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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. Sharp decline in temperatures: Possible impacts on the Kansas wheat crop

The sudden, sharp drop in temperatures across Kansas observed in late-October 2019 could have varying consequences to the wheat crop, ranging from no impact to some injury in particular fields. Average temperatures dropped from around mid-60 to 70 degrees F on October 26 to approximately -1 to 14 degrees F on October 31 (Figure 1).

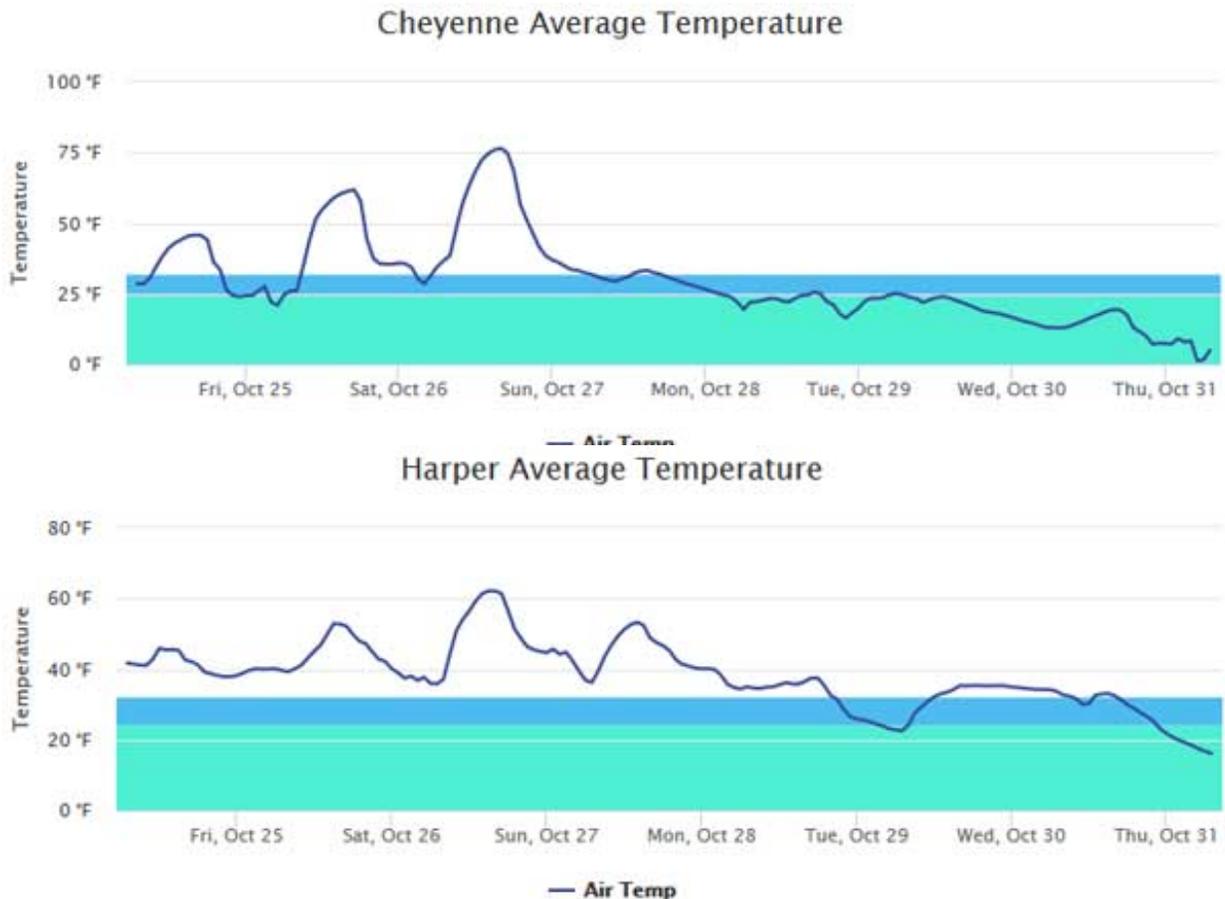
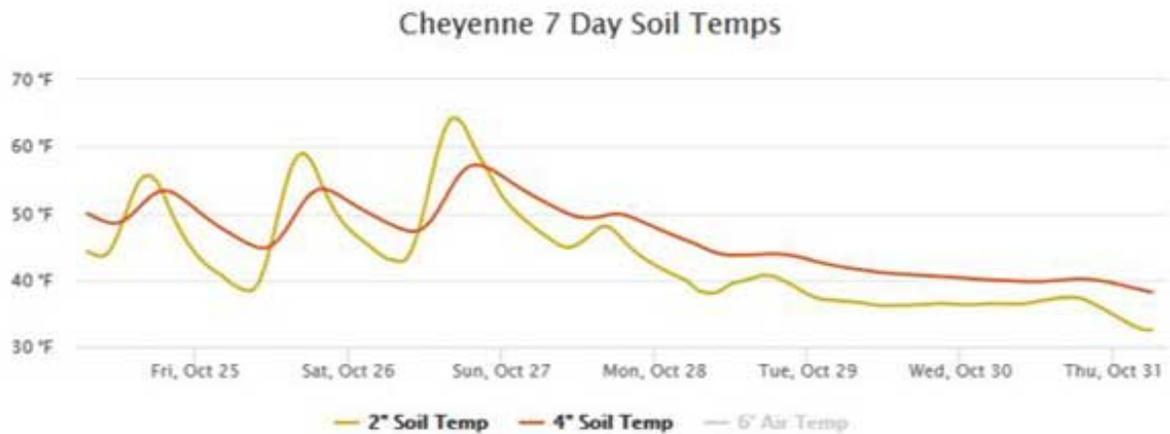


Figure 1. Hourly temperature dynamics from Oct 25 through Oct 31 for Cheyenne (upper panel), and Harper (lower panel). Data courtesy of Kansas Mesonet.

The actual consequences of this temperature drop should be field-specific, depending on the region within the state and several other factors. The snowfall amount and moisture level in the topsoil will be important to help buffer possible injuries resulting from cold temperatures. When more than 2-3 inches of snow is on the soil surface, it helps protect the wheat crop by buffering temperature changes in the surface soil. Topsoil moisture is very variable across the state, with topsoil (2-inch depth) percent of saturation ranging from 17% in Garden City to 93-98% in southeast Kansas (mesonet.ksu.edu/agriculture/soilmoist). Where the soil is dry, it will cause the soil to have a lower thermal buffer capacity, compared to a moist soil, and winter injury might be more pronounced.

While the average soil temperatures followed a similar trend compared to air temperatures, the minimum 2-inch soil temperatures measured across the state was about 26 degrees F in parts of

southwest Kansas (mesonet.ksu.edu/agriculture/soiltemp). While these soil temperatures are relatively low, they could help buffer any negative effects of the sharp air temperature drop (Figure 2).



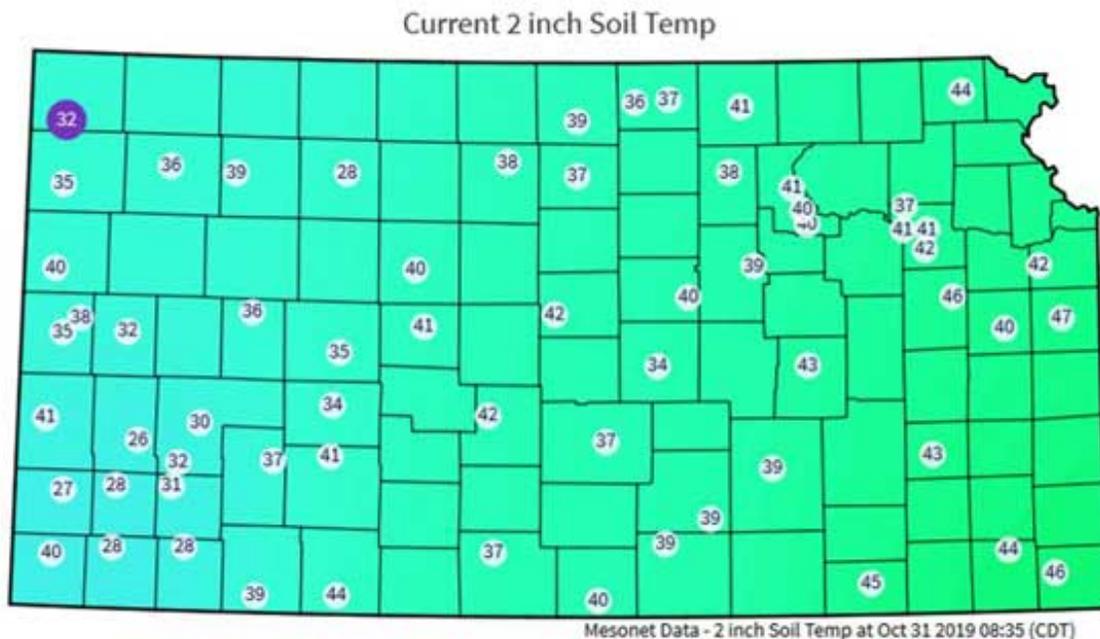


Figure 2. Average soil temperature at the 2-inch and 4-inch depth from 25 Oct to 31 Oct for Cheyenne (upper panel) and Harper (middle panel). Lowest 2-inch soil temperature during the last 7 days (from Oct 25) across the state. Minimum soil temperatures did not reach values lower than 26°F across the state. Data courtesy of Kansas Mesonet.

Possible exceptions could include fields planted in heavy no-till residue, where the furrow might not have been closed properly at sowing, or where there was not good seed-soil contact. Under these circumstances, the lack of furrow closure results in a less protected seedling (and in some fields, crown) which might be more exposed to cold temperatures (Figure 3). Producers are encouraged to start checking for possible injury on lower portions of the fields and especially in no-till fields with heavy residue in the near future, but no immediate damage will be apparent. The cold temperatures also will be more likely to cause injury to wheat if the plants were showing drought stress symptoms and soil temperature might have fallen below those shown on Figure 2, as dry soils will get colder more easily than wet soils. Additionally, the drier and looser the seed bed soil is, the greater the potential for the planting to be exposed to cold temperatures resulting in injury. Meanwhile, firmer and moister soils should help to minimize rapid fluctuations in soil temperatures allowing the wheat to better withstand cold temperatures.



Figure 3. Effect of soybean residue on wheat cold damage. Yellow portions of the field correspond to greater residue left by the combine at soybean harvest and resulted in poorer seed-soil contact at wheat planting. As a consequence, the plants are more exposed to colder temperatures and potential injury. Photo provided by Romulo Lollato, K-State Research and Extension.

Another factor affecting wheat's response to the cold is whether the wheat had time to become properly cold-hardened. It is important to remember that a large portion of the Kansas wheat crop was planted late, after soybean harvest. Therefore, it is still too early to suggest that the wheat has been cold-hardened. In fact, many fields have not even emerged at this point or are just now starting to emerge.

In fields that have not yet emerged but in which seeds are already sprouted, no significant injury should be expected for two main reasons:

1. Recently sprouted wheat generally handles temperatures above 5-10 degrees F well, and soil temperatures never reached those levels.
2. Recently sprouted wheat is still below the soil surface and the warm soil temperatures will likely help buffer the seedling from being damaged by the cold.

In fields where the crop has already emerged, temperatures of around 15 degrees F or less can injure the newly emerged wheat, and these limits decrease as the crop progresses to tillering later in the fall and become more cold-hardy. Thus, some fields in western Kansas where the crop has recently emerged, especially the northwest part of the state, could sustain some level of damage. We likely won't know for sure until temperatures warm up and give us an opportunity to scout.

If fields were affected, the first symptom will be burndown of the wheat from these cold temperatures as shown in Figure 3. If the wheat was bigger-than-normal, the plants may look “rough” with a lot of brown, dead-looking foliage on the soil surface. That doesn’t mean the plants are dead. The important factor will be whether the crown below the soil surface remains alive. Having a well-developed secondary root system will help the plants survive. As temperatures did not drop as low in the central portion of the state, the concern with possible cold injury is not as great as fields that recently emerged in northwest Kansas.

The extent of the unusually large and rapid drop in temperatures is a concern in certain scenarios described above. In fields that were planted earlier, if the wheat did not develop sufficient cold-hardiness, it will be more susceptible to injury from the recent cold snap.

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2. Management adjustments when sowing wheat late

According to the most recent USDA report, about 88% of Kansas wheat has been planted this fall, which is slightly above the 5-yr average of 85%. However, some producers may have delayed planting for different reasons, including harvesting a summer crop during late October or waiting for significant precipitation to occur. Planting wheat in early November is within the acceptable range in southeast and far south central Kansas. In other areas of the state, this is later than desirable, and later than the cutoff date for full crop insurance benefits. Although good yields may still be reached when wheat is planted outside the optimal planting window, late-planted wheat is often subjected to colder fall temperatures and has less time to tiller prior to winter dormancy, which can reduce wheat yield potential and increase the risks of winter injury. Under these circumstances, some management adjustments can be made to try to compensate for the consequences of late planting. These adjustments include:

Increase seeding rate

Late-planted wheat tends to produce fewer tillers during the fall than wheat planted at the optimal time. Fall tillers are generally more productive than spring tillers, contributing more to the crop's yield potential. Therefore, there is a need to compensate for the reduced tillering by increasing seeding rates and adding extra seed per row foot. Wheat seeding rates for Kansas vary depending on the precipitation zone, and increase from west to east (Table 1). Likewise, every week planting is delayed from the end of the optimal planting date range should be compensated by increasing seeding rates by about 150,000 – 225,000 seeds per acre (or 10 to 15 lb/acre) in western Kansas, or 225,000 – 300,000 seeds per acre (15 – 20 lb/acre) in eastern Kansas. Final seeding rate should not be above 90-100 pounds per acre in western Kansas and 120-130 pounds in eastern and central Kansas for grain-only wheat production.

Table 1. Seeding rates for different Kansas regions when planted during optimum planting dates and in grain-only systems. Upwards adjustments to these rates are needed when planting wheat late.

Region within Kansas	Seeding rate for grain-only wheat production, assuming optimum planting date			
	seeds/acre		seeds/sq. ft.*	
	Min.	Max.	Min.	Max.
Western	750,000	900,000	17	21
Central	900,000	1,125,000	21	26
Eastern	1,125,000	1,350,000	26	31
Irrigated	1,200,000	1,500,000	28	34

*To determine row length needed for one square foot based on row spacing, divide 12 by the row spacing of your field. For example, if row spacing is 7.5 inches, $12/7.5 = 1.6$ feet, or 19.2 inches of row

are needed to be equivalent to one square foot.

Maintain the optimal planting depth (1 to 1.5 inch deep)

Wheat needs at least 4-5 leaves and 1-2 tillers prior to winter dormancy for maximum cold tolerance. Late-planted wheat will most likely have fewer tillers and leaves than wheat planted at the optimal timing, and therefore will be more susceptible to winter kill. It is important to plant wheat at the normal planting depth (1 to 1.5 inches below the soil surface) to ensure good root development and anchorage, as well as good crown insulation by the soil during the winter, increasing the chances of winter survival. Shallow-planted wheat is at greater risk of winter injury. If the seed is placed too deeply, it may not have enough vigor in cold soils to emerge well.

Place starter phosphorus (P) fertilizer with the seed

Phosphate-based starter fertilizer promotes early-season wheat growth and tillering, which can help compensate for the delayed sowing date. Additionally, P is less available under colder soil temperatures, which can result in P deficiency under cold weather conditions. When planting late, producers should strongly consider using about 20-30 lbs/acre of P fertilizer directly with the seed, regardless of soil P levels. This placement method is more effective at that time of year than other application methods. The later the planting date, the more fall root development is slowed. The closer the fertilizer is to the seed, the sooner the plant roots can get to it.

Use fungicide seed treatment or plant certified seed

Late-planted wheat is sown into colder soils, which generally increases the time needed for germination and emergence to occur. As a consequence, there is increased potential for seed and soil-borne diseases that affect seedlings and early-season wheat development. Fungicide seed treatment can protect the seed and seedling during the extended time it is subjected to potential seedling diseases, improving stand establishment under poor growing conditions. It is important that the seed treatment thoroughly coat the seeds to ensure good protection. For fungicide seed treatment options, please refer to the most current version of K-State fungicide seed treatment chart available at: <https://www.bookstore.ksre.ksu.edu/pubs/MF2955.pdf>

Variety selection

It is probably too late to make any changes as far as which wheat variety to plant this fall. However, a few points to consider when it is known that wheat will be planted late (e.g. when planning to sow wheat following soybeans) are tillering ability and maturity. A variety that has good tillering ability may offset some of the consequences of late planting, as it might still be able to produce one or two tillers during the fall whereas a low-tillering variety may produce none. Also, late-planted wheat is typically behind in development going into the winter, which might translate into slower development in the spring. This delay can result in plants being exposed to moisture stress and especially heat stress during grain filling, reducing the duration of the grain filling period. Thus, selecting an early-maturity variety with good yield potential may offset to some extent the consequences of late planting by decreasing the chances of a grain filling period subjected to warmer temperatures.

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3. Replanting decisions for winter wheat

As wheat growers evaluate their wheat stand, some may be considering replanting fields yet this fall. In some cases, the emergence might be spotty, with lower areas in the field presenting the worst stand establishment (Figure 1). These low-lying areas are typically not as well-drained, which creates conditions that cause the poor emergence. Other fields might have experienced heavy rains after planting, causing soil crusting and prevented the coleoptile from breaking through the soil surface. If the coleoptile stays underground for more than a week or so, it will start losing viability. At that point, the producer will need to consider replanting.



Figure 1. Poor wheat emergence in lower portions of a wheat field in Saline County, Kansas. Higher areas, as seen in the back of the photo, tend to have good emergence and stand establishment. Photo taken mid-October 2017 by Tom Maxwell, KSRE Agent for the Central Kansas District.

When deciding whether to replant wheat fields it is helpful to consider these factors: i) stand uniformity, ii) percent stand compared to the target stand, iii) replanting date, iv) weed control, and v) insurance cutoff date.

Stand uniformity

As shown in Figure 1, poor wheat emergence caused by poor soil water drainage often results in recognizable field patterns associated with the excessively moist soils. In this case, stands might be relatively uniform in better-drained areas, but non-existent in poorer-drained areas, leading to a high within-field variability. In this case, replanting large areas with poor emergence should have top-priority once conditions are suitable for fieldwork. If a stand is sparse in areas that already emerged, producers should also consider replanting these areas with lower seeding rates to bring final population closer to the desired stand, as discussed below.

Percent stand compared to the goal

In areas with suboptimal and thinner stands than desired, counting the number of emerged plants per row foot and comparing the observed stand to target populations (Table 1) is a good place to start.

The target number of plants per row foot (Table 1) is influenced by seeding rate, seed size, and row spacing, and considering 80% emergence. If seed size is not known, 14,000 to 16,000 seeds per pound can be used for most wheat varieties in Kansas, except those with rather large or small kernels. To determine the average number of plants per foot of row, several random plant counts across the field should be taken, given a more or less uniform emergence throughout the field. If the average number of plants is about 50 percent or more of normal and the stand is evenly distributed, the recommendation is to keep the stand. Wheat's tillering ability can greatly compensate for poor stand provided soil fertility is adequate and the weather is favorable. With less than 40 percent of normal stand, the recommendation is to replant the field. If possible, replanting should be done at a 45-degree angle to the original stand to minimize damage to the existing stand.

Recent K-State research indicates that a minimum of approximately 900,000 emerged plants per acre is needed for most varieties to maximize yields under normal fertility conditions in Kansas. Thus, if producers are not aware of their target plants per row foot, the above threshold might be a good goal for central Kansas producers.

Table 1. Target plants per row foot (80% emergence) based on seeding rate, seed size, and row spacing.

Seeding rate	Seed size	Row spacing (inches)				
		6	7.5	8	10	12
lb/ac	seeds/lb	Target plants per row foot (80% emergence)				
45	12,000	5	6	7	8	10
	14,000	6	7	8	10	12
	16,000	7	8	9	11	13
	18,000	7	9	10	12	15
60	12,000	7	8	9	11	13
	14,000	8	10	10	13	15
	16,000	9	11	12	15	18

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	18,000	10	12	13	17	20
75	12,000	8	10	11	14	17
	14,000	10	12	13	16	19
	16,000	11	14	15	18	22
	18,000	12	15	17	21	25
90	12,000	10	12	13	17	20
	14,000	12	14	15	19	23
	16,000	13	17	18	22	26
	18,000	15	19	20	25	30
120	12,000	13	17	18	22	26
	14,000	15	19	21	26	31
	16,000	18	22	24	29	35
	18,000	20	25	26	33	40

Replanting date and seeding rate

As of late October, most of the state has passed the optimum sowing date, with maybe the exception of south-central or southeast Kansas. For portions of the field with no established stand (the entire stand will need to be replanted), producers should plan to increase their seeding rates by 10-15% for every week past the optimum sowing date.

In areas where a partial stand was achieved but for a total of about 50% stand, or parts of the field that did not emerge evenly, or that the seedlings have perished after planting, producers should make the decision about replanting immediately to avoid further compromising the yield potential.

In portions of the field where stand is below optimum, producers can cross-drill at the rate of 30-40 pounds per acre in western Kansas and 40-60 pounds per acre in central and eastern Kansas, using a double-disc opener drill, if at all possible, to minimize damage to the existing stand. If the replanting is done in November or later, increase the seeding rates to 60-75 pounds per acre in western Kansas and 75-90 pounds per acre in central Kansas. If stands are less than 30 percent of normal, increase these seeding rates by 20-30 pounds per acre. The higher seeding rates are needed because the cool soil temperatures encountered by late planted wheat will likely slow emergence, favor seedling diseases and reduce the potential for fall tillering. Using a fungicide seed treatment can reduce the potential for seedling disease and help achieve the target populations.

Weed control – Pay attention to application timing

A thin wheat stand can increase the potential for weed and grass infestations. In fields with a history of severe weed problems, the wheat stand should probably be replanted or thickened. Keep in mind that the uneven wheat stands can also influence herbicide timing due to different staging of the crop within the same field. Herbicides, such as 2,4-D and dicamba, have very specific application guidelines and attention must be paid to the herbicide label to avoid injury to the wheat crop. Paying attention to wheat leaf staging when controlling weeds can help minimize the consequences of applying these herbicides outside the labeled recommendations. Potential problems due to improper application timing include trapped heads, missing florets, or twisted awns. More-developed plants during the fall often hold the best yield potential; thus, this factor might be considered if a decision needs to be taken between risking some herbicide injury to more developed

plants versus those that emerged late in uneven wheat fields.

Insurance cut-off dates

Finally, some producers might also consider insurance cut-off dates, as they need to ensure their crop is planted prior to this date. The 2019 crop year final plant dates for wheat are shown in Figure 2.

For insurance purposes, crops planted before these dates are insured with no reduction in coverage or adjustment to premium. The final plant date is already past for parts of western Kansas, which means that producers replanting after this date will have a reduction in 1% coverage per day until the end of the late-planting period. For wheat, the late-planting period often occurs about 15 days after the final plant date (Figure 2).

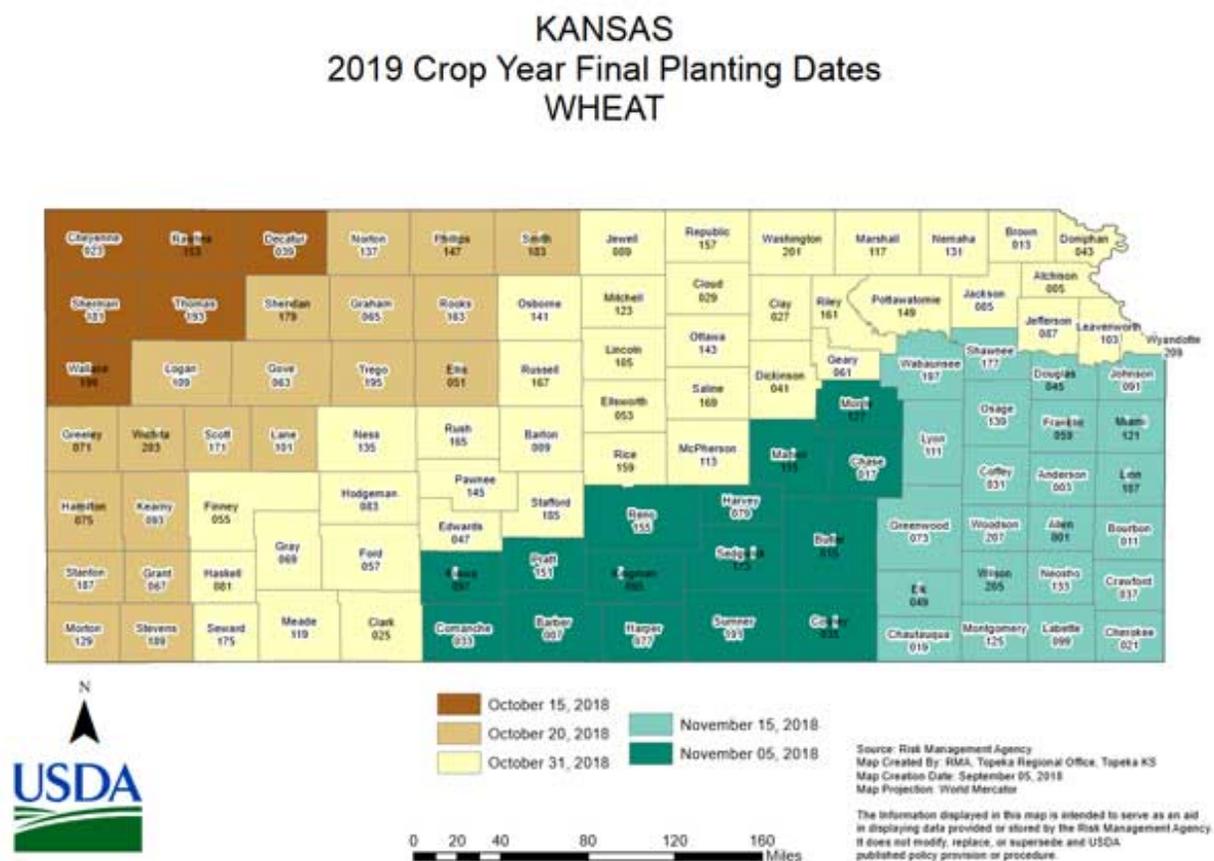


Figure 2. USDA 2019 crop year final planting date for wheat. Crops planted before the dates above can be insured with no reduction in coverage or adjustment to premium. The final planting date for wheat is generally 15 days after the dates above, at a reduction in coverage of 1% per day during the period between initial and final plant date.

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4. As temperatures fall, what factors influence the survival of winter canola?

There was a narrow window for planting winter canola in September 2019. For those in northern parts of the growing area, early September rains set the stage for favorable conditions for stand establishment. Others in central and southern Kansas weren't as lucky as producers waited on a rain to plant the crop. September began with dry conditions and ended with heavy rains. This delayed planting even further as producers waited for dry field conditions, and some were delayed to the point where they couldn't get the crop in on time. In southwest Kansas, dryland establishment of canola would have been complicated, if not compromised, by dry soils. Soil moisture aids rapid and timely emergence of canola, which is critical in attaining the right amount of top and below-ground growth heading into the winter months. How could this, and other factors, affect the winter survival of canola?

Effect of canola plant size on winter survival

Canola overwinters -- and is the most tolerant to cold temperatures -- in the rosette growth stage. At this stage, the crown develops at the soil surface with larger, older leaves at the base and smaller, newer leaves at the center. The stem thickens but its length remains unchanged. To have the best chance at survival, a winter canola plant needs 5 to 8 true leaves, 6 to 18 inches of fall growth, a root collar diameter of $\frac{1}{4}$ to $\frac{1}{2}$ inch, and an extensive root system. Adequately hardened winter canola can withstand temperatures below 0 degrees F for short periods of time.

On the other hand, canola that has too much top growth (typically 24 inches or more) can succumb to winterkill for a number of reasons, including overuse of available soil water and nutrients, stem elongation above the soil surface, and physical damage to the unprotected crown as winter temperatures arrive.

Causes of excessive fall stem elongation

Stem elongation in the fall -- not to be confused with bolting, i.e. stem elongation with visible flowering structures -- may occur because:

- The crop was planted too early allowing growth to continue longer than necessary.
- The crop was seeded at higher-than-optimal plant populations, leading to competition for light resources. This causes etiolation, or an overextension of the plant hypocotyl (the part of the stem between the roots and the cotyledons).
- Excessive soil fertility is present (particularly nitrogen) causing an overabundance of top growth.
- An unusually warm fall persists with no hard freeze events to slow the crop down
- Selection of a poorly adapted cultivar that is more prone to fall stem elongation
- A combination of any of these factors

To explain, closely spaced and crowded canola plants increase early plant-to-plant competition for light. This "reaching" for light may lead to an extension of the growing point above the soil surface.

Any time the growing point (rosette) is elevated, the chances for winterkill are increased because overwintering plant parts are in an unprotected position above the soil surface.

Another factor in stem elongation and winter survival is the amount of surface residue present in the seed row, especially in no-till cropping systems. Too much residue in the seed row can have a buffering (lowering) effect on the temperature surrounding canola plants. This temperature lowering can have a negative impact on survival. In addition, K-State research has shown that residue removal from the seed row is important for keeping the rosette close to the soil surface and more protected. Appropriate residue management (any method to remove residue from the seed row) greatly benefits winter survival.

Planting dates in 2019

As mentioned above, soil moisture conditions dictated planting dates for winter canola in 2019. Late September rains, although needed, delayed planting (Figure 1) in southern Kansas as soils did not dry out in a timely manner. Starting out too dry and ending too wet was a significant challenge in southern Kansas. Fortunately, planting dates can be delayed into October in Barber, Harper, and Sumner counties, and the crop should be able to overwinter if warmer than normal conditions persist in November.



Figure 1. Winter canola plots were seeded into a stale seedbed with highly favorable moisture conditions near Caldwell, KS on October 15, 2019. This is about 10 days beyond the optimum for planting canola in this part of the state (Photo by Mike Stamm, K-State Research and

Extension).

Where canola was seeded on time near Manhattan and Belleville, we are seeing adequate fall growth and there should be little initial concern for this crop going into the winter (Figure 2). At the South Central Experiment Field near Hutchinson, trials were planted on September 20 and a rain was needed for emergence to happen (Figure 3). There is some concern that the current late-October cold snap could negatively affect survival of the crop. Because of the delayed emergence (2 to 3 weeks post planting), the plants do not possess adequate size for overwintering at this time. If temperatures rebound to the 40s and 50s for highs with lows near freezing for a few weeks, this crop should continue to add leaf area before repeated hard freezes move it into dormancy. Warmer temperatures would greatly benefit any late-planted canola.

For those producers concerned about cold temperature effects, visit canola fields about five days after the hardest freeze event. Look for bleached (whitened) leaves, wilted plants, and dead plants (dry and brown) where temperatures dropped below 30 degrees F for several hours. Plant loss will be the biggest concern on canola with 2 or fewer true leaves. Canola that emerged late because of too much or too little soil moisture will be at the greatest risk for cold temperature losses.



Figure 2. Canola plots near Manhattan, KS on October 11, 2019. These plants have four true leaves and are continuing to add leaf area (Photo by Scott Dooley, K-State Research and Extension).



Figure 3. Winter canola stands at the South Central Experiment Field, Hutchinson, planted on September 20. These plants are smaller-than-normal for October 18. Emergence was delayed until rain fell in early October (Photo by Scott Dooley, K-State Research and Extension).

Will the fields with small canola succumb to winterkill?

It is hard to answer this question because there are a number of factors that can affect winter survival. Good winter survival begins with selecting a winter hardy cultivar. Management of the crop, including planting date, fertilization, and seeding rate, can affect overwintering. The environment has the biggest influence and individual canola fields may see different effects from the cold. The ultimate low temperature and the duration of below-freezing temperatures are things to keep in

mind when weighing what might happen. In addition, better survival is often seen when temperatures gradually drop versus rapidly drop. Soil moisture can also influence survival when canola is small, as cold and wet conditions often promote better survival than cold and dry conditions. In the end, an interaction of all these factors will determine how the crop will overwinter. November is typically when canola begins to acclimate to winter conditions. Low temperatures at or below 30 degrees F repeated over several days are essential for winter hardening.

Cultivar differences in overwintering potential

Cultivar differences exist for fall vigor, the ability to avoid fall stem elongation, and winter survival, so it is important to consider these traits when considering what cultivar to grow. Certain open-pollinated and hybrid cultivars have quick establishment in the fall. This is an important trait because it results in rapid plant development, both above and below ground, which is essential for overwintering. However, there can be a tradeoff between excellent fall vigor and too much fall growth, and this usually has to be managed by agronomic practices such as planting date and seeding rate. Planting later to take advantage of vigor may present challenges with winter survival if weather conditions are not favorable for fall growth, which was the case for many in central and southern Kansas.

The K-State Canola Breeding program has been selecting for cultivars that avoid fall stem elongation regardless of the planting date or seeding rate and this often translates into better winter survival. These cultivars have prostrate fall growth which keeps the crown (growing point) more protected at the soil surface. This trait could be especially useful in years when soil moisture conditions are ideal for planting but the calendar indicates it is too early to plant. We hope to broaden the planting window by planting these cultivars earlier while avoiding the risks of fall stem elongation and winterkill.

Current research

K-State agronomists continue investigating production practices to help manage fall vigor and growth. We have recently completed studies evaluating seeding rate by cultivar (open pollinated vs. hybrid) in narrow and wide row spacing (9-in and 30-in). In these studies, winter survival was greater with reduced seeding rates, and yield was similar to that achieved with higher seeding rates. In narrow row spacing, seeding rates around 275,000 seeds per acre were optimal for hybrids and seeding rates around 375,000 seeds per acre were optimal for open-pollinated varieties. In wide row spacing, seeding rates should not exceed 300,000 seeds per acre for both hybrid and open-pollinated varieties.

We are evaluating different plant growth regulators and their ability to help manage fall growth. Using plant growth regulators to manage fall growth in winter canola is a common practice in major winter canola growing regions. In addition to the products, we are evaluating at what growth stage and at what rate do we apply these products in the fall.

We are evaluating the effects of planting systems (planter vs. drill) under different seeding rates to better understand the effects of planting conditions and optimal number of plants under different soil and productivity environments.

Lastly, we are conducting a synthesis and review analysis to identify the main weather and genotype factors affecting winter survival in canola.

Summary

Having too little or too much fall growth in winter canola depends on an interaction of the cultivar chosen, management practices, and the weather. Predicting the weather is challenging enough and this can be stressful on producers. Through breeding and production research at K-State, we hope to find improved ways to manage these risks in winter canola.

For additional information on canola production, please refer to the recently revised "Great Plain Canola Production Handbook" available through K-State Research and Extension.

<https://www.bookstore.ksre.ksu.edu/pubs/MF2734.pdf>

For more information about canola growth and development stages, please consult the K-State Canola Growth and Development poster: <https://www.bookstore.ksre.ksu.edu/pubs/MF3236.pdf>

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