Issue 793

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eUpdate

04/03/2020

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. What are the causes of yellow wheat?

During this time of the year, it is normal to start seeing some wheat fields turn yellow. The pattern may vary from field to field, sometimes as large areas, small patches, or streaks of yellowish wheat in some fields this spring. What are some of the main causes of yellow wheat in the spring?

Nitrogen deficiency. As the crop starts to grow in the spring, its nitrogen (N) demand increases and it is common to see an N deficiency, especially while the temperatures are lower and not much N is mineralized from the soil organic matter. Nitrogen deficiency causes an overall yellowing of the plant, with the lower leaves yellowing and dying from the leaf tips inward (Figure 1). Nitrogen deficiency also results in reduced tillering, top growth, and root growth. The primary causes of N deficiency are insufficient fertilizer rates, application problems, applying the nitrogen too late, leaching from heavy rains, denitrification from saturated soils, and the presence of heavy amounts of crop residue, which immobilize nitrogen. This year, the excessive soil moisture in parts of the state might have increased leaching in sandier soils and denitrification under water-logged soil conditions.

Figure 1. Nitrogen deficiency on wheat. The lower leaves are the first to become chlorotic (yellow). Photo by Dorivar Ruiz Diaz, K-State Research and Extension.

Sulfur deficiency. Similar to nitrogen, the crop's sulfur requirement increases in the spring as it takes off on reproductive growth. Due to a decrease in sulfur deposition in the rainfall, there has been an increasing number of fields with sulfur deficiency symptoms in Kansas in recent years. Deficiencies can be more common in areas where organic matter levels are low -- especially on sandier soils or eroded areas of a field. It can also occur where soils are cold in the spring due to a reduced rate of release of sulfur from organic matter. The symptoms of sulfur deficiency are very similar to nitrogen

deficiency. However, sulfur deficiency differs from N deficiency in that the whole plant is pale, with a greater degree of chlorosis (yellowing of plant tissue) in the young leaves (Figure 2). The pattern of chlorosis may show gradation in intensity with the younger leaves at the tip yellowing first because sulfur is not easily translocated within the plant. But the entire plant can quickly become totally chlorotic and take on a light yellow color. Symptoms often become more pronounced when plants begin growing rapidly while soil conditions are such that organic matter mineralization and sulfur release rates are low. Symptoms may disappear as the temperature warms up and moisture conditions improve, which increases the rate of mineralization of sulfur from organic matter and the rate of root growth.

Figure 2. Sulfur deficiency in wheat, with symptoms appearing first on the younger leaves. Photo by Romulo Lollato, K-State Research and Extension.

Poor root growth. This may be due to dry soils, later sowing, waterlogging, or elevated crown height caused by shallow planting depth or excessive residue in the root zone (Figure 3). If the plants have a poor root system, then the root systems are not extensive enough to access enough nutrients causing the plant to turn yellow.

Figure 3. Left panel shows the lack of development of the crown rooting system of a wheat field due to drought conditions in the topsoil. Photo taken by Romulo Lollato, K-State Research and Extension. Right panel shows a slightly more developed but also extremely shallow rooting system, likely due to a restrictive dry topsoil layer. Photo taken by Tyler Ediger, wheat producer in Meade County, KS.

Cold weather injury at the tillering stage. A sudden drop in temperatures after the wheat has greened up but before it reaches the jointing stage will burn back the top-growth, often giving the field a yellowish cast but not necessarily reducing yield potential (Figure 4). The cold temperatures experienced late March and early April this year might cause these symptoms in the next few weeks. This injury is likely cosmetic, provided the growing point is still healthy. Variety release from winter dormancy can also affect the extent of the symptoms, as early varieties would have been less cold hardy and thus likely sustain more injury.

Figure 4. Yellowing wheat from cold weather injury at the tillering stage. Wheat variety on the left (WB-Grainfield) has a later release from winter dormancy as compared to WB-Cedar (variety depicted in the right). Thus, WB-Cedar sustained more leaf injury. Photo by Romulo Lollato, K-State Research and Extension.

Freeze injury at the jointing stage. Jointing wheat can usually tolerate temperatures in the mid-to-upper 20's with no significant injury. But, if temperatures fall into the low 20's or below for several hours, the lower stems, leaves, or developing head can sustain injury (Figure 5). Temperatures dropped suddenly on April 3; thus, producers whose fields are already jointed should scout their fields to assess the yield potential. If the leaves of tillers are yellowish when they emerge from the whorl, this indicates those tillers have been damaged.

Figure 5. Comparison between a healthy developing wheat head (left hand side, typically light green and firm) versus a developing wheat head that sustained freeze injury (right hand side, whitish/brown and mushy). Photo by Romulo Lollato, K-State Research and Extension.

While the extent of potential freeze damage depends on minimum temperatures achieved, duration of cold temperatures, and stage of wheat development; other factors such as crop residue, position on the landscape, wind speed, snow cover, and soil temperatures also play a role. Figure 6 shows an example of the effect of heavy residue on potential wheat damage. In this photo, parts of the field with a heavier layer of residue show greater cold damage than lighter residue. This can be partially explained because under a thicker layer of residue, the wheat crown tends to form closer to the surface and therefore is more exposed to freezing temperatures.

Figure 6. Effect of soil residue on wheat freeze damage. Wheat is showing more damage from freezing temperatures in thicker residue layers. Photo by Tyler Ediger, wheat producer in Meade County, KS.

Leaf senescence and opportunistic leaf spotting diseases. After the winter, it is normal for some of the leaves in the lower canopy to go through senescence and perish, sometimes translocating nutrients to the new growth and sometimes just due to different natural reasons. This causes a yellowing of the lower wheat canopy. Some opportunistic saprophytic fungi or fungal diseases such as leaf spot (Septoria tritici), may colonize these dying tissues as shown in Figure 7. For the most part in Kansas, these diseases do not cause economic damage as long as they remain on the lower leaves, especially if they occur in tissue that is dying already. They might become a problem and warrant a fungicide application in specific situations, such as a susceptible variety planted in heavy-residue

continue wheat no-till fields (see the leaf blotch, Septoria tritici, in Figure 8).

Figure 7. Septoria tritici (leaf spot) colonizing tissue from the lower wheat canopy that was already senescing. Photo by Romulo Lollato, K-State Research and Extension.

Figure 8. Stagonospora tritici (leaf botch) colonizing live tissue on the upper wheat canopy. Photo by Romulo Lollato, K-State Research and Extension.

Iron chlorosis. Iron chlorosis is not common in wheat in Kansas, but does occur on certain high-pH, calcareous soils in western Kansas. Newly emerging leaves will have green veins, with yellow striping between the veins. Eventually, the entire leaf may turn yellow or white.

Soilborne mosaic or spindle streak mosaic. Soilborne mosaic and spindle streak mosaic are viral diseases that occur primarily in eastern and central Kansas, but are rare in western Kansas. These diseases are most common in years with a wet fall, followed by a cool, wet spring. These diseases are often most severe in low areas of a field where soil conditions favor infection. Symptoms are usually most pronounced in early spring, then fade as temperatures warm. Leaves will have a mosaic of

green spots on yellowish background. Infected plants are often stunted in growth.

Wheat streak mosaic complex. This viral disease is vectored by the wheat curl mite. Yellow areas in field will appear in spring around that jointing stages of growth; usually on field edges adjacent to volunteer wheat. Leaves will have a mosaic of yellow streaks, stripes, or mottling. Plants infected with wheat streak mosaic are often smaller than healthy plants.

Barley yellow dwarf. This viral disease is vectored by bird cherry oat aphids and greenbugs. Small or large patches of yellow plants will occur, typically around boot stage. Leaf tip turns yellow or purple, but midrib remains green. The yellowing caused by barley yellow dwarf are less botchy than the yellowing caused by other viral diseases. Plants infected by barley yellow dwarf are often stunted.

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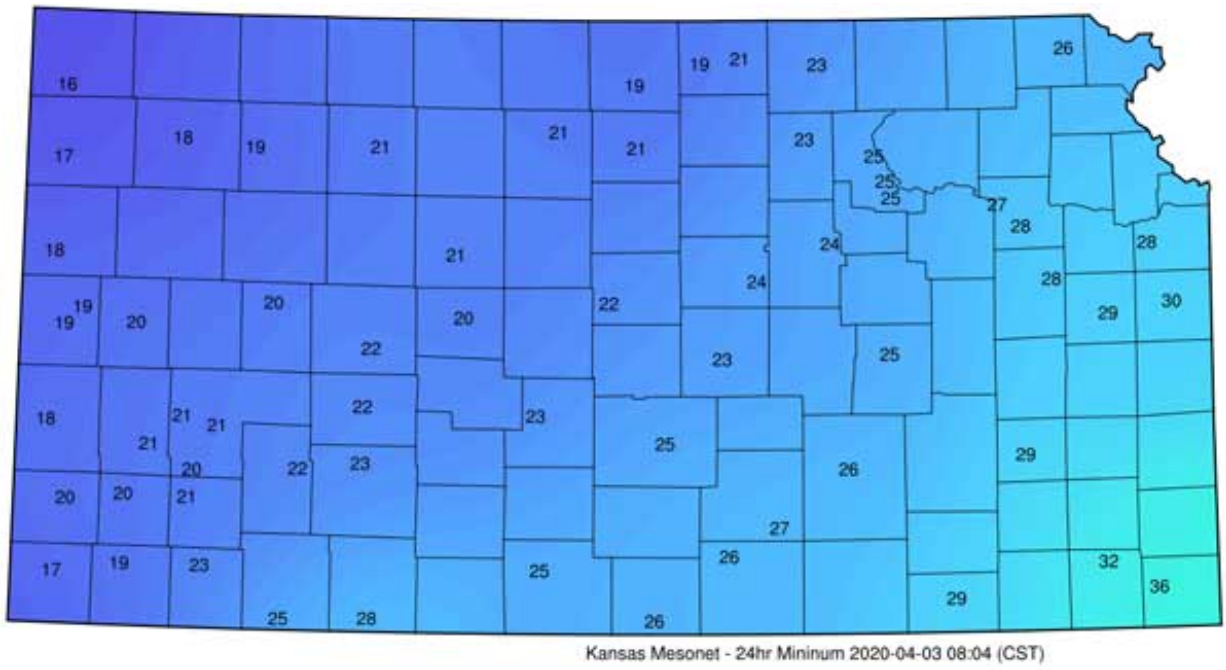
2. UPDATE - Potential for spring freeze injury to wheat on April 3, 2020

Many areas of Kansas experienced freezing temperatures on April 3, 2020. Freeze events are common this time of year in this part of the country. In fact, April 3 is still well before the historical normal frost free date (i.e. date of last spring freeze). History has taught us, however, that freezing temperatures in April can potentially damage the yield potential of the Kansas wheat crop.

The main factors determining the potential for freeze damage are: **1) minimum temperatures achieved and duration of the cold conditions; and 2) the growth stage of the crop.** The overlap or interaction of these factors strongly influences the risk of freeze injury. The greatest risk of damage occurs in regions where the crop is most vulnerable and temperatures were below freezing for a long time.

How cold did it get?

The weather event on April 3 had minimum air temperatures ranging from 16 to 36 ^{o}F (Figure 1). The number of hours that temperatures were below 24 ^{o}F depended on the region. The south central and southeast portions of Kansas did not record temperatures lower than 24 degrees. Central, southwest, and north central Kansas recorded as much as 11 hours below 24 degrees, and northwest Kansas recorded up to 21 hours (Figure 1).



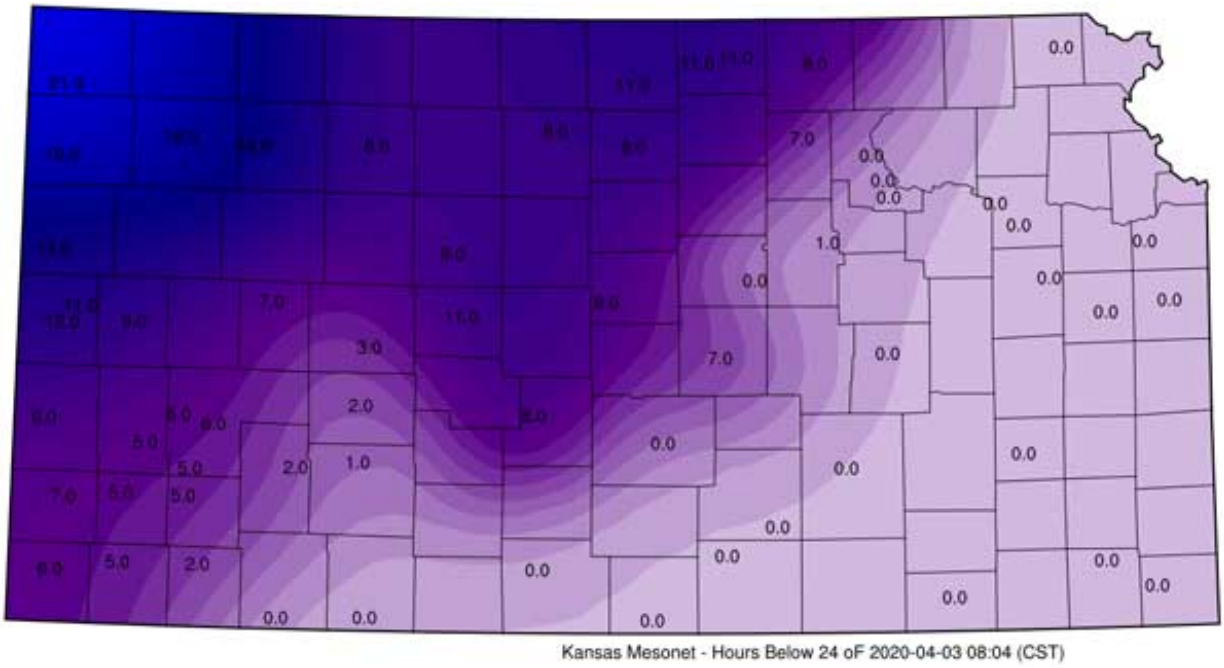
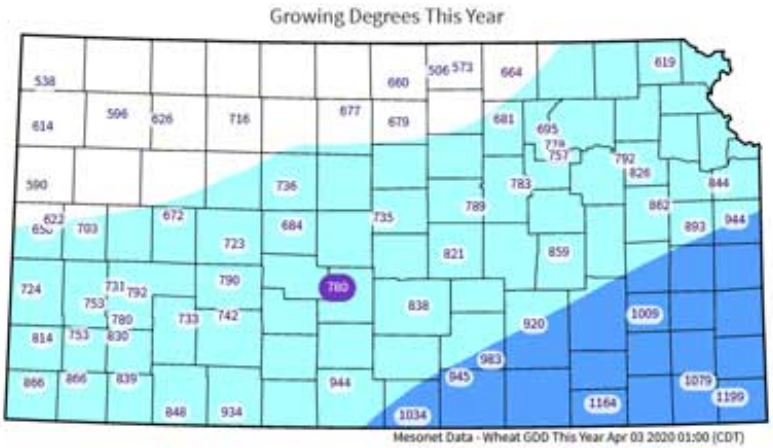


Figure 1. Minimum air temperatures recorded during the recent freeze event across Kansas (upper panel) and number of hours below 24 degrees Fahrenheit (lower panel). Map generated by the Kansas Mesonet.

What is the growth stage of the wheat crop?

The most advanced wheat fields in Kansas are usually located in south central and southeast Kansas. In that region, our wheat development model (based on temperature accumulated since January 1st) indicates that the majority of the fields are about Feekes 6 (first node), but some more advanced early-planted fields might be getting to the second node (Fig. 2). The majority of the crop in the central and southwest portions of the state should be at about Feekes 4-5 (strongly erect leaves through first hollow stem – this would be valid for fields that emerged last fall), and the fields in northwest and north central Kansas are still going through the late stages of tillering.

The more advanced the wheat crop, the more sensitive it is to colder temperatures. Thus, from a development standpoint, the crop in south central KS would naturally be the most exposed to any potential damage from the freeze. While a crop that is tillering can handle temperatures as low as 12 degrees F without necessarily suffering injury, a crop that is jointed can suffer injury if temperatures of about 24 degrees F occur consecutively for up to two hours. This sensitivity increases so that a crop that is at the boot stage can handle temperatures of about 28 degrees for the same two hours.



Color	GDD °F	Estimated Wheat Growth Stage
	< 600	Seedling growth or tillering
	600 to < 800	Tillering or strongly upright tillers
	800 to < 1000	Strongly upright tillers or jointing (first node)
	1000 to < 1200	Jointing (first node) or approaching flag leaf emergence
	1200 to < 1400	Flag leaf emergence or boot
	1400 to < 1600	Boot or heading
	1600 to < 1800	Heading to flowering

Color	GDD °F	Estimated Wheat Growth Stage
	1800 to < 2000	Heading or flowering
	2000 to < 2200	Flowering or watery ripe
	2200 to < 2400	Watery ripe or milk
	2400 to < 2600	Milk or dough
	2600 to < 2800	Dough or kernels maturing
	2800 to < 3000	Kernels maturing or physiologically mature
	>= 3000	Physiologically mature or approaching harvest

Figure 2. Estimated wheat growth stage across Kansas based on accumulated temperatures. Map generated by the Kansas Mesonet.

Will there be freeze damage from weather on April 3?

Based on the three pieces of information above (minimum temperatures achieved, number of hours below critical thresholds, and stage of crop development), it is likely that the majority of the Kansas wheat crop will not be damaged by this cold spell. In general, it appears that the coldest temperatures occurred in regions where the crop was not at growth stages vulnerable to freeze injury. Some exceptions to this could apply to the most advanced fields in each of the different regions. For example, fields that were planted early, to an early-maturing variety, could possibly be more advanced than what our model suggests in Figure 2. Consequently, the more advanced fields in south central Kansas might already be at the second node, or perhaps jointing in central/north central Kansas. These fields would be more exposed to potential freeze damage and some tillers could be lost.

Other important factors determining freeze damage

Density of the stand and condition of the plants. If the stand is thick, that will tend to reduce the extent of freeze damage as the warmth of the soil will radiate up into the canopy. On the other hand, well-fertilized succulent wheat has often sustained more freeze injury than wheat that is not as well fertilized. Thin stands are at higher risk of injury because the air can penetrate the stand more easily. If the plants were wet before the freeze, this can result in a coat of ice on the plants that may protect the growing point to some extent. If temperatures get too low, however, the cold will go through the ice.

Residue. No-till fields often sustain more freeze damage because the residue acts as a blanket and doesn't allow the heat from the soil to radiate up into the plant canopy.

Soil moisture. There is often less freeze injury at a given temperature when soils are wet than when dry. Wetter soils tend to buffer temperature changes better than dry soils. These warm, moist soils also often radiate a little more warmth than dry soils. On the other hand, drought-stressed plants tend to be more hardened against cold injury and their lower leaf water content tends to decrease the severity of the freeze injury.

Wind speed. Windy conditions during the nighttime hours when temperatures reach their lows will reduce the amount of warmth radiating from the soil and increase the chance of injury.

Temperature gradients within the field (position on the landscape). Low spots in the field are almost always the first to have freeze injury. The coldest air tends to settle in the low areas, especially under calm wind conditions.

Wheat variety. Although the sensitivity to freezing temperatures at a given growth stage is very similar across all varieties, varieties can differ in their release from winter dormancy by as much as three weeks. Wheat varieties that break dormancy (late-release varieties) may escape a freeze injury because they are less likely to be at vulnerable growth stages.

Injury symptoms

There are many possible scenarios after a freeze, and producers should not take any immediate decision following a freeze event. Several days of warm temperatures are needed to properly assess freeze damage to the wheat crop. Where wheat was at the jointing stage, producers should watch their fields closely over the next 7 to 10 days from the freeze event for the following:

- **The color of newly emerging leaves**. If they are nice and green, that probably indicates the tiller is alive. If newly emerging leaves are yellow, that probably indicates the tiller is dead. The color of existing leaves is not terribly important, except for the flag leaf, which should not have emerged at this point in time yet. Existing leaves will almost always turn bluish-black after a hard freeze, and give off a silage odor. Those leaves are burned back and dead, but that in itself is not a problem as long as newly emerging leaves are green.
- **The color of the developing head or growing point in wheat that has jointed**. As long as heads are light green, crisp, and turgid, the head in that tiller is fine. If the head is whitish, wilted, and mushy, it has died (Figure 3).
- **Ice in the stems**. If there was ice in the stems below the first node the morning of the freeze, those tillers may be damaged (although not always) and may not produce grain. You may see split stems from ice accumulation.
- **Stem integrity**. If the wheat lodged immediately after the freeze, that indicates stem damage. Later tillers may eventually cover the damaged tillers. Even if there is no immediate lodging, look for lesions or crimps anywhere on the stems. If these symptoms are present, it usually means the wheat will lodge at some point during the season. If the stems look undamaged, that's a good sign.

Figure 3. Following an early freeze, crops at jointing might still develop healthy heads (left panel), but depending on minimum temperatures and duration of the freeze event, the developing head might be killed even if still within the stem killed (right panel). The dead head is whitish and flaccid while the healthy head is light green and turgid. Photos by Romulo Lollato, wheat and forage specialist, K-State Research and Extension.

The best thing producers can do for the first few days is simply walk the fields to observe lodging, crimped stems, and damaged leaves. Producers should not take any immediate actions as a result of the freeze, such as destroying the field for re-cropping. It will take several days of warm weather to accurately evaluate the extent of damage. After several days, producers should split open some stems and check the developing head.

Where stems and/or growing points were killed by the freeze, new tiller growth (coming from the crown area) will occur (Fig. 4). In many cases, new tiller growth can be observed even when the stems do not show any symptoms of freeze damage for some time. In those cases, the first sign that the tillers are dead is the sudden growth of new tillers at the base of the plant.

If secondary tillers may begin growing normally and fill out the stand, the wheat may look ragged because the main tillers are absent. Producers should scout for bird cherry oat aphids and other potential insect or disease problems on these late-developing tillers. Enough tillers may survive to produce good yields if spring growing conditions are favorable. If both the main and secondary tillers are injured, the field may eventually have large areas that have a yellowish cast and reduced yield potential.

Figure 4. Left: A stem that was split open by having ice form within the stem. This stem has died and a new tiller has begun to grow at the base. Right: Some of the tillers on this plant had freeze damage to the lower stems. These stems are dying, but the symptoms may not be immediately evident. The growth of new tillers from the base of the plant is a sure sign that the main tillers are dead or dying. Note the brown lesion on the stem with the two new tillers. Photos by Jim Shroyer, professor emeritus, K-State Research and Extension.

More information on freeze damage to wheat is available in *Spring Freeze Injury to Kansas Wheat*, K-State Research and Extension publication C646, available at:
http://www.ksre.ksu.edu/bookstore/pubs/C646.pdf

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3. Soil temperature and moisture update in Kansas - April 2, 2020

Selection of the optimal planting date is one of the most critical factors in the decision-making process for farmers. In making this decision, producers should consider soil temperatures rather than just calendar dates. After a very mild start to March, air temperatures across Kansas cooled this past week.

For the week of March 27-April 2, average weekly soil temperatures at 2 inches among crop reporting districts ranged from 47 °F in northern locations to 63 °F in southern locations (Figure 1). For example, in the northeast region, soil temperatures ranged from 51 to 55 °F; while in the southwest region, soil temperatures varied from 49 to 63 °F. Soil temperatures were around 47-51 °F for the northwest region (Figure 1).

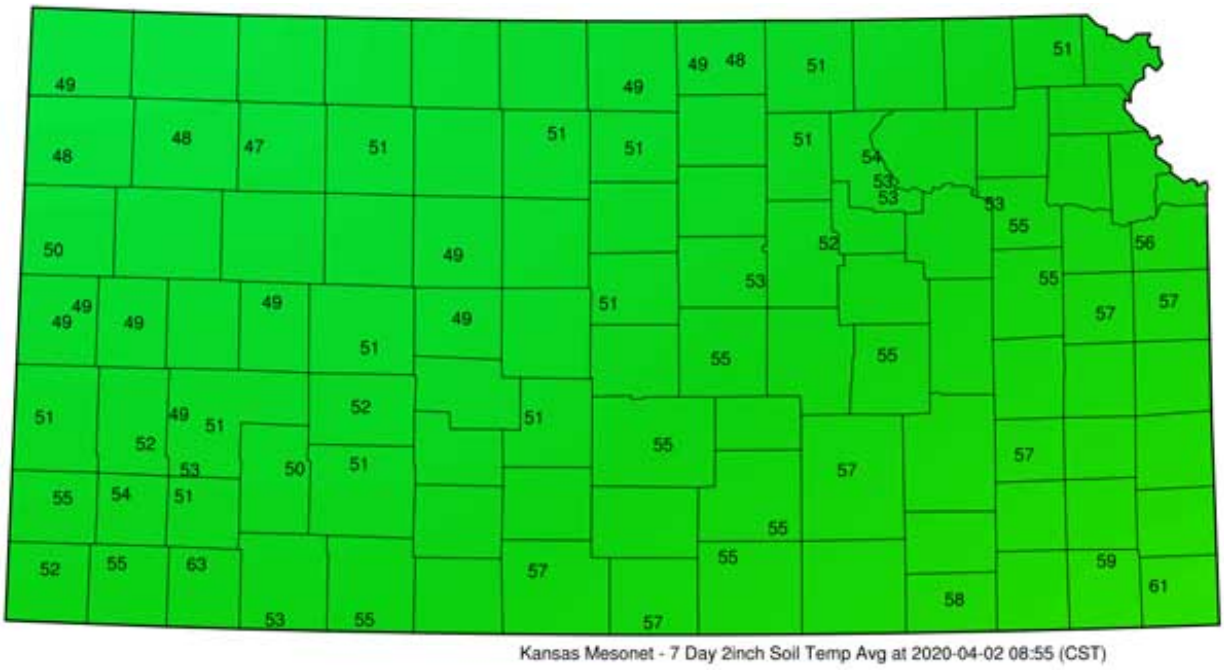

Figure 1. Average soil temperatures at 2-inch soil depth for the week of March 27-April 2, 2020. (http://mesonet.k-state.edu/)

Differences in soil temperatures were related to the large variations in average air temperatures experienced last week, from 42 °F in northern portions of the state to 64 °F for areas in southeast Kansas (Figure 2).

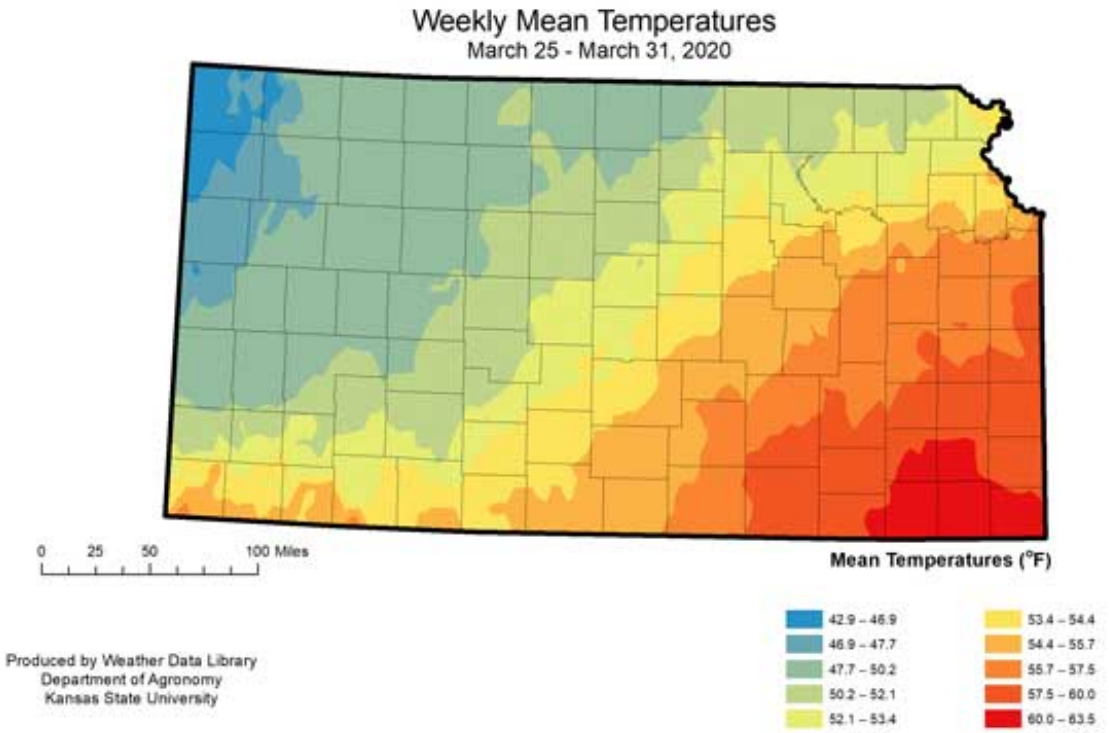

Figure 2. Weekly mean air temperatures for the week of March 25-31, 2020.

Projections for the coming weeks call for warmer-than-normal temperatures to the southeast and cooler-than-normal temperatures to the northwest. Warm, dry conditions in the southwest will speed the process of warming up the soils. Cool air temperatures or wet conditions will slow the warmup. (Figure 3).

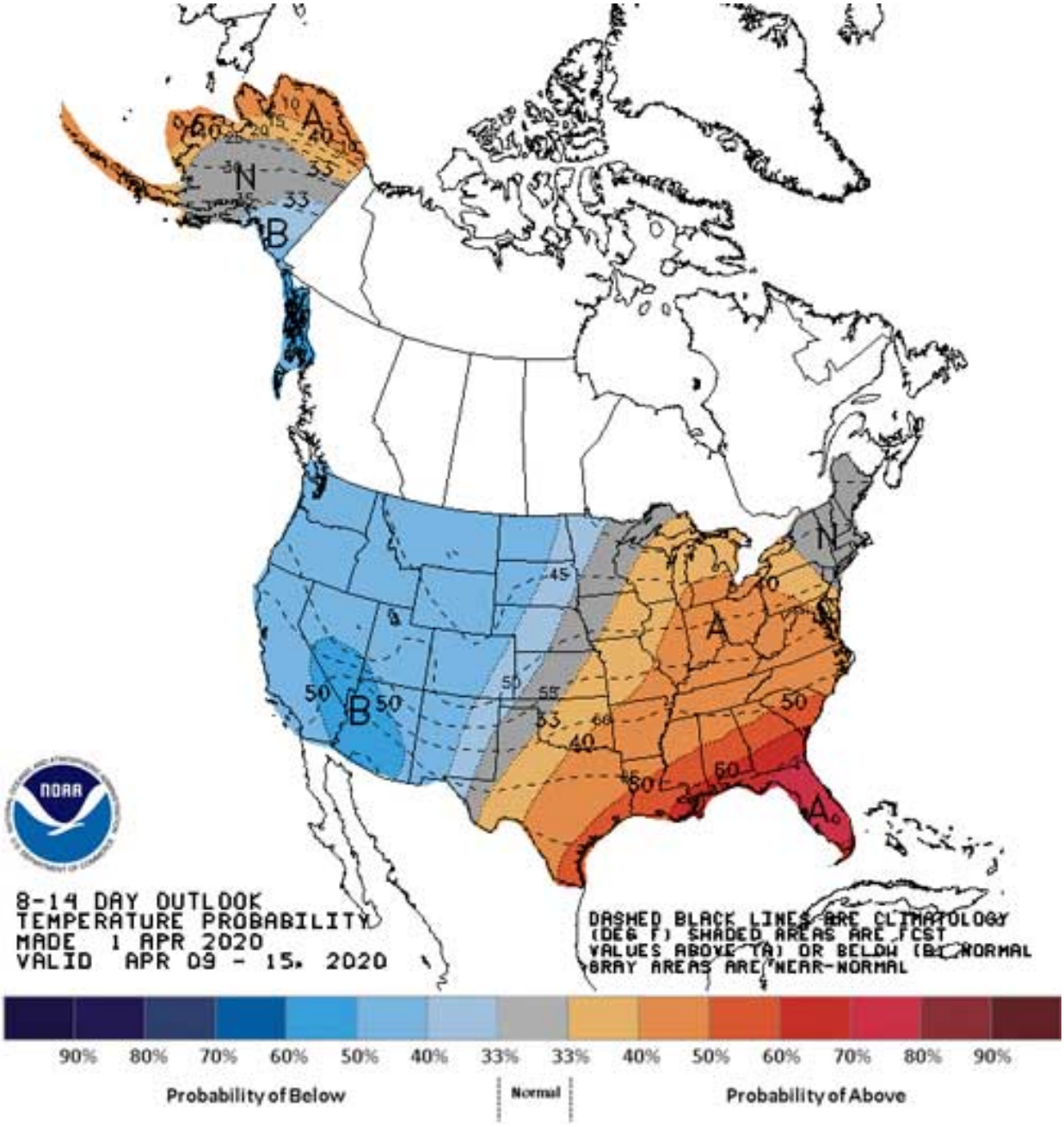

Figure 3. 8 to 14-day outlook temperature probability for April 9 – April 15, 2020. (NOAA)

The actual change in soil temperatures in any given field will be affected by amount of **residue cover**, **soil moisture**, and **landscape position**. Wet soils in a no-till situation will be slower to warm. Dry soils will fluctuate more rapidly, matching air temperatures, particularly if skies are clear. (Figure 4).

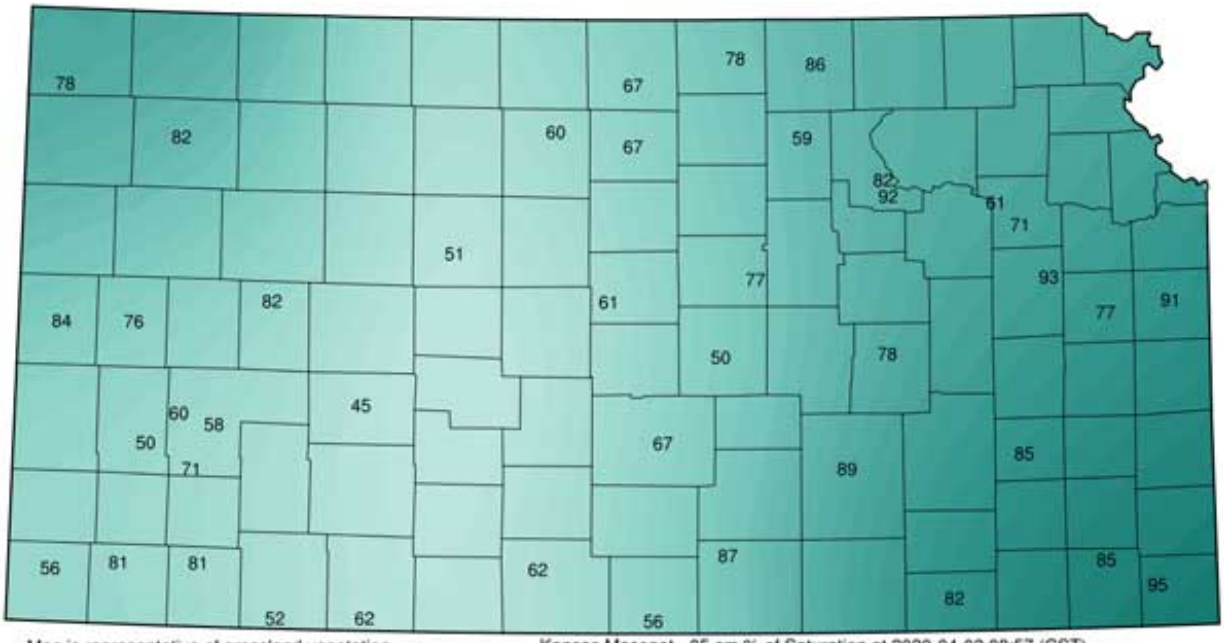

Figure 4. Soil moisture at approximately 2 inches as of April 2, 2020 (Kansas Mesonet).

Current moisture status across Kansas is quite wet, with the largest weekly departure in precipitation in the northwest corner, although the southeast continues to be well above normal (Figure 5). Projections for coming weeks are for precipitation to be above normal for the eastern regions and drier for the western parts of Kansas (Figure 6), slowing down soil warming and plans for an early start to planting.

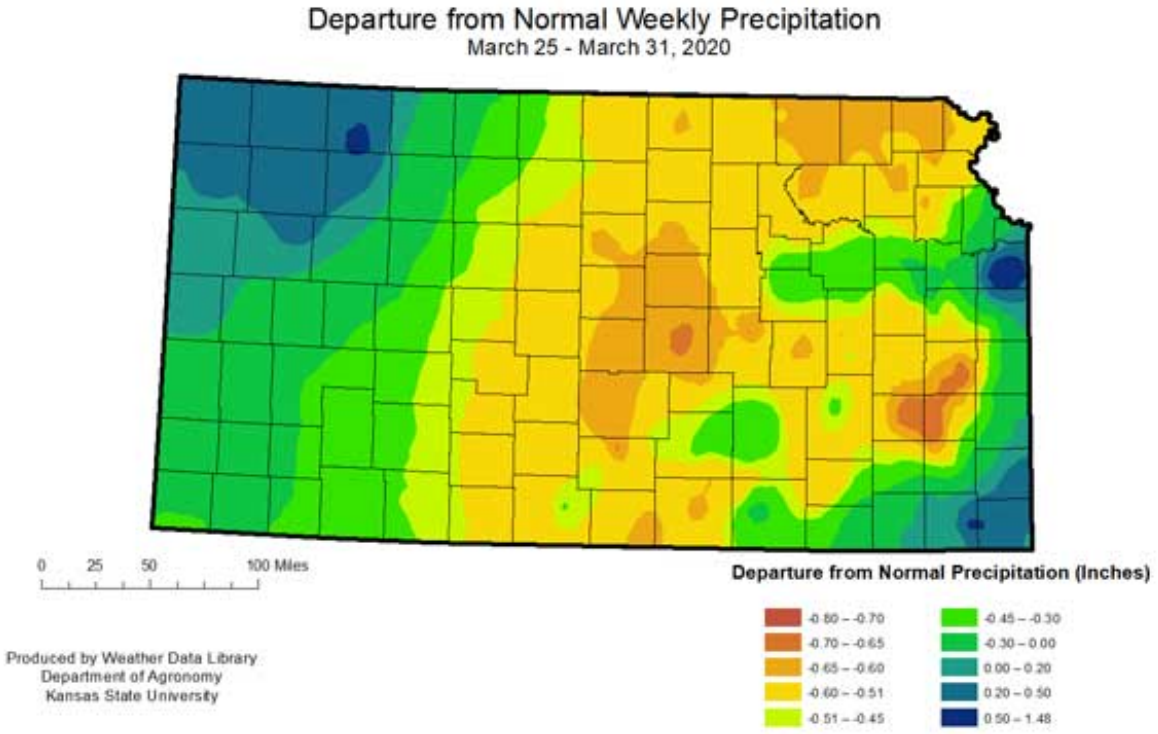

Figure 5. Departure from normal precipitation for the week of March 25 – March 31, 2020.

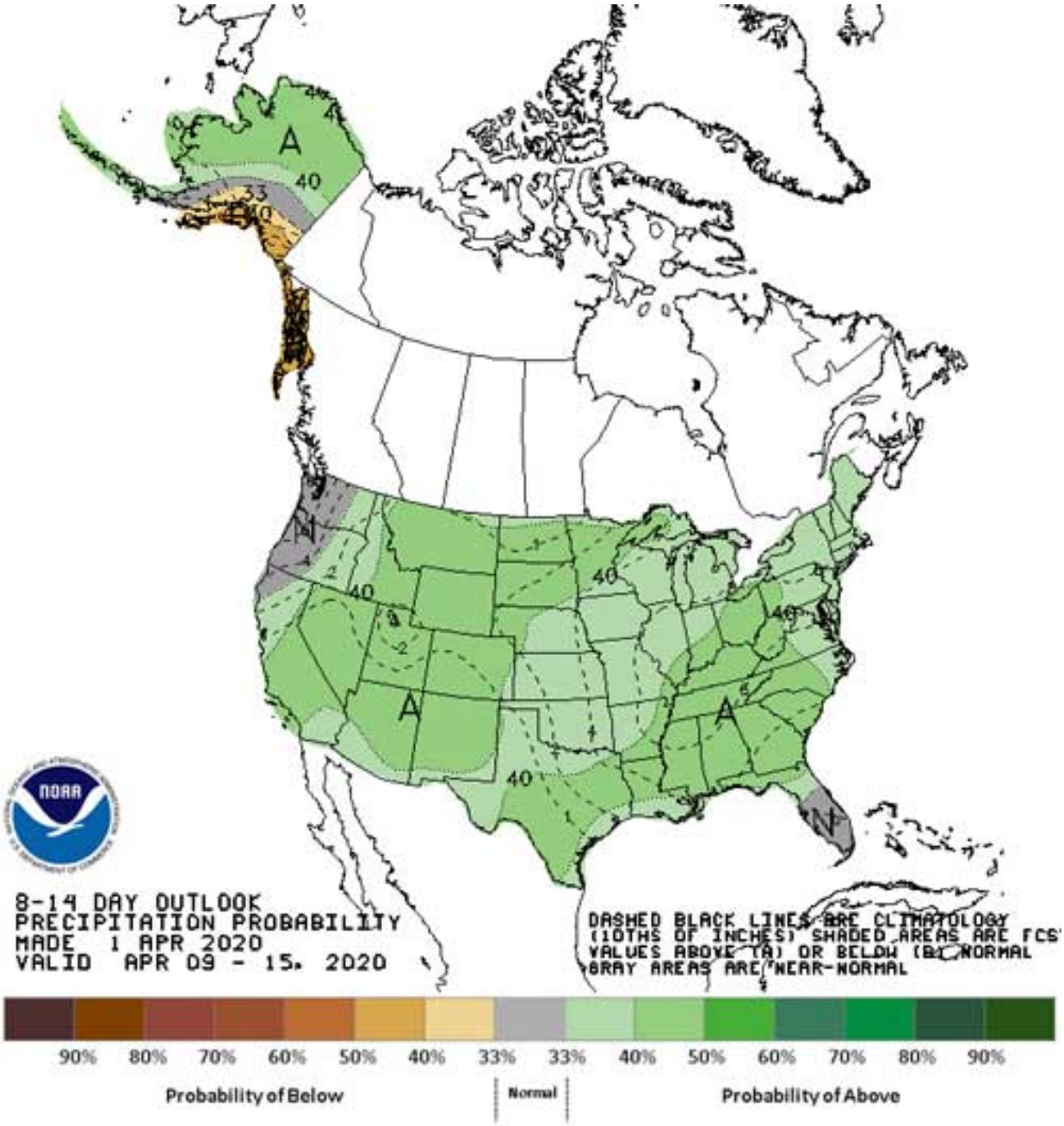

Figure 6. 8 to 14-day outlook precipitation probability for April 9 – April 15, 2020. (NOAA)

Optimal soil temperature for emergence

Every summer row crop has an optimal soil temperature for emergence. A minimum for corn is 50 ^{o}F for germination and early growth. However, uniformity and synchrony in emergence is primarily achieved when soil temperatures are above 55 ^{o}F. Uneven soil temperatures around the seed zone can produce non-uniform crop germination and emergence. Lack of uniformity in emergence can greatly impact corn potential yields. This is particularly true for corn, since it is the earliest summer row crop planted. When soil temperatures remain at or below 50 ^{o}F after planting, the damage to

germinating seed can be particularly severe.

Impact of a hard freeze on corn

Corn is also more likely than other summer crops to be affected by a hard freeze after emergence if it is planted too early. The impact of a hard freeze on emerged corn will vary depending on how low the temperature gets, the intensity and duration of the low temperatures, field variability and residue distribution, tillage systems, soil type and moisture conditions (more severe under dry conditions), and the growth stage of the plant. Injury is most likely on very young seedlings or on plants beyond the V5-6 growth stage, when the growing point is above the soil surface.

The average day for last spring freeze (32 ^{o}F) is quite variable around the state (Figure 7). The largest variability is from southeast to northwest Kansas; with the earliest last spring freeze date for the southeast region (April 5-15) and latest for the northwest area (>May 3). Corn planting dates before April 15 in the southeast region would increase the likelihood of the crop suffering from a late spring freeze. Similar conditions can be projected for northwest Kansas if corn is planted before May 3.

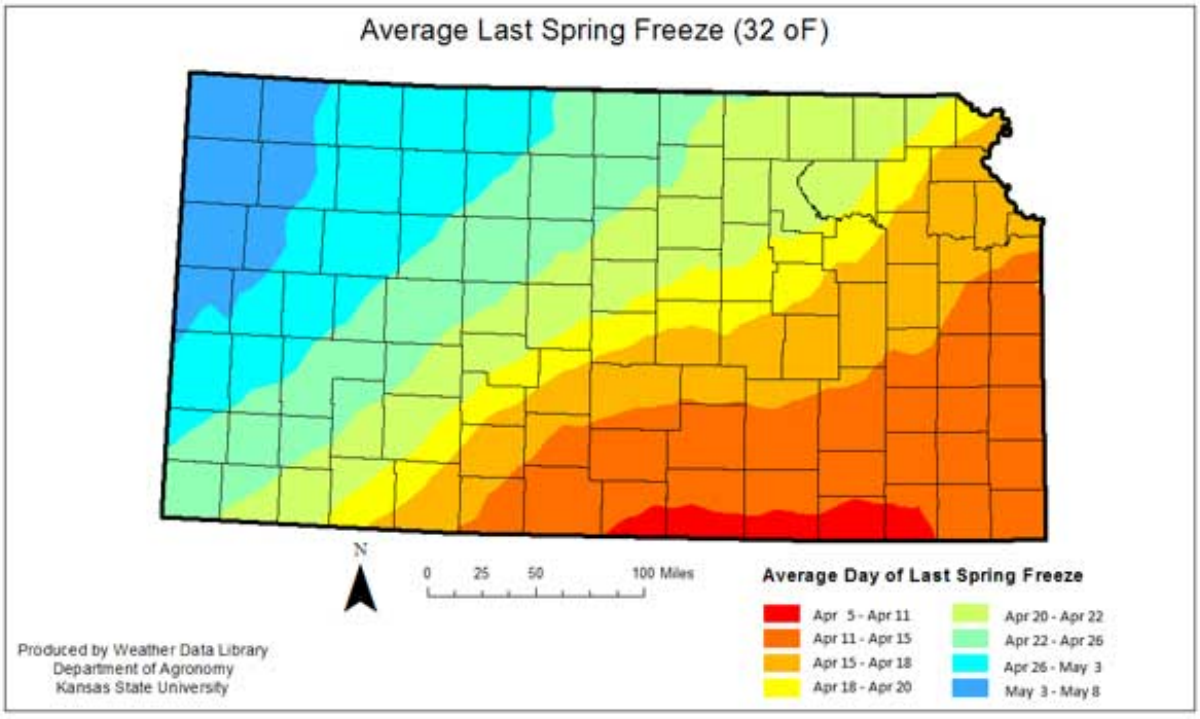

Figure 7. Average day for the last spring freeze (32 ^{o}F) for Kansas.

Producers should consider all these factors when deciding on the optimal planting time.

More information about the planting status of summer row crops will be provided in upcoming issues of the Agronomy eUpdate. Stay tuned!

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4. Pre-emergence herbicides for corn

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

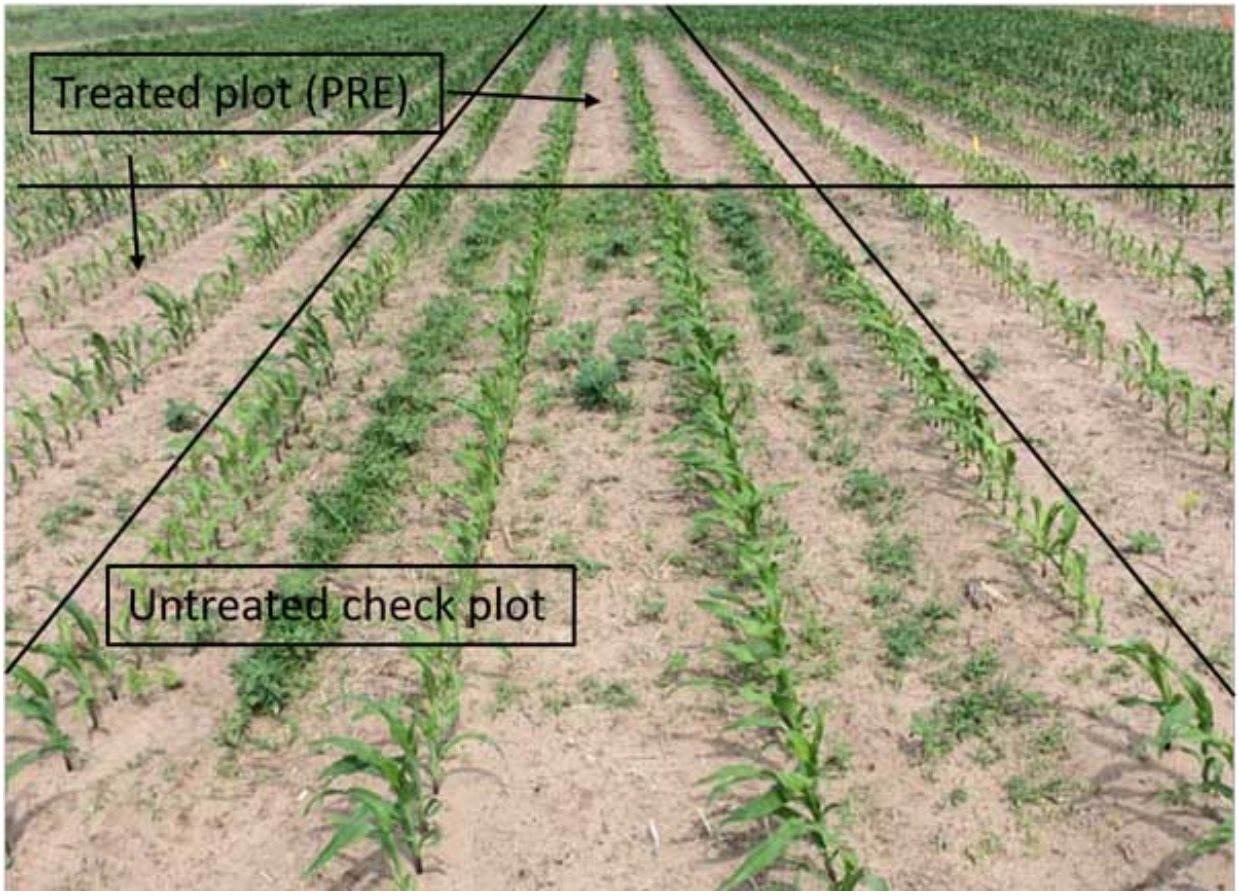

Figure 1. The corn plot in the foreground received no pre-emergence herbicide. The plots adjacent to the untreated check received an application of pre-emergence herbicide. The photo was taken just prior to the prescribed post-emergence treatment in May 2018 at the Kansas River Valley Experiment Field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

Much of the resistance to glyphosate has developed from over-reliance on post-emergence herbicide applications, thus it is essential to include one or more of the pre-emergence residual herbicides available for corn. However, it is also important to remember to change pre-plant and pre-emergence herbicide programs from time to time to prevent selection of tolerant or resistant weeds.

The specific herbicide you use is important, but it is usually less important than making the decision

to use a pre-emergence herbicide. But, it is important to know the strengths and weaknesses of each product in terms of the spectrum of weeds controlled. A table summarizing weed species response to various corn herbicides can be found on pages 24-26 of *2020 Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland* (SRP 1155) at:
https://www.bookstore.ksre.ksu.edu/pubs/SRP1155.pdf

Categories of soil-applied residual herbicides for corn

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

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

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

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

water table is less than 25 feet below the soil surface. Balance Flexx does not provide adequate control of sunflower.

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

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

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

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5. Weed management considerations for flooded fields

Many Kansas fields were affected by flooding in 2019 (Figure 1). These fields will likely need some special considerations as weed management plans are finalized for the 2020 field season.

Figure 1. Partially flooded corn field near Manhattan, KS on May 8, 2019. Photo by K-State Research and Extension.

Expect larger weed populations if weeds were not managed before producing seed last year. Early pre-plant or burndown herbicide applications may be especially beneficial in these fields. Be sure to include a product that has some residual activity in this application. Also, consider that many of the seeds produced last year will remain dormant this year and will be present in the field for years to come.

Remember that flood waters leave a variety of items as they recede. Be on the lookout for newly-introduced weed species and adjust your weed management plan accordingly. New soil with different chemical and physical characteristics may have also been deposited. Soil properties, such as texture and CEC, influence the activity and application rate of many residual herbicides.

Flooding may have affected the breakdown of some soil-active herbicides. Most herbicides are

broken down by soil microorganisms, which are generally less active in saturated soils. Some herbicides that may degrade slower and cause concern for carryover include: metribuzin, imazethapyr (Pursuit), and dimethenamid (Outlook).

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6. Placement and rate considerations for nitrogen application with starter fertilizer

Starter fertilizer is typically considered as the placement of a small rate of fertilizer, usually nitrogen (N) and phosphorus (P), near the seed at planting time. The idea is this fertilizer "jump starts" growth in the spring, and it is not unusual for a producer to see an early-season growth response to starter fertilizer application. But some producers might also consider using this opportunity apply higher rates of fertilizer that can supply most of the N and P needs for the corn crop. Wet soil conditions in many areas of Kansas during the fall and winter months may have limited N applications for corn. Under these conditions, N application at planting time can provide a good alternative for some producers.

Producers should be very cautious about applying starter fertilizer that includes high rates of N (and/or K). It is best to have some soil separation between the starter fertilizer and the seed. The safest placement methods for starter fertilizer are either as a deep-band application 2 to 3 inches to the side and 2 to 3 inches below the seed (2x2), or as a surface-band application to the side of the seed row at planting time (2x0), especially in conventional tillage or where farmers are using row cleaners or trash movers in no-till (Figure 1).

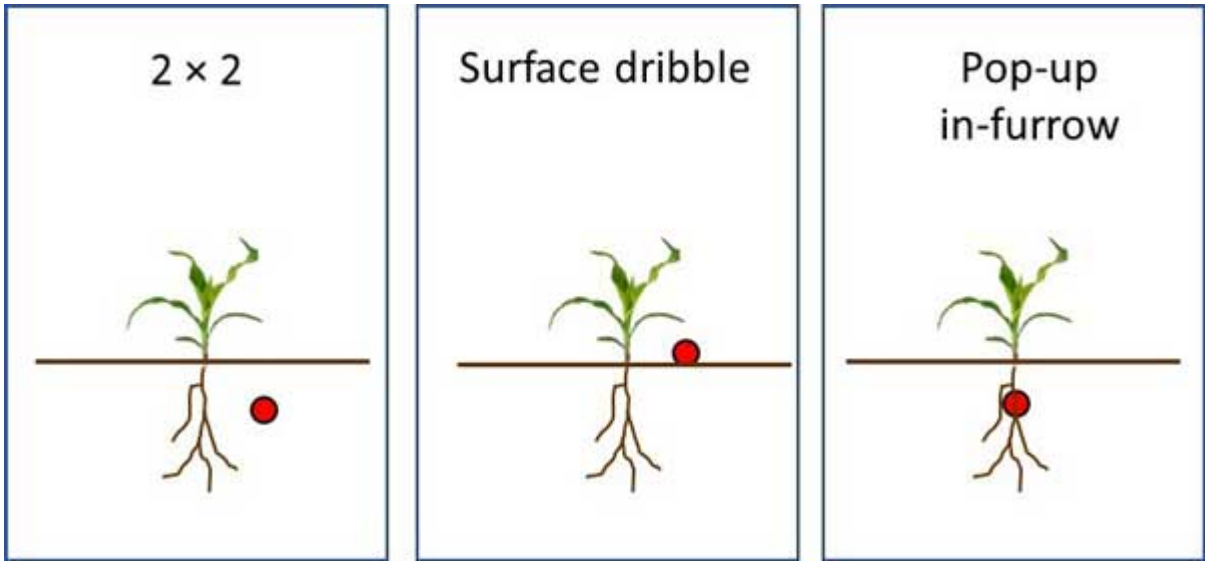

Figure 1. Example illustrations of starter fertilizer placement with respect to the corn plant. Graphic by Dorivar Ruiz Diaz, K-State Research and Extension.

What are the risks with "pop-up" placement?

If producers apply starter fertilizer with the corn seed ("pop-up" in-furrow), they run an increased risk of seed injury when applying more than 6 to 8 pounds per acre of N and K combined in direct seed contact on a 30-inch row spacing (Table 1). Nitrogen fertilizer can result in injury from salts, but also from ammonia toxicity when using urea-containing fertilizers. Urea converts to ammonia, which is very toxic to seedlings and can significantly reduce final stands (Figure 2).

What is a "salt"?

"Salts" are ionic compounds that result from the neutralization reaction of an acid and base. Most fertilizers are soluble salts (e.g. KCl from K+ and Cl-). Salt injury can occur when fertilizer addition increases the osmotic pressure in the soil solution (due to an increase in salt concentration) around the germinating seed and roots which can cause plasmolysis (i.e. water moves out of the plant cell, cell membranes shrink, and the cell collapses). Symptoms of salt damage are short, discolored roots and a reduced corn population.

Figure 2. Symptoms of ammonia toxicity from urea-containing fertilizers placed too close to the seed. Photos by Dorivar Ruiz Diaz, K-State Research and Extension.

Table 1. Suggested maximum rates of fertilizer to be applied directly with corn seed for "pop-up" fertilizer.

	Pounds N + K_2O (No urea or UAN)	
Row Spacing (inches)	**Medium-to-fine textured soil**	**Sandy soil**
40	6	4
30	8	6
20	12	8

N rates with 2x2 placement or "surface dribble"

Starter fertilizer placement, such as 2x2 or surface dribble, provides enough soil between the fertilizer and the seed and are considered safe alternatives for higher rates of N application. Recent studies in Kansas suggests that the full rate of N can be applied safely using these placement options. One concern from some producers is related to the additional time demands for the application of high rates of fertilizer during planting. However, this can be an excellent time for N application, minimizing potential N "tie-up", and providing available N to the corn, particularly under no-till systems with heavy residue.

In summary, producers can apply most of the N needs for corn at planting as long as the fertilizer placement provides enough soil separation between the fertilizer and the seed. The best options are the 2x2 placement or surface-dribble with similar results in terms of crop response. Nitrogen applications with the starter fertilizer can provide an excellent alternative for producers who might not have the opportunity for anhydrous ammonia applications this spring or are planning to apply additional N as side-dress.

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7. Update on insect activity - alfalfa weevils and army cutworms

Alfalfa weevil feeding seems to be just starting in north central Kansas. This early feeding is usually first noticed as either "pinprick"-sized holes in the leaves (Figure 1) or small, chewed-up terminals.

Figure 1. Early feeding by alfalfa weevils, leaving “pinprick” holes in the leaves. Photo by Cayden Wyckoff, K-State Research and Extension.

These small, yellowish or lime green larvae will become more plentiful and larger, and thus cause more damage, in the next couple of weeks as the weather warms (Figure 2). Treatment thresholds vary widely for alfalfa depending upon end use, but a common threshold is to initiate treatment at 33-50% infestation, i.e. 1 larva for every 2-3 stems using the “stem shake” bucket method. Next, sample again 10-14 days after treatment making sure to ALWAYS follow the insecticide's label for treatment, re-entry, etc.

Figure 2. Alfalfa larvae. Photo by Cayden Wyckoff, K-State Research and Extension.

Army cutworms

Army cutworms have been foraging on alfalfa and wheat in the western half of Kansas since last fall. However, much of that feeding has just become evident in the last couple of weeks as these larvae get larger and consume more plant tissue (Figure 3).

Figure 3. Army cutworm larvae. Photo by Cayden Wyckoff, K-State Research and Extension.

Most larvae sampled in north central Kansas are progressing to their latter stages of larval development--but will probably feed for at least another week. However, that week could be stretched out over several actual weeks because of cool weather. As they decimate their original host's plant tissue (Figure 4), these larvae will move, usually in large numbers, to more succulent plants, thus the name "Army" cutworm. Several of these masses have been noticed already this year. But, they are not moving to pupate, they are looking for more food.

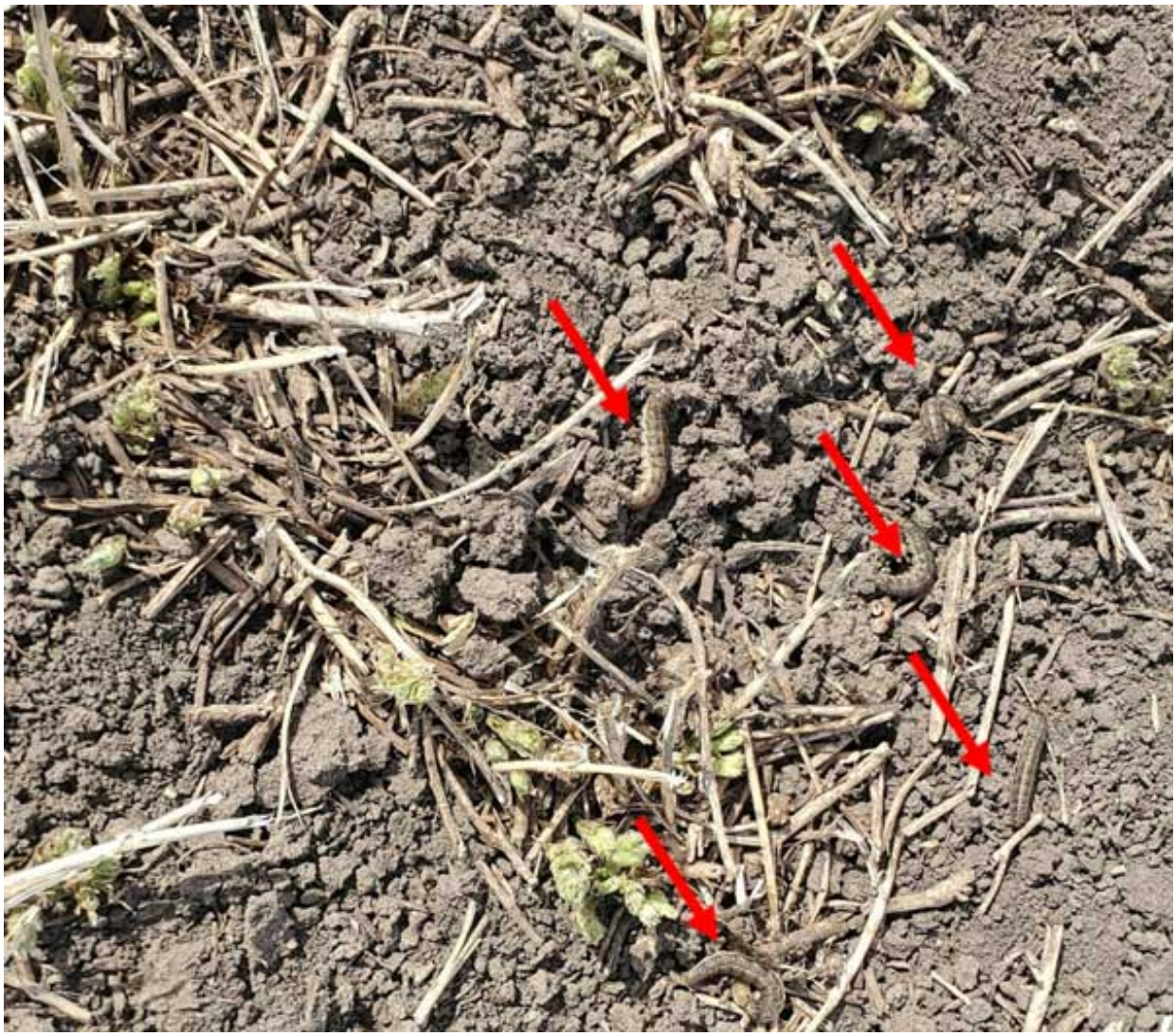

Figure 4. Alfalfa decimated by army cutworm larvae. Photo by Jay Wisbey, K-State Research and Extension.

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8. Severe weather preparedness during COVID-19

The current situation with COVID-19 and the "stay at home" order/social distancing rules does not eliminate the potential for a severe weather outbreak, including the possibility of tornadoes. However, it does require a little extra preparation for such an event as we enter the peak of our storm season. Planning can reduce the danger should a tornado warning be issued.

The first step is to have an emergency plan for your household. The plan will include identifying the safest location for shelter in your home, preparing an emergency kit, and checking your method of receiving alerts and warnings.

Best places to shelter

If you live in a mobile home, there is no safe place to take shelter in that structure. Check with your park management on shelter capabilities and make plans accordingly. Verify that these are open and available to you and the other residents despite the recent COVID-19 protocols.

Individuals in apartment complexes will have a bigger challenge. If their building or complex has a shelter, use that. Verify that these are open and available to you and the other residents despite the recent COVID-19 protocols. If no shelter is available, check for space on the lowest level, without windows, and put as many walls between you and the outside as possible.

In a house without a basement, put yourself on the lowest level with as many walls between you and the outside as possible. Centrally-located halls and bathrooms are the safest location to seek shelter (Figure 1). If you have a basement, that is by far the best location to go. Often going under the stairwell will protect you from falling debris.

Figure 1. Ideal tornado sheltering locations within a house. Graphic from NOAA (weather.gov/tornado)

Emergency kit supplies

An emergency kit should consist of water (one gallon of water per person per day for at least three days, for drinking and sanitation), at least a three-day supply of non-perishable food, flashlight, first aid kit, extra batteries, whistle to signal for help, dust mask to help filter contaminated air, plastic sheeting and duct tape to shelter-in-place, moist towelettes, garbage bags and plastic ties for personal sanitation, wrench or pliers to turn off utilities, manual can opener for food, and cell phone with chargers and a backup battery.

Best options for severe weather updates

Smart phones and the internet are a common method of getting weather updates. However, it is helpful to have backup methods in case these systems are down. A NOAA weather radio is an important tool to receive these warnings. When purchasing a weather radio, make certain that it has a signal in the location that you will use for shelter and is programmed for your area.

Use this time at home to plan

With a statewide "stay home" order in effect, many people are spending more time than normal at their residences. While this will provide additional challenges for individuals in apartment complexes, etc. – it does provide a fantastic opportunity for everyone to plan and rehearse. Disaster plans shouldn't be limited to severe weather! Prepare and practice for fires, earthquakes, and other disasters in this time of isolation.

Highlights

- In the case of a warning, your #1 priority is to protect yourself from a potential tornado!
- Have multiple modes of receiving an alert or warning – with at least one form of alert not reliant upon cellular communications.
- Identify the safest shelter location – either in your home or in a communal shelter.
- If using a communal shelter – i.e. mobile home park or apartment complex – confirm that the shelter is open and what distancing practices are in place.

For more severe weather safety tips visit: https://www.weather.gov/mob/Severe_Tornado

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9. Review of drought-tolerant corn hybrids: Yield benefits

Drought may not be on the minds of producers across the state given the current soil moisture levels. However, the growing season is long and drought could become a problem later in the season. Based on the soil moisture profile and weather forecast conditions, it would be unlikely to see drought issues until the late vegetative or reproductive stages for corn this year. Nonetheless, this article emphasizes the importance of understanding your hybrids and hybrid selection for improving yields. One of the main points to highlight for the current growing conditions is that drought tolerant (DT) hybrids have the potential to yield similarly to non-DT hybrids when water is not *limiting.*

Despite the recent wet years, drought is always a possibility in Kansas. That has raised questions about the utilization of corn as the main crop for maximizing yield production per unit of available water in dryland environments.

Non-transgenic, conventionally bred, "drought-tolerant" (DT) corn hybrids from Pioneer and Syngenta were released to the market with the expectation of increasing corn production in water-limited regions. Monsanto also released biotech transgenic DT hybrids.

Overall, the information from seed companies indicates that DT hybrids could provide from 2 to more than 15 percent yield increase over "competitor hybrids" in non-limiting and water-limiting environments, respectively.

K-State research conducted over the 2012-2015 growing seasons across the state has been summarized and is available in a K-State Research and Extension publication (discussed at the end of this article). The objective of this article is to present an overview of the DT vs. non-DT responses to management practices such as plant population and irrigation.

The information below is intended to provide some guidance to farmers, consultants, and agronomists in making the right decision for selecting corn hybrids. In addition, we hope to develop a better understanding of the kinds of environments in which DT hybrids could be most likely to result in a yield benefit. These hybrids are generally targeted for water-limited environments in the Western Great Plains.

Summary of results

This research compared DT hybrids from diverse companies with a standard non-DT counterpart of similar maturity. The tests also evaluated the yield response to varying plant population and irrigation levels.

At the plant scale, our analysis did not reveal any change in the plant response to plant population between DT and non-DT hybrids. This indicates no need to change plant population when using DT hybrids.

We also analyzed yields at the plot level for DT vs. comparable non-DT hybrids with similar maturity. The information presented in the figure below (Figure 1) depicts the association of the yields for the DT vs. non-DT corn hybrids: Yellow points = research plots (2012-2013); blue points = on-farm plots; green points = 2014; red points = 2015 growing season plots.

Overall, the analysis found a yield benefit of 3 percent for DT vs. non-DT hybrids under diverse environments and stress conditions across Kansas during the 2012-2015 seasons. In absolute terms, the yield advantage of using DT hybrids was around 5 bushels per acre compared to the non-DT material. Similar yield trends were observed in research plots and on-farm demonstration plots. A great proportion of DT and non-DT yields were similar -- within a 5% confidence interval as highlighted in Figure 1 -- except in low-yielding and high-yielding environments. In low yielding-environments, DT out-yielded non-DT corn hybrids more often compared to the situation in higher-yield environments.

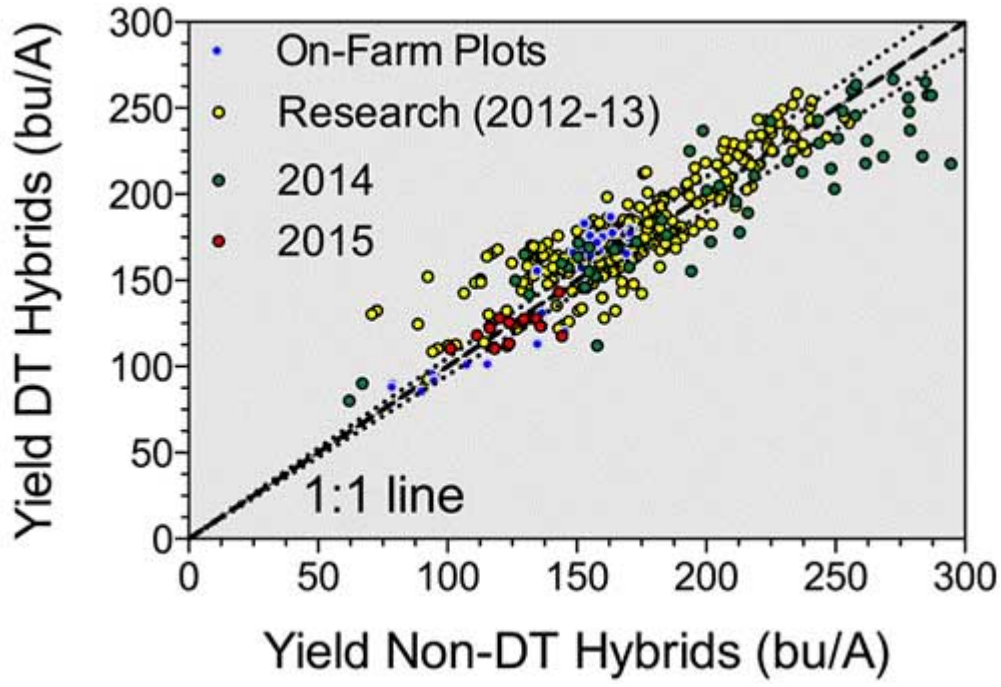


Figure 1. Yield for the DT versus non-DT corn hybrids across site-years for the 2012, 2013, 2014, and 2015 growing seasons.

DT vs. non-DT corn hybrids: Yield environment analysis

The analysis of information across diverse yield environments allows us to more clearly understand where there would be a yield advantage from planting DT hybrids. It is clear from Figure 2 that the yield advantage of DT corn hybrids increases as the yield potential of the crop decreases. This graph shows that there is basically no yield difference between DT and non-DT hybrids when yields are around 170 bushels per acre or greater. The yield advantage for DT hybrids gradually increases as the yield of the regular hybrids decreases from 170 bushels per acre.

However, it is important to note that these are generalized relationships and that there are varied responses at each yield level. Some individual points show no difference between DT vs. non-DT hybrids at yields around 100 bushels per acre. Other points show a 30-bushel-per-acre yield advantage for non-DT hybrids at 160 to 170 bushels per acre, and still others show a 60-bushel-per-acre yield advantage for DT hybrids when non-DT hybrid yields were near 70 bushels per acre. On the opposite side of the yield environments, under high yield environments (>220 bushel-per-acre), individual points show a 30 to 60-bushel-per acre yield advantage for non-DT hybrids when DT

hybrid yields were above 220 bushels per acre. How individual hybrids respond to a specific environment is influenced by a number of factors, including the timing and duration of the stress.

One more technical clarification is important to note. The linear response and plateau (LRP) function model fitted in Figure 2 (adjusted to the 2012-2013 data), presented an R^2 of 0.26 units, which can be interpreted to indicate that this model is accounting for only slightly more than one-fourth of the total variation presented in the data. Even when including observations from studies conducted in the last two years (2014-2015), the trend observed in the DT yield advantage versus the non-DT yield values (Figure 2) is not being modified. From all these years of data collection and analysis, we can conclude that there are many management factors involved in the yield results which makes it difficult to separate out the effect of hybrid alone.

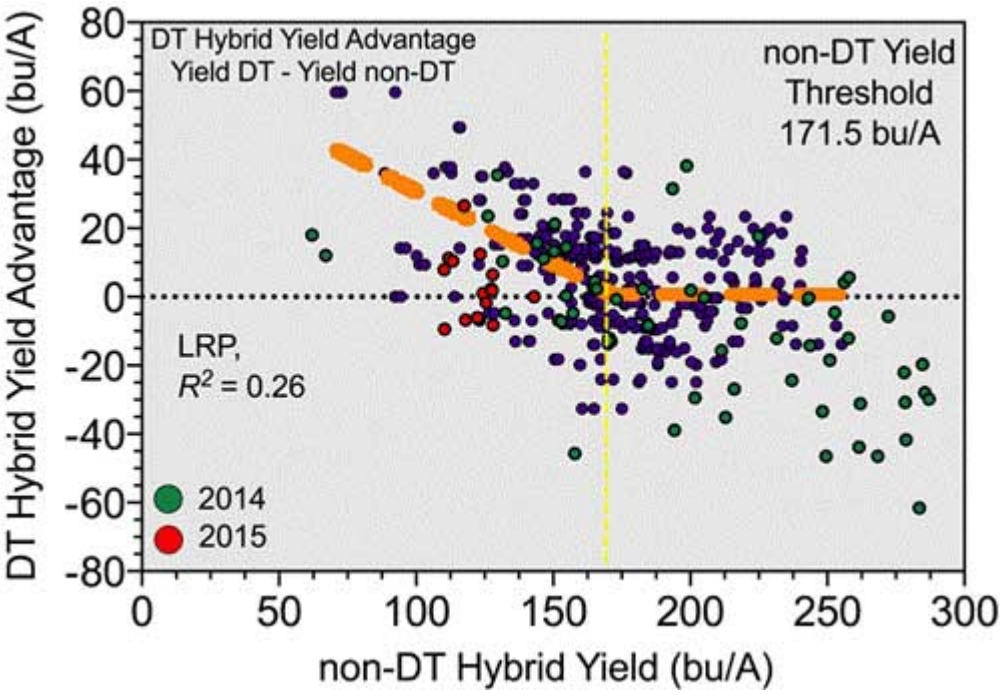


Figure 2. Yield advantage for DT compared to non-DT corn hybrids in the same environment and at the same population, ranging from low-yielding environments to high-yielding environments across site-years for the 2012, 2013, 2014, and 2015 growing seasons.

Still, we need to be cautious when using and interpreting this information. More experiments and research data need to be collected, and a deeper understanding is needed to more properly analyze the main causes of the yield differences of DT vs. non-DT corn genotypes.

Potential interpretations offered for the yield advantage for the DT corn hybrids in certain environments are:

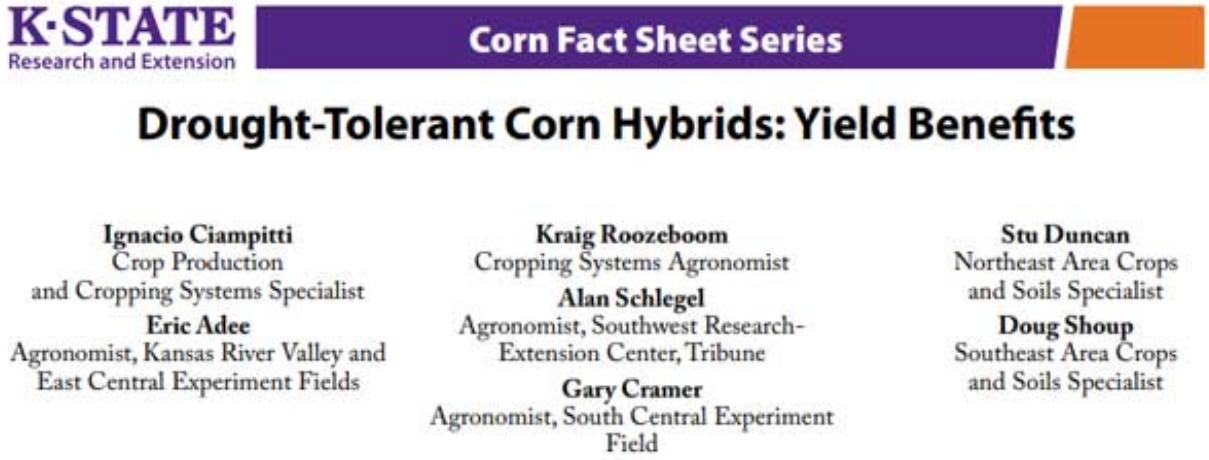
- Slower vegetative growth, saving water for reproductive stages (stress avoidance)
- Greater root biomass with superior water uptake
- Differential regulation in the stomata opening, controlling water and CO_2 exchange processes

- Other potential physiological modifications

K-State Research and Extension publication

A publication titled *Drought-tolerant corn hybrids: Yield benefits* was published by K-State Research and Extension in 2017. This publication was supported by Kansas Corn Commission.

This publication presents research information conducted by K-State Research and Extension to evaluate drought-tolerant hybrids in a wide range of production environments. You can view the publication at https://www.bookstore.ksre.ksu.edu/pubs/MF3338.pdf


K·STATE Research and Extension

Corn Fact Sheet Series

Drought-Tolerant Corn Hybrids: Yield Benefits

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Summary of general observations:

1. Performance of individual hybrids within DT and non-DT types may vary. Some non-DT hybrids can perform nearly as well as the DT hybrids even in stressful conditions, and DT hybrids have the potential to yield with non-DT hybrids when water isn't limiting.
2. The advantage of the DT hybrids became more evident when the water stress increased to the point of leaves rolling most days.
3. From the information at hand, it is reasonable to expect a DT hybrid to serve as a type of insurance policy to sustain yield potential under water-limited environments. It also appears that there is no yield penalty associated with DT hybrids if water-limiting conditions do not occur.
4. Lastly, it is critical to understand that these corn genetic materials will not produce yield if the environment is subjected to terminal drought. We cannot expect them to thrive when moisture is severely limited, especially in dryland systems. As properly and explicitly stated by all seed companies, these DT materials have demonstrated the ability maintain yields to a certain degree in water-limited situations, and those yield differences will likely be in the order of 5 to 15 bushels per acre (depending on the environments and crop practices), when compared with a similar maturity non-DT corn hybrid.

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10. K-State's Soil Testing Lab and Plant Disease Diagnostic Lab are OPEN!

During this time of reduced operations at K-State due to COVID-19, there have been questions on the operational status of the Soil Testing and Plant Disease Diagnostic Labs on the Manhattan campus. Both of these labs are open and accepting samples, however submission of samples has been modified to accommodate new distancing guidelines. Please read below for specific instructions on how to submit samples (each lab has their own instructions).

KSU Soil Testing Lab

The Soil Testing Lab is fully staffed and operational. Given that we are able to operate with a full staff, the turnaround time for sample analysis is not expected to change. However, sample submission procedures have been modified and are outlined below.

- **No in-person sample delivery to lab**. However, samples can be left in the **Soil Drop Box** located on the NW side of Throckmorton (1712 Claflin Rd.) There is map on the door of the building or on the Lab website at https://www.agronomy.k-state.edu/services/soiltesting/ (Figure 1). Samples will be picked up at least twice a day.

- **Samples can be mailed via USPS or UPS.** To create a UPS shipping label, please visit our website and input your mailing address: https://ksusoiltesting.com/ups_form.php. If using the U.S. Postal Service, the mailing address for the lab is:

KSU Soil Testing Lab
2308 Throckmorton Plant Science Center
1712 Claflin Road
Manhattan, KS 66506-5503

- **Samples can be submitted to your local county Extension office.** County offices will forward samples to the lab (postage and handling may be charged). Contact your local office for samples bags, instructions, and if you have questions.

Figure 1. Location of the Soil Sample Drop Box located on the NW side of Throckmorton Plant Sciences Center in Manhattan.

Homeowners and producers are encouraged to contact the lab with any questions. The Soil Testing Lab is working hard to best accommodate the soil testing needs for everyone during this critical time of the year. **Please reach out by phone at 785-532-7897 or by email at soiltesting@ksu.edu.**

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KSU Plant Disease Diagnostic Lab Update

The KSU Plant Disease Diagnostic Lab continues to remain open at this time. However, we are working under limited operations and staff, so turn around may take a little longer than usual. There have been a few changes to our submission procedures. Please read the information below:

- **No in-person sample delivery to lab**. Instead, if you are in **Manhattan** please use the **soil drop box** located on the Northwest side of Throckmorton PSC (Figure 1).
- **USPS sample delivery to 4032 Throckmorton PSC 1712 Claflin Rd Manhattan, KS 66506**

is still available, but will be checked at a minimum of twice a week. Time sensitive samples such as **Wheat should NOT use USPS** and instead use the new temporary address below.

- **The best mailing option for samples to the plant disease diagnostic lab** is BELOW.

Please email us the tracking # so we know that a sample is coming to the lab.

Our NEW TEMPORARY SHIPPING ADDRESS for UPS/FEDEX packages

KSU Plant Disease Diagnostic Lab
1310A Westloop Pl #351
Manhattan, KS 66502

The growing season is about to kick off and we want to support Kansas growers and county extension offices. If you have questions, please contact us at **clinic@ksu.edu**

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