



Extension Agronomy

eUpdate

05/25/2019

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. Wet soils and N loss: How much of the applied nitrogen has undergone nitrification?

With the excessive and continual wet weather during most of May, many parts of eastern and central Kansas are faced with the potential for leaching and/or denitrification losses of valuable nitrogen (N) from fields already planted or intended for corn and sorghum. The potential for N loss is much greater when the weather is warm than when it is cool.

The leaching and denitrification processes are quite different, and normally occur on different types of soils and under different situations. However, it is important to keep in mind that both processes involve the **nitrate** form (NO_3^-) of nitrogen. The nitrate-N present in fertilizers such as urea ammonium nitrate (UAN) solution (25% nitrate), is immediately susceptible to leaching or denitrification loss. Other forms of N have to be converted in the soil to nitrate-N before leaching or denitrification would become a problem. This microbial conversion process is called **nitrification** and requires oxygen in the soil (an oxidation process). Before estimating how much N may have been lost in wet soils, producers should first try to get some idea of how much of the applied N may have undergone nitrification into nitrate-N at this point in the season.

Factors affecting nitrification (conversion from NH_4^+ to NO_3^-)

Several factors influence how quickly ammonium-N converts to nitrate-N in soil. These factors include:

- Soil oxygen content
- Soil temperature
- Soil pH
- N fertilizer application method
- Certain characteristics of the N fertilizer

Nitrification is an aerobic microbial process and requires high levels of soil oxygen. Conditions that reduce oxygen supplies, such as saturated soils, will inhibit nitrification and keep N in the ammonium form (Figures 1 and 2). Optimum soil temperatures for nitrification are in the range of 75-80 degrees F. When urea or UAN are broadcast, nitrification will occur more rapidly than when those materials are banded. The nitrification rate of anhydrous ammonia is even slower due to the impact of the ammonia on the organisms in the application band. The use of a nitrification inhibitor, especially with banded ammonia, will slow the process of nitrification even further.

Nitrate Leaching

Leaching involves the movement of nitrate-N below the root zone with water. Leaching losses are primarily a concern on coarse-textured (sandy) soils, where water moves quickly through the soil profile. Ammonium-N is not readily lost to leaching, even on coarse-textured soils. Ammonium-N has a positive charge and is retained on the cation exchange capacity (CEC) sites of soils. Conversely, nitrate-N has a negative charge and is repelled by the soil, thus remaining in the soil water to

potentially leach out of the root zone.

Denitrification

Denitrification is the conversion of nitrate-N to gaseous N by soil microbes in anaerobic (waterlogged) soils. Denitrification loss is a problem normally associated with medium- to fine-textured soils under wet and warm soil conditions. Criteria that must be met for denitrification in soils to occur include:

- Nitrate-nitrogen. Denitrification only affects nitrate-N; it has no impact on ammonium-N. Maintaining N in an ammonium form is an effective strategy to avoid denitrification losses.
- Lack of soil oxygen. The specific soil microbes responsible for denitrification only function under anaerobic soil conditions. Poorly-drained or waterlogged soils have the highest potential for denitrification loss. Poorly-drained soils in central and eastern Kansas, and the claypan soils of southeast Kansas, are normally the soils with the most significant potential for denitrification.
- Warm soil temperatures and high organic residue and/or organic matter. Denitrification is a microbial process, and need ample food (organic materials) and warm soil temperatures are required for microbial activity. Like nitrification, the optimum temperatures for denitrification are in the 75-80 degree F range.

Table 1. Effect of soil temperature and duration of waterlogged soil conditions on denitrification. From publication EC155, University of Nebraska.

Length of Saturation (days)	Soil Temperature (degrees F)	Nitrate-N Loss (% of nitrate present)
5	55 - 60	10
10	55 - 60	25
3	75 - 80	60

Table 1 presents some data regarding the potential for denitrification N loss at several soil temperatures and provides some general guidelines for potential N loss. Loss was minimal with soil temperatures of 55-60 degrees F, but severe at soil temperatures of 75-80 degrees. The average soil temperatures at the 2-inch depth for selected Kansas Mesonet stations are shown in Figure 1. Note that Table 1 represents the amount of nitrate-N potentially lost via denitrification – **not necessarily the portion of total N applied**. The portion of soil N in the form of ammonium-N is not subject to denitrification.

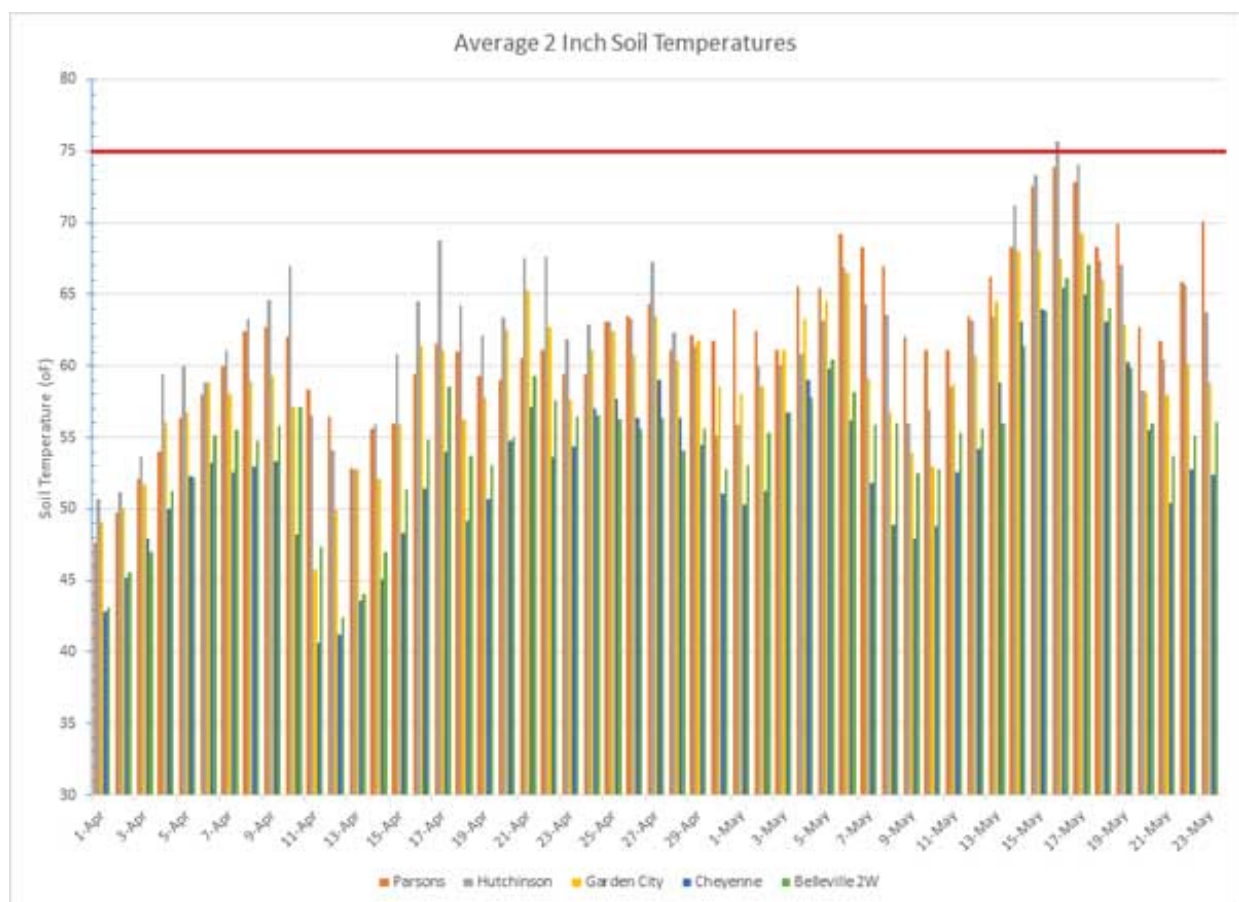


Figure 1. Average 2-inch soil temperatures in degrees F (KS Mesonet).

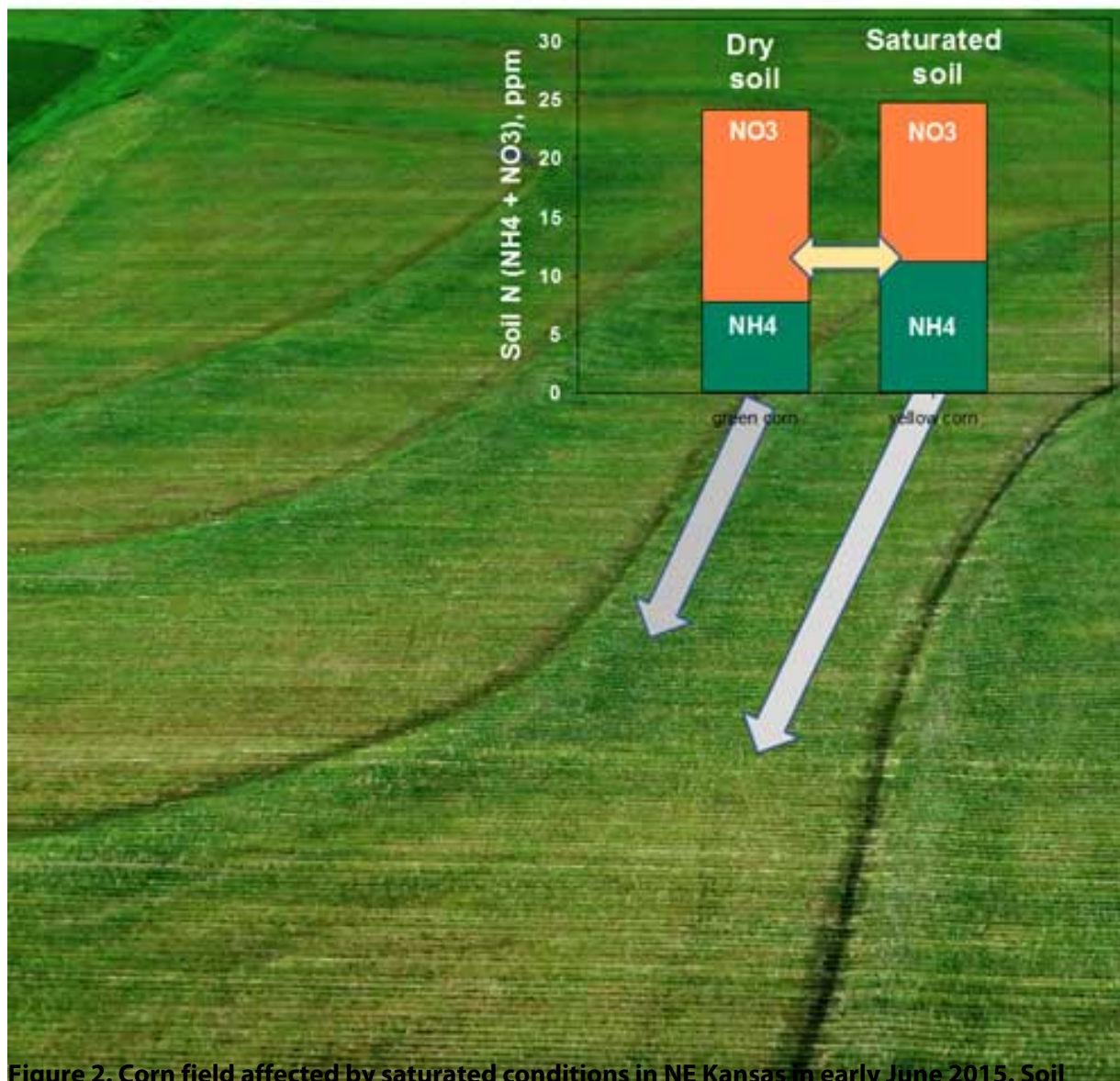


Figure 2. Corn field affected by saturated conditions in NE Kansas in early June 2015. Soil samples in saturated areas (yellow corn) and dry areas (green corn) reveal similar total N amounts, however the NH4 fraction was higher in the saturated areas (lower nitrification rate due to lack of oxygen). The yellow corn in this case is due to lack of oxygen in the soil rather than a lack of nitrogen. Photo and graph provided by Dorivar Ruiz Diaz, K-State Research and Extension.

Summary

Thus far this year, the saturated soil conditions have been accompanied by low soil temperatures (Figure 1), therefore we can expect that a good amount of the N applied in late fall or early spring to still be in the ammonium form. This would suggest a lower risk for N loss at this point in the season. However, producers that applied all their N very early in the fall should be in position to apply an additional 30 to 50 lbs of additional N if needed. Keep in mind that from the N uptake standpoint, we have a big window for any "supplemental" N application. Recent work at K-State has shown that N applied close to tasseling can be used effectively by corn. That will require dribbling the N on

between the rows with high-clearance application equipment. If your corn “runs out of gas” later in the season, it gives you an option to correct the problem.

All corn that appears yellow at this time will not be seriously N deficient. In fields where N application was delayed until late April or early May, especially where ammonia was applied, the majority of the N is likely still present in the soil and the corn is probably yellow due to “wet feet” and will green up when things dry out and oxygen gets back into the soil. Thus, no additional N will be needed.

Trying to sort out exactly how much N loss has occurred in a specific field is difficult, if not impossible. Producers can establish some reference strips in the field to serve as a base for comparison. Apply the equivalent of an additional 50 to 75 pounds of N per acre to 3 to 5 areas in a field. These areas can serve as a point of reference for evaluating your crop.

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2. 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 may just have a few spikelets showing the discoloration.

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

Premature dying (drowning). As wheat begins to mature, plants in some areas of the field may have an off-white color similar to take-all. This premature dying could be due to drowning, hot dry winds, or some 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 low test weight. Due to the recent rainfall events from mid-March through mid-May, with many areas of the state receiving over 10 inches of rainfall, several fields across south central and central Kansas are showing drowning symptoms on poorly-drained areas (Figure 1).





Figure 1. Large patches of drowned wheat in central Kansas (upper photo) and south central Kansas (lower photo). Photos taken May 16 and 17, 2017, by Romulo Lollato, K-State Research and Extension.

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

In years when the freeze occurs about the boot stage or a little earlier, such as this growing season, 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.

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 throughout the fields, in no particular pattern. 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.

Hail. Hail can cause 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 to the heads may also remove spikelets and expose the rachis

(Figure 3).



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.

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 (Fig. 4). 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 4. 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 most of 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 5). 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, as well as by a darker discoloration to the rachis of the wheat head. During the current growing season, head scab has been observed in south-central and southeast Kansas, but it is probably still early to see symptoms in central and north-central Kansas as it takes approximately three weeks from flowering

for the first symptoms to appear.



Figure 5. 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 function of wheat stem maggot (Figure 6).



Figure 6. 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.

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3. Corn planting progress for Kansas and other Corn Belt states

Corn planting in U.S. Corn Belt and in Kansas is advancing in one of the slowest rates ever recorded. For Kansas, corn planting progress increased from 46 to 61 percent from May 13 to 20 (USDA-NASS Kansas Crop Progress and Condition Report). Similar progress has been observed for Iowa and Nebraska, but with Illinois and Indiana are still quite behind (Figure 1).

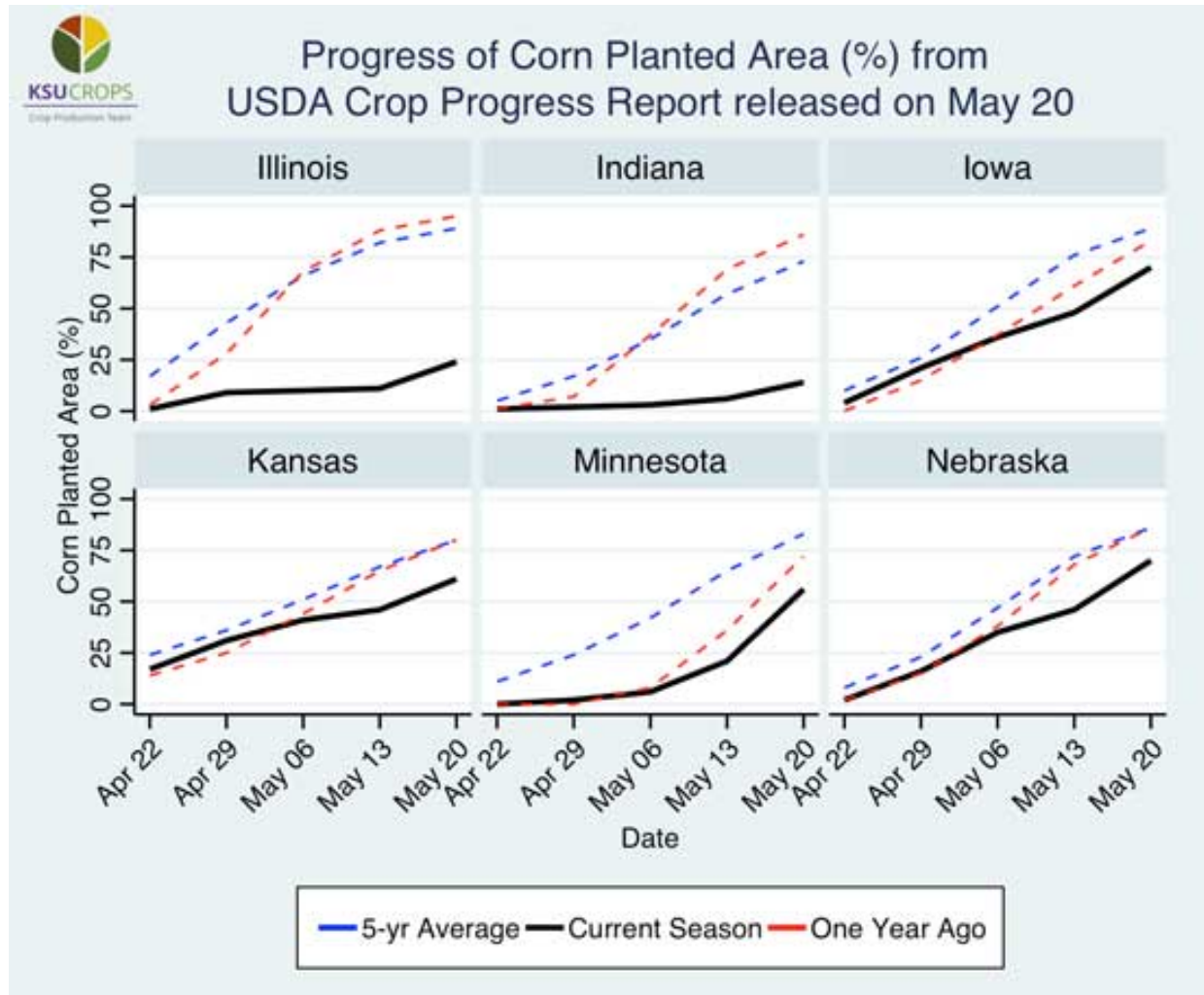


Figure 1. Progress of corn planted area (%) from USDA Crop Progress Report, May 20, 2019.

For Kansas, as well as the many other states, corn planted area (%) is still behind from the planted progress recorded in 2018, 61 versus 80% (Figure 2). Similarly, the proportion of emerged plants is quite behind relative to the reported from last year's average (37 vs. 53%), reflecting the poor early-season growing conditions for the planted fields (combination of low temperatures and wet-to-saturated soil conditions).

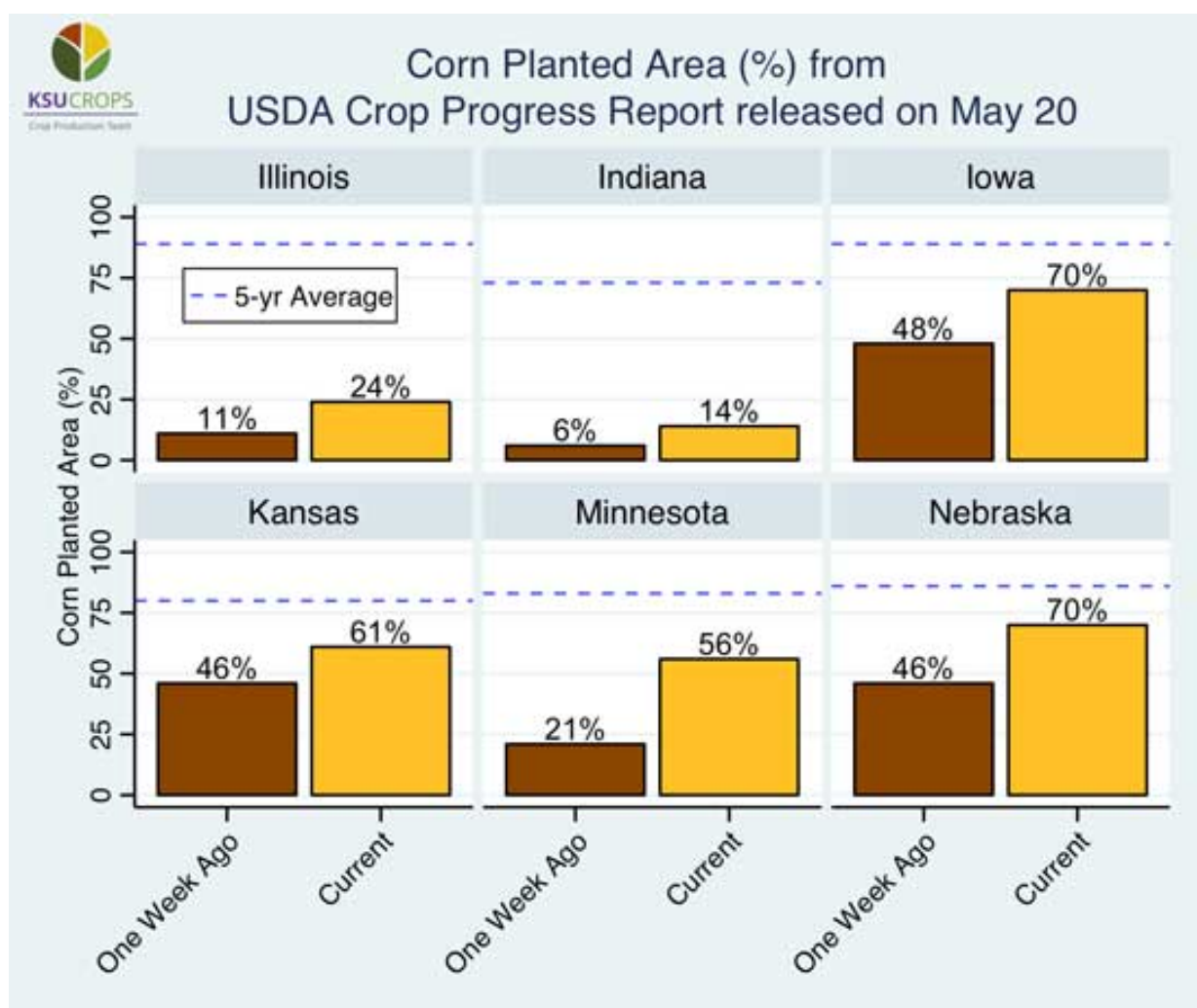


Figure 2. Progress of corn planted area (%) from USDA Crop Progress Report, May 20, 2019.

The weather pattern in the past weeks and the projected three-month outlook indicates a 40% likelihood of above-normal precipitation and below-normal temperatures for most of Kansas (from the National Weather Service Climate Prediction Center (<http://www.cpc.ncep.noaa.gov/>)). Saturated soil conditions impacted the expected number of suitable working days in a given period of time. Knowing how many suitable working days might be available to conduct fieldwork for a given crop operation impacts crop choice and machinery investment decisions. The most active planting dates for corn are usually between April 15 and May 15 (20th to 80th percentile, respectively) and for soybeans and grain sorghum, those dates will go from May 15 to June 20 (20th to 80th percentile, respectively) (2010 USDA NASS handbook).

Since the week of April 29 for Kansas (Figure 3), the number of days suitable for fieldwork has been declining, with the lowest point being less than 2 days, which in many situations was potentially only 1 day before the next rain event.

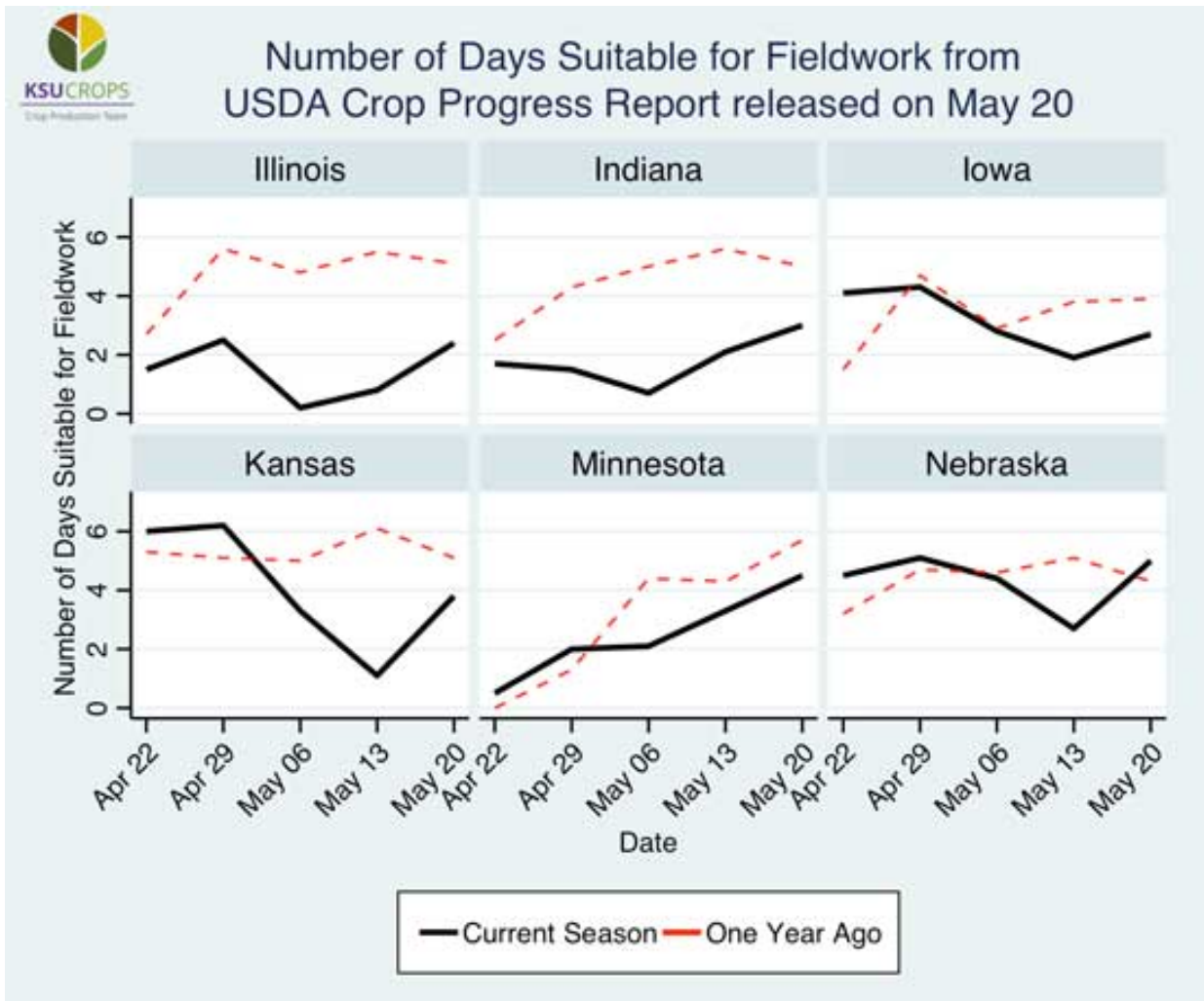


Figure 3. Number of days suitable for fieldwork from USDA Crop Progress Report released May 20, 2019.

As previously discussed, the number of days suitable for fieldwork remained below normal relative to the average for the last year across the main corn producing states in the U.S. In parallel, the topsoil moisture conditions across many states is reflecting adequate-to-surplus moisture. The states presenting the largest delay in corn planted progress are also the ones documenting more than 50% surplus of topsoil moisture conditions. For Kansas, the topsoil moisture condition (reflected as an average of the state-level cropland area) reached the maximum point of close to 25% of surplus topsoil moisture condition from May 13 (Figure 4). The latter reflects the main challenges faced by farmers for planting crops during this unusually wet spring conditions.

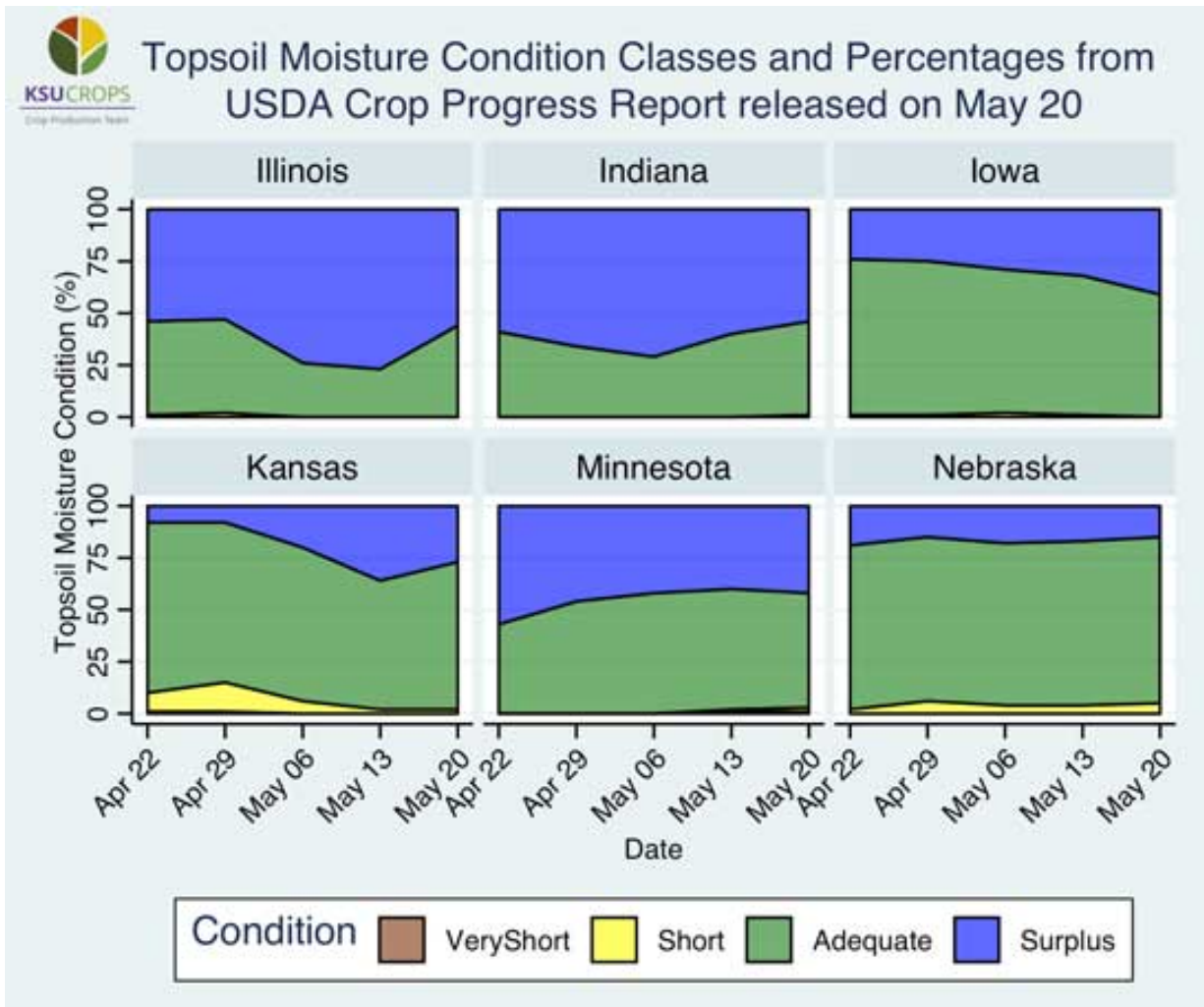


Figure 4. Topsoil moisture conditions classes and percentages from USDA Crop Progress Report released May 20, 2019.

In summary, corn was trailing the respective five-year and last-year progress averages last week, with soybeans in a similar situation.

Depending on your location, delayed planting will be a normal situation considering the weather experienced during this spring. Considering crop insurance and the main agronomic practices to achieve a successful crop will be critical factors guiding our planting decisions.

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4. Can excessive rainfall prematurely kill the wheat crop in parts of Kansas and Oklahoma?

Parts of central Kansas and northern Oklahoma received as much as 10.23 inches of rainfall in the last 7 days (Figure1). Excessive rainfall caused flooded fields in the region from Harper to Cherokee counties in southern Kansas and from McPherson to Miami counties in central and east central Kansas (Figure 2).

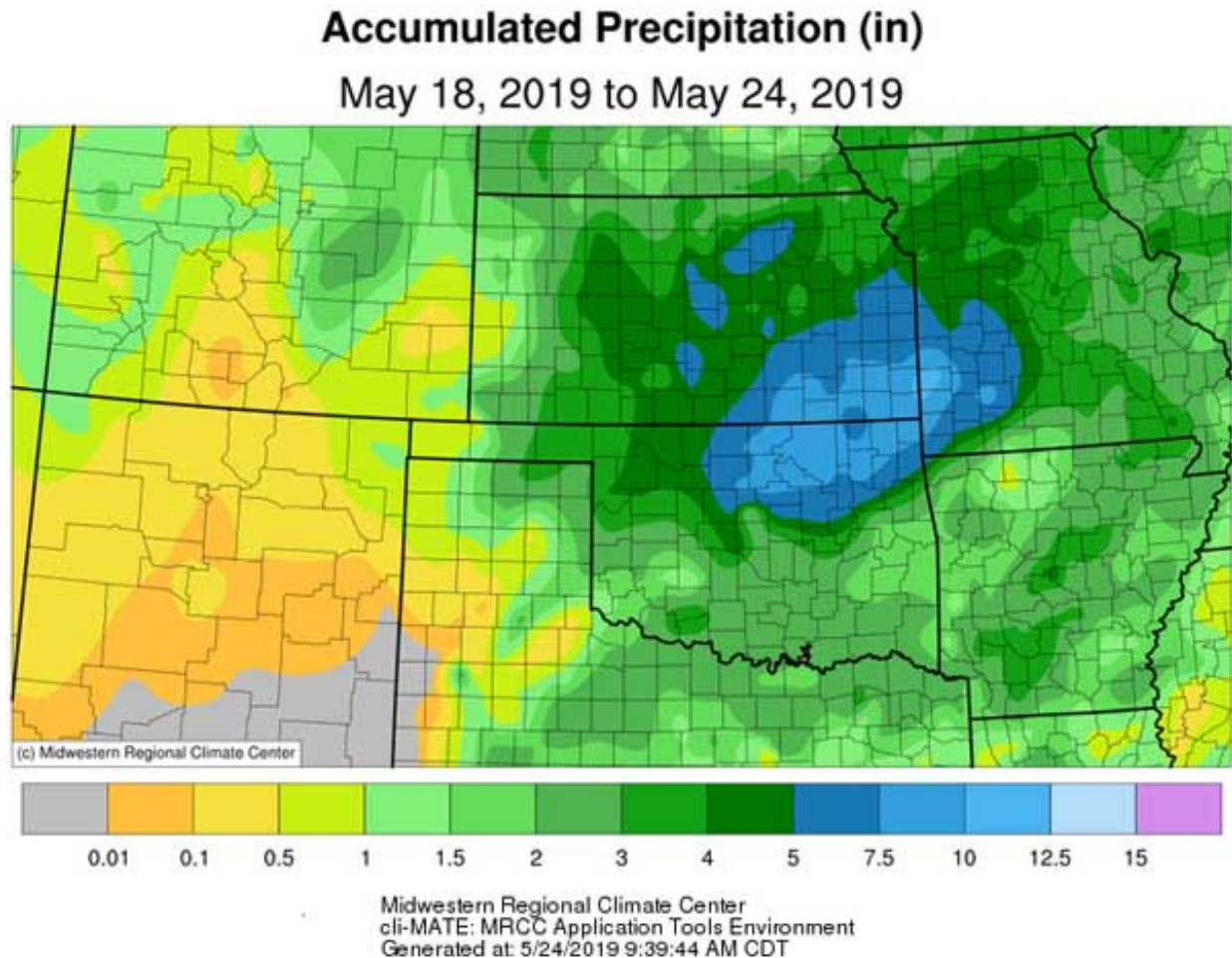


Figure 1. Accumulated precipitation for the week ending May 24, 2019. Map from Midwest Regional Climate Center.



Figure 2. Flooded wheat field in Barton Co, Kansas. Photo taken on May 21, 2019 by Alicia Boor, Cottonwood Extension District Agent.

The recent, historical rainfall events will absolutely negatively impact the wheat crop in central Kansas and Oklahoma. Low-lying field areas, such as terrace channels and old plow furrows, had already caused premature death of the crop due to saturated soil conditions even prior to this most recent rain (Figure 3). This week, other low-lying areas of fields started to turn white due to saturated soil conditions (Figure 4). Damage from flooding will be the most immediately observable impact of the recent rain, but saturated soil conditions will negatively impact yield even in areas that are not flooded.



Figure 3. Low-lying areas were already saturated prior to the recent excessive rains in parts of central Kansas and Oklahoma. Photo taken in Marion County, Kansas, on May 3, 2019, by Romulo Lollato, K-State Wheat Specialist.



Figure 4. Low-lying areas of the fields started to turn white in central Kansas due to saturated soil conditions. Photo taken in south-central Kansas on May 22, 2019 by Erick DeWolf, Extension Wheat Pathologist, Kansas State University.

The amount of damage from flooding depends on the amount of time the crop was under water and the growth stage of the crop. Wheat that was covered by standing water more than 24 hours is the greatest concern. Wheat in the later stages of kernel development, such as into the soft dough stage or later, will likely see reduced test weight and an increase in shriveled or shrunken grains. This was the case for the majority of the Oklahoma wheat crop. For wheat that is further behind, such as fields just starting grain fill or not yet at grain filling, the injury will likely be greater and range from moderate damage to a complete loss. This would be the case for fields in central Kansas, which are about 10 to 15 days behind in development as compared to their normal course.

Even fields that were not flooded did not escape weather-related injury. Top-heavy wheat plants and saturated soil conditions make fields prone to lodging this time of year, and there was a significant amount of lodging associated with the recent storms. Plants that are “kinked” or “broken” have little chance of recovery. Plants that are crooked or leaning might make a partial recovery and attempt to stand back upright. Wheat that was just beginning to head has a greater chance of recovery than wheat that was well into grain fill.

Lodging and excessive moisture can also worsen the incidence and severity of many fungal diseases. In south central Kansas, wheat varieties susceptible to stripe rust were showing 70-80% of flag leaf already compromised by the fungus where it was not sprayed with a foliar fungicide. These damp

conditions, coupled with the cool temperatures, are near perfect for stripe rust development, so there is a chance it could cause serious yield losses for fields that escaped from the flooding.

All of these issues are going to require a field-by-field observation to determine the extent of damage. We know that the crop as a whole is negatively impacted, but the impacts are farm-specific. There is really nothing a producer can do at this point other than sit and wait. We should know a lot more in the next 7 to 10 days. There are not any products or spray applications we recommend at this time to assist in recovery from flooding or lodging. However, producers should continue to monitor fields for pests such as armyworms and make decisions based on pest thresholds and remaining yield potential.

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5. Effect of delayed planting on corn yield

With soils continuing to be very wet in parts of Kansas, more questions have been coming in about the effect of delayed planting on corn yield. A series of studies at K-State looking at delayed corn planting was conducted a few years ago (Figure 1).

Three hybrid maturities were tested: 100-, 108-, and 112-day. Over the two years and three locations (Belleville, Manhattan, and Hutchinson), there were three distinct growing season environments (as related to the environmental stress):

- Low Stress – where rainfall was favorable during the entire growing season
- Early Stress – where cool temperatures and wet conditions limited early corn growth, followed by favorable growing conditions
- High Stress -- where conditions (rainfall and temperatures) were favorable early in the season, but the mid-summer was hot and dry

In the *Low Stress* environments, yields were reduced by less than 20% when planting was as late as mid-June. Yields were not statistically different for any planting date before May 20 (starting from early April). Maximum yield in these non-irrigated environments was 176 bu/acre. The yield responses were similar for hybrids of all maturities.

In the *Early Stress* environments, yields actually increased as planting was delayed until late June. This response was similar for all hybrid maturities. These environments had favorable temperatures and rainfall throughout July and early August. Maximum yield in these environments was 145 bu/acre.

In the *High Stress* environments (hot, dry summer conditions), yields dropped by about 1% per day of planting delay, depending on hybrid maturity. The shorter-season hybrids had the best yields if they were planted before late May (max. yield = 150 bu/acre), but all hybrids had yield reductions of more than 50% when planting was delayed until early to mid-June.

In many ways, the current growing season is shaping up like the “Early Stress” scenario above, with cool conditions early in the season. Will this cool spring be followed by favorable temperatures and rainfall, or by hot and dry conditions during the rest of the growing season?

While long-term weather predictions are less reliable, the National Weather Service Climate Prediction Center (<http://www.cpc.ncep.noaa.gov/>) three-month outlook indicates a 40% likelihood of above-normal precipitation and below-normal temperatures for most of the state.

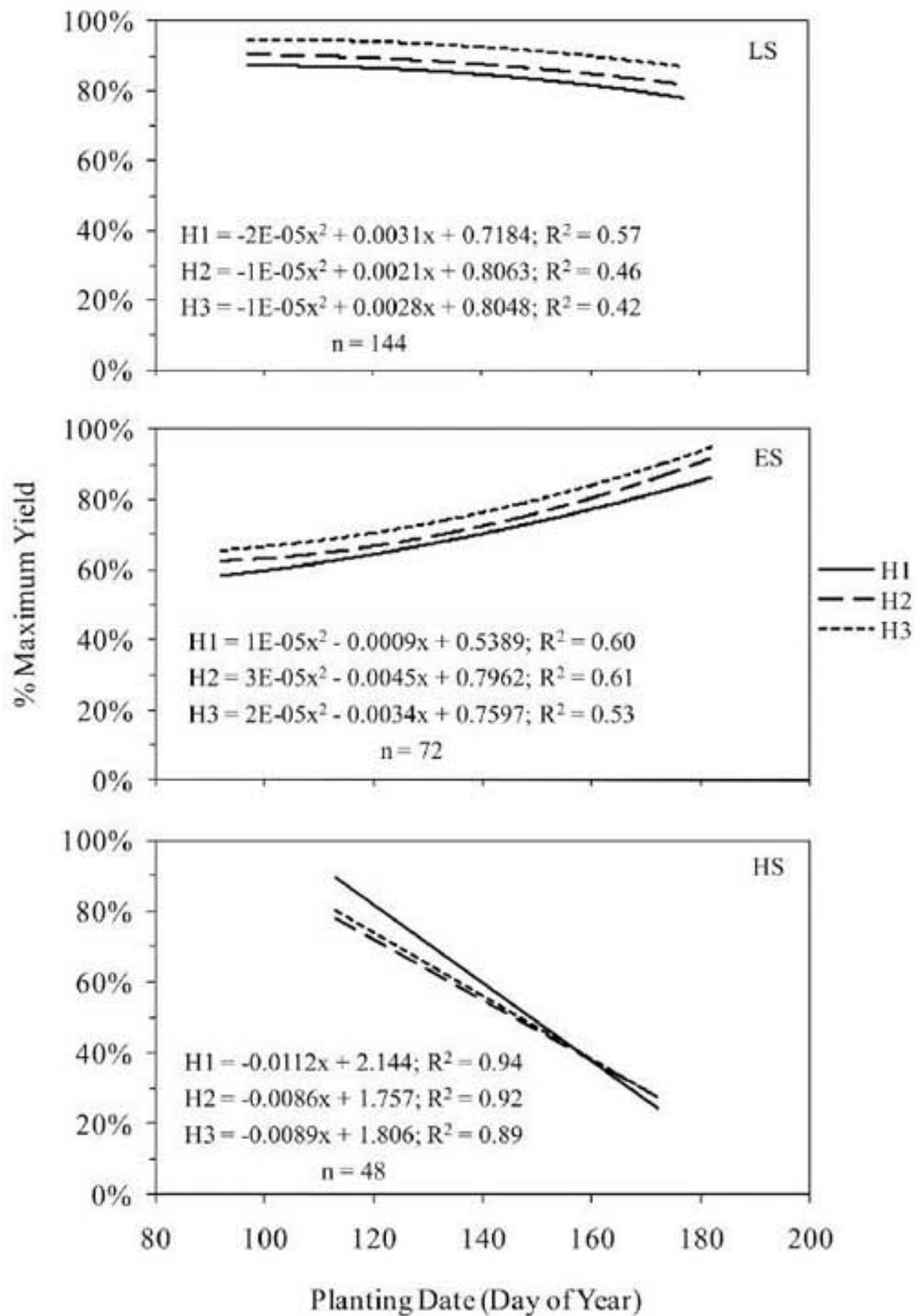


Figure 1. The top chart (LS, or Low Stress) shows how little corn yields changed as planting dates got later when growing conditions were good through the remainder of the season. The middle chart (ES, or Early Stress) shows that corn yields actually increased with later planting dates when conditions were too cool and wet early, but then became more favorable. The lower chart (HS, or High Stress) shows how dramatically corn yields decreased when conditions were favorable early in the season, but the mid-summer was hot and dry. H1 refers to the 100-day hybrid. H2 refers to the 108-day hybrid. H3 refers to the 112-day hybrid.

Using Web-Support Decision Tool: “Useful to Usable”

A web-support decision tool called “Useful to Usable” (<https://hprcc.unl.edu/gdd.php>) can help in making hybrid maturity decisions when planting late. For example, for the Manhattan location, if a 111-comparative relative maturity (CRM) corn hybrid will be planted in May 31, it will take 2,666 growing degree days (GDD) from planting to physiological maturity (black layer). That means it will reach black layer around the last week of September. The earliest first freeze experienced at this location was early October; thus, planting in late-May presents a small risk for early termination of the crop by the first frost (Figure 2).

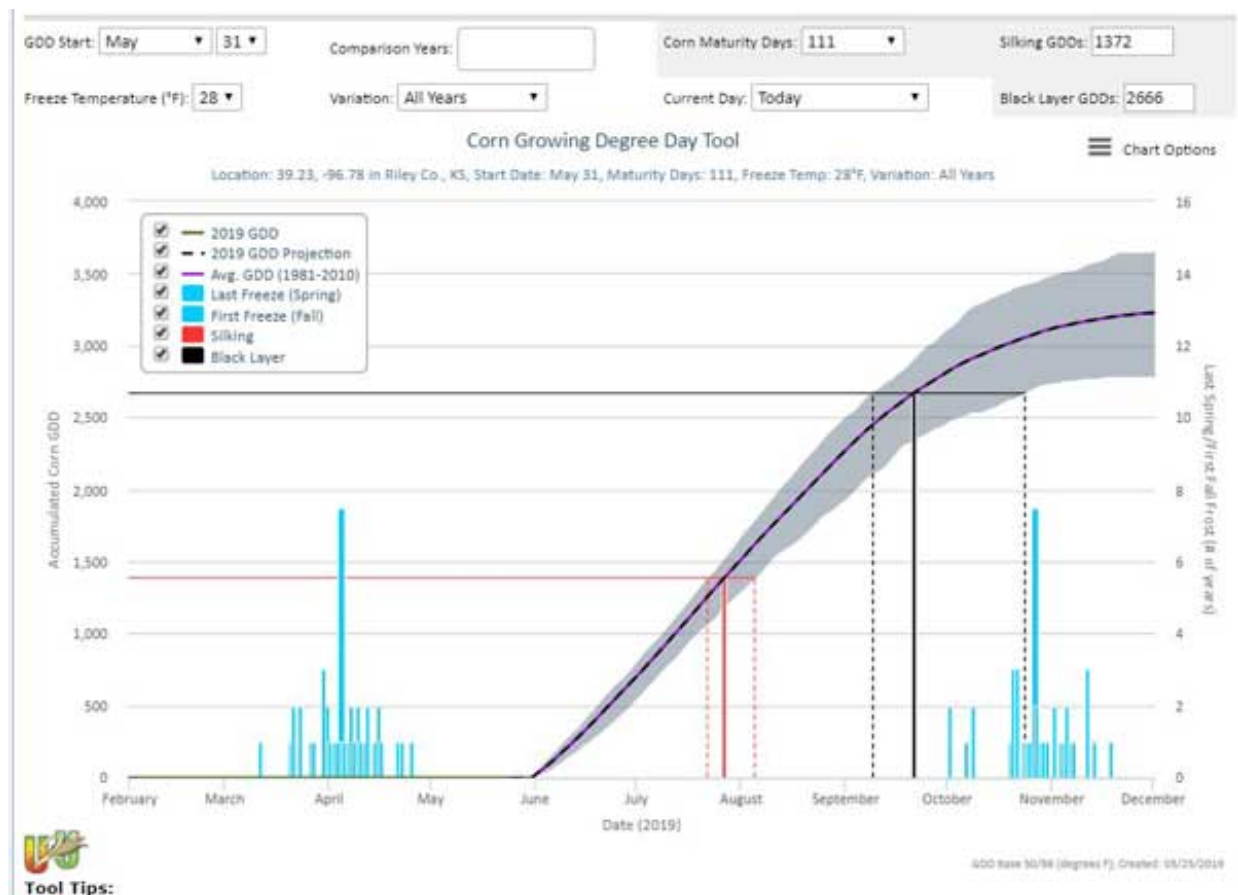


Figure 2. Corn growing degree day tool for a 111-CRM projected to be planted in May 31, 2019. From <https://hprcc.unl.edu/gdd.php> (“Useful to Usable” website).

If the planting date is delayed until June 15, without changing the CRM, the final GDD is the same,

which may not hold true due to less GDD requirement since the hybrid is planted at later calendar date. Black layer will be reached sometime from mid-to-late October. This late planting situation clearly increases the risk of damage from an early fall freeze (Figure 3), which will result in a low test weight and high moisture content in the grain due to a shortening of the grain filling and drying down period.

By keeping the same planting time (June 15), but switching to a shorter CRM corn hybrid (e.g. 105 CRM), corn would reach black layer about the same time as the 111-CRM hybrid planted May 31 (Figure 4). Thus, changing to a shorter CRM would increase the probability of reaching maturity with a small risk of being impacted by an early fall freeze.

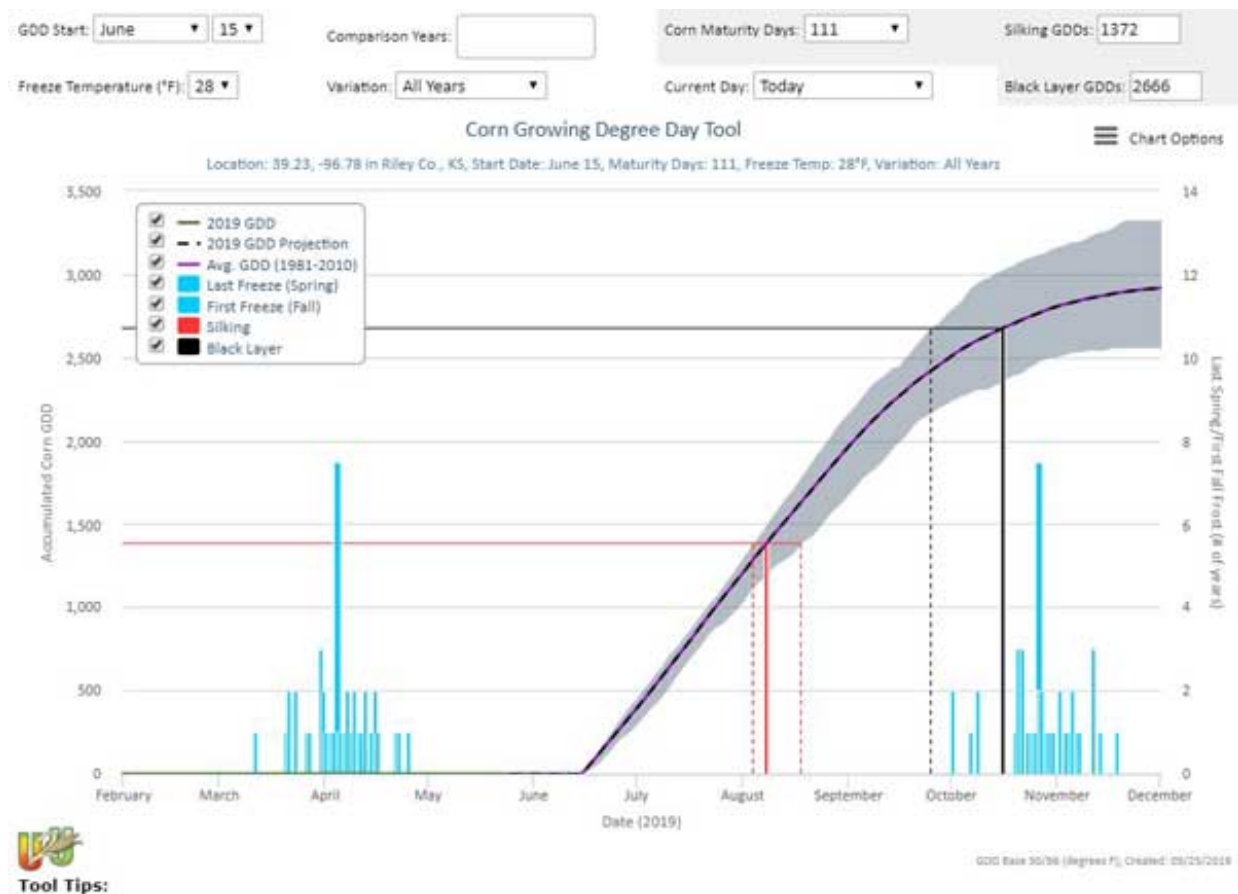


Figure 3. Corn growing degree day tool for a 111-CRM projected to be planted in June 15, 2019. From <https://hprcc.unl.edu/gdd.php> ("Usable to Useful" website).



Figure 4. Corn growing degree day tool for a 105-CRM projected to be planted in June 15, 2019. From <https://hprcc.unl.edu/gdd.php> ("Usable to Useful" website).

As you move south and east from Manhattan, the risk of early termination from a fall freeze will decrease, but the risk will increase as you move north and west.

For a new GDD tool with more focus on Kansas information, the Kansas Mesonet has a Degree Days page – <http://mesonet.k-state.edu/agriculture/degreedays/> – is designed to provide greater flexibility to our users, including options to select the time period and more built-in calculations.

Below are examples of using this tool, looking at May 31 for planting date at a Scandia location. For this scenario, looking to the 2018 growing season, corn will reach maturity close from mid-to late October.

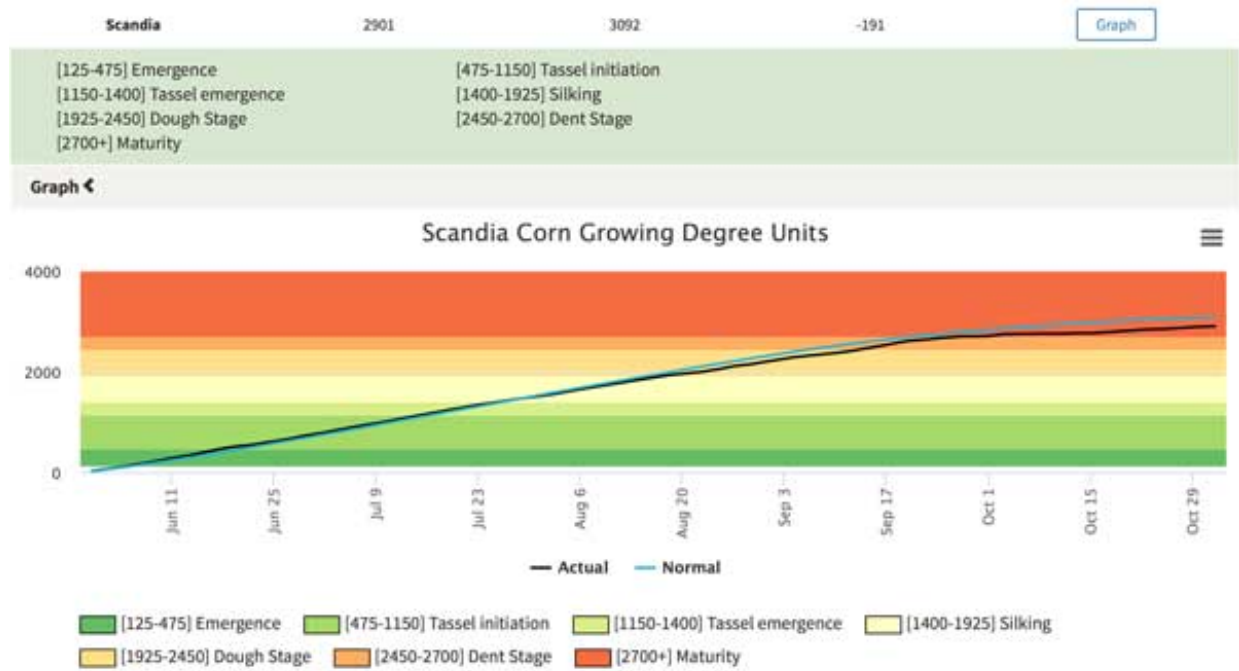


Figure 5. Corn growing degree day tool for a corn hybrid planted in May 31 in Scandia, KS, reaching maturity by early to mid- October (Kansas Mesonet).

So, depending on your location and what you believe will happen during the rest of the growing season, delayed planting may or may not have much of an effect on corn yields.

When making decisions on delayed planting of corn, crop insurance considerations are often an important factor in addition to agronomic considerations. For more information on hybrid selection and crop insurance considerations, see the companion article in this eUpdate issue, "Late planting of corn: Hybrid selection and crop insurance considerations".

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6. Late planting of corn: Hybrid selection and crop insurance considerations

While the precipitation received across Kansas has been wonderful for filling the soil profile and thus has increased yield potentials for some, it has been too much in other areas. Across the entire state it has created significant delays in planting both irrigated and dryland corn. This late planting situation raises several considerations for producers, particularly hybrid selection with respect to maturity and potential crop insurance implications of late planting from a risk management standpoint.

Corn Hybrid Maturity

Many growers are familiar with corn hybrid maturity being expressed as days of “relative maturity (RM)” or “comparative relative maturity (CRM). These systems, in place for many years, have generally been more effective at comparing hybrid maturities within a company as opposed to across companies. Fortunately, in recent years many seed companies have started providing maturity information expressed as growing degree units (GDU’s). Some companies provide both GDU’s to silking and GDU’s to maturity.

What is a GDU?

Growing degree units or growing degree days (GDD) are a weather-based scale to measure the progression of crop phenology in thermally-driven crops such as corn. GDD or GDU’s are calculated as:

$$\text{GDU} = (\text{Daily Maximum Air Temperature} + \text{Daily Minimum Air Temperature})/2 - 50$$

In the case of corn, when the maximum air temperature is greater than 86 degrees F then the maximum air temperature is set to 86 degrees F, as the rate of growth for corn does not increase with increasing temperature above 86 degrees F. Similarly, when the minimum air temperature is less than 50 degrees F, we use 50 as the value.

In general, it takes 90-120 GDU’s for corn to emerge, residue and soil conditions contribute a great deal of variability to this range. A 110-day hybrid typically needs around 1500 GDU’s to reach silking and 2670 GDU’s to reach black layer or physiological maturity.

Probabilities of Corn Reaching Physiological Maturity based on Location, Planting Date, and Hybrid Maturity

Using historical weather data, the probability of reaching physiological maturity before a 28 degrees F freeze can be calculated. The threshold of 28 degrees F was used as long-term weather records only report the minimum, and not the duration of any given temperature. It takes multiple hours of 32 degrees F to kill corn, but only a few minutes of temperatures at 28 degrees F.

GDU’s were totaled for each year from each of multiple planting dates to determine cumulative GDU’s. This calculation was performed across 11 planting dates and 8 maturities for 36 locations in Kansas and 12 locations in bordering states. GDU’s to physiological maturity for a given days of relative maturity were determined by averaging the GDU’s of a given relative maturity across multiple hybrids from multiple companies.

As an example, the probability table for Colby is shown below in Figure 1. This is based on weather records from 1900 through 2016. If we were to plant a 113-day hybrid on May 22, we see that the probability of reaching physiological maturity before a 28-degree F freeze is 52.4%. Switching to a 108-day hybrid would improve that probability to 80%.

Historical Probability of Reaching Black Layer Before a 28° F Freeze - Colby, 1900-2016												
Hybrid		Planting Date										
Relative Maturity	Black Layer GDU	17-Apr	24-Apr	1-May	8-May	15-May	22-May	29-May	5-Jun	12-Jun	19-Jun	26-Jun
118	2815	88.9%	83.8%	81.9%	78.1%	58.1%	43.8%	28.6%	16.2%	10.5%	1.0%	0.0%
113	2768	91.5%	88.6%	85.7%	81.9%	71.4%	52.4%	33.3%	17.1%	11.4%	1.9%	0.0%
110	2670	95.7%	93.3%	91.4%	85.7%	81.0%	73.3%	50.5%	31.4%	17.1%	10.5%	0.0%
108	2604	97.4%	96.2%	94.3%	91.4%	85.7%	80.0%	68.6%	46.7%	21.0%	13.3%	1.0%
105	2520	98.3%	97.1%	96.2%	95.2%	92.4%	86.7%	80.0%	59.0%	40.0%	18.1%	7.6%
103	2463	100.0%	99.0%	97.1%	95.2%	93.3%	90.5%	82.9%	78.1%	50.5%	21.0%	13.3%
96	2357	100.0%	100.0%	100.0%	98.1%	96.2%	94.3%	90.5%	84.8%	72.4%	44.8%	18.1%
91	2250	100.0%	100.0%	100.0%	100.0%	100.0%	97.1%	96.2%	91.4%	85.7%	61.9%	32.4%
Average GDU		3158	3099	3038	2969	2891	2799	2701	2593	2470	2336	2188
Maximum GDU		3849	3778	3689	3579	3460	3325	3236	3102	2944	2817	2650
Minimum GDU		2492	2421	2358	2302	2254	2144	2054	1984	1841	1706	1593

Figure 1. Historical probability of reaching black layer before a 28 degree F freeze for Colby, KS, 1900-2016.

Local data is important in evaluating these probabilities as relatively short distances can result in large changes in probability of success for a given hybrid x planting date combination due to changes in elevation and rate of in-season accumulation of GDU's. For example, again looking at a 113-day hybrid planted on May 22, while the probability at Colby is only 52.4% (red circled value), it is 91.3% at Hill City, 64 miles to the east, and 88.5% at Hoxie, a mere 33 miles to the east (Figure 2).

Historical Probability of Reaching Black Layer Before a 28° F Freeze - Hoxie, 1939-2016												
Hybrid		Planting Date										
Relative Maturity	Black Layer GDU	17-Apr	24-Apr	1-May	8-May	15-May	22-May	29-May	5-Jun	12-Jun	19-Jun	26-Jun
118	2815	97.4%	96.2%	96.2%	93.6%	92.3%	84.6%	67.9%	39.7%	17.9%	5.1%	0.0%
113	2768	98.7%	97.4%	96.2%	96.2%	93.6%	88.5%	75.6%	52.6%	24.4%	7.7%	0.0%
110	2670	98.7%	98.7%	98.7%	97.4%	94.9%	93.6%	87.2%	73.1%	46.2%	16.7%	5.1%
108	2604	98.7%	98.7%	98.7%	98.7%	97.4%	93.6%	92.3%	82.1%	59.0%	26.9%	7.7%
105	2520	98.7%	98.7%	98.7%	98.7%	98.7%	96.2%	94.9%	89.7%	74.4%	43.6%	16.7%
103	2463	100.0%	100.0%	100.0%	100.0%	98.7%	98.7%	96.2%	91.0%	82.1%	59.0%	23.1%
96	2357	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	98.7%	96.2%	89.7%	79.5%	44.9%
91	2250	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	96.2%	89.7%	69.2%
Average GDU		3403	3336	3267	3188	3099	2999	2891	2772	2640	2495	2339
Maximum GDU		3993	3941	3830	3701	3611	3480	3368	3222	3060	2918	2745
Minimum GDU		2520	2520	2488	2469	2423	2367	2330	2256	2166	2023	1881

Figure 2. Historically probability of reaching black layer before a 28 degree F freeze for Hoxie, KS, 1939-2016.

It is important to note that these tables likely represent the “worst-case” scenario for probabilities of success. Data from the eastern Corn Belt and some preliminary data in eastern Kansas suggest that when a hybrid is planted later than its optimal planting date it takes fewer GDU's to reach physiological maturity. Their data suggest that GDU requirements for maturity are reduced by 6.8 GDU's for every day that planting occurs after May 1. Unfortunately, I have not been able to find data from the Great Plains to either confirm that rate or suggest another rate.

It's reasonable to believe that corn hybrids here will also reduce their GDU requirement with later planting. To get a full view of possibilities I would recommend you look at the probabilities for the maturity of the hybrid you are considering and then also the probabilities for a hybrid that is 3-6 day shorter. This will likely give you a realistic range of potential outcomes. For example, if you are considering the probabilities for a 110 day / 2670 GDU hybrid, you should consider the range of likely scenarios to be between the values listed for that hybrid and those listed for 108 or 105-day hybrid. So for a 110 day/2670 GUD hybrid planted May 29 at Hoxie, the range of probabilities would be 87.2 to 94.9% (green circled probabilities in Figure 2).

Probability charts for additional locations can be found at www.northwest.ksu.edu/agronomy

Locations included in the analysis with tables that can be found at the link include: Alton, Atwood, Belleville, Beloit, Big Bow, Bison, Brewster, Burr Oak, Cimarron, Colby, Concordia, Ellsworth, Garden City, Goodland, Hays, Hill City, Hoxie, Johnson, Lakin, Leoti, Lincoln, Ness City, Norton, Oberlin, Phillipsburg, Plainville, Quinter, Russel Springs, Scott City, Sharon Springs, Smith Center, St. Francis, Syracuse, Tribune, Ulysses, and WaKeeney in Kansas; Arapahoe, Bonny Reservoir, Burlington, Cheyenne Wells, and Wray in Colorado; and Benkelman, Cambridge, Culbertson, Harlan County Lake, McCook, Trenton, and Red Cloud in Nebraska.

Insurance Implications

The final planting date for corn in the majority of Kansas was May 15 in southeast, May 25, through central, northeast, and east-central, and May 31 for western Kansas (Figure 3). After the final planting date there is a “late planting period” that extends for 20 days after the final plant date.

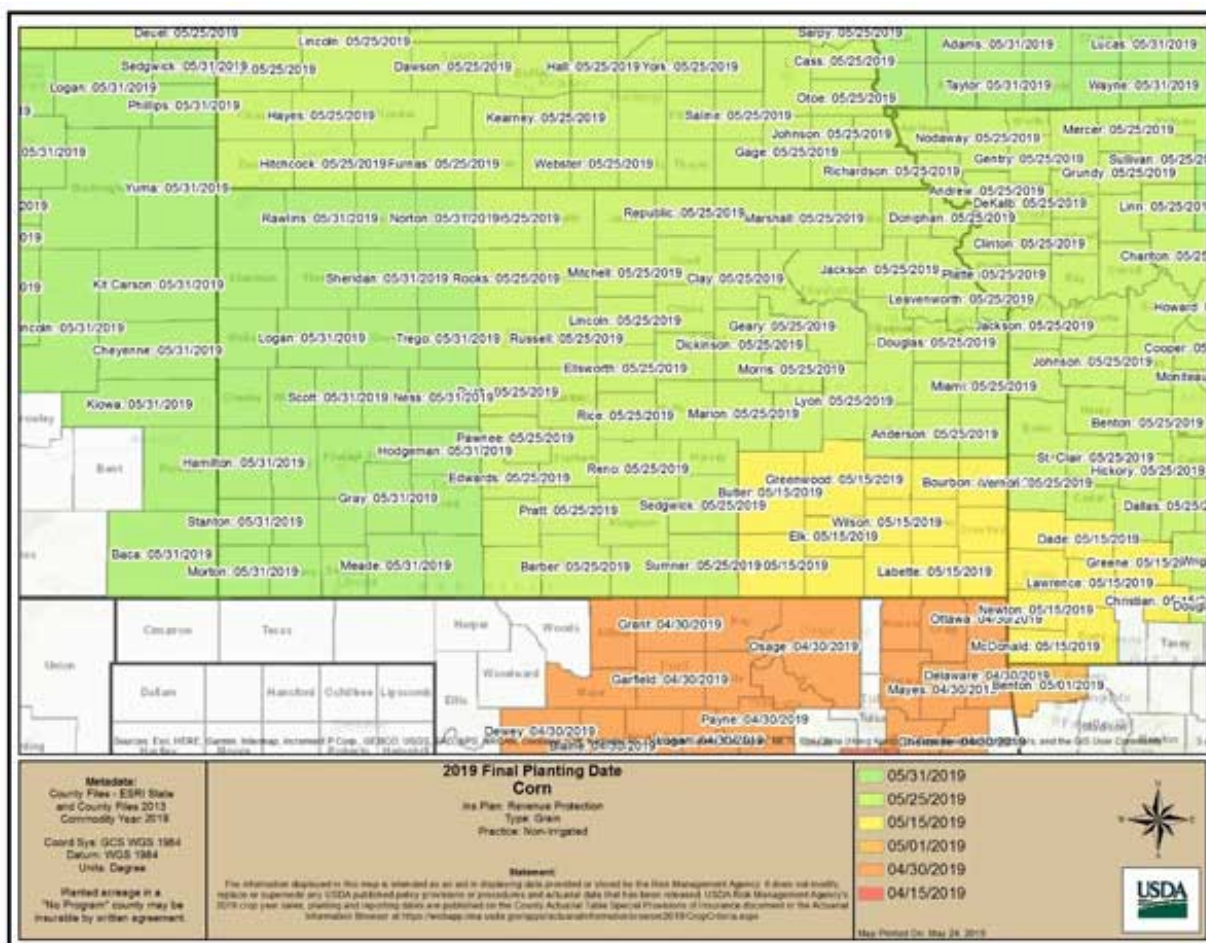


Figure 3. 2019 Final Planting Date for Corn in Kansas.

For corn acres that haven't been planted by the final planting date growers have several options:

1. Plant the insured crop during the late planting period, and insurance coverage will be provided. The late planting period for corn in Kansas and Nebraska is 20 days after the final planting date. The production guarantee is reduced 1% per day for each day that planting is delayed after the final planting date. The late planting period ends June 4 for southeast Kansas, June 14 for northeast and east-central Kansas, and June 20 for western Kansas.
2. Plant the insured crop after the late planting period has ended if you have been prevented from planting during the late planting period, and insurance coverage will be provided. The insurance guarantee will be 55% of the original production guarantee.
3. Acreage that was prevented from being planted due to an insured cause of loss can be left idle and receive a full prevented planting payment, also equal to 55% of the original production guarantee.
4. Plant a cover crop during or after the end of the late planting period and receive a full prevented planting payment as long as it is not hayed or grazed before November 1. The cover crop cannot be harvested for grain or seed at any time.
5. Plant another crop (second crop) after the late planting period (if also prevented from planting through the late planting period), and receive a prevented planting payment equal to 35% of the prevented planting guarantee.

For example, consider a grower with a dryland corn APH yield of 105 bushels per acre who has signed up for Revenue Protection coverage with a 75% coverage level. Using the spring-projected price of \$3.96/bushel, this grower would have a production guarantee of 78.8 bushels per acre and a revenue guarantee per acre of \$311.85 (= 105 bu./acre x 75% x \$3.96/bu.). An acre of corn planted five days after the final planting date, for example, would have its production guarantee reduced 5% (1% for each late day), meaning the revenue guarantee would decline 5% from \$311.85 to \$296.26.

Monte Vandever, K-State Ag Economist, outlines further details and examples on the economic implications of late planting and prevented planting in an article found at:

<http://www.agmanager.info/crop-insurance/risk-management-strategies/prevented-planting-options-2019-kansas-corn-growers>.

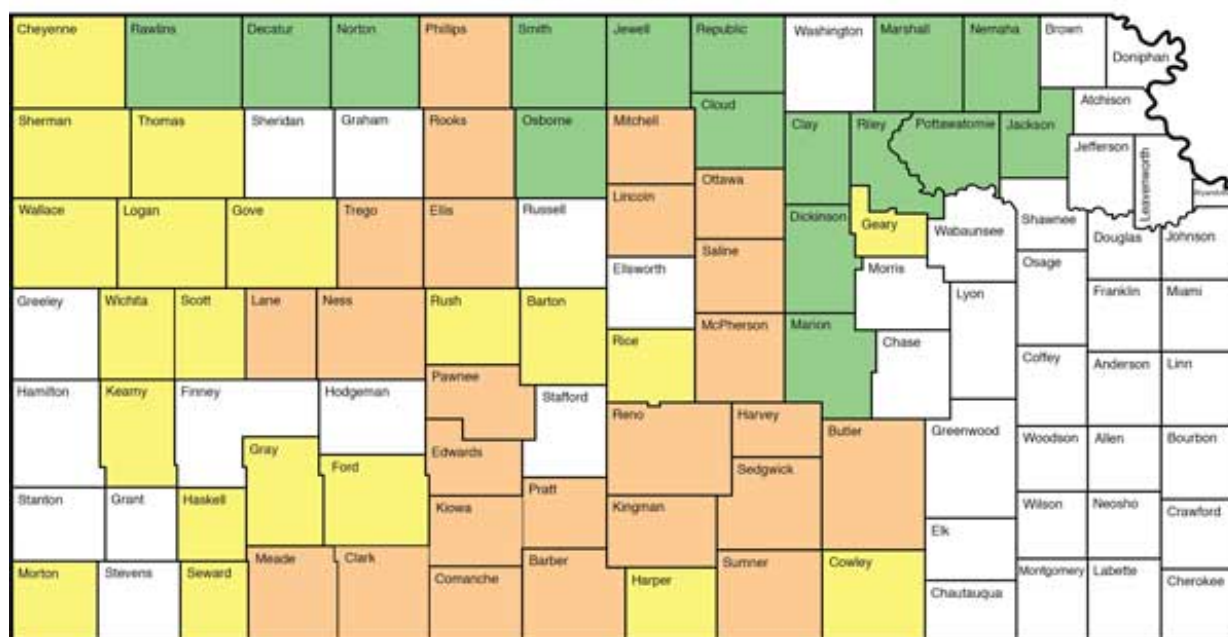
Lucas Haag, Northwest Area Agronomist, Northwest Research-Extension Center – Colby
lhaag@ksu.edu

7. Update on stripe rust and leaf rust in wheat - Late May 2019

Wheat in many areas of central Kansas is rapidly moving from the flowering to early stages of grain fill. In south central Kansas, the crop is at the watery ripe – early milk stages of kernel development. As we move west in the state, the crop is at various stages of heading and flowering, with the far northwest portions of the state still in the boot stage.

The distribution of stripe rust and leaf rust continues to expand with low levels of disease reported this week in north central and northwest Kansas (Figure 1). In the south central region, where the disease has been active for nearly a month, the severity of stripe rust and leaf rust is highly variable. Severe stripe rust was observed on susceptible varieties (Everest, LCS Mint) in Barber, Kingman, and Sedgwick counties. Although still present and active on varieties that were historically resistant (Larry, Zenda, SY Monument, LCS Chrome), stripe rust has not progressed as rapidly and severity remains low.

Distribution of Wheat Stripe Rust May 24, 2019



Disease Risk

- Stripe rust not observed
- Stripe rust observed on lower leaves
- Stripe rust observed on upper leaves

Disease observation map based on reports from: KSU: E. De Wolf, R. Bowden, R. Lollato, L. Haag, S. Duncan, S. Campbell, J. Carr, J. Falk-Jones, A. Esser, D. Hallauer, R. Hong, T. Hsu, C. Long, M. Mackey, S. Marston, C. Miller, T. Maxwell, C. Ott, J. Seiler, C. Seaman, K. Vanskive, S. Wick, J. Wisby; Wheat Breeders: S. Battenfeld; Growers: J. Basil, D. Edgar, V. Ehrke; C. Fabrizius; Consultants: H. Bartel, M. Padgham, M. Pappas

Distribution of Wheat Leaf Rust

May 24, 2019

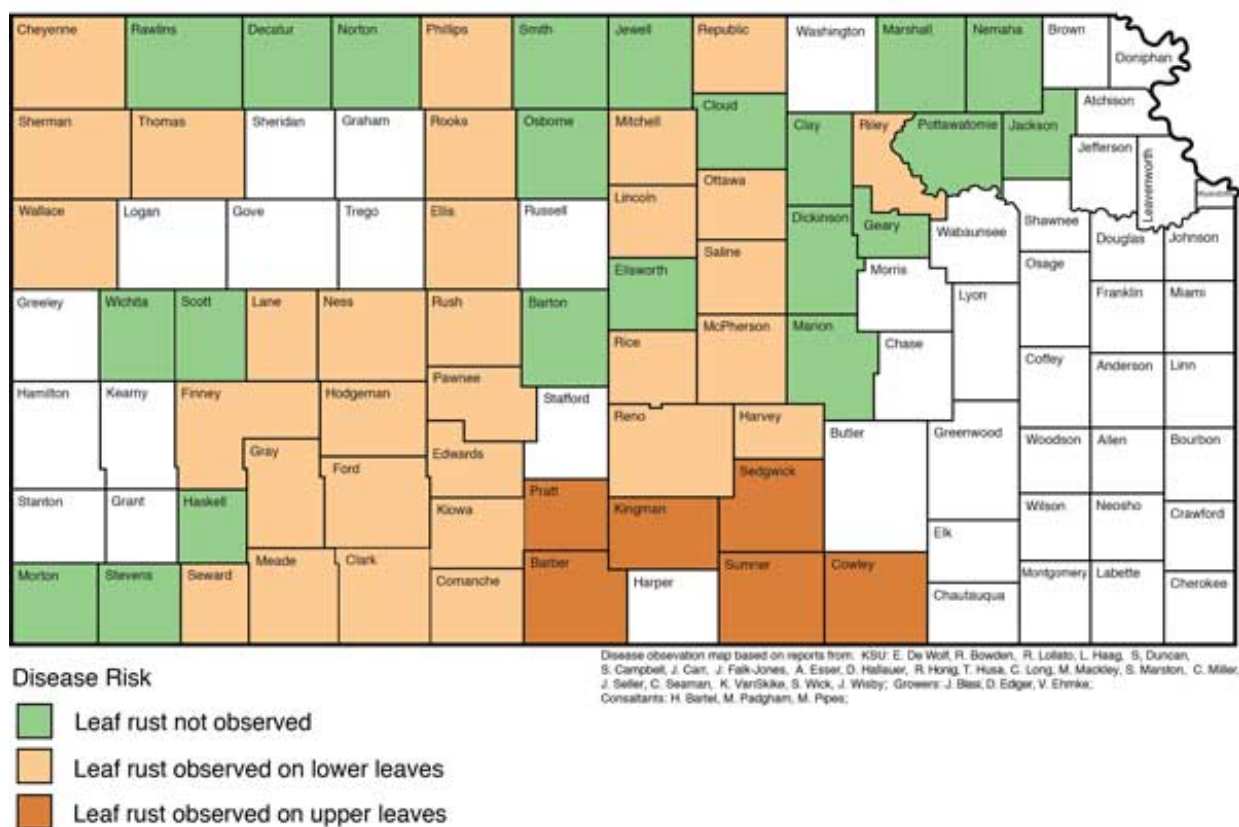


Figure 1. Distribution of wheat stripe rust (upper map) and leaf rust (lower map) in Kansas as of May 24, 2019. Maps created by Erick DeWolf, K-State Research and Extension.

Leaf rust remained at low to moderate levels in most fields and research plots that were visited this week. The most severe leaf rust occurred in Cowley county, where susceptible varieties had flag leaf severities approaching 70% at the watery ripe - early milk stages of development.

Low levels of Fusarium head blight (head scab) were observed in research plots in some areas of the south central region this week. There was also evidence of additional infections that were just beginning to express symptoms. The symptoms of fusarium head blight are most evident 21-28 days after flowering. This means that infections of this disease should become visible in southeast and south central Kansas over the next 7-10 days. Fusarium causes large tan lesions on the wheat heads with entire spikelets or portions of the head affected (Figure 2).



Figure 2. Wheat with symptoms of Fusarium head blight. Photo by Erick DeWolf, Research and Extension.

Erick De Wolf, Extension Plant Pathology
dewolf1@ksu.edu

8. Update on current and ongoing flooding in Kansas

After a brief reprieve last week, heavy rains have returned to Kansas with a vengeance. Extensive flooding has resulted across the state, especially in central and eastern Kansas. These waters have created excessive water ponding, creeks/ivers to run high (Figure 1), and lake levels to rise - rapidly in some cases. In fact, many are currently at moderate-to-major flood stage (Figure 1). These high flows/levels created substantial disruptions to travel and recreation activities with costly damages.

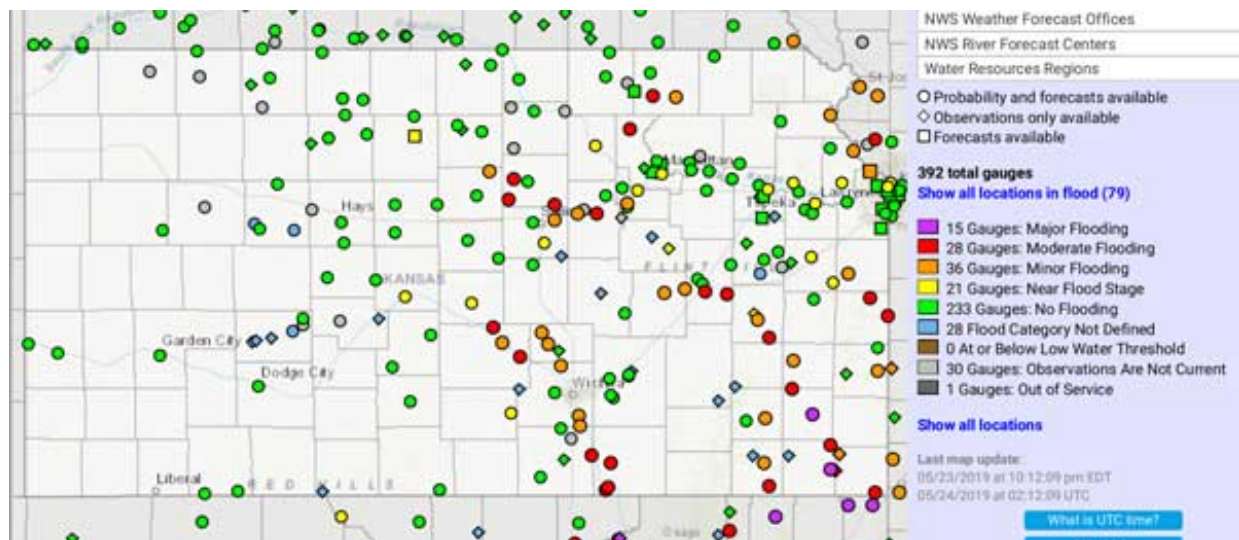


Figure 1. NWS/USGS river/stream data as of Thursday, May 23, 2019
(<https://water.weather.gov/ahps>).

The high stream flows are not good news for many of the lakes in Kansas. These rivers are discharging large amounts of water into these bodies of water and stressing the storage capacities of many reservoirs (Figure 2).

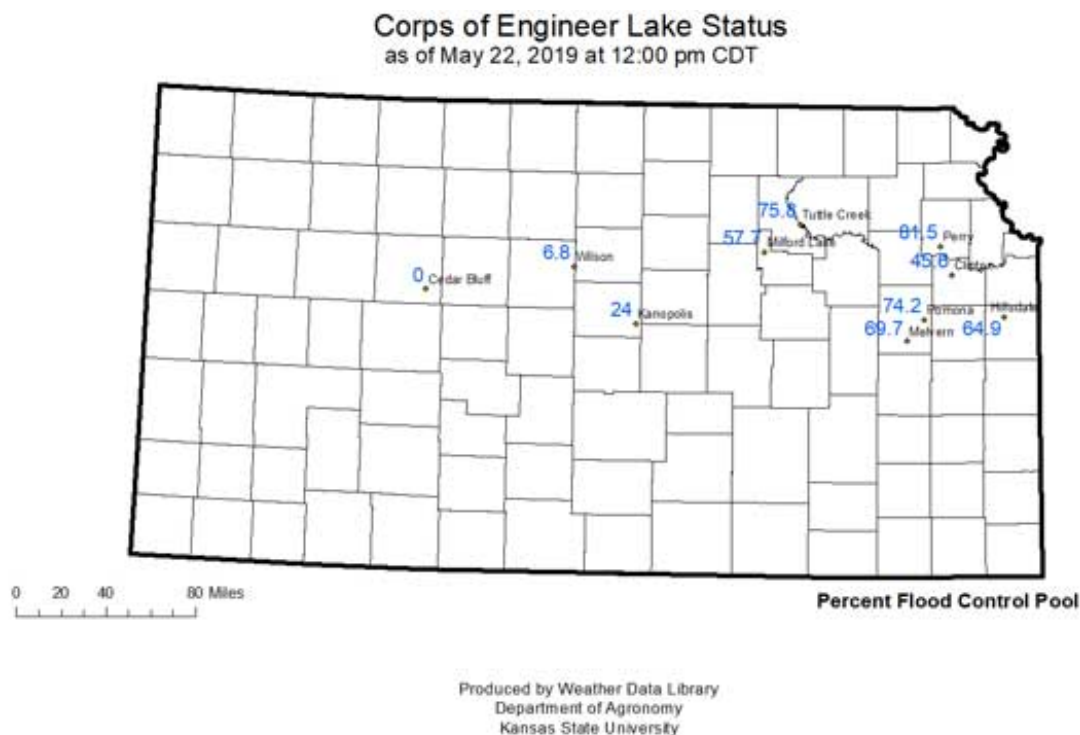


Figure 2. Percent of flood control pool (based on U.S. Army Corps of Engineers data as Wednesday, May 22, 2019).

To make matters worse, rainfall is not able to infiltrate the soil and surface runoff is increasing. Due to above-average rainfall this spring, the surface soil is completely saturated and has remained so with continuing moisture (Figure 3). With May and June typically being the wettest months of the year, this does not bode well for reducing flood issues in the coming weeks.

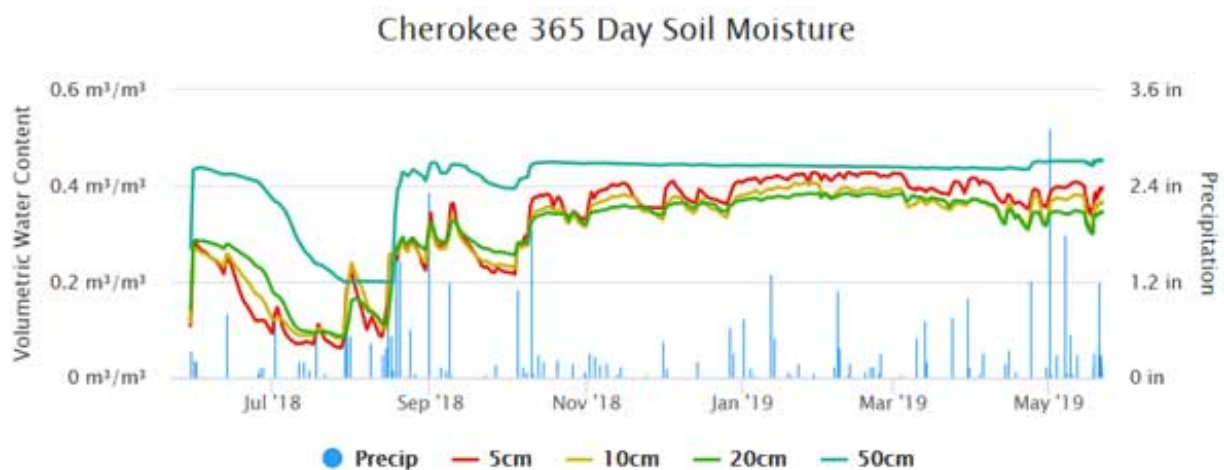


Figure 3. Soil moisture for four depths at the Cherokee Mesonet station. Soils have been completely saturated since October 2018 (<http://mesonet.ksu.edu/agriculture/soilmoist>).

Forecast for June 2019

Unfortunately, rainfall forecasts in the medium range are not promising. The persistent pattern has consisted of a back and forth movement of a stationary front across the Central Plains. This front is separating cold, with below-normal temperatures to the north/west, and above-normal temperatures to the east/south. With the stagnant pattern, this has and will continue to allow periods of heavy rain/thunderstorms to persist along the front. Where the front sets up daily will be the focus for the heaviest flooding rains. Thus, the Climate Prediction Center has much of the state in chances of excessive rain (Figure 4). With nearly the entire region having seen too much moisture, resulting flooding issues are not expected to subside. It is almost a guarantee that water control issues will continue into June - if not worsen.

Below-normal temperatures are also anticipated to continue across the region due to not only the heavy rain, but the unseasonably cold air mass that will periodically surge across the state (Figure 4). This will not help efforts to dry up the regions' soil. Cooler temperatures will result in less evaporation and evapotranspiration resulting in longer residence time of moisture. Cool weather and persistent moisture will also result in crop delays, additional disease control issues, and impeding field work.

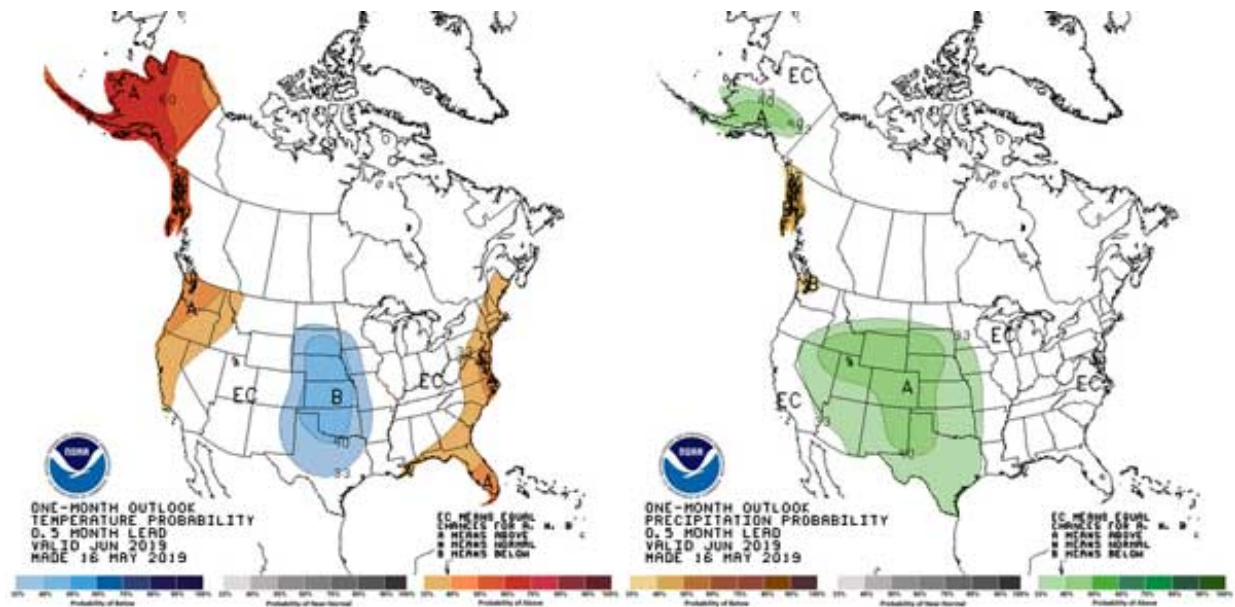


Figure 4. Climate Prediction Center outlooks for June (left map: temperature; right map: precipitation. <http://www.cpc.ncep.noaa.gov>).

Extended outlook

As we move past June, temperatures will seasonably warm, coinciding with yearly average peaks. This usually brings a break in moisture and the corn really begins to grow. However, bearing some unforeseeable dry spell that defies meteorologists/climatologists alike, there will still be very persistent surface moisture across the region. When temperatures warm, evaporation/transpiration rates will increase as well. This will input more moisture than normal into the atmosphere and likely result in continued shower/thunderstorm activity into summer, likely more than normal. This

additional moisture may offset the typical dry trends we see in the summer with a weak El Niño. Therefore, this increases the confidence in the outlook predicting near-to-above normal moisture throughout much of the summer.

Impacts of the outlook

Current stream and tributaries tend to ebb/flow directly with recent rainfall. The lakes/reservoirs/river typically take much longer to fluctuate. With the recent moisture, all of the above are running very, very full. Many reservoirs are not releasing to allow for extra river capacity in preparation of heavy rains. An unfortunately-placed heavy rain event could result in rapid river rise with attendant flooding. Depending on the location, it could also force increased releases from a reservoir, with enhancement of flood issues downstream.

Another consideration will be the duration of flooding that will occur, especially along major rivers like the Neosho (Figure 5). After several rain events, these waterways tend to quickly fall back to normal. However, due to the duration of the heavy rains and the need for many reservoirs to release water in the future to return to normal pool, flooding will persist for quite some time. Even without more moisture, it is likely to take months before flows return to normal. Every rainfall we get in the process will push back that return, possibly substantially.

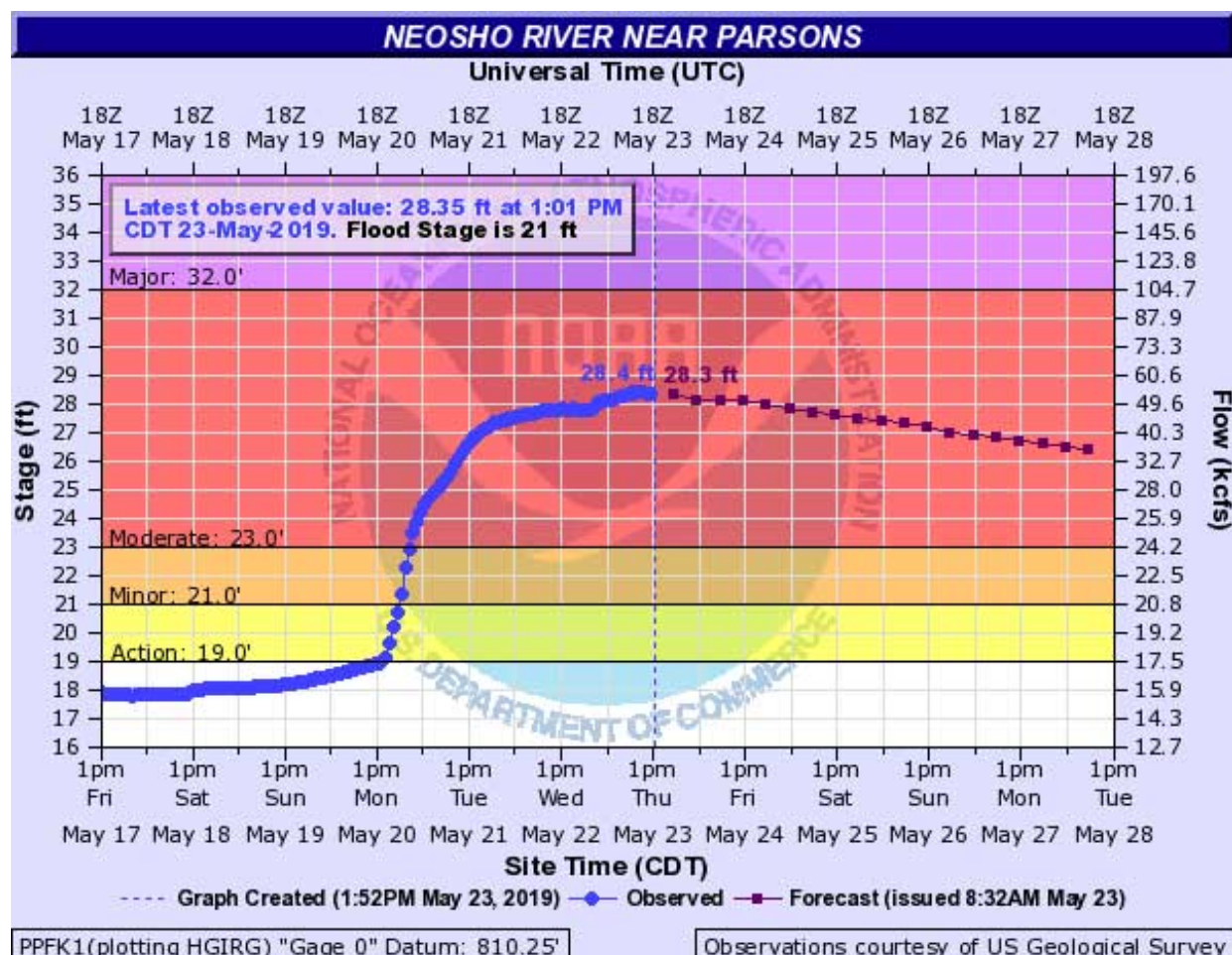


Figure 5. Stage levels of the Neosho River near Parsons (NWS,

https://water.weather.gov/ahps2/hydrograph.php?wfo=ict&gage=ppfk1&prob_type=stage&source=hydrograph).

Response and planning resources

It will be a difficult time for many. There are numerous resources available to help. We have listed a few of them below.

- Road conditions: kandrive.org
- Personal resources: flood.unl.edu
- Disaster resources: fema.gov
- Weather forecasts: weather.gov
- Rainfall data: mesonet.ksu.edu
- River stage information: water.weather.gov/ahps
- Reservoir level information: <http://www.kwo.ks.gov/reservoirs>

Christopher "Chip" Redmond, Kansas Mesonet
Christopherredmond@ksu.edu

Mary Knapp, Weather Data Library
mknapp@ksu.edu

9. K-State wheat plot tours for May 28-31, 2019

The week of May 28-31 features several wheat plot tours in Kansas. Producers wanting to learn about the different varieties can choose to attend one (or several) plot tours in their county or agricultural district.

The plot tours generally include a discussion of wheat conditions across the state, as well as tips on what to look for when selecting wheat varieties. New and upcoming varieties are discussed, as well as older and more established ones, and a discussion of how all these varieties are responding to this growing season's conditions.

For the week of May 28-31, the plot tour locations include:

Tuesday, 5/28/2019, 8:30 am

Location: LaCrosse, Rush Co.

Contact: Chris Long, clong@ksu.edu

Directions: From LaCrosse, go 6 miles west on Hwy 4 to CR 190, 1 1/4 south, just south of 190 and N road, on east side of road.

Tuesday, 5/28/2019, 2:00 pm

Location: Ness City, Ness Co.

Contact: Chris Long, clong@ksu.edu

Directions: From Ness City, go 7 miles south on Hwy 283 to 60 Rd, west 7 miles to L Rd, south 1 1/4 lines on east side of road.

Tuesday, 5/28/2019, 6:00 pm

Location: Dighton, Lane Co.

Contact: Chris Long, clong@ksu.edu

Directions: From Dighton, go west on 96 for about 7 miles, turn south, go 1 1/2 miles, on east side of road.

Wednesday, 5/29/2019, 10:00 am

Location: Smith Center, Smith Co.

Contact: Sandra Wick, swick@ksu.edu

Directions: West of Smith Center on HWY 36 X miles, on the N side/ Lunch on Trinity Ag, LLC - Athol, KS at 12:00 pm

Wednesday, 5/29/2019, 4:30 pm

Location: Beloit, Mitchell Co.

Contact: Sandra Wick, swick@ksu.edu

Directions: South of Beloit on Hwy 14 to X road, then 6 miles W to 230 road, north 3 3/4 miles on the east side. Supper at 5:45 pm at Fletchall house.

Thursday, 5/30/2019, 9:30 am

Location: Liberal, Seward Co.

Contact: Joshua Morris/Kylee Harrison, kharrison@ksu.edu

Kansas State University Department of Agronomy

2004 Throckmorton Plant Sciences Center | Manhattan, KS 66506

www.agronomy.ksu.edu | www.facebook.com/KState.Agron | www.twitter.com/KStateAgron

Directions: Ag Building on the northeast corner of the campus of SCCC (1801 N. Kansas, Liberal)

Thursday, 5/30/2019, 9:00 am

Location: Sebetha, Nemaha Co.

Contact: David Hallauer, dhallaue@ksu.edu

Directions: NW of the intersection of W and 184th Roads, 1.5 miles west of Sabetha.

Thursday, 5/30/2019, 8:30 am

Location: Hoisington, Barton Co.

Contact: Stacy Campbell, scampbel@ksu.edu

Directions: From Hoisington go N. on blacktop to Susank; at Susank go 4 miles E. on the blacktop 190 NE Rd., turn S. onto NE 40th Ave. and go ½ mile, on W. side of the road.

Thursday, 5/30/2019, 6:00 pm

Location: Newton, Harvey Co.

Contact: Ryan Flaming, flaming@ksu.edu

Directions: 6:00 pm meal at Camp Hawk (1801 SW 36th, Newton). 7:00 pm tour. From Camp Hawk, SW 48th and Meridian Road, approx. 1/2 mile west and then south 3/4 mile on the west side of the road.

Thursday, 5/30/2019, 6:30 pm

Location: Randolph, Riley Co.

Contact: Greg McClure, gmcclure@ksu.edu

Directions: Bruce Kaump Farm, 3 miles east of HWY 77 on Rose Hill Road (North of Randolph)

The eUpdate will highlight upcoming tours each week. Stay tuned!

Romulo Lollato, Extension Wheat Specialist

lolato@ksu.edu

Erick DeWolf, Extension Wheat Pathologist

dewolf1@ksu.edu

10. Kansas Composting Operators' School, June 11-12 in Manhattan

The Kansas Composting Operators' School provides hands-on training in municipal, agricultural, and commercial large-scale composting for operators and managers of compost facilities who want to gain knowledge and experience in composting. The school will take place on June 11-12 at Pottorf Hall on the Riley County Fairgrounds, 1710 Avery Ave, Manhattan, 66503.

The program includes classroom and laboratory instruction along with field activities. Field activities will include a demonstration of composting equipment such as a turner, and collection of compost samples for testing for maturity as well as chemical and physical properties.

Instructors for this year will be DeAnn Presley, K-State Agronomy Department and Emery Wiens, Kansas Department of Health and Environment.

Training topics will include:

- Composting science and methods
- Compost biology
- Compost feedstocks
- Food waste composting
- Determining compost mixes
- Permit and legal requirements
- Site design and maintenance
- Compost equipment
- Windrow construction and aeration
- Compost moisture
- Field and laboratory monitoring
- Learn to measure moisture, temperature, pH, soluble salts, maturity, and interpreting lab data
- Compost quality and use
- Methods of composting: static vs. active

Registration is due by **June 3** and class size is limited to 20 people. The registration fee (\$195) will include lunches, breaks, and training materials. Participants are responsible for travel and lodging. Payment (payable to KSU Agronomy) must accompany registration. Mail payment and the registration portion on the flyer included below to: Extension Agronomy, 2014 Throckmorton Plant Sciences Center, Kansas State University, Manhattan, KS 66506. Online registration is available for credit card payment (additional fees apply): <http://www.agronomy.k-state.edu/extension/soil-management/>.

DeAnn Presley, Soil Management Specialist
deann@ksu.edu

Kansas Composting Operators' School



June 11-12, 2019

Pottorf Hall, Riley County Fairgrounds
1710 Avery Ave, Manhattan, KS 66503



The Kansas Composting Operators' School provides hands-on training in municipal, agricultural, and commercial large-scale composting for operators and managers of compost facilities who want to gain knowledge and experience in composting.

The program includes classroom and laboratory instruction along with field activities. Field activities will include a demonstration of composting equipment such as a turner, and collection of compost samples for testing for maturity as well as chemical and physical properties.

Training Topics

- ✓ Composting science and methods
- ✓ Compost biology
- ✓ Compost feedstocks
- ✓ Food waste composting
- ✓ Determining compost mixes
- ✓ Permit and legal requirements
- ✓ Site design and maintenance
- ✓ Compost equipment
- ✓ Windrow construction and aeration
- ✓ Compost moisture
- ✓ Field and laboratory monitoring:
- ✓ Learn to measure moisture, temperature, pH, soluble salts, maturity, interpreting laboratory data
- ✓ Compost quality and use
- ✓ Methods of composting: static versus active



Instructors

DeAnn Presley
KSU Agronomy Department
Email: deann@ksu.edu

Emery Wiens
Kansas Department of Health & Environment
Email: emery.wiens@ks.gov

REGISTRATION: Kansas Composting Operators' School

Name _____ Company or Employer _____

Address _____ City _____ State _____ ZIP _____

Phone _____ E-Mail _____

Company/Agency: _____

Please mention any mobility issues or dietary preferences here: _____

Fee: \$195 – Includes lunches, breaks, and training materials. Participants are responsible for travel and lodging. Payment (payable to KSU Agronomy) must accompany registration. Mail to: Extension Agronomy, 2014 Throckmorton Plant Sciences Center, Kansas State University, Manhattan, KS 66506. Online registration available for those who want to pay with a credit card (additional fees apply), <http://www.agronomy.k-state.edu/extension/soil-management/>. Registration due by June 3, 2019. Class size is limited to 20 people.