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eUpdate

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These e-Updates are a regular weekly item from K-State Extension Agronomy and Kathy Gehl, Agronomy eUpdate Editor. All of the Research and Extension faculty in Agronomy will be involved as sources from time to time. If you have any questions or suggestions for topics you'd like to have us address in this weekly update, contact Kathy Gehl, 785-532-3354 kgehl@ksu.edu, or Dalas Peterson, Extension Agronomy State Leader and Weed Management Specialist 785-532-0405 dpeterso@ksu.edu.

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1. Considerations when planting wheat into dry soil

Soils in portions of western and central Kansas have become steadily drier through the late summer and early fall. Topsoil conditions are now very dry in many areas of Kansas (Figure 1). For wheat yet to be planted in these areas, producers are left with a few options.

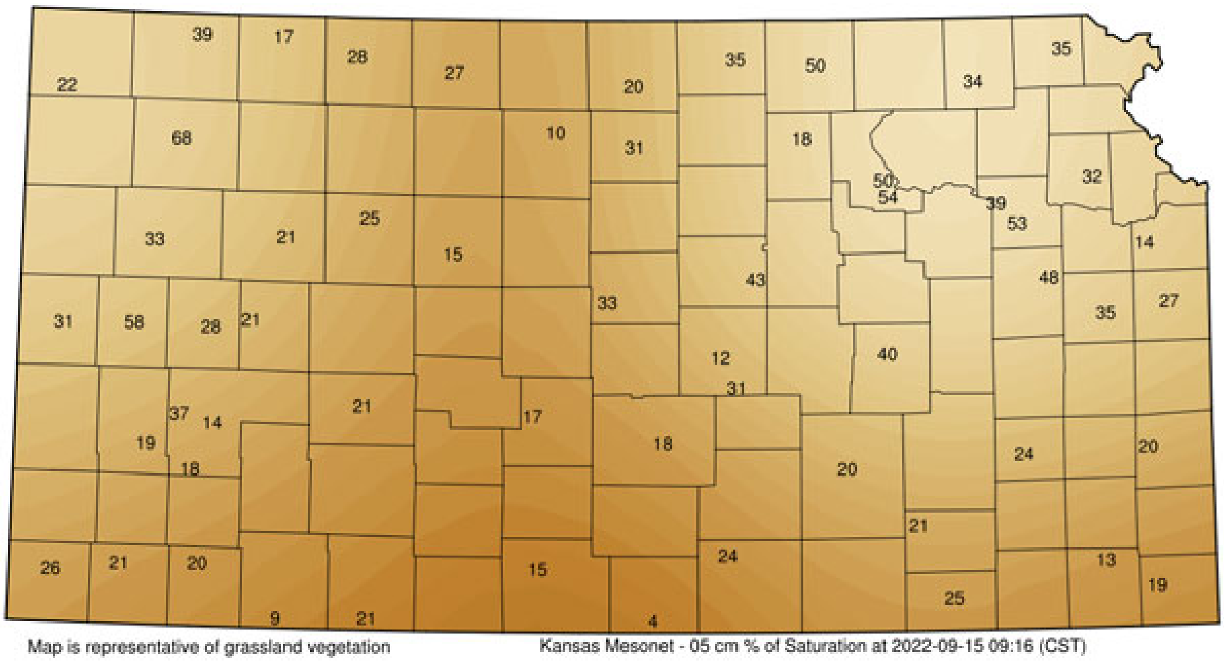

Figure 1. Topsoil moisture conditions at 2 inches (5 cm) reported as % saturation at the 5cm depth on September 15, 2022. Map by Kansas Mesonet found here: (https://mesonet.ksu.edu/agriculture/soilmoist).

Option 1: "Dust in" the wheat

Producers can choose to "dust in" the wheat at the normal seeding depth and normal planting date, and hope for rain (Figure 2). Some farmers may consider planting it shallower than normal, but this could increase the potential for winterkill or freeze damage. Planting the wheat crop at the normal depth and hoping for rain is probably the best option where soils are very dry. The seed will remain viable in the soil until it gets enough moisture.

Figure 2. Wheat dusted in near Belleville in October 2015. Photo by Romulo Lollato, K-State Research and Extension.

Before planting, producers should look at the long-term forecast and try to estimate how long the dry conditions will persist. Current short term outlook (8 to 14-day) suggests below-normal precipitation is favored statewide. Looking long-term, the new October outlook also indicates higher confidence in below-normal conditions across most of Kansas (Figure 3).

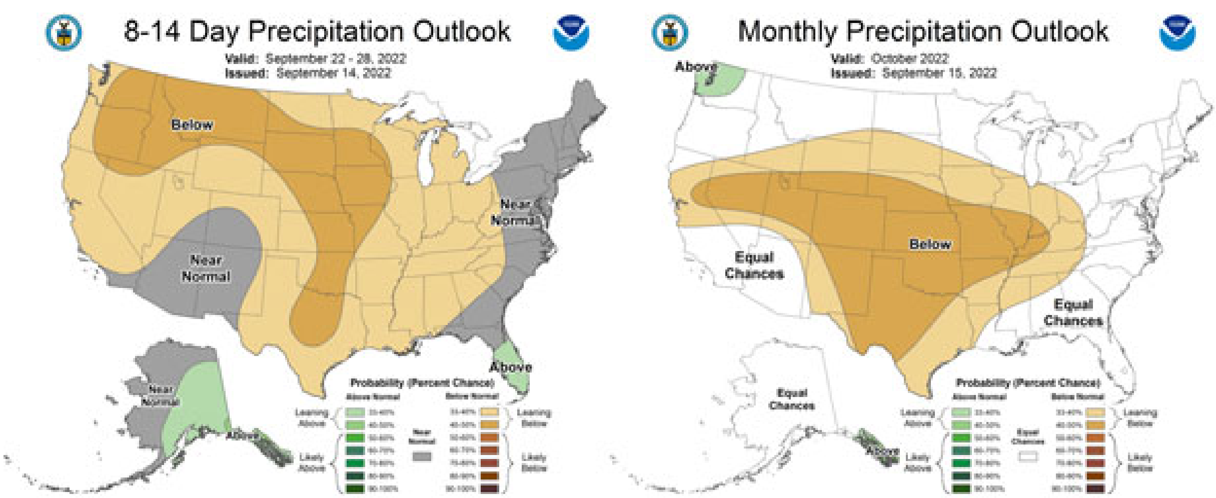

Figure 3. Precipitation outlook issued on September 15 for the next 8-14 days (left) and for

October (right). Source: CPC.

There is a good chance the dry weather will continue until at least the back end of the optimum range of planting dates. Producers should treat the fields as if they were planting later than the optimum time, as the emergence date will be delayed. Rather than cutting back on seeding rates and fertilizer to save money on a lost cause, producers should increase seeding rates, consider using a fungicide seed treatment, and consider using a starter phosphorus fertilizer to improve early season development. However, producers should be cautious with in-furrow nitrogen or potassium fertilizers as these are salts and can make it more difficult for the seed/seedling to absorb water needed for germination. The idea is to make sure the wheat gets off to a good start and will have enough heads to have good yield potential, assuming it will eventually rain and the crop will emerge late. Wheat that emerges in October may still hold full yield potential, but wheat that emerges in November almost always has fewer fall tillers and therefore can have decreased yield potential.

There are some risks to this option. First, a hard rain could crust over the soil or wash soil off planting ridges and into the seed furrows, potentially causing emergence problems - although heavy rain events are more likely to occur during summer months than in the fall. Another risk is the potential for wind erosion if the field lies unprotected with no ridges. Also, the wheat may not come up until spring, in which case it may have been better not to plant the wheat at all and plant a spring crop instead. In fact, not planting wheat and allowing soil moisture to build for a summer crop planted next spring is an option. If the wheat fails to emerge, then there would be little difference in soil moisture whether planted or not. If the wheat crop fails and a spring crop is planted consider herbicide use and plant back restrictions.

Probably the worst-case scenario for wheat planted into dry soils would be if a light rain occurs and the seed gets just enough moisture to germinate but not enough for the seedlings to emerge through the soil or to survive very long if dry conditions return. Once the coleoptile extends to the soil surface, the plant must have enough moisture to continue growth otherwise it will perish. This situation may be worsened if producers are planting wheat following a summer crop such as corn, soybean, or sorghum, which depleted subsoil moisture through late summer. Without subsoil moisture to sustain growth, there can be a complete loss of the wheat stand. If late October brings cooler temperatures, dusting wheat in becomes a more interesting option as soil moisture from a possible rainfall event could be stretched further.

Option 2: Plant deeper than usual into moisture with a hoe drill

Planting deeper than usual with a hoe drill can work if the variety to be planted has a long coleoptile, the producer is using a hoe drill, and there is good soil moisture within reach. The advantage of this option is that the crop should come up and make a stand during the optimum time in the fall. This could potentially keep the soil from blowing.

The main risk of this option is poor emergence. Deep-planted wheat normally has below-normal emergence, so a higher seeding rate should be used. Any rain that occurs before the seedlings have emerged could add additional soil into the seed furrow, making it even harder for the coleoptile to reach the soil surface. Any time you increase the seeding depth, the seedling will have to stay within the soil just that much longer before emerging through the soil surface.

Delayed emergence leads to more potential for disease and pest problems. Additionally, deep-planted wheat generally results in reduced tillering and consequently a reduced number of heads, which directly reduces the yield potential of the crop. It's even possible that the wheat would get planted so deep that it would germinate but never emerge at all, especially if the coleoptile length is too short for the depth of planting (Figure 4). Generally speaking, it's best to plant no deeper than 3 inches with most varieties. It is also important to keep in mind that ridges formed by narrow press wheels can make the effective planting depth much deeper if the seed furrows fill in during a heavy rainfall event.

Figure 4. Deep-planted wheat can result in variable stands depending on if the coleoptile of the plants reach the soil surface (plant on the left) or if it does not (plant on the right). In cases where the coleoptile does not reach the soil surface, chances are that the first true leaf will emerge below ground and perish with an accordion-like format. Photo by Romulo Lollato, K-State Research and Extension.

Option 3. Wait for rain before planting

To overcome the risk of crusting or stand failure, producers may decide to wait until it has rained and soil moisture conditions are adequate before planting. Under the right conditions, this would result in good stands, assuming the producer uses a high seeding rate and a starter fertilizer, if appropriate. If it remains dry well past the optimum range of planting dates, the producer would then have the option of just keeping the wheat seed in the shed until next fall and planting spring crop next year instead.

The risk of this option is that the weather may turn rainy and stay wet later this fall, preventing the producer from planting the wheat at all while those who dusted their wheat in have a good stand. There is also the risk of leaving the soil unprotected from the wind through the winter until the spring crop is planted.

Crop insurance considerations and deadlines will play a role in these decisions. Another consideration is to delay the bulk of nitrogen application until topdress time in the spring, as wheat does not require much nitrogen in the fall. This would defer expenses until an acceptable wheat stand is assured.

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2. Planting wheat too early can lead to several problems

The general target date for planting wheat for optimum grain yields in Kansas is within a week of the best pest management planting date, or BPMP (formerly known as the "Hessian fly-free") date (Figure 1). If forage production is the primary goal, earlier planting (mid-September) can increase forage yield. However, if grain yield is the primary goal, then waiting until the BPMP date to start planting is the best approach (Figure 2). Planting in mid-September is ideal for dual-purpose wheat systems where forage yields need to be maximized while reducing the effects of early planting on reduced grain yields. Notice that, due to the current dry conditions, coupled with the outlook of continued drought in Kansas, planting wheat for dual-purpose or for forage only does not seem like viable options this year.

Optimum wheat planting dates in Kansas depend on location within the state. Suggested planting dates by zone are as follows:

Zone 1: September 10-30

Zone 2: September 15 – October 20

Zone 3: September 25 – October 20

Zone 4: October 5 – 25

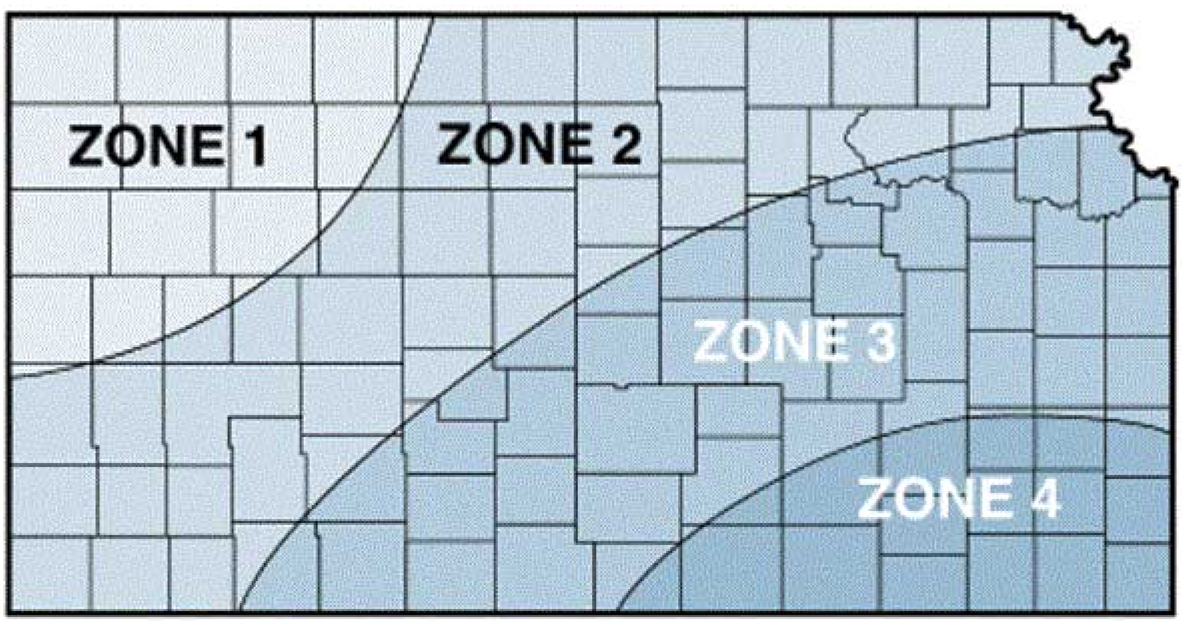

Figure 1. Optimum wheat planting dates by zone in Kansas.

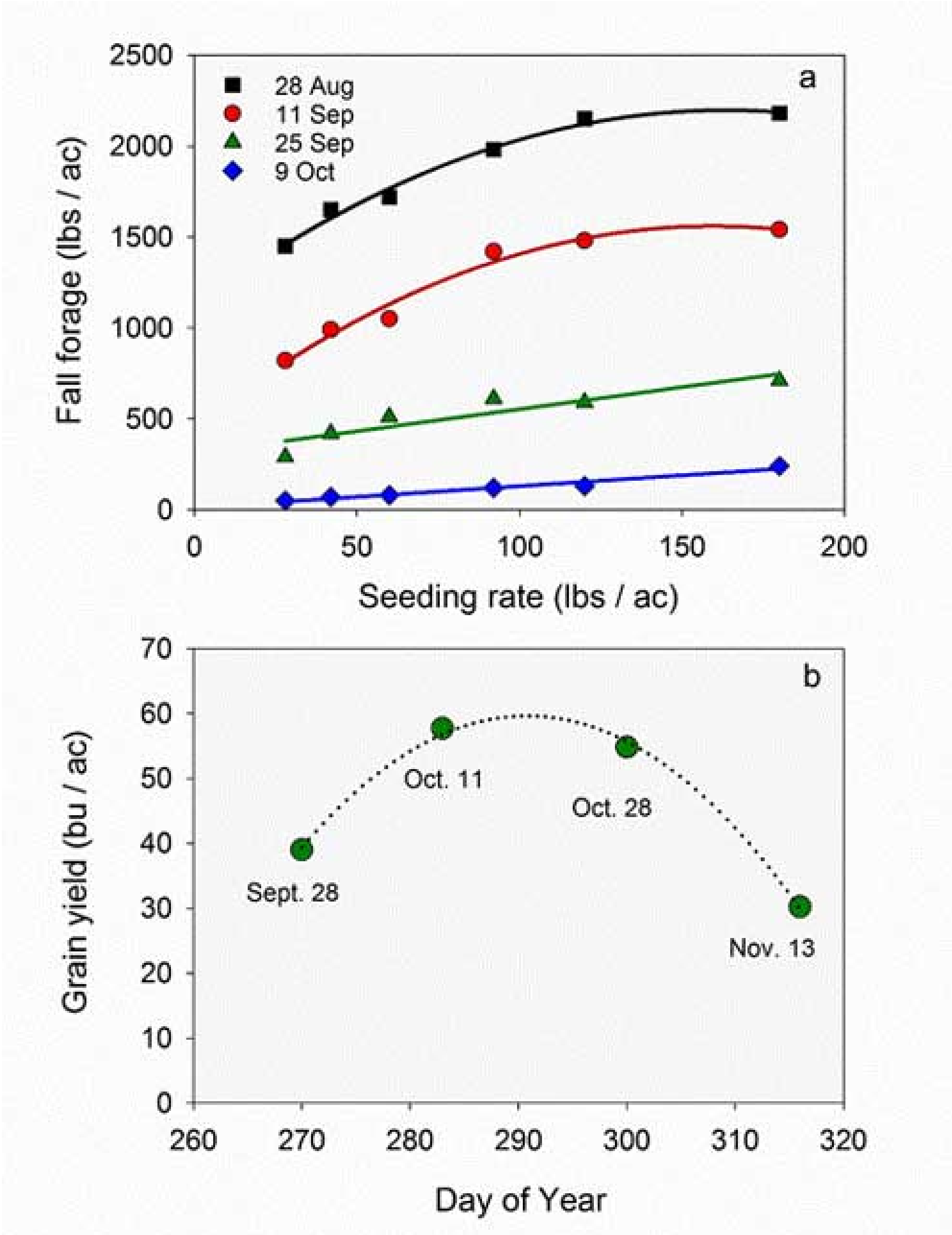

Figure 2. Effect of planting date and seeding rate on wheat fall forage yield in Lahoma, north-central Oklahoma (a) and effect of planting date on wheat grain yield near Hutchinson, south-central Kansas (b). Figure adapted from KSRE numbered publication MF3375.

While the effects of planting date on wheat yield shown in Figure 2 will hold true for most years, they will largely depend on environmental conditions and disease pressure during the growing season. In some years, earlier-planted wheat does best and some years the later-planted wheat does best, and these year-specific performances usually relate to the weather experienced in the fall and spring. For instance, early-planted fields in growing seasons with a warm fall might produce excessive biomass that will use an excessive amount of water during the fall. If the following spring is dry, soil water deficit during grain filling then can reduce grain yield. Conversely, a warm fall would favor tillering of a later-planted wheat crop, helping to compensate for this delay. The opposite is also true: in years with an early onset of cold temperatures during the fall, an earlier planted crop might perform better than a later planted crop due to its ability to produce enough fall tillers to still maximize grain yield. Research conducted by Merle Witt with late-sown wheat in Garden City from 1985 through 1991 is summarized in Figure 3. Averaged across all these years, delaying wheat sowing from October 1 to November 1 delayed heading date by 6 days and decreased wheat yields in 23%. The grain-filling period was progressively shortened by about 1.7 days and occurred under hotter temperatures (about 1.5°F) for every month of delay in sowing date.

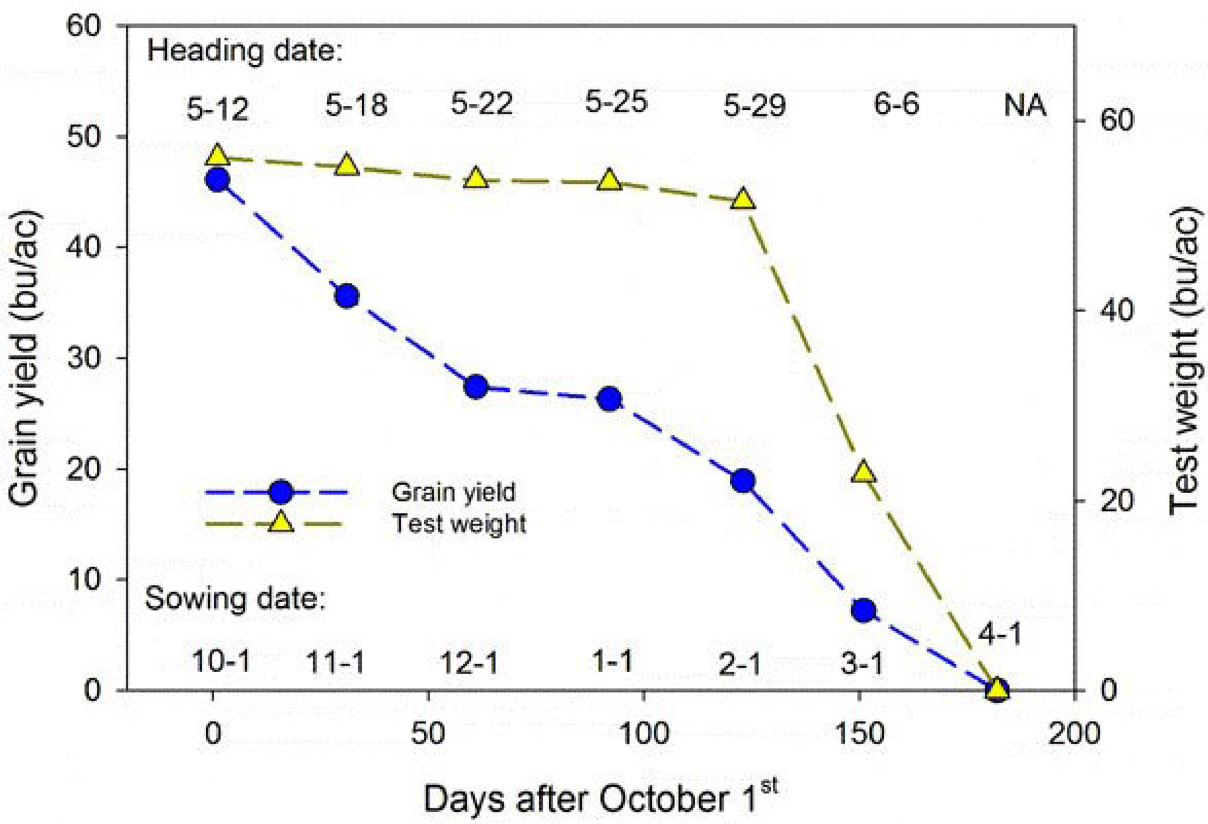

Figure 3. Wheat grain yield, test weight, and heading date responses to sowing date between 1985 to 1991. [Data adapted from Kansas Agric. Exp. St. SRL 107](#).

In dry years, seedling emergence and stand establishment can be uneven. These dry conditions can also lead to poor crown root development and fall tillering. If fields become too wet to plant by mid-October and stay that way through the remainder of the fall, then producers end up planting much later than the optimum planting date. Following an unusual year, producers will often start planting earlier than the recommended date if soil conditions are good, because the negative consequences of adverse conditions are fresh on their minds. However, planting early also increases the risk of other production problems including multiple diseases, insect pests, weed infestations and undesirable growth of the crop.

Potential risks of planting wheat early

Increased risk of **wheat streak mosaic and related diseases**. Wheat curl mites that spread these diseases survive the summer on volunteer wheat and certain other grasses. As those plants die off, the wheat curl mites leave in search of new plants to feed on. Early-planted wheat is likely to become infested, and thus become infected with wheat streak mosaic virus, high plains virus, and Triticum mosaic virus. The wheat curl mites are moved by wind and can be carried a mile or more before dying, so if wheat is planted early, make sure all volunteer wheat within a mile is completely dead at least two weeks before planting. For growers considering planting early, a good management consideration would be to select wheat varieties with resistance to the wheat streak mosaic virus and/or with tolerance to the wheat curl mite, especially in the western portions of the state.

Increased risk of **Hessian fly**. Over the summer, Hessian fly pupae live in the old crowns of wheat residue. After the first good soaking rain in late summer or early fall, these pupae (or "flaxseed") will hatch out as adult Hessian flies and start looking for live wheat plants to lay eggs on. They are most likely to find either volunteer wheat or early-planted wheat at that time. After the BPMP date, many of the adult Hessian fly in a given area will have laid their eggs, so there is generally less risk of Hessian fly infestation for wheat planted after that date. Hessian fly adult activity has been noted through November or even early December in Kansas. If planting early, consider varieties with improved tolerance to Hessian fly.

Armyworms and other lepidopteran larvae may also still pose a serious problem to early planted wheat. They may feed on the green wheat plants until the first cold front comes through (temperatures in the mid 20-degree F range for a couple hours). Insecticide seed treatments do not work well against lepidoptera larvae.

Volunteer wheat herbicide applications and insecticides

Because of the relatively large and widespread populations of armyworms/fall armyworms in 2020 and 2021, many wheat producers have been talking about adding an insecticide to their herbicide application this year for volunteer wheat in order to save on application costs. Last year, many fields of volunteer wheat were heavily infested with these caterpillars, which wasn't bad as they helped control some volunteer wheat stands but some were still around when the planted wheat germinated. The addition of an insecticide to a volunteer wheat herbicide application is probably not a good idea for several reasons: 1) If armyworms/fall armyworms are present in volunteer now, killing the volunteer should cause the larvae to starve, or initiate pupation if they are far enough along in their development, or expose them to birds and/or other predators; 2) you should NOT use an insecticide unless the pest is at a vulnerable stage and has reached a treatment threshold; and 3) insecticides applied with a herbicide will not have insecticidal activity by the time the planted wheat germinates anyway. Please resist the urge to mix an insecticide with a volunteer wheat herbicide application but do control the volunteer wheat.

Increased risk of **barley yellow dwarf**. Many types of aphids can spread barley yellow dwarf. In Kansas, greenbugs and bird cherry-oat aphids are the primary vectors of this viral disease. These insects are more likely to infest wheat during warm weather early in the fall than during cooler weather. Planting wheat after the BPMD reduces the risk of problems with aphids and barley yellow dwarf. If planting early, consider varieties with improved tolerance to Barley Yellow Dwarf virus, especially in central and eastern Kansas or consider the use of seed treatments with imidacloprid (such as Gaucho XT or Rancona Crest).

Increased risk of **excessive fall growth and excessive fall tillering**. For optimum grain yields and winter survival, the goal is for wheat plants to go into winter with established crown roots and 3-5 tillers. Wheat that is planted early can grow much more than this, especially if moisture, temperature, and nitrogen levels are not limiting. If wheat gets too lush in the fall, it can use up too much soil moisture in unproductive vegetative growth. These fields often experience more drought stress in the spring if soil conditions remain dry, and can show more symptoms of low temperature damage during the winter (Figure 4). The wheat on the left (showing white discoloration of the leaves) was planted mid-September for dual-purpose evaluation, and had an excessive amount of fall growth (near 3,000 pounds of dry matter per acre). The wheat on the right was planted early-to-mid October for grain-only purposes and had much more limited fall biomass. The white discoloration of the high biomass plots occurred after a late-winter, early-spring freeze that was more damaging to the dual-purpose crop. Notice the darker green plots in the upper left corner, amid discolored plots: while these were planted early, their growth was cut back by simulated grazing.

Figure 4. Aerial photo of side-by-side wheat trials near Hutchinson, KS, during the 2021-22 growing season. Photo taken March 2022 by Jorge Romero Soler.

Increased risk of **take-all, dryland foot rot, and common root rot**. Take-all is usually worse on early-planted wheat than on later-planted wheat. In addition, one of the ways to avoid dryland foot rot (*Fusarium graminearum* and other *Fusarium* species) is to avoid early seeding. This practice promotes large plants that more often become water stressed in the fall predisposing them to invasion by the fungi. Early planting of wheat also favors common root rot because this gives the root rot fungi more time to invade and colonize root and crown tissue in the fall. Seed treatments are an option to early season seedling diseases. More information: https://bookstore.ksre.ksu.edu/pubs/MF2955.pdf

Grassy weed infestations become more expensive to control. If cheatgrass, downy brome, Japanese brome, or annual rye come up before the wheat is planted, they can be controlled with glyphosate or tillage. If wheat is planted early and these grassy weeds come up after the wheat has emerged, producers will have to use an appropriate grass herbicide to control them.

Germination problems due to high soil temperatures. Early planted wheat is sown in hotter soils, which may become problematic because some wheat varieties are sensitive to high-temperature during germination. In fact, some varieties will not germinate when soil temperatures are greater than 85°F. Additionally, some varieties can have their coleoptile length reduced in as much as 40% in hot as compared to cool soils. If planting early, it is important to select varieties that do not have high-temperature germination sensitivity or sow sensitive varieties later in the fall, when soil temperatures have cooled down.

Emergence problems due to shortened coleoptile length. Hotter soils tend to decrease the coleoptile length of the germinating wheat. Therefore, deeply planted wheat may not have long-enough coleoptiles to break through the soil surface resulting in decreased emergence and poor stand establishment. When soil temperatures are hot, it is often better plant wheat at a shallower depth (3/4 to 1 inch deep) even if moisture is absent in the top layers of soil. Planting wheat deep (>2 inches) increases the risk of poor emergence and unacceptable stands.

Summary

Early sowing of wheat can lead to several problems, from increased chances of insect- or mite-transmitted viral diseases to decreased emergence due to high temperatures and its consequences on wheat germination of particular varieties and reduced coleoptile length. Ideally, growers would consider planting around the optimum window; but, if planting early due to moisture availability or a dual-purpose system, growers should consider selecting wheat varieties with tolerance to the major yield-reducing factors in their respective region. Growers should strongly consider a seed treatment with both fungicides and insecticides if planting wheat early in Kansas.

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3. In-furrow fertilizers for wheat

Wheat is considered a highly responsive crop to band-applied fertilizers, particularly phosphorus (P). Application of P as starter fertilizer can be an effective method for part or all the P needs. Wheat plants typically show a significant increase in fall tillers (Figure 1) and better root development with the use of starter fertilizer (P and N). Winterkill can also be reduced with the use of starter fertilizers, particularly in low P testing soils.

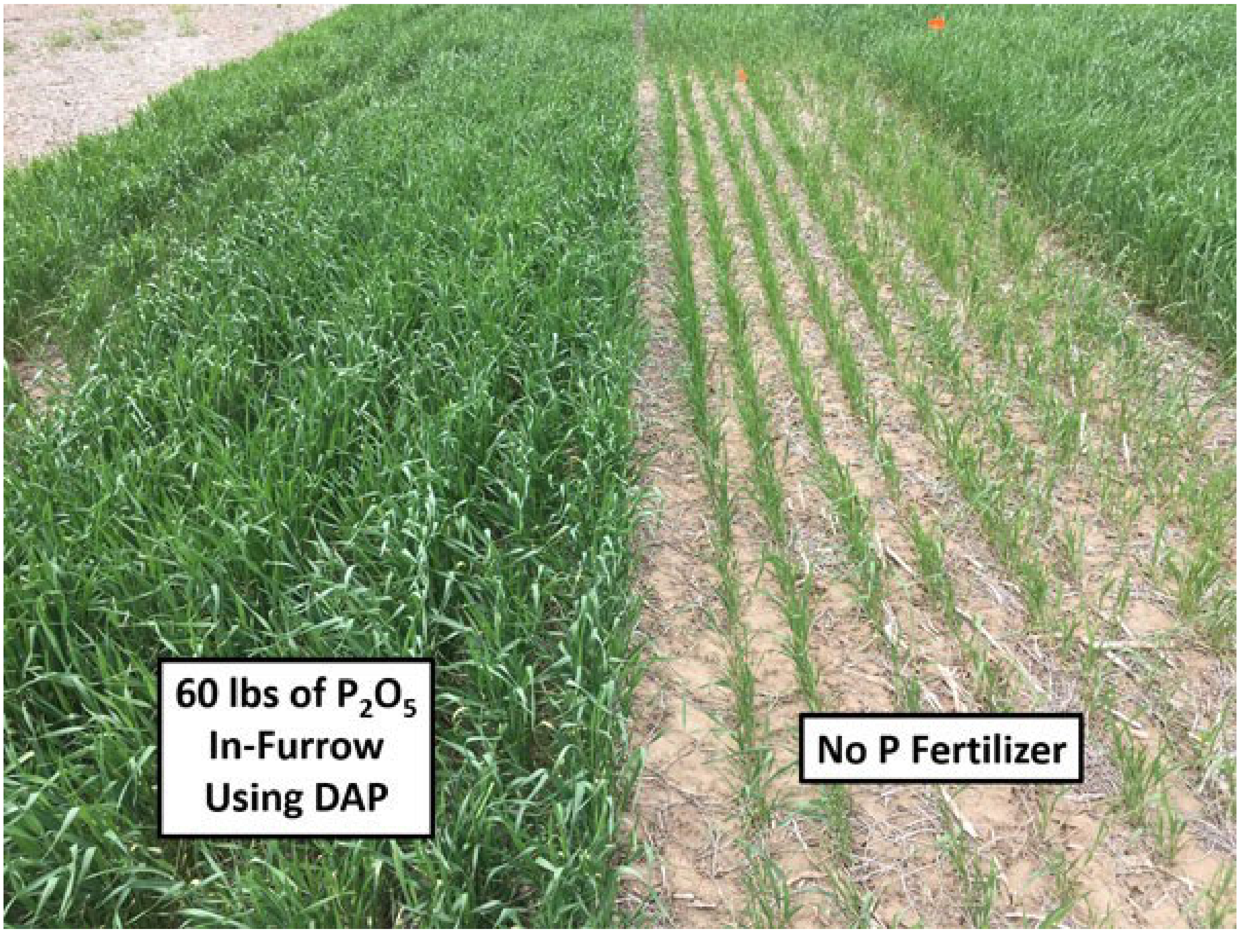

Figure 1. Effects on wheat tillering and early growth with in-furrow P fertilizer on soil testing low in P. Photo taken in 2020 in Manhattan, KS. Photo by Chris Weber, K-State Research and Extension.

In-furrow fertilizer application

Phosphorus fertilizer application can be done through the drill with the seed. In-furrow fertilizer can be applied, depending on the soil test and recommended application rate, either in addition to or instead of, any pre-plant P applications. The use of dry fertilizer sources with air seeders is a very popular and practical option. However, other P sources (including liquid) are agronomically equivalent and decisions should be based on cost and adaptability for each operation.

When applying fertilizer with the seed, rates should be limited to avoid potential toxicity to the seedling. When placing fertilizer in direct contact with wheat seed, producers should use the guidelines in Table 1.

Table 1. Suggested maximum rates of fertilizer to apply directly with the wheat seed

Row spacing (inches)	Pounds N + K_2O (No urea containing fertilizers) Medium-to-fine soil textures	Course textures or dry soils
15	16	11
10	24	17
6-8	30	21

Air seeders that place the starter fertilizer and seed in a 1- to 2-inch band, rather than a narrow seed slot, provide some margin of safety because the concentration of the fertilizer and seed is lower in these diffuse bands. In this scenario, adding a little extra N fertilizer to the starter is less likely to injure the seed - but it is still a risk.

What about blending dry 18-46-0 (DAP) or 11-52-0 (MAP) directly with the seed in the hopper? Will the N in these products hurt the seed?

The N in these fertilizer products is in the ammonium-N form (NH_4^+), not the urea-N form, and is much less likely to injure the wheat seed, even though it is in direct seed contact. As for rates, guidelines provided in the table above should be used. If DAP or MAP is mixed with the seed, the mixture can safely be left in the seed hopper overnight without injuring the seed or gumming up the works. However, it is important to keep the wheat mixed with MAP or DAP in a lower relative humidity. A humidity greater than 70% will result in the fertilizer taking up moisture and will cause gumming or caking within the mixture.

How long can you allow this mixture of seed and fertilizer to set together without seeing any negative effects to crop establishment and yield?

The effects of leaving DAP fertilizer left mixed with wheat seed for various amounts of time is shown in Figure 2. Little to no negative effect was observed (up to 12 days in the K-State study).

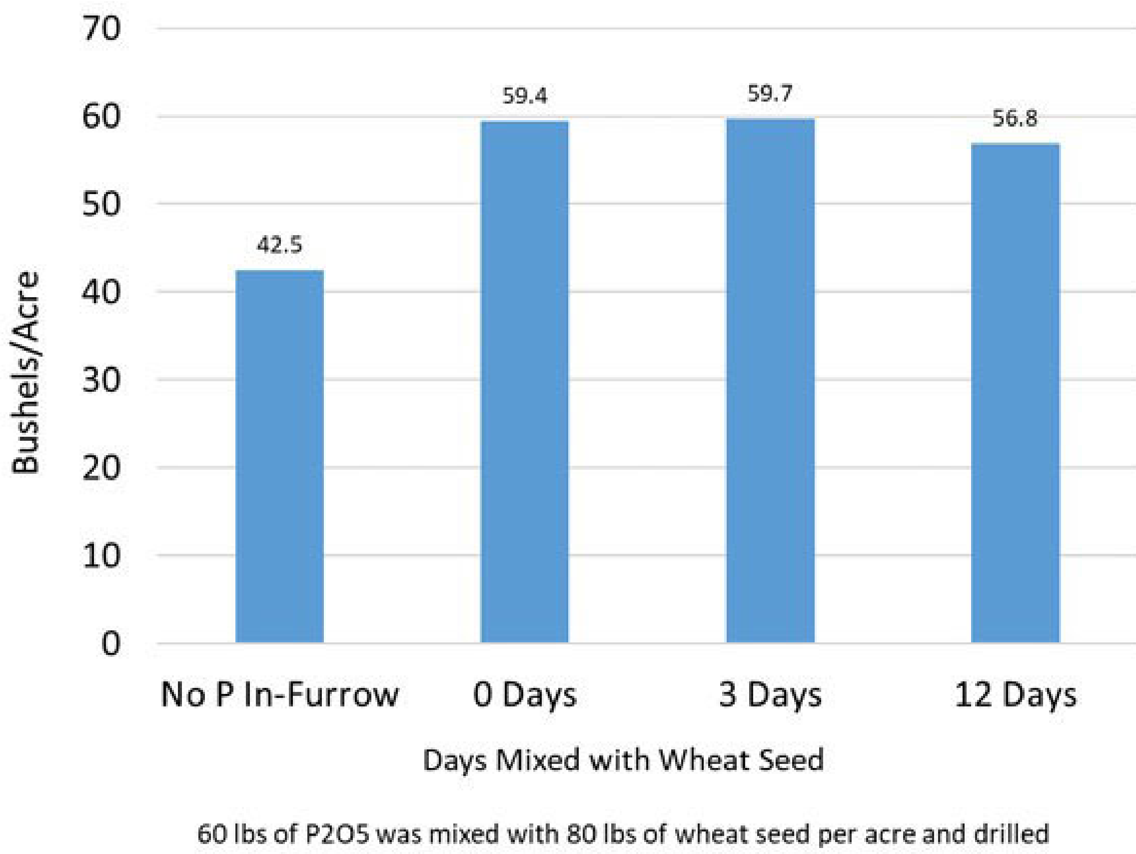

Figure 2. Effects on wheat yield from mixing P fertilizer with the seed. Study conducted in 2019 and 2020 at four sites. Graph by Chris Weber, K-State Research and Extension.

Although the wheat response to these in-furrow fertilizer products is primarily from the P, the small amount of N that is present in DAP, MAP, or 10-34-0 may also be important in some cases. If no pre-plant N was applied, and the soil has little or no carryover N from the previous crop, the N from these fertilizer products could benefit the wheat.

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4. Common causes of late-season stalk lodging in corn

Stalk lodging in corn occurs when the stalk weakens and breaks at some point below the ear (Figure 1). When this occurs, it results in harvest losses and slows down harvesting considerably. Grain moisture levels may also be unacceptably high in lodged corn.

Figure 1. Stalk rot in corn at Kansas River Valley Experiment Field, 2016. Photo by Eric Adee, K-State Research and Extension.

Two common causes of stalk lodging are stalk rot disease organisms or corn borer damage. Stalk rotting diseases in Kansas include charcoal rot, Fusarium, Gibberella, anthracnose, and Diplodia. Stalk rotting diseases are present in the soil or on old crop debris every year, but disease only develops when certain other factors predispose the plants to disease infection.

What are the most common causes of stalk lodging in corn throughout the state?

Carbohydrate depletion in the stalk during grain fill. High-yielding, "racehorse" hybrids tend to produce superior yields at the expense of late-season stalk integrity. These hybrids translocate a high percentage of carbohydrates from the stalks to the ears during grain fill. The latter is reflected with a substantial reduction in the stalk diameter from flowering until maturity (stem shrinking process). This weakens the lower stalk until eventually it will break over, possibly after becoming infected with a stalk rot disease. However, this does not mean producers should stay away from these hybrids. These hybrids have to be managed well. They should be harvested early, shortly after physiological maturity. This may mean harvesting the corn at about 20-25 percent grain moisture. Early harvest can result in discounts for high moisture, but it is better than leaving those hybrids in the field so long that stalks break.

Hybrid differences in stalk strength or stalk rot susceptibility. Some hybrids have genetically stronger stalks than others do. This is often related to a hybrid's yield potential, as mentioned above, and how it allocates carbohydrates during grain fill. However, there are also genetic differences in stalk strength due to other reasons, including better resistance to stalk rot diseases. If a field of corn has stalk lodging problems, it could be due in part to hybrid selection.

Poor root growth and other stresses. Cold, waterlogged soils, severe drought (critical factor for this season), and soil compaction can all result in short, inadequate root systems and crowns that are damaged to the point that water and nutrients cannot effectively move through them. Under these conditions, the roots may not be able to extract enough water and nutrients from soil to support plant growth and carbohydrate production. When carbohydrate production is below-normal during any part of the growing season, the ears will continue to take what they need during grain fill, which can leave the stalks depleted even under average yield conditions. The developing ear always has priority for carbohydrates within the plant.

Poor leaf health. Any factor that results in poor leaf health will reduce carbohydrate production. When carbohydrate production from photosynthesis is inadequate due to loss of green leaf area in the leaves, the plant will mobilize reserves from the crown and lower stalk to complete grain fill (see carbohydrate depletion above).

Gray leaf spot is an important foliar disease in Kansas that can affect stalk rot (Figure 2).

Figure 2. Gray leaf spot on corn. Photo courtesy of Alison Robertson—© APS. Reproduced, by permission, from Wise, K., et al., eds. 2016. A Farmer's Guide to Corn Diseases. American Phytopathological Society, St. Paul, MN.

Many of the highest yielding hybrids lack good resistance to leaf diseases because the use of resistance genes can cause a "yield drag" in the hybrid. Therefore, when growing these hybrids, producers should be ready to apply a fungicide should leaf diseases develop. Bacterial leaf streak continues to spread in the state, however, its relationship to yield loss or increases in stalk rot are still unknown.

Stay green, another characteristic in hybrids, is highly correlated to stalk rot resistance and reduced lodging. The stay green effect associated with the use of strobilurin fungicides has also been reported to reduce lodging. This same characteristic may also interfere with grain dry-down in the field.

High plant density. Plants become tall and thin when supra-optimal populations are used, which result in thin stalks with inadequate strength (Figure 3). In addition, plant-to-plant competition for light, nutrients, and water enhances the competition for carbohydrates between the stalk and ear within the plant, thus reducing the vigor of the cells in the stalk and predisposing them to invasion by stalk rot.

Nutrient imbalances and/or deficiencies. Nutrient imbalances and/or deficiencies predispose corn plants to stalk rot and stalk lodging. Both potassium and chloride deficiency have been shown to reduce stalk quality and strength, and stalk rot resistance. High nitrogen levels coupled with low potassium levels increase the amount of premature stalk death and create an ideal situation for stalk rot and lodging. Soil chloride levels should be maintained above 20 lbs per acre.

Figure 3. High plant density corn presenting late-season stalk lodging. Photo by Ignacio Ciampitti, K-State Research and Extension.

Corn rootworm and corn borers. Damage caused by the corn rootworm and the European corn borer can predispose the corn plant to invasion by stalk rotting organisms, as well as lead to outright yield loss.

Mid-season hail damage. Similar to the damage caused by insects, the physical damage caused by mid-season hail can set up the plant for invasion by stalk rotting organisms. Stalk bruising and the resulting internal damage may also physically weaken corn stalks, making them more likely to lodge later in the season.

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5. Check for stalk rots prior to grain sorghum harvest

It is important to check corn and sorghum fields for stalk rot diseases prior to harvest. The two most common types of stalk rot in grain sorghum and corn are charcoal rot and Fusarium stalk rot. Both diseases are known to survive in crop residue and can survive in the soil for many years. Stalk rots have somewhat similar symptoms so it is useful to be able to tell them apart.

Even in fields where lodging is has not yet occurred, producers should be prepared to deal with stalk rot issues. Stalk rot can be more problematic in sorghum than in corn due to generally thinner stalks in sorghum.

Figure 1. Sorghum lodging caused by Fusarium stalk rot. Photo by Kim Larson, Agronomist.

Annual losses are difficult to determine because, unless lodging occurs, the disease mostly goes unnoticed. The best estimates are that at least 5% of the sorghum crop is lost each year to stalk rot. The incidence of stalk rot in individual fields may reach 90 to 100% with yield losses of 50%. The most obvious losses occur when plants lodge. More important may be the yield losses that go unnoticed. In sorghum, yield losses are caused by reduced head size, poor filling of grain, and early head lodging as plants mature early.

Symptoms generally appear several weeks after pollination when the plant appears to prematurely ripen. The leaves become dry, taking on a grayish-green appearance similar to frost injury. The stalk usually dies a few weeks later. Diseased stalks can be easily crushed when squeezed between the thumb and finger and are more susceptible to lodging during wind or rainstorms. The most characteristic symptom of stalk rot is the shredding of the internal tissue in the lowest internodes of the stalk, which can be observed when the stalk is split. This shredded tissue may be tan colored (Fusarium stalk rots); red or salmon, (Fusarium and Gibberella stalk rots); or grayish-black (charcoal rot).

Table 1. Summary of stalk rots in grain sorghum.

Disease	**Symptoms**	**Weather**
Charcoal rot stalk rot	Internal shredding of lower nodes; black microsclerotia attached to the vascular tissue	High soil temperatures (>90 °F) and low soil moisture during grain fill
Fusarium stalk rot	Internal shredding of lower nodes; tan or pink-to-purple internal discoloration	Dry conditions early and warm (82-86 °F) wet weather 2 to 3 weeks after pollination

Charcoal rot

Hot, dry weather with soil temperatures in the range of 90 °F or more are ideal for the development of charcoal rot. Drought does not cause the problem, but it weakens the plants' defenses. Charcoal rot is usually less severe if drought stress is not a factor.

While it is difficult to separate the effects of charcoal rot from simple drought stress, a good rule of thumb is that plants infected with charcoal rot will die about two weeks earlier from dry weather than plants that do not have charcoal rot. Grain fill that would have occurred during this period is the amount of yield loss that can be attributed to charcoal rot.

The plants will die prematurely. When stalks are split, the typical shredded appearance in the lower stalk associated with all stalk rots will be present. Additionally, there will be a gray to black discoloration of the inner stalk caused by numerous sclerotia (small, black survival structures of the fungus) forming on the vascular bundles and decaying tissue.

Figure 2. Close-up of charcoal rot in grain sorghum. Photo by Doug Jardine, K-State Research and Extension.

Fusarium stalk rot

Fusarium root and stalk rot is generally found in the same areas where charcoal rot develops. The pith of Fusarium stalk rot infected plants will have a shredded appearance and is typically tan in color, but in some hybrids the pith in the lower stalk may be pink to red in color. Plants may die prematurely or lodge.

Fusarium stalk rot is favored by wet conditions early in the season when denitrification or nitrogen loss from leaching. Research has shown that mid-season dry weather may predispose plants to later season problems. Later in the season, following pollination, warm (82 to 86 °F), wet weather can leach remaining nutrients from the soil resulting in late-season nitrogen stress and an increase in stalk rot.

Figure 3. Fusarium stalk rot in grain sorghum. Source: Stalk Rots of Corn and Sorghum**, K-State publication L-741.**

The most recent drought monitor index map for Kansas provides clues as to where stalk rot problems may occur (Figure 4). In the areas of the state currently under drought stress, charcoal rot may be more common. In other parts of the state where there have been alternating wet and dry periods throughout the growing season, Fusarium stalk rot may be more common.

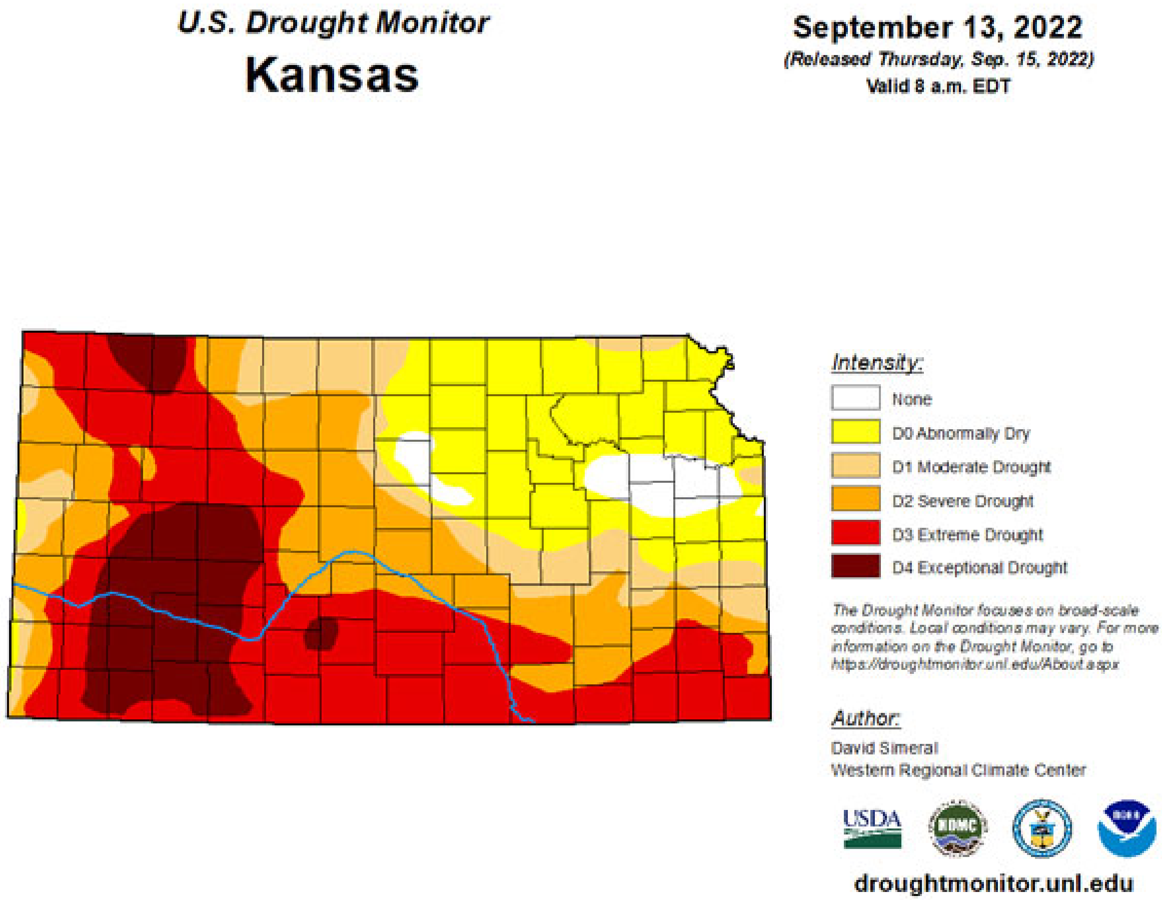

Figure 4. U.S. Drought Monitor Index map for Kansas as of September 13, 2022. https://droughtmonitor.unl.edu/

General considerations

Stalk rot is a stress-related disease. Any stress on a crop can increase both the incidence and severity of stalk rot. Research has indicated that when the carbohydrates used to fill the grain become unavailable due to nutrient shortage, drought stress, leaf damage from insects, hail, disease or reduced sunlight, the plant uses nitrogen and carbohydrate reserves stored in the stalk to complete grain fill. When sugarcane aphid pressure is heavy, there will likely be an increase in the incidence of stalk rot and producers should be prepared to harvest as soon as the grain is ready.

The loss of nitrogen and carbohydrate reserves resulting from leaf damage weakens stalk tissues and results in increased stalk rot susceptibility. Early maturing hybrids are generally more susceptible than full-season hybrids.

Other than irrigation or rain, there is little that can be done to prevent stalk rot by late summer. No hybrid has complete immunity to the stalk rotting pathogens. When choosing a hybrid, a grower should select a hybrid that is not only a high yielder, but one that has good standability and "stay-green" characteristics. This will help assure that if stalk rot does occur, losses due to lodging will be minimal. A balanced nutrition program based on soil tests should be used. Overall fertility levels should be adjusted to fit the hybrid, plant population, soil type, environmental conditions and management program. An excess, as well as a shortage, of nitrogen can lead to increased stalk rot problems.

Producers can check their sorghum for stalk rots by squeezing the lower stem with their thumb and fingers. If the stalks crush easily, they are probably infected with one of the stalk rot organisms and may lodge at any time. Check 100 plants across the field to determine the percent of affected plants. If the percentage of stalk-rot-infected plants is high, sorghum should be harvested as soon as possible, even if it hasn't dried down adequately in the field. If the stalks are firm, the plants will probably be able to stand just fine in the field for several more weeks if necessary.

Rotation with non-susceptible crops, such as small grains and alfalfa, will reduce the severity of stalk rot but will not eliminate it. A good insect control program is a must in limiting losses to stalk rot. In addition to the effect of leaf damage on stalk integrity, pathogens may enter stalks or roots through wounds created by insects. Hail damage will generally increase the amount of stalk rot damage.

For more information, see "Stalk Rots of Corn and Sorghum," K-State publication L-741, at: http://www.plantpath.k-state.edu/extension/publications/L741.pdf

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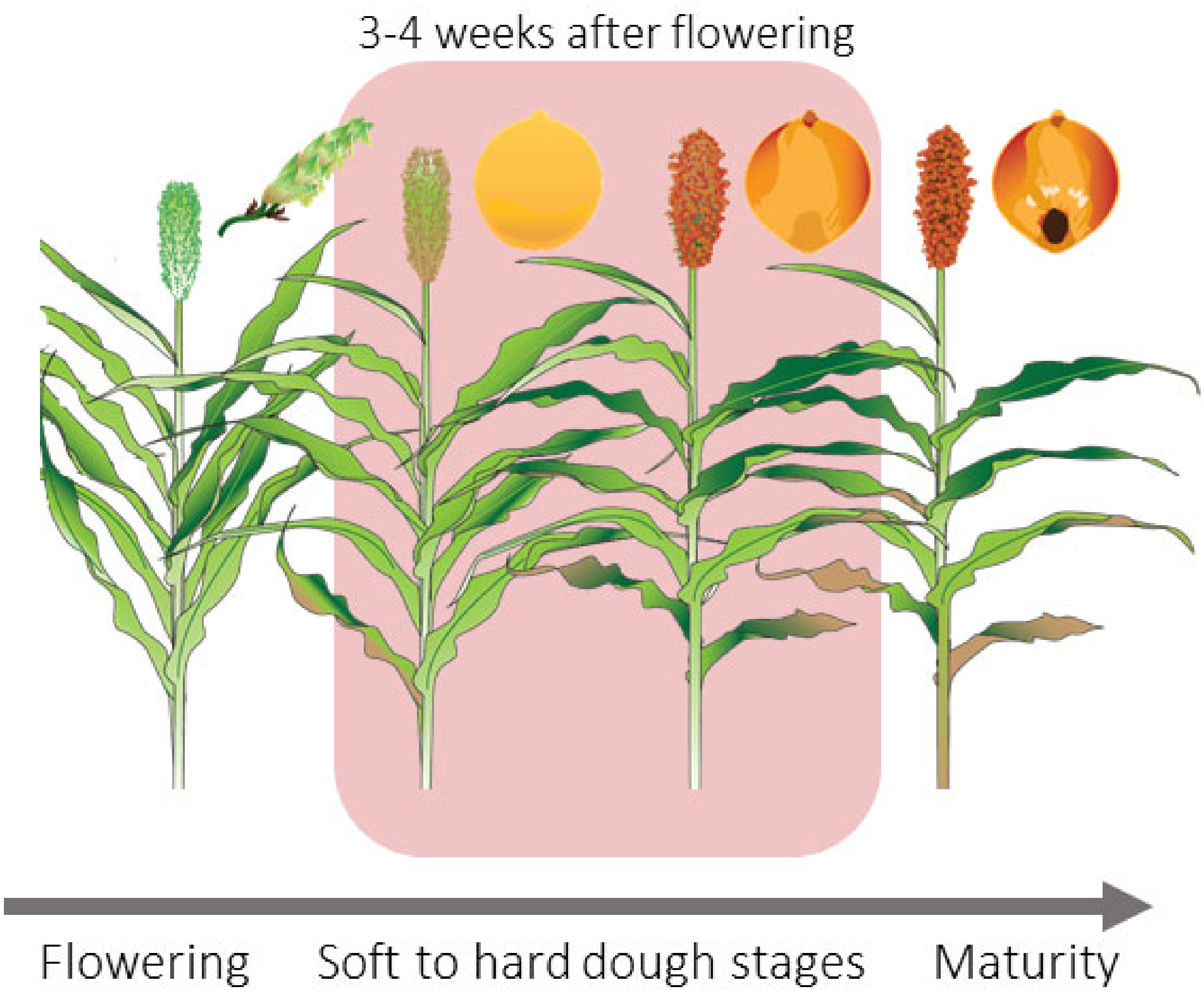
6. Grain sorghum yield potential: An on-farm calculation

Even though estimating crop yields before harvest can be difficult, these estimates are valuable pieces of information for producers which helps them to make informed decisions on inputs.

When can I start making sorghum yield estimates?



As sorghum gets closer to maturity, yield estimates will be more accurate. Nonetheless, we can start taking yield estimations three to four weeks after flowering (from soft to hard dough stages). At these stages, the final seed number can still change. In addition to the seed number, the seed weight will be only partially determined – approximately 50 to 75% of dry mass accumulation as compared to the final weight attained at maturity.

Each of the main sorghum yield components is discussed in more detail in a companion article in this eUpdate issue, "Grain sorghum yield potential: Understanding the main yield components".

Variability within the field

Variability between plants needs to be properly accounted for when estimating sorghum yields using the on-farm approach (see next section). Another important factor is the variation between different areas in the field. In general, it is recommended to perform yield estimations in at least 5 to 10 sections of the field to account for field variability.

On-farm approach for estimating sorghum yields

The estimation of sorghum yields should consider the main driving forces:

1. Total number of heads per unit area [number of plants per acre x heads per plant]
2. Total number of seeds per head
3. Number of seeds per pound
4. Pounds per bushel, or test weight, which for sorghum is **56 lbs/bushel**

The final equation for estimating sorghum yield in bu/acre is:

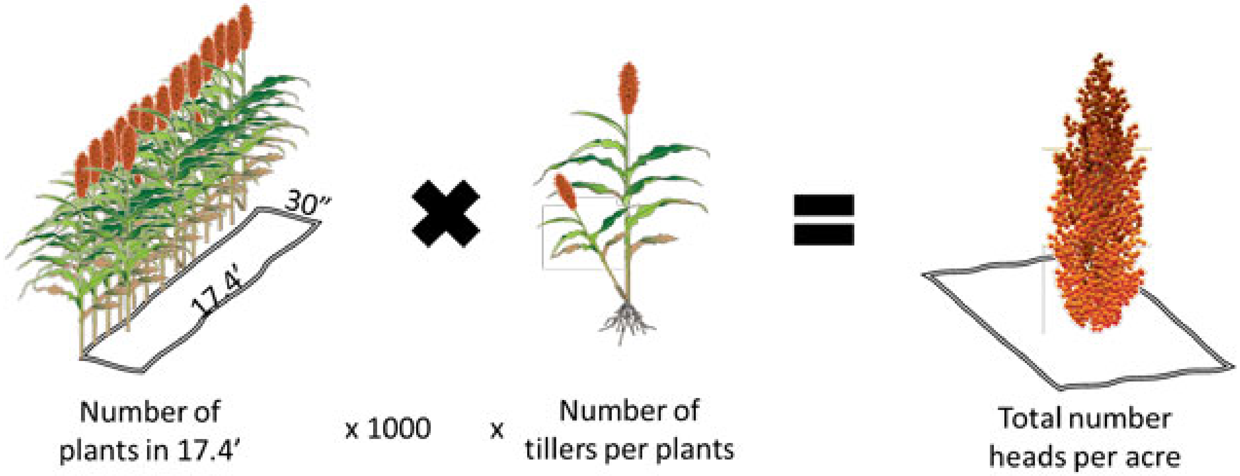
$$\frac{\text{Total number of heads per acre} \times \text{Total number of seeds per head} \div \text{Number of seeds per pound}}{\text{Pounds per bushel } \left(56\,\frac{\text{lbs}}{\text{bu}}\right)}$$

Take the following steps for making sorghum yield estimates:

Step 1. Number of heads per unit area:

For this on-farm approach, start by counting the number of heads from a 17.4-foot length of row when the sorghum is in 30-inch row spacing. This sample area represents 1/1000th the area of an acre. If the sorghum is in 15-inch row spacing, then count the number of heads in two rows. For a 7.5-inch spacing, take into account four rows. In all scenarios, the area counted will be equal to 1/1000th of an acre.

Take head counts in several different areas of the field to properly account for the potential yield variability. If the proportion of smaller heads (less than 3 inches in height) is very low (< 5%), those heads could be avoided due to the smaller proportion for determining the final yield estimation.



Step 2. Estimation of the number of seeds per head:

The seed number is, by far, one of the most complicated yield components that needs to be estimated. The total number of seeds per head can vary from 100 to 5,000 seeds per head, but almost ¾ of the seed number distribution is around 1,500 to 2,500 seeds per head.

A quick method uses an estimate of seed counts per head, we can utilize a very simple association between the yield level, conditions around pollination/grain set time, and the number of grains per heads (Figure 1). The number of seeds per pounds, or seed weight, is also a factor we need to estimate, but this factor is relevant for yield contribution, with a less clear relationship with yield (Figure 1).

This method of estimating seed counts is summarized in Table 1. If conditions were very poor during pollination and grain set and the general yield environment is low, the total number of seeds per head will average around 500-1,000 seeds per head (900; Table 1). If conditions around flowering were very favorable and the general yield environment is very high, then the number of seeds per head could be around 1,500 to 3,500 (2,500). Intermediate yield environment scenarios can occur if a portion of the three-to-four week period around flowering was favorable and part of it was unfavorable. In that case, the number of seeds per head could range from 1,000-3,500, with an average of 1,745 seeds per head.

This information is provided only for general guidance on estimating sorghum yield potential using the on-farm approach.

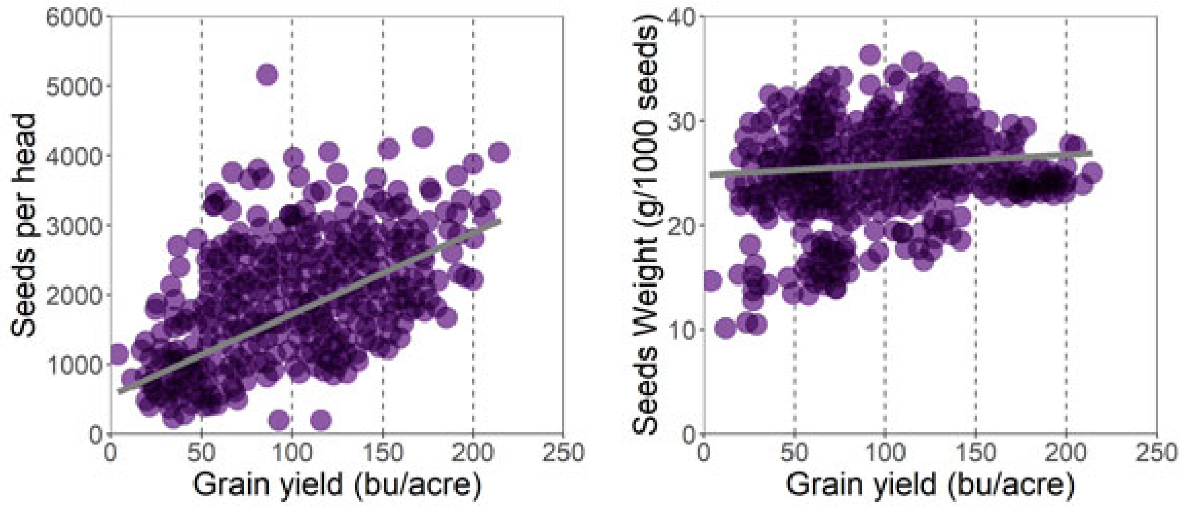


Figure 1. Relationship between grain yield and yield components, seeds per head (left panel) and seed weight (right panel). The number of seeds per head has the most direct relationship with yield.

Table 1. Total number of seeds per head and seed weight components.

Yield range (bu/acre)	Crop condition	Average Seeds per head	Average Seed weight (g/1000)	Number of observations
<50	Very poor	900	24.5	154
50-100	Poor	1500	25.5	391
100-150	Fair	2000	26.2	495
150-200	Good	2500	25.6	129
>200	Excellent	3330	25.5	5

Step 3. Estimation of the Seed Weight:

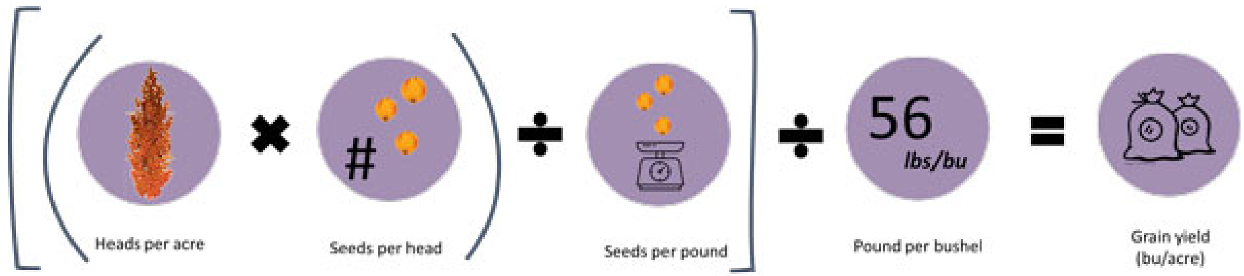
A similar procedure can be followed to estimate the seed weight (Table 1). For the seed weight component, the dataset showed a very narrow variation as compared with the variability in the seed number. In general, it seems that lower seed weight is expected at low yield, but the difference among yield levels is negligible. Table 2 shows the conversion from average seed weight to seeds per pound.

Table 2. Seed weight, seeds per pound.

Yield range (bu/acre)	Crop condition	Average Seed weight (g/1000)	Seeds per pound

<50	Very poor	24.5	18520
50-100	Poor	25.5	17793
100-150	Fair	26.2	17318
150-200	Good	25.6	17723
>200	Excellent	25.5	17793

Step 4. Final calculation using "On-Farm" Yield Estimation Approach:



<u>Example A. Good Crop Condition:</u>

Irrigated sorghum with adequate plant density (48,000 plants/acre), average number of tillers per plant of 1.3, and good yield environment with adequate flowering and grain filling periods:

(48 plants in 17.4 foot -1/1000th of an acre- x 1.3 fertile tillers per plant) = 62 heads/acre
Yield Estimation = [(62 x 2,500) x 1,000 ÷ 17,723] ÷ 56 = **156 bu/acre**

<u>Example B. Poor to Fair Crop Condition:</u>

Dryland sorghum with adequate plant density (40,000 plants/acre), average number of tillers per plant of 1.3, and poor flowering but fair grain filling period:
Yield Estimation = [(52 x 1,500) x 1,000 ÷ 17,723] ÷ 56 = **79 bu/acre**

<u>Example C. Very Poor Crop Condition:</u>

Dryland sorghum with adequate plant density (40,000 plants/acre), average number of tillers per plant of 1.0, and poor yield environment and growing season (poor flowering and grain filling period):
Yield Estimation = [(40 x 900) x 1,000 ÷ 18,520] ÷ 56 = **35 bu/acre**

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7. Grain sorghum yield potential: Understanding the main yield components

In order to best estimate the yield potential of grain sorghum, we need to understand the main plant components of yield (Figure 1). The main yield-driving factors are:

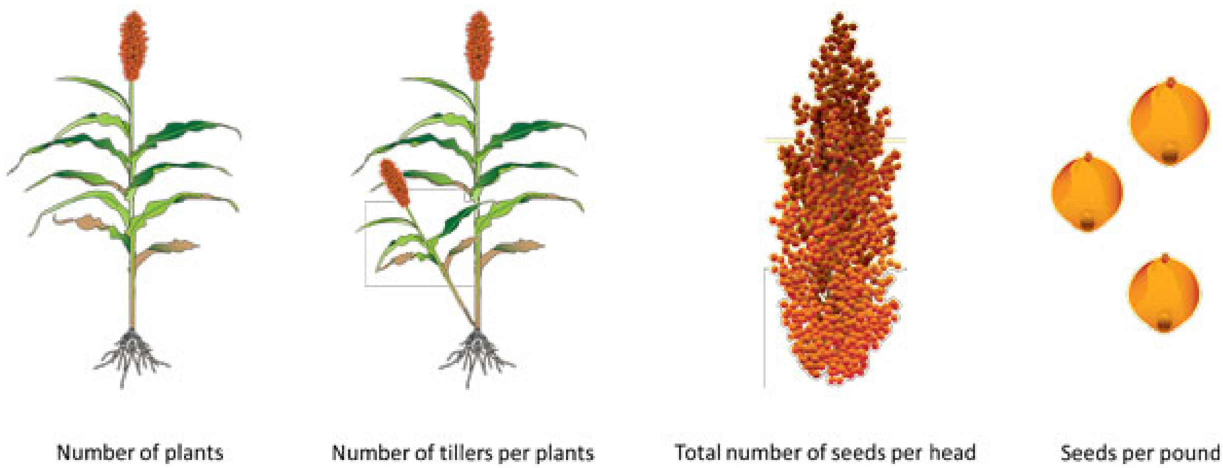

Figure 1. The four main plant components for grain sorghum yield are number of plants, tillers per plant, seeds per head, and seeds per pound. Graphic by Ana P. Carcedo, K-State Research and Extension.

The number of plants and the number of tillers per plant are two of the main components and are determined well before the end of the growing season. The initial plant density, planting date, and the environment, among other factors, influence those two yield components. To learn more about an on-farm approach for calculating sorghum grain yield potential before harvest, please see the companion eUpdate article in this issue, "Grain sorghum yield potential: An on-farm calculation".

Understanding sorghum yield components

Increasing the number of plants per acre potentially increases competition for resources, which can diminish the plant's capacity to produce tillers. In addition, the interaction of planting date with plant density can have a similar effect. As planting date is delayed, the capacity of the plant to produce tillers will be reduced; thus, plant population needs to be increased to compensate for the reduction in the number of tillers. Previous research at K-State showed sorghum produces more tillers when planted early (mid-to-late May) at lower plant populations as compared with late planting dates (mid-to-late June).

The environment also plays an important role in the final number of heads per unit area. Heat and drought stress will reduce the plant's ability to produce more tillers and could severely reduce the tiller survival rate. The total number of seeds per head will be determined within the one- or two-week period before flowering until milk to soft dough stages (approximately two to three weeks after flowering).

Seed size will be determined close to the end of the season. In the 15 to 25 days after flowering, during the soft dough stage, sorghum grains have already accumulated about 50% of the final dry mass. Thus, the period around flowering is critical for defining not only the final number of grains per head but also the potential maximum kernel size. Final seed weight will be determined when the grains reach physiological maturity (visualized as a "black-layer" near the seed base). From this time until harvest, the grains will dry down from approximately 35% to 20% moisture content.

The interaction among all four components will determine the actual yield, but a wide range of variation can be expected in all these main yield-driving forces (Figure 2).

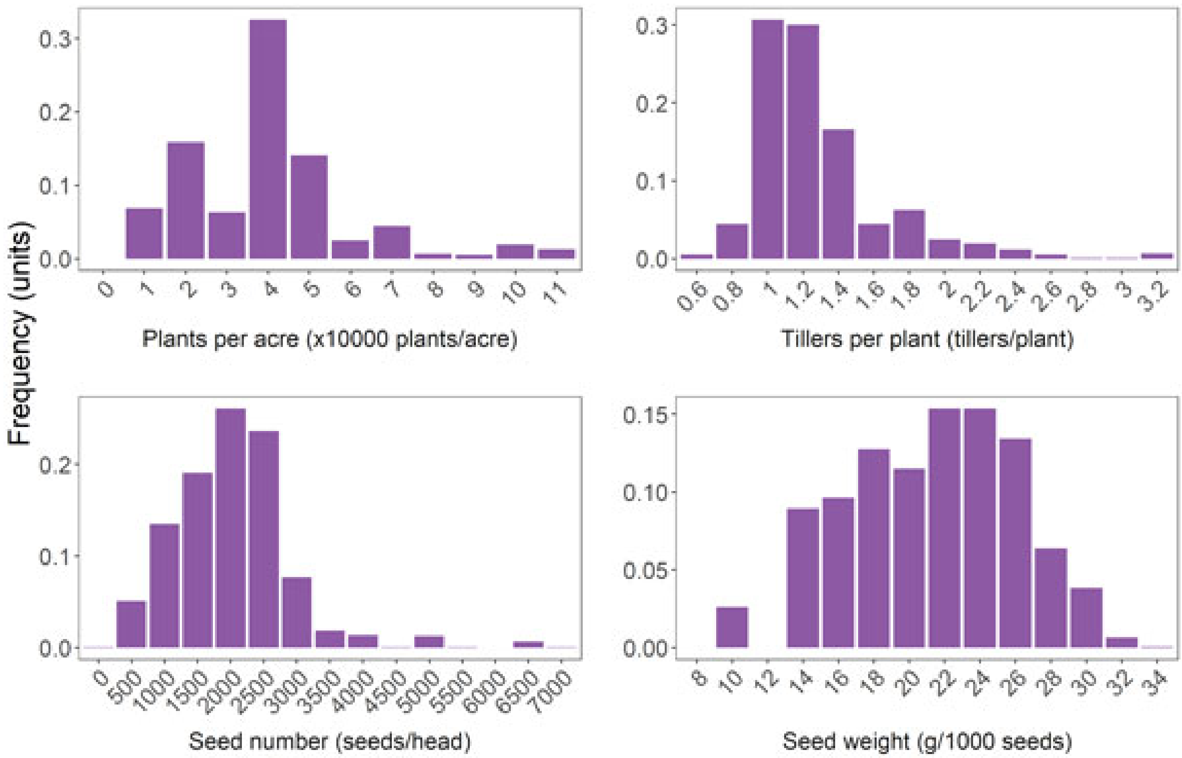

Figure 2. Example of the variation expected to be found in the main sorghum yield components. The number of tillers per plant can also be interpreted as the number of heads per plant, considering that all tillers have one fertile head.

Seed number is the main driving force of sorghum yield. Actual seed counts per head would make the estimates more accurate but requires considerable time and effort.

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8. When do the first freeze and first frost events typically occur in Kansas?

By definition, meteorological fall runs from September 1 through November 30. During this 3-month period, the weather changes dramatically. For example, in Manhattan the average low temperature falls from 62°F to 27°F, and Goodland's normal lows drop from 56°F to 21°F. Somewhere in between the start and end of meteorological fall we expect both a *first frost* and a *first freeze*, the latter of which puts an end to the growing season. The timing varies from year to year, but when on average do these events occur in Kansas? In this report, we take a look at when we typically experience our first frost and first freeze across the state.

Data for 20 sites in Kansas were examined, using the full period of record at each location. For the purposes of this study, the first frost date is defined as the first occurrence of a temperature at or below 36°, and first freeze is defined as the first occurrence of 32° or colder. The dates that the first frost occurred each year were sorted from earliest to latest, and then the dates on which 10%, 20%, 30%, etc., of the first frosts occurred on or before were identified. This methodology was repeated for the first freeze data. In the absence of short-term forecasts, the percentages can be considered probabilities of event occurrence on or before each given date for each location.

First Frost Probabilities

Looking at the first frost data (Table 1), the median date is in October, except for the far west and northwest areas of Kansas where it is in September. The median date is when there is a 50% chance of the first frost having already occurred. The earliest median date is in Oberlin (September 26), and the latest is in Wichita (October 18). Except for Wichita, there is a 10% probability of the first frost occurring before the first of October at all locations, and a 90% probability that the first frost has occurred by the end of October.

Table 1. Probabilities of first fall frost occurring before the given dates.

Probability of First Frost (36°F)									
	10%	20%	30%	40%	50%	60%	70%	80%	90%
Chanute	29-Sep	3-Oct	6-Oct	9-Oct	12-Oct	15-Oct	20-Oct	25-Oct	29-Oct
Concordia	21-Sep	28-Sep	1-Oct	5-Oct	8-Oct	11-Oct	13-Oct	18-Oct	24-Oct
Dodge City	25-Sep	29-Sep	5-Oct	8-Oct	10-Oct	11-Oct	15-Oct	19-Oct	23-Oct
Emporia	28-Sep	1-Oct	6-Oct	8-Oct	10-Oct	13-Oct	16-Oct	19-Oct	25-Oct
Fort Scott	27-Sep	1-Oct	6-Oct	9-Oct	12-Oct	17-Oct	20-Oct	25-Oct	30-Oct
Garden City	20-Sep	25-Sep	27-Sep	30-Sep	5-Oct	8-Oct	10-Oct	13-Oct	18-Oct
Goodland	13-Sep	17-Sep	21-Sep	26-Sep	28-Sep	30-Sep	4-Oct	6-Oct	9-Oct
Hill City	16-Sep	20-Sep	23-Sep	27-Sep	29-Sep	5-Oct	7-Oct	10-Oct	15-Oct
Horton	21-Sep	25-Sep	28-Sep	30-Sep	6-Oct	8-Oct	10-Oct	16-Oct	20-Oct
Manhattan	21-Sep	25-Sep	29-Sep	1-Oct	5-Oct	8-Oct	10-Oct	12-Oct	17-Oct
Marysville	18-Sep	22-Sep	27-Sep	29-Sep	2-Oct	4-Oct	7-Oct	10-Oct	14-Oct
Oberlin	15-Sep	19-Sep	20-Sep	22-Sep	26-Sep	27-Sep	30-Sep	5-Oct	9-Oct
Olathe	26-Sep	1-Oct	5-Oct	8-Oct	10-Oct	13-Oct	17-Oct	20-Oct	26-Oct
Pratt	21-Sep	28-Sep	4-Oct	7-Oct	10-Oct	13-Oct	19-Oct	23-Oct	26-Oct
Russell	22-Sep	26-Sep	1-Oct	3-Oct	6-Oct	10-Oct	11-Oct	15-Oct	21-Oct

Salina	24-Sep	30-Sep	4-Oct	6-Oct	10-Oct	12-Oct	15-Oct	19-Oct	25-Oct
Sedan	27-Sep	30-Sep	5-Oct	8-Oct	12-Oct	16-Oct	19-Oct	23-Oct	26-Oct
Topeka	24-Sep	29-Sep	4-Oct	7-Oct	9-Oct	12-Oct	16-Oct	22-Oct	26-Oct
Tribune	14-Sep	17-Sep	21-Sep	24-Sep	27-Sep	30-Sep	3-Oct	7-Oct	13-Oct
Wichita	1-Oct	7-Oct	10-Oct	13-Oct	18-Oct	22-Oct	24-Oct	27-Oct	3-Nov
	10%	20%	30%	40%	50%	60%	70%	80%	90%

First Freeze Probabilities

There is a 60% or greater chance that the first freeze occurs by the end of October at all locations (Table 2), but the probabilities are higher for earlier dates in the west and north. As was the case with the first frost data, Oberlin has the earliest median date (October 3) and Wichita has the latest date (October 28). September freezes do happen on occasion, and occasionally it's November before the first freeze happens (as was the case for many locations in Fall of 2021). However, October is on average the month when the growing season ends (Figure 1). You can track the current length of the growing season and when the first freeze occurs real-time at http://mesonet.k-state.edu/airtemp/min/hoursbelow/#mtIndex=7&tab=table-tab. You can also determine how long your area was below certain temperatures thresholds of interest to agriculture in the fall and through the winter.

Table 2. Probabilities of first freeze occurring before the given dates.

Probability of First Freeze (32°F)									
	10%	20%	30%	40%	50%	60%	70%	80%	90%
Chanute	10-Oct	16-Oct	19-Oct	22-Oct	25-Oct	27-Oct	29-Oct	3-Nov	6-Nov
Concordia	6-Oct	10-Oct	12-Oct	16-Oct	19-Oct	22-Oct	25-Oct	27-Oct	30-Oct
Dodge City	6-Oct	11-Oct	15-Oct	19-Oct	21-Oct	23-Oct	25-Oct	28-Oct	2-Nov
Emporia	7-Oct	10-Oct	15-Oct	18-Oct	22-Oct	25-Oct	28-Oct	31-Oct	5-Nov
Fort Scott	9-Oct	16-Oct	19-Oct	22-Oct	24-Oct	27-Oct	28-Oct	2-Nov	6-Nov
Garden City	28-Sep	4-Oct	8-Oct	10-Oct	14-Oct	17-Oct	19-Oct	23-Oct	27-Oct
Goodland	22-Sep	26-Sep	30-Sep	4-Oct	8-Oct	11-Oct	13-Oct	18-Oct	22-Oct
Hill City	26-Sep	1-Oct	5-Oct	9-Oct	11-Oct	13-Oct	16-Oct	21-Oct	24-Oct
Horton	29-Sep	5-Oct	7-Oct	10-Oct	12-Oct	17-Oct	22-Oct	25-Oct	29-Oct
Manhattan	1-Oct	7-Oct	10-Oct	12-Oct	15-Oct	19-Oct	21-Oct	25-Oct	29-Oct
Marysville	23-Sep	1-Oct	5-Oct	7-Oct	9-Oct	12-Oct	15-Oct	18-Oct	23-Oct
Oberlin	20-Sep	24-Sep	27-Sep	29-Sep	3-Oct	6-Oct	9-Oct	12-Oct	16-Oct
Olathe	8-Oct	12-Oct	17-Oct	22-Oct	25-Oct	27-Oct	31-Oct	4-Nov	7-Nov
Pratt	6-Oct	10-Oct	14-Oct	19-Oct	22-Oct	24-Oct	27-Oct	31-Oct	5-Nov
Russell	3-Oct	6-Oct	10-Oct	13-Oct	17-Oct	19-Oct	23-Oct	25-Oct	29-Oct
Salina	6-Oct	10-Oct	14-Oct	18-Oct	22-Oct	25-Oct	26-Oct	31-Oct	5-Nov
Sedan	6-Oct	12-Oct	18-Oct	20-Oct	24-Oct	27-Oct	29-Oct	4-Nov	8-Nov
Topeka	4-Oct	8-Oct	12-Oct	17-Oct	20-Oct	24-Oct	27-Oct	29-Oct	3-Nov
Tribune	21-Sep	25-Sep	28-Sep	4-Oct	7-Oct	10-Oct	11-Oct	14-Oct	20-Oct
Wichita	10-Oct	19-Oct	23-Oct	26-Oct	28-Oct	31-Oct	3-Nov	6-Nov	10-Nov

Figure 1. Average first Fall freeze in Kansas (Kansas Weather Data Library).

October is also the month when the normal lows each day decrease the fastest (Table 3); the daily normal temperatures drop by 11 to 14 degrees. By month's end, Goodland, Oberlin and Tribune all have normal lows below freezing. Only locations in eastern and southern Kansas have normal lows in the 40s by October 31; all other locations have normal lows in the 30s.

Table 3. Normal low temperatures for selected dates in October across Kansas. Normals are based on the period 1991-2020.

Change in Normal Low Temperatures Through October							
	Oct 1	Oct 6	Oct 11	Oct 16	Oct 21	Oct 26	Oct 31
Chanute	53	51	49	47	45	43	42
Concordia	50	48	46	44	42	39	37

Dodge City	50	48	45	43	41	38	36
Emporia	51	49	47	45	43	41	39
Fort Scott	53	51	49	47	45	43	42
Garden City	48	45	43	40	38	36	34
Goodland	44	41	39	37	35	33	31
Hill City	47	45	42	40	38	35	33
Horton	49	47	44	42	40	38	36
Manhattan	51	49	46	44	42	40	38
Marysville	48	46	43	41	39	37	35
Oberlin	44	42	40	37	35	33	31
Olathe	52	51	49	47	45	43	41
Pratt	50	48	46	43	41	39	37
Russell	50	48	45	43	40	38	36
Salina	52	49	47	45	43	41	38
Sedan	52	50	48	46	44	42	40
Topeka	51	49	47	45	43	41	39
Tribune	44	41	39	36	34	33	31
Wichita	54	52	49	47	45	43	41

As October draws near, monthly and 8 to 14-day outlooks will better define the chances for the first frost and freeze this year, but until then, understanding the range of possibilities helps to plan for the inevitable return of shorter days, colder nights, and sub-freezing temperatures. Until then, let's enjoy the warmer temperatures while they last, because they won't for much longer.

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