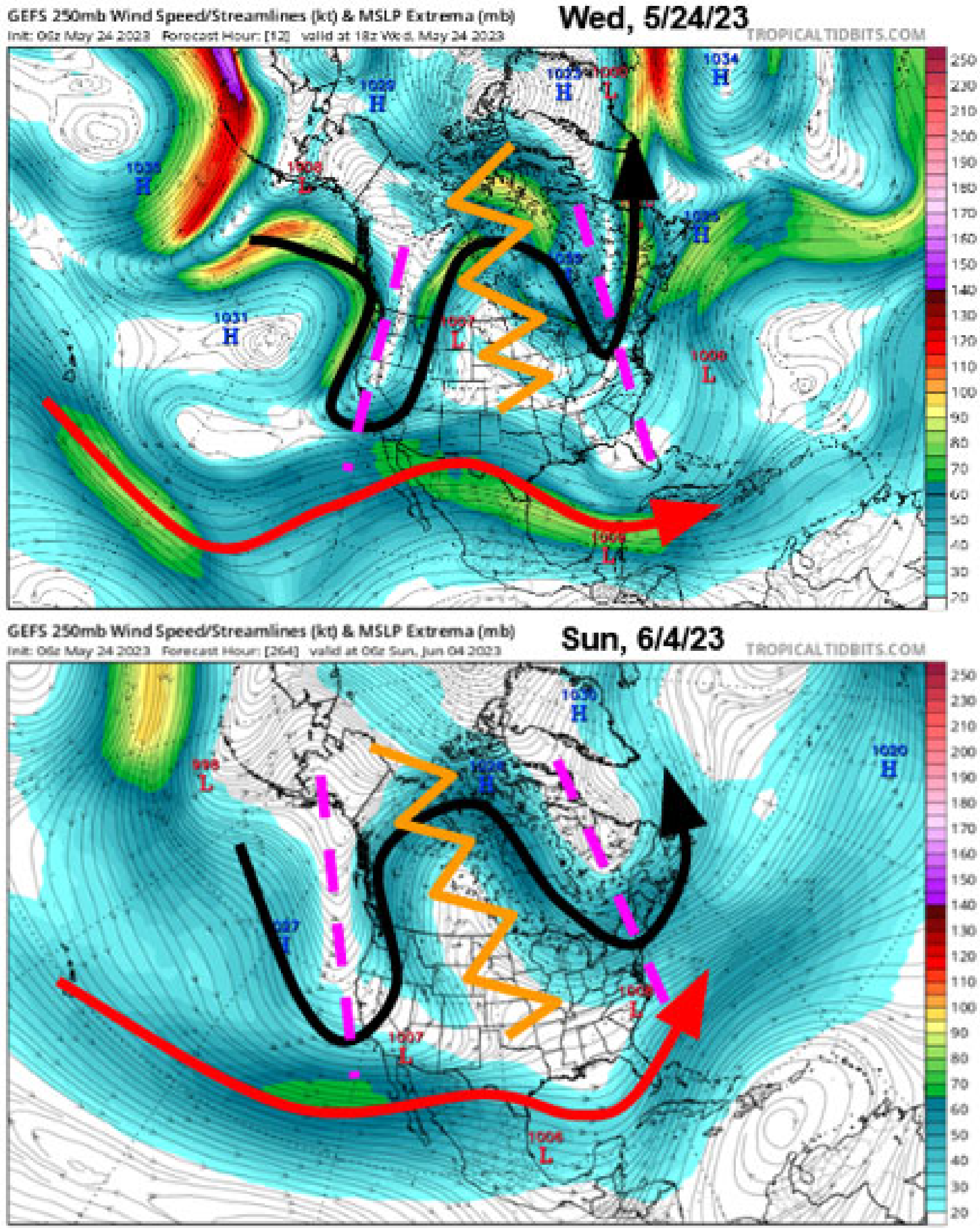

Figure 4. Upper-level wind patterns over North America from the GEFS forecast model on Wednesday (5/24/23 top) and on Sunday (6/4/23 bottom). The jet stream remains in split flow with the northern jet (black) in a persistent omega block (a ridge, orange jagged line bookended by two troughs of low pressure in the dashed purple lines) and the southern Jetstream (red) in a weak flow but ample enough to transport Gulf moisture north into the High Plains. Image source: tropicaltidbits.com with annotation by Chip Redmond, Kansas Mesonet Manager.

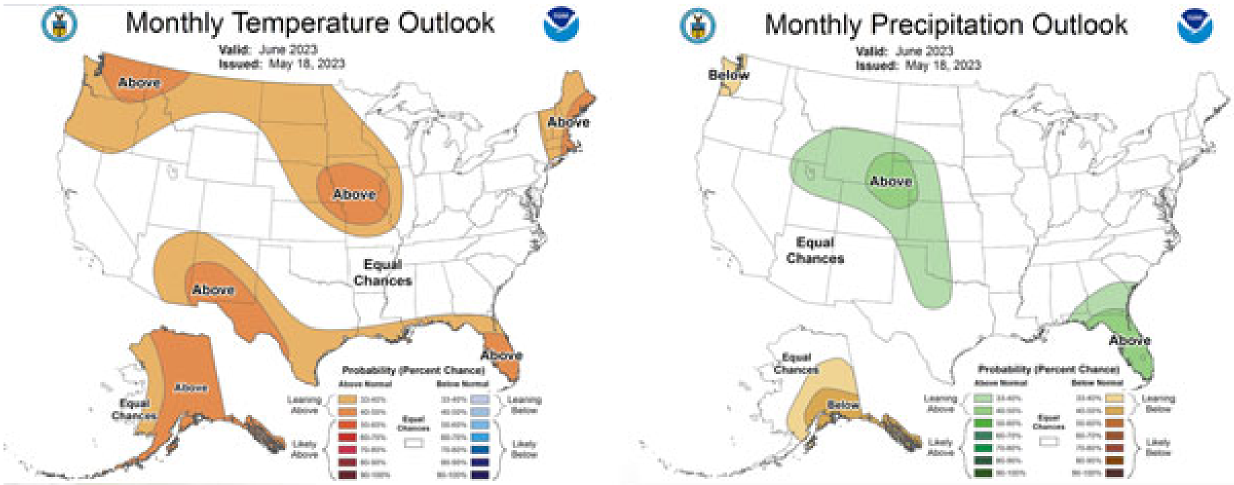

Figure 5. June temperature (left) and precipitation (right) outlooks from the Climate Prediction Center.

There are currently two factors that may help degrade the current pattern towards something more progressive. While we need continued moisture across the western part of the state, much of central and eastern Kansas is observing a growing precipitation demand. The first hope is the degradation of the strongly negative Pacific Decadal Oscillation. It strengthened last month and the cold Pacific water off the West Coast definitely aided the development of this pattern. However, these waters have begun to warm up in recent weeks. Should this diminish the –PDO, it would help suppress high pressure across western Canada and the northwest US and allow for a more active overall pattern. It would just take time, potentially not until mid-to-late June, which could be too late for some crops and water sources in the central/east.

A second area of hope to expand precipitation is the current typhoon Mawar impacting Guam. Some medium-range forecast models show this storm slowly moving to the west/northwest and eventually becoming wrapped into the northern jet stream. This may be just enough to kick the pattern out and finally break down the persistent ridge. Although the impacts are still greatly in question, its presence presents the potential opportunity for a potentially active western Pacific typhoon season.

Notice, we haven't mentioned the notorious El Niño Southern Oscillation. During the winter, ENSO is typically the least impactful for Kansas. Therefore, the current summer outlook for average overall of June, July and August, mostly favors equal chances of at/below/near normal conditions for a majority of the state (Figure 6). Warmer than normal temperatures are slightly favored with summer post-La Niña favoring southwest US dryness/warmth. This seems a likely outcome with conditions potentially drying out this summer for the High Plains. However, some increased favorability resides along the Missouri border should El Niño dominate earlier than thought. This overall switch in the pattern may be favorable for agriculture in the state.

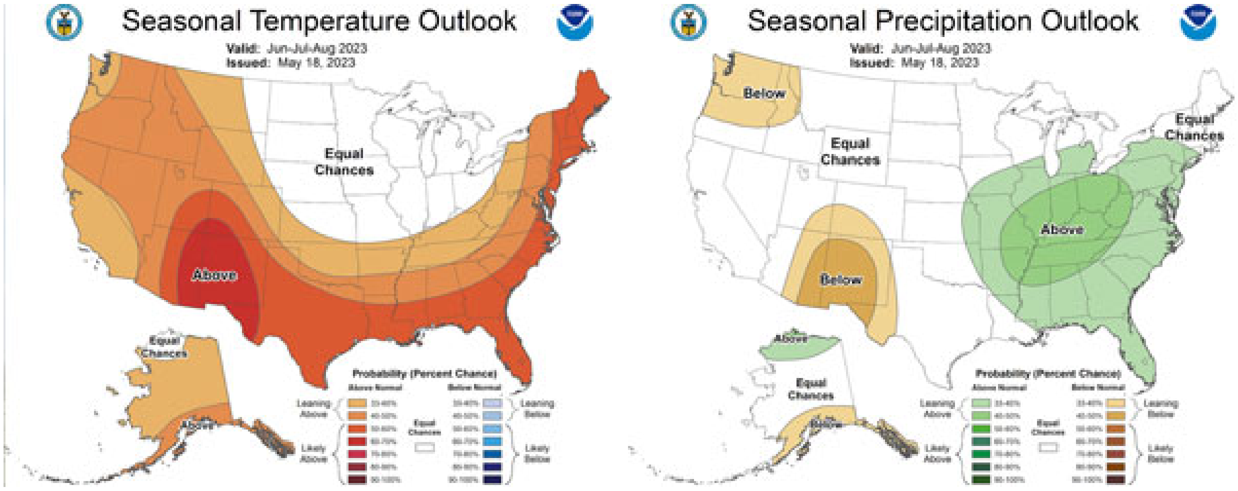

Figure 6. June, July, and August average temperature (left) and precipitation (right) outlooks from the Climate Prediction Center.

Considering further into the future

Now we are currently in an El Niño watch with a 70% probability of El Niño emerging in the eastern Pacific this summer. This is a pretty high potential, however, should the current neutral conditions (remember, we already got rid of La Niña, that is a start) evolve into warmer El Niño waters, impacts would be assumed to begin in the late fall and early winter. There is quite a bit of favorability in the models of increasing Kansas moisture especially come October/November timeframe. This wouldn't help the current crop but is something to consider for next year's winter wheat. El Niño strengthens the southern jet stream and results in cool/wet conditions to our south and warmer conditions to our north. That would once again, like La Niña, put us in the battleground of uncertainty. Current CPC outlooks hold to the uncertainty with equal chances statewide through the end of the year (Figure 7).

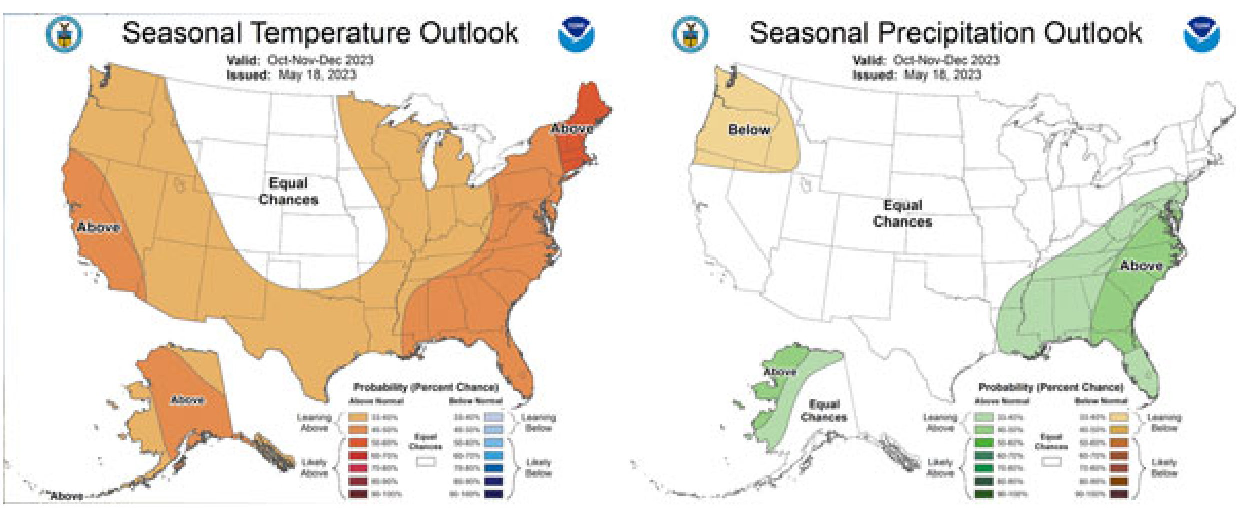

Figure 7. October, November, and December average temperature (left) and precipitation

(right) outlooks from the Climate Prediction Center.

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9. 2023 Wheat Plot Tours - Updated for May 26 through June 8

The Department of Agronomy and K-State Research and Extension is hosting several winter wheat variety plot tours in different regions of the state. Make plans to attend a plot tour near you to see and learn about the newest available and upcoming wheat varieties, their agronomics, and their disease reactions. A preliminary list of plot tour dates, times, and directions was published in a previous eUpdate. This article contains the updated details for May 26 through June 8 plot tours.

Romulo Lollato, Extension Wheat Specialist
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Date	Time	County	Location	Directions	Agent/Contact
5/26	8:30 AM	Saline	Solomon	Ryan family farm: 3 miles west of Solomon on Old Hwy 40 and 2.5 miles S on Gypsum Valley Road	Jay Wisbey
5/26	11:00 AM	Saline	Mentor	Isaacson Family Farm, West of Mentor on Old 81 Highway	Jay Wisbey
5/26	3:00 PM	Cloud	Minneapolis	Tim and Ryan Myers, 1.5 Miles West of K-106 Highway on Justice Road	Jay Wisbey
5/30	4:30 PM	Phillips	Phillipsburg	North of Phillipsburg in the corner of Hwy 183 ad E Osage Road. Supper served after the meeting at the Phillipsburg Fair Building (sponsored by Amber Wave)	Cody Miller
5/31	10:00 AM	Post Rock District	Lebanon	Highway 281, 1 mile S of Lebanon, East side of highway	Sandra Wick
5/31	1:30 PM	Post Rock District	Jewell	Off of Hwy 14 north of Jewell, then west on K Road for 2 1/2 miles on the south side of the road.	Sandra Wick
5/31	CANCELED	Post Rock District	Beloit	CANCELED	Sandra Wick
6/1	8:00 AM	Republic	Belleville	2 miles west of Belleville on Hwy 36 at K-State North Central Experiment Field	Luke Byers
6/1	10:00 AM	Republic	Belleville	Polansky Seed East Location (1.5 mi. E of Belleville on Hwy. 36)	Luke Byers
6/1	6:00 PM	Ellis	Hays	Golf Course Rd. & 180th Ave. at intersection go 1.5 miles S. on 180th Rd	Stacy Campbell

6/2	8:00 AM	Republic	Belleville	2023 In-Depth Wheat Diagnostic School (CEU/CCA credits, full day program). Registration required. 2 miles west of Belleville on Hwy 36 at K-State North Central Experiment Field.	Romulo Lollato
6/5	7:00 AM	Dickinson	Abilene	Intersection of HWYs 15 and 18 North of Abilene.	Rickey Roberts
6/6	9:00 AM	Thomas	Levant	9 miles south of the Levant I-70 interchange on the east side of the blacktop road.	Emily Bennigsdorf
6/8	5:00 PM	Washington	Palmer	Ohlde Seed Farms (3 mi. E of Palmer on 4th Rd)	Luke Byers

10. Wheat Disease Field Day in Manhattan - June 5, 2023

The Department of Plant Pathology and K-State Research and Extension will be hosting a wheat disease field day on Monday, June 5 at the Rocky Ford Plant Pathology Farm just north of Manhattan (1700 Barnes Rd., Manhattan).

This will be a great opportunity to see several wheat diseases in the field and to learn about the latest K-State wheat disease management and breeding advances.

Topics that will be covered include:

- Wheat disease management research updates
- Breeding efforts for Fusarium head blight, stem rust, barley yellow dwarf virus, and tan spot
- Pre-breeding efforts using WGRC collection of wheat wild relatives
- Predictive models for forecasting wheat diseases
- Wheat disease diagnostics and updates from the K-State Disease Diagnostic Lab

Registration will begin at 8:00 am and the program will begin at 8:30 am. Lunch will be served at noon.

There is no cost to attend this field day. Registration is requested for meal planning purposes. Please use this link for registration: https://shorturl.at/goKT1. You can also contact Amy Geyer at ageyer@ksu.edu or 785-532-6176.

K-State Plant Pathology

Wheat Disease Field Day

Monday, June 5th 2023
8:00 AM – 1:00 PM
K-State Rocky Ford Plant Pathology Research Farm

Address: 1700 Barnes Road,
Manhattan, KS 66502
*South side of the road

Registration 8:00-8:30
Lunch 12:00 – 1:00 pm

Speaker lineup:


Kelsey Onofre
Wheat Extension Pathologist


Jessica Rupp
Applied Wheat Pathologist


Erick De Wolf
Wheat Pathologist


Eduard Akhunov
Wheat Geneticist


Allan Fritz
Wheat Breeder


Robert Bowden
USDA Plant Pathologist


Mary Guttieri
USDA Research Geneticist


Chandler Day
Diagnostician

Topics:

Come visit the K-State Plant Pathology Farm and hear about the latest updates in wheat disease management and breeding for disease resistance from K-State, with topics including:

- Wheat disease management research updates
- Breeding efforts for Fusarium head blight, stem rust, barley yellow dwarf virus, and tan spot
- Pre-breeding efforts using WGRC collection of wheat wild relatives
- Predictive models for forecasting wheat diseases
- Wheat disease diagnostics and updates from the diagnostic lab

Registration not required, but requested to ensure we have enough food for lunch. To register scan the QR code or fill out this survey: https://shorturl.at/goKT1. You can also email (ageyer@ksu.edu) or call (785-532-6176) Amy Geyer.

Register:

KANSAS STATE UNIVERSITY
Department of Plant Pathology