K·STATE
Research and Extension

Kansas Corn Management 2025

MF3208 Crop Production

This publication offers advice to producers, crop consultants, and agronomists to manage Kansas corn crops as efficiently and profitably as possible. The recommendations provide guidelines and must be tailored to each producer's cropping conditions.

Planting Practices

Planting date. Plant corn early to maximize productivity and to use the entire growing season. Optimum planting times in Kansas vary from late March in the southeast to mid-May in the northwest. The optimum soil temperature to start planting corn is when the soil at a 2-inch soil depth reaches 55 degrees Fahrenheit. Check the soil temperature for three consecutive days. It is important to check the temperature forecast to avoid "imbibitional chilling." Optimum planting time should synchronize flowering with adequate summer rains. The distribution and amount of rainfall around flowering (and during grain-filling) greatly influences defining yield potential because they affect grain number and grain size. For rain-fed conditions, planting dates after mid-May decreased yields in eastern Kansas. In the central and northeastern regions, corn yields remained stable from early- to late-planting dates (April 1 to July 1) but significantly increased the risk of frost damage, with effects on yields, after June 15 (more than 20%). For more information, refer to *Corn Planting Dates and Frost Risk in Central and Eastern Kansas,* MF3610, *bookstore.ksre.ksu.edu/pubs/MF3610.pdf.* In this context, in addition to the conventional planting time, farmers in the central region of the state are testing opportunities of delaying planting to better match the critical period around flowering with more favorable precipitation, promoting better yield stability from year-to-year variation. Current research shows this effect is more favorable under yield environments below 150 bushels per acre; however, further evaluation is ongoing to understand the management changes required to improve overall yield for late-planted corn environments.

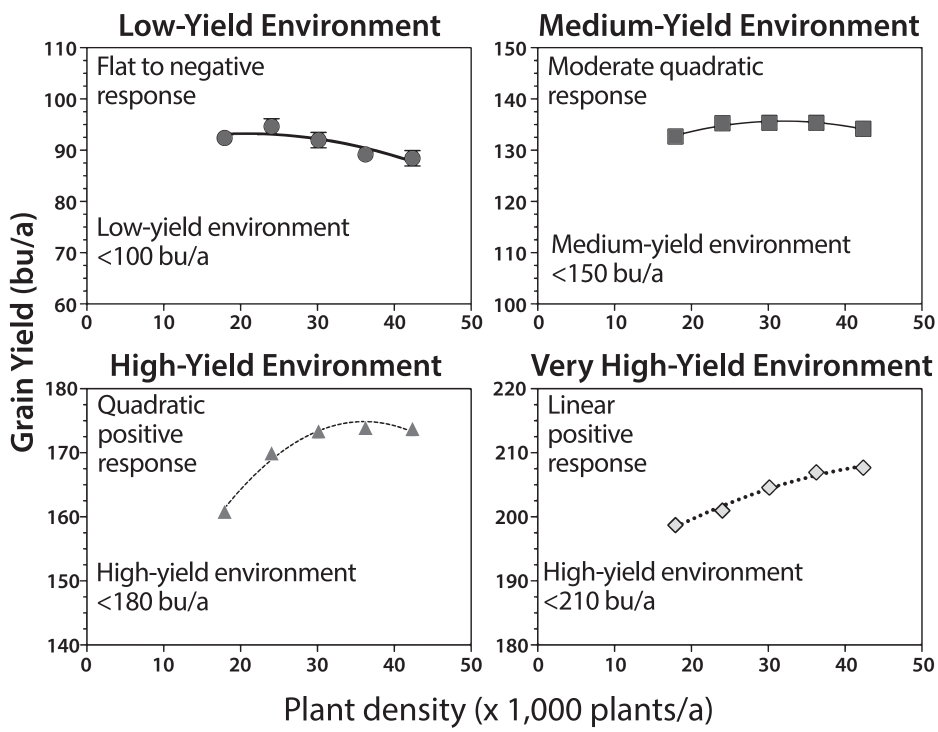


Figure 1. *Corn grain yield response to plant density in four different productivity environments: low yielding <100 bushels per acre; medium yielding 100–150 bushels per acre; high yielding 150–180 bushels per acre; and very high yielding 190–210 bushels per acre. Vertical bars for each mean observation represent the standard error. (Assefa et al., 2016, Crop Sci J).*

Row width. Narrow rows (20- or 15-inch rows) result in greater yields relative to 30-inch rows when yields are greater than 180 bushels per acre. Narrow rows have several advantages, such as rapid canopy closure, weed suppression, improved light capture, and reduced erosion. Plant-to-plant uniformity is a key factor influencing yields. Narrow rows can reduce yields in low-yielding environments (less than 120 bushels per acre).

Planting depth. Optimum planting depth is from 1.5 to 2 inches. Sandy soils (which warm more rapidly), and late planting dates under dry conditions require deeper seed placement to place the seed into moisture. Planting depths of more than 3 inches can result in poor stands in

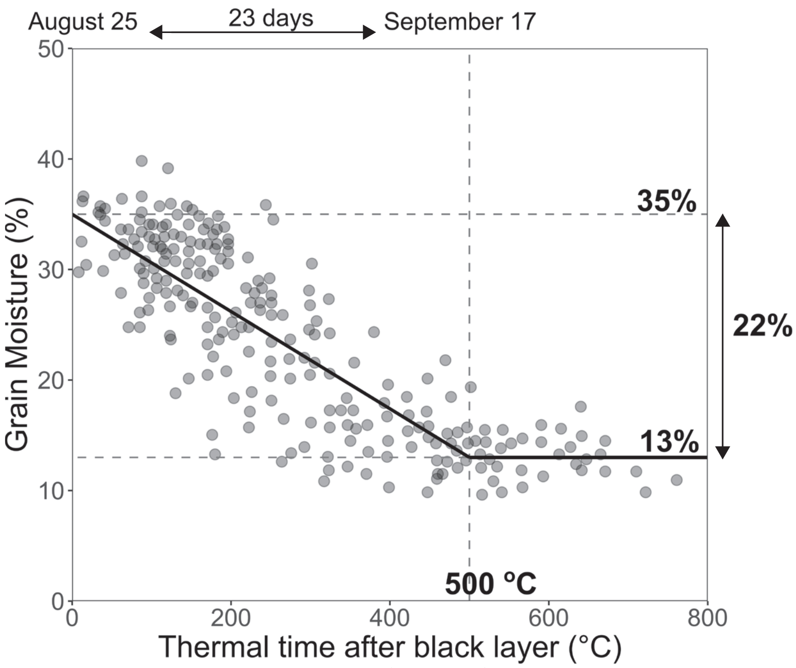


Figure 2. *Grain moisture dry down (solid line) across three hybrids and different nitrogen rates near Manhattan, Kansas. Horizontal dashed lines marked the 35% grain moisture at black layer formation and 13% grain moisture around harvest time.*

any soil condition, which can be exacerbated by soil crusting and greater disease and insect pressure.

Plant Density and Yield Gain

Seeding rate. The optimal seeding rate depends on the environment, hybrid, and practices selected. Producers can look at previous corn crops and evaluate whether plant density was adequate. Consider that yield response to plant density varies with the yield potential for each environment when deciding seeding rates (Figure 1). For low- and medium-yield environments, below 150 bushels per acre, response to plant density tends to be flat or slightly negative at rates higher than 24,000 plants per acre. High-yielding environments (greater than 200 bushels per acre) generally need at least 30,000 plants per acre. More details are available at *https://eupdate.agronomy.ksu.edu/article/optimal-corn-seeding-rate-recommendations-380*.

Dry Down before Harvest

Grain water loss occurs at different rates but with two distinct phases: before "black layer" or maturity and after black layer. For the first phase, Figure 2 shows the changes in grain moisture from maturity to harvest readiness humidity content. The dry-down rate can range from 0.5 to 1.5% per day. The dry-down process after black layer (maturity) can be delayed by low temperatures, high humidity, and high grain moisture content at black layer (38 to 40%). These main factors should be considered when scheduling corn harvest.

The dry-down rate is expected to decrease to less than 0.5% per day for late-planted corn entering reproductive stages later in the growing season. Expect a similar decrease for corn exposed to late-season stress conditions (e.g., drought, heat). Under these conditions, maturity may be reached with high grain-water content, and the last stages after black layer formation could face lower temperatures and higher humidity.

Weed Management

Weeds are a major production problem in corn. An integrated weed-management program consisting of cultural, chemical, and mechanical practices provides the most consistent control of weeds and helps manage and prevent the development of herbicide-resistant weeds (Table 1). An effective herbicide program should include three components: no actively growing weeds at crop emergence, multiple effective herbicide modes of action, and overlapping residual herbicides.

Multiple-pass herbicide programs using diverse herbicide sites of action are key to managing herbicide-resistant and other difficult-to-control weeds. Starting with a clean seedbed is especially important for managing herbicide-resistant weeds and minimizing weed competition. Fall or early spring burndown applications in a no-till system using glyphosate and a product containing dicamba and/or 2,4-D help manage winter-annual and early-spring germinating summer-annual weeds. The choice between 2,4-D and dicamba depends on weed species present. Dicamba products are more effective on kochia and marestail, while 2,4-D is more effective on winter-annual mustards. Applying residual herbicides like atrazine and dicamba in January to early March is key to controlling kochia. Herbicide-resistant weeds make preemergence herbicides essential.

Atrazine (Group 5). Atrazine is a common component of many preplant and preemergence herbicide premixes for corn, as well as being a key component in many postemergence programs. Early-spring applications of atrazine with crop-oil concentrate and 2,4-D or dicamba can control winter-annual weeds such as mustards and marestail and provide control of most germinating weeds up to planting, including kochia. Postemergence atrazine is often included to broaden the spectrum of broadleaf weed control and enhance the activity of some other herbicides, especially Group 27 herbicides. Atrazine-resistant populations of pigweed

Table 1. *Confirmed herbicide-resistant weeds in Kansas.*

Weed species (Number of populations reported)	**Confirmed herbicide resistance**
Palmer amaranth (6)	Group 2 (ALS inhibitors), Group 4 (plant growth regulators), Group 5 (atrazine), Group 9 (glyphosate), Group 14 (PPO inhibitors), Group 27 (HPPD inhibitors), 3-way, 5-way, 6-way
Waterhemp (4)	Group 2 (ALS inhibitors), Group 5 (atrazine), Group 9 (glyphosate), Group 14 (PPO inhibitors), 2-way
Kochia (5)	Group 2 (ALS inhibitors), Group 4 (plant growth regulators), Group 5 (atrazine), Group 9 (glyphosate), 2-way, 4-way
Marestail (2)	Group 2 (ALS inhibitors), Group 9 (glyphosate)
Shattercane (1)	Group 2 (ALS inhibitors)

species and kochia are becoming more common in Kansas; therefore, other effective herbicides, such as those from Groups 27 or 14 should be considered. When controlling atrazine-resistant Palmer amaranth, atrazine should only be considered a synergist for HPPD-inhibiting herbicides rather than an effective site of action to delay the onset of resistance.

Very Long Chain Fatty Acid Inhibitors (VLCFA, Group 15). Common VLCFA-inhibiting herbicides used in corn are acetochlor (Harness, others), S-metolachlor (Dual II Magnum, others), dimethamid-P (Outlook), and pyroxasulfone (Zidua, Anthem). These products provide residual control of annual grasses (except shattercane and perennial johnsongrass) and small-seeded broadleaf weeds such as Palmer amaranth and waterhemp. Group 15 herbicides, except for Zidua, offer poor control of kochia. These herbicides have no postemergence activity and should be applied preemergence or tank mixed with postemergence herbicides as an overlapping residual to provide extended control of problem weeds such as pigweed species. Many metolachlor-containing herbicides are available; however, preference should be given to S-metolachlor, which contains the more effective form of the herbicide molecule. In K-State field trials, up to 50% more metolachlor is required to achieve weed control comparable to S-metolachlor.

HPPD-inhibitors (Group 27). Many available premixes include an HPPD-inhibiting herbicide with atrazine to synergize the foliar and residual activity of the HPPD-inhibitor. Some Group 27 herbicides provide residual weed control (isoxaflutole - Balance), some provide residual and foliar activity (mesotrione - Callisto and bicyclopyrone – component of Acuron), and others provide mostly foliar activity (tembotrione – Laudis, topramezone – Impact/Armezon, and tolpyralate – Shieldex). Products may be applied either preemergence or early postemergence to corn, or both. Group 27 herbicides control pigweed species, kochia, and many other broadleaf weeds but vary in their effectiveness on annual grasses. The most consistent weed control will be observed when an HPPD-inhibitor is applied with at least 0.5 pound per acre atrazine and a Group 15 herbicide.

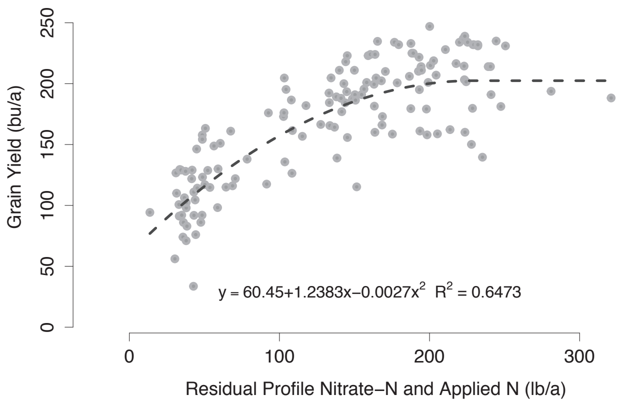
PPO-inhibitors (Group 14). Examples of PPO-inhibitors include flumioxazin (Valor), saflufenacil (Sharpen), and tiafenacil (Reviton). Flumioxazin must be applied 7 days before corn planting in no-till systems and 30 days before corn planting in conventional tillage. These products provide excellent early-season residual control of pigweeds; however, they are marginal on kochia and many grasses. Sharpen has excellent activity on pigweeds, kochia, and large-seeded broadleaf weeds. The length of residual of Sharpen is short compared to other preemergence products at full rates. PPO-inhibiting herbicides that can be applied in-crop include carfentrazone (Aim), fluthiacet (Cadet), and flumiclorac (Resource), which provide good control of velvetleaf, but poor control of pigweed species.

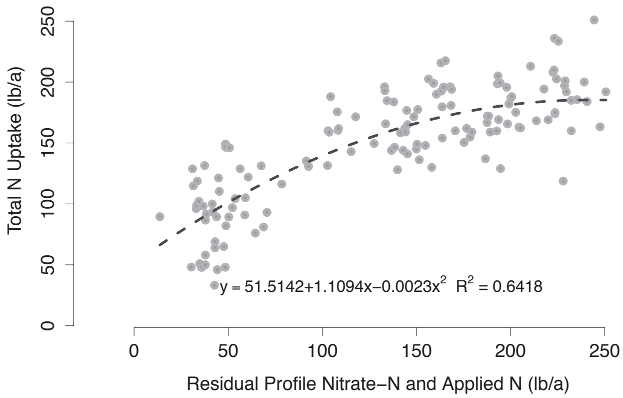
ALS-inhibitors (Group 2). Several ALS-inhibitors are used both preemergence and postemergence in corn and can provide broad-spectrum control of many broadleaf and grass weed species. Many fields contain weeds that are resistant to Group 2 herbicides; however, ALS-inhibitors can be highly effective on susceptible weeds. ALS-inhibitors are often premixed with other classes of herbicides to broaden the spectrum of weeds controlled.

Synthetic auxin herbicides (Group 4). Group 4 herbicides used in corn include dicamba, 2,4-D, clopyralid (Stinger), and fluroxypyr (Starane). These products control broadleaf weeds with varying levels of effectiveness depending on the species treated. Special attention to crop development stage should be given to ensure undue crop injury does not occur when using a Group 4 herbicide.

Other postemergence herbicides. Key postemergence products include glyphosate (Group 9) and glufosinate (Liberty, Group 10), which provide broad-spectrum control of emerged grass and broadleaf weeds but require planting corn with the corresponding herbicide-resistant trait. Many weed populations are resistant to glyphosate, which may limit its effectiveness on weeds such as kochia, Palmer amaranth, marestail, and giant

Figure 3. *Corn grain yield and total plant nitrogen uptake vs. residual profile nitrate–nitrogen and fertilizer–applied nitrogen for corn across several sites over the past 6 years.*





ragweed. See K-State's *2025 Chemical Weed Control of Field Crops, Pastures, Rangeland, and Noncropland*, SRP1190 for more details regarding herbicide options for corn.

Nutrient Management

Fertilizer and nutrient inputs are key components of corn production costs, consider these points when making 2023 production plans.

Test to determine your soil nutrient needs. Before investing money in nitrogen, phosphorus, potassium, sulfur, or zinc, invest in good soil tests for these nutrients. Also, consider testing both the 0- to 6-inch surface soil and the 0- to 24-inch soil profile to improve the reliability for mobile nutrients such as nitrogen, sulfur, and chloride. Nutrient levels vary from field to field, and in different areas of fields, so determine nutrient needs before investing in fertilizer. Obtaining accurate information on soil nutrient levels can allow for significant savings on fertilizer, resulting in a substantial increase in profitability, given the high fertilizer prices. If the phosphorus soil test using the Mehlich 3 test exceeds 20 ppm and the potassium soil test level exceeds 130 ppm, the chances of an economic response to fertilizer in any given year is low.

Starter fertilizer. Most corn in Kansas is planted into cool soils, and much is planted using no-till cropping systems. Research shows placing a band of nitrogen and phosphorus on the soil surface near the seed row enhances early growth, speeds up tasseling, and, in many cases, increases yield — especially in low-phosphorus testing soils or no-till corn planted into corn, sorghum, or wheat stubble. When starter fertilizer is placed with the seed in-furrow, application rates should be limited to no more than 10 pounds per acre of N + K_2O to avoid salt damage and stand reduction.

Nitrogen. Figure 3 shows the relationship between soil test nitrate and fertilizer-applied nitrogen and grain yield and total nitrogen uptake in several corn nitrogen trials across Kansas. There is considerable scatter as results include both irrigated and dryland fields; and water, or lack of water, significantly affects the results. Nitrogen recommendations are strongly improved when the soil test nitrate-nitrogen level is considered. A profile soil test is probably the single most important thing a farmer can do to reduce fertilizer costs and maximize nitrogen use efficiency in corn. A profile soil sample is also valuable for estimating sulfur and chloride needs for corn in Kansas.

When to apply nitrogen. Kansas weather typically gives us dry winters and springs with rainfall increasing in May, June, and July before tapering off through the late summer and fall. Corn typically takes up little nitrogen until the 6- or 7-leaf stage of growth, typically late May or early June. During June and July, corn normally takes up half or more of its total nitrogen; however, this corresponds to the period of maximum rainfall in many years, which corresponds to periods of high potential nitrogen loss. By using a split nitrogen application system that supplies some nitrogen early to support key growth functions such as ear formation, which occurs around V-6, with the balance applied later, nitrogen loss can be minimized, and less total nitrogen will need to be applied. An active crop sensor, such as a Greenseeker or AgLeader OptRx system, can be used to estimate corn nitrogen needs during the growing season. To get the best performance from this tool, limit total nitrogen applications before or at planting to 40 pounds per acre or less and add the remaining nitrogen during sidedressing or a combination of sidedressing and fertigation.

Summary. There are several tools available to help growers take advantage of nutrients stored in the soil and reduce fertilizer application. By incorporating these technologies in a nutrient-management program, Kansas farmers can minimize both input costs and any adverse effects on water supplies. For fields with good yields in 2024, the residual nitrogen is likely very low, and additional fertilizer may be required in 2025 to reach optimum yields. But with widespread drought in some regions of Kansas, yield potential was significantly lower, including complete crop failure in some cases, likely leaving significant amount of nutrients. Adjustment can be made based on profile soil nitrogen test values.

Diseases

During the 2022 season, yield losses from disease in Kansas were estimated at 10.022%. Of that percentage, 4.0% is attributable to nematodes, 1.37% comes from foliar diseases, 1.1% from ear rot diseases, and 3.12% from stalk rot diseases.

Of important note in 2022, tar spot of corn, a disease caused by the fungus *Phyllachora maydis*, was officially detected in Nemaha, Doniphan, Brown, Jackson, Atchison, and Jefferson counties in Kansas. These are the first reports of this disease in Kansas. It is believed the onset of the disease in the 2022 season was too late for significant yield losses; however, the presence of the disease adds a higher risk for the 2025 corn season. Tar spot lesions are black, raised, and have a round/elliptical shape. This pathogen can survive in crop residue, and spores can blow from neighboring fields. There is some evidence that well-timed fungicide applications effectively control tar spot.

Because all commercial seed corn comes pretreated with fungicides, outbreaks of seed rot or seedling blight are not common. The bulk of the yield loss from soil-borne organisms is from nematodes. The most prevalent nematode is the root lesion nematode. It is present at some level in most corn fields in the state. Yield losses in individual fields vary with nematode population density, but average around 5% across the state.

Management options for root-lesion nematodes are limited. Although several nematode-protectant seed treatments are commercially available, the performance of these products has been inconsistent in university trials. Crop rotation can be an effective management strategy when the host range of a particular species of root-lesion nematode is known. Sorghum and soybean, for example, are poor hosts for the most prevalent species of root-lesion nematode associated with corn in Kansas. Other plant-parasitic nematodes that occasionally cause losses include sting and stubby-root nematodes. The risk of damage from these nematodes is greater than for root-lesion nematodes, but both are rare.

In recent years, foliar fungicide use has increased, limiting losses to certain foliar diseases, most importantly gray leaf spot. At the same time, southern rust has become an increasingly important disease. Rising average temperatures have allowed the disease to become established a full month earlier than in the past. When corn is planted late because of wet fields, or when it is double cropped after wheat, southern rust can cause yield losses ranging from 5% to 30%. For additional information, see *Gray Leaf Spot of Corn (www.bookstore.ksre.ksu.edu/pubs/mf2341.pdf), Corn Rust Identification and Management in Kansas* (*www.bookstore.ksre.ksu.edu/pubs/MF3016.pdf*), *Southern Rust* (*www.cropprotectionnetwork.org/encyclopedia/southern-rust-of-corn*) and *Fungicide Efficacy for Control of Corn Diseases* (*www.cropprotectionnetwork.org/publications/fungicide-efficacy-for-control-of-corn-diseases*).

Two bacterial foliar diseases, Goss's leaf blight and corn bacterial streak, cannot be treated with fungicides. Goss's blight management consists almost entirely of resistant hybrid selection. Corn bacterial streak is a relatively new disease. Research to determine if it is yield limiting is in progress. The primary issue with bacterial streak is that its symptoms are easily confused with gray leaf spot, resulting in the misapplication of fungicides. For more information, see *Goss's Bacterial Wilt and Blight (www.cropprotectionnetwork.org/publications/an-overview-of-gosss-bacterial-wilt-and-blight)* and *Bacterial Leaf Streak (www.cropprotectionnetwork.org/encyclopedia/bacterial-leaf-streak-of-corn)*.

Stalk rots cause plants to die prematurely. Under severe conditions, lodging can occur, making harvest more difficult and increasing the overall yield loss. More common, however, is that losses are the result of smaller ears. Four stalk rots commonly occur in Kansas. Fusarium, sometimes known as Gibberella stalk rot, is by far the most common. In hot, droughty years, charcoal rot becomes more common. In areas of the state with higher rainfall and cooler temperatures, anthracnose and Diplodia (Stenocarpella) stalk rot also occasionally occur. Stalk rot management is a combination of hybrid selection, good weed and water management, providing adequate fertility, and managing foliar diseases.

The final group of diseases that cause yield loss are the ear rots. The most common are Aspergillus, Fusarium, Gibberella, and Diplodia (Stenocarpella) ear rots. Severity of any ear rot disease depends on the environment. Aspergillus is more severe under hot, dry conditions. It produces aflatoxin, a mycotoxin that is highly regulated by the FDA because it is a potent carcinogen.

Fusarium and Gibberella also can produce mycotoxins. Fusarium can produce fumonisin, a mycotoxin

Table 2. *Miticides available for controlling spider mites in corn. All product data in this table is directly from the manufacturer.*

Trade name	Active ingredient	Grp #	Residual activity	Knock down	Kills eggs already laid?	Kills newly laid eggs?	Kills larvae?	Kills nymphs?	Kills adults?
Portal XLO	Fenpyroximate	21A	10-14 d	Yes	Yes	No	Yes	Yes	Yes
Comite II	Propargite	12C	30 d	Yes	No	No	Yes	Yes	Yes
Oberon 4SC	Spiromesifen	23	14-30 d	Limited	Yes	Yes	Yes	Yes	Yes (F only)
Hero	Bifenthrin/ zeta-cy	3	10-14 d	Fair	No	No	Yes	Yes	Fair
Brigade	Bifenthrin	3	10-14 d	Fair	No	No	Yes	Yes	Fair
Dimethoate	dimethoate	1	5-7 d	Yes	No	No	Yes	Yes	Yes
Zeal SC	Etoxazole	10B	varies	Minimal	Yes	Yes	Yes	Minimal	Minimal
Onager	Hexythiazox	10A	60 d	No	Yes	Yes	Yes	Yes	No

regulated by the Food and Drug Administration (FDA), and the fungus causing Gibberella ear rot is the same fungus responsible for head scab in wheat, so rotating wheat after corn in a reduced- or no-till tillage system is not recommended.

Diplodia ear rot is common when frequent rains occur at silking and for the 2 to 3 weeks afterward. The shrunken, discolored kernels, combined with excessive debris from shattered cobs, often results in a significant dockage at the elevator. It does not produce mycotoxins.

For more information, see *Ear Rots (www.cropprotectionnetwork.org/encyclopedia/diplodia-ear-rot-of-corn), Mycotoxin FAQs (www.cropprotectionnetwork.org/publications/mycotoxin-faqs), Grain and Silage Sampling for Mycotoxin Testing (www.cropprotectionnetwork.org/publications/grain-and-silage-sampling-and-mycotoxin-testing),* and *Storing Mycotoxin-Affected Grain (www.cropprotectionnetwork.org/publications/storing-mycotoxin-affected-grain)*.

Few other diseases have the potential for economic loss. Common corn smut, however, can be especially severe in corn fields that have been hailed on or are under severe drought stress at the time of silking.

Insect Management

There are several options available for managing both above-ground corn pests, like ear-feeding caterpillars, stalk borers, and foliage feeders, as well as belowground pests, such as western corn rootworm and wireworms. With many fields in Kansas planted to continuous corn, insect resistance management is important to consider when purchasing seed and insecticides for the next growing season. All corn-feeding insects can develop resistance if they are exposed to the same products year after year, so choosing seed with different Bt traits and rotating in-furrow and seed-applied insecticides with different modes of action help minimize this potential problem. For more information on selecting traits visit *www.texasinsects.org/bt-corn-trait-table.html*, and check with your local seed company or extension personnel for the types of Bt resistance present in your area.

Populations of western corn rootworm showing some level of pyrethroid resistance have been documented in western Kansas; minimizing pyrethroid exposure to both larvae and adults in this area is advised. Many ear-feeding caterpillars are showing reduced control by certain insecticides and hybrids expressing Bt toxins; it is advisable to monitor fields to ensure products are controlling caterpillar pests as expected. If control is less than expected (i.e., high larval or adult survival), contact the product sales representative and your local extension agent/entomologist for help determining whether resistant pests are present in your field. It is important to do this immediately before an additional product is applied since resistance is determined by sampling live insects, which are taken directly from the field in question.

When controlling spider mites in corn, there are two things to consider: 1) conserving your beneficial insects whenever possible and 2) not all miticides show the same level of control. Beneficial insects and mites that prey on spider mites are essential to reduce any spider mites remaining in a corn field after miticides have been applied. Spider mites can multiply quickly in the absence of predators, and mites that survive an insecticide application due to poor coverage or timing can multiply exponentially. Harsh insecticides that kill beneficial organisms often cause "flaring" of mite populations post application. Some miticides kill only certain stages of spider mites, while others are more detrimental to beneficials, so knowing how each product works helps producers make more informed decisions about spider mite management (see Table 2).

Japanese beetles are migrating east to west across Kansas and may cause concern if feeding on emerging silks.

See the latest K-State *Corn Insect Management Guide*, MF810, (*www.bookstore.ksre.ksu.edu/pubs/mf810.pdf*) for more details about all insect management options for corn and visit *www.myfields.info/pests* for more information about specific pests in your area.

Machinery

Planting systems have transformed over the last 3 to 5 years. More producers managing large farming operations are adopting 24-row units, although the 16-row unit system is the most common among small- to medium-acreage operations. Newer systems have enhanced sensor integration for accurate control of seed spacing, depth, and seed-to-soil contact. Most new planters use electric seed metering systems. Seed plates are either mounted directly on the electric motor shaft, or the seed plate has gears that mesh with another gear on the electric motor to run the seed plate. A row control module (RCM), either integrated with the electric motor or standalone, receives target motor rpm over the controller area network (CAN) from the electronic control unit (ECU) based on the speed of row unit, population, and seed plate notches/holes. The operational meter rpm implemented over the controller area network provides standalone seed plate functionality independent of other row units. The electric metering units provide many advantages over hydraulic and mechanical systems. The biggest benefit of electric seed meters is fewer moving and serviceable components compared to hydraulic systems, which require maintenance of gears, shafts, hex-shafts, hydraulic systems, and clutches.

In addition to lower maintenance requirements, electric seed meters provide technologies such as automatic row shut-off; turn compensation; any population any row; and two hybrid planting options. The seed tube sensor on each row unit provides feedback on seed singulation, doubles and misses, to a field computer. The newer seed tube also has positive seed delivery using a motorized brush or slot belt with a sensor to provide feedback. The seed tube, with motorized control, releases seed approximately 2 inches from the bottom of the trench at nearly zero relative speed with respect to the ground thereby minimizing seed roll or ricochet and enhancing seed spacing uniformity.

Seed depth uniformity is the next key goal while planting. Consistent seeding is particularly imperative with high-speed planters operating at 7 to 10 mph. An accurate seed depth and seed-to-soil contact is vital for uniform emergence and maximum yield potential. Planter active downforce control is another technology being introduced in most commercial planters. Planters typically use either individual row unit or section (simultaneous control of two or more row units) control to monitor and manage uniform gauge wheel load. Once the planter is set for target seed depth, the user assigns the target gauge wheel load, or margin, into the field computer. Load cells measure real-time gauge wheel load (load distribution between opening discs and gauge wheels) and provide feedback to the field computer for row unit downforce control.

During field operation, if the real-time gauge wheel load decreases from the target value, the downforce system exerts additional pressure on the row unit through parallel linkages to increase the downforce/gauge wheel load, and vice versa in case gauge wheel load increases. These newer technologies along with telematics provide users with real-time planting performance. Users can monitor operating parameters such as speed, population on each row, downforce, singulation, and row unit ride quality to optimize performance, increase efficiency, and enhance productivity.

Irrigation

Corn is the most commonly irrigated crop in Kansas with more than a third of the approximately 3 million irrigated acres in Kansas producing corn. The statewide, irrigated corn yield has steadily risen at a rate of about 2.1 bushels per acre per year since 1974. Although corn does have a sensitive or critical crop growth stage at the beginning of its reproductive stage, it has an excellent water productivity or water use-yield response curve, often making it the most economically sound crop for both full irrigation and deficit irrigation production. In a decade-long research project at Scandia, Kansas, data showed that irrigation applied at the most critical stage of tasseling more than doubled the yield compared to dryland.

Water use requirements. Corn grown in Kansas has reported growing-season crop-water-use requirements ranging from 20.12 to 31.60 inches for the full-season varieties grown (Table 3). The average crop water use for the state would be about 23 inches with a slightly higher value in the west than in the east. The amount varies depending on weather conditions and can be influenced, to a lesser degree, by population and maturity. Daily crop water use can exceed 0.50 inch per day,

Table 3. *Crop water use rates compiled from multiple irrigated crop studies.**

Crop	Seasonal Crop Water Use (ET) (Inches)	Generalized or Reported Maximum Daily Peak Crop Water Use (Inches)
Alfalfa	31.5 – 63.0	0.55
Corn	15.6 – 31.6	0.50
Soybean	17.4 – 27.6	0.49
Grain Sorghum	16.0 – 30.6	0.51
Sunflower	16.0 – 39.4	0.28*
Wheat	15.4 – 25.6	0.54

**Value appears low; see Agricultural Crop Water Use, L934 for more discussion.*

but a three-day average peak crop water use rate is 0.3 to 0.35 inch per day, which is typical with all summer-grown seed crops. Crop water use rate increases with crop growth from emergence until full cover is reached at the beginning of the reproductive stage. This rate begins to diminish as the crop approaches physiological maturity. More information on crop water use of Kansas crops is available in K-State Research and Extension publication *Agricultural Crop Water Use*, L934 (*www.bookstore.ksre.ksu.edu/pubs/L934.pdf*).

Average net seasonal irrigation requirements for corn in Kansas range from about 5 inches in the east to nearly 16 inches in the west. For drier years, net irrigation requirements for 80% chance rainfall (i.e., a dry year value on which the amount of rain one would expect to equal or exceed eight out of 10 years) increase to a range of about 9 inches in the east to more than 17 inches in the west. Yield response to irrigation by corn is excellent. To achieve high crop-water productivity, irrigation systems must be efficient and irrigation water should be scheduled. Scheduling can be achieved by various methods; the most common are soil or climate based. Climate based is often referred to as evapotranspiration (ET) based scheduling. ET is a scientific term for crop water use. A combination of soil- and ET-based scheduling is also complementary since the two methods use different information sources to develop the irrigation schedule and serve as a check. The KanSched irrigation scheduling program is available along with other irrigation decision support tools at *www.milab.ksu.edu/*.

Figure 4. *Corn relative yield response to irrigation at Garden City, KS for 2005 – 2011 (Klocke, et al. 2015).*

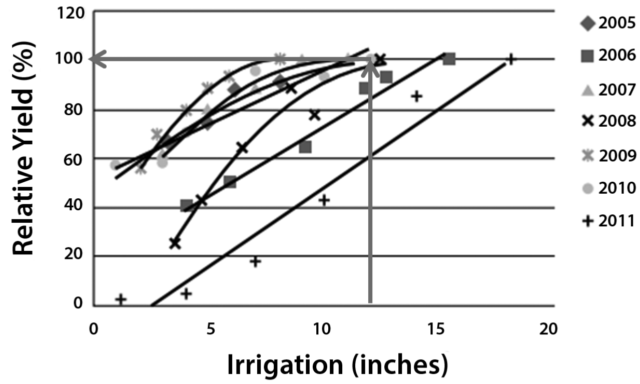


Figure 4 illustrates the importance of scheduling irrigation water based on the need. In this example, six levels of irrigation water were applied each year to develop the annual irrigation water response curve. The yield is shown as relative yield, which is the yield of each year divided by the yield of the highest irrigation treatment yield for that year. The applied irrigation amount for the 100% relative yield for this period of record ranged from about 7 inches to almost 19 inches with an average of about 12 inches, which is marked in Figure 4 with an arrow. If an annual irrigation schedule were based on this average, the irrigation schedule would have been correct for only one year (2008) in terms of matching total irrigation need. Daily scheduling of irrigation amounts would have still been needed to account for the variances of precipitation during the growing season.

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