K·STATE
Research and Extension

Kansas Corn Management 2018

MF3208 | Crop Production

How to Use This Guide

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. To maximize productivity and use of the entire growing season, it is critical to plant corn early. Optimum planting times in Kansas vary from late March in the southeast to mid-May in the northwest. Optimum soil temperature to start planting corn is when the soil at a 2-inch depth reaches 55 degrees Fahrenheit. In medium- to low-yielding environments, below 170 bushels per acre, optimum planting time should synchronize flowering time with adequate summer rains. The distribution and amount of rainfall around flowering (and during grain-filling) have a large influence in defining yield potential, affecting grain number and seed size.

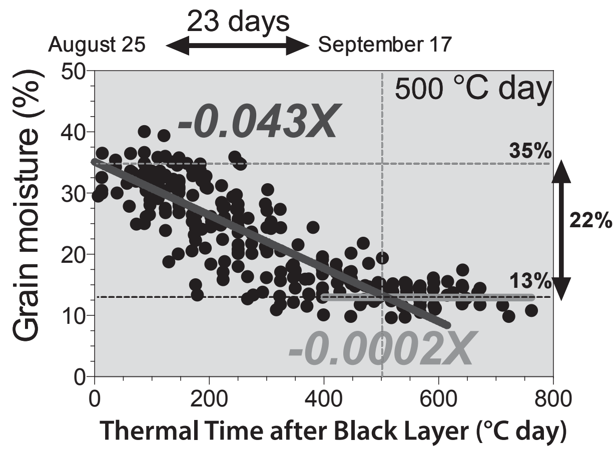
Row width. Narrow rows (20- or 15-inch rows) result in greater yields compared to 30-inch rows in conditions with yields greater than 180 bushels per acre. Narrow rows have several advantages, such as rapid canopy closure, enhanced weed control, improved light capture, and reduced erosion. Narrow rows can present poor and non-uniform stands (use of grain drills or air seeders — without metering seeds). Plant-to-plant uniformity is a key factor influencing corn yields. In low-yielding environments (less than 120 bushels per acre), narrow rows can reduce yields.

Planting depth. Optimum planting depth is from 1.5 to 2 inches. Sandy soils, which warm more rapidly, and late planting time 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 any soil conditions, which can be exacerbated by soil crusting and greater disease and insect pressures.

Plant Density and Yield Interaction

Seeding rate. The optimal seeding rate depends on the environment, hybrid, and practices selected. Producers can look at previous corn crops and evaluate whether that plant density was adequate. Planting date, hybrid (genotype), row spacing, and rotations also influence the yield response to plant density.

Figure 1. *Grain moisture dry down (orange line) across three hybrids and different nitrogen rates near Manhattan, Kan. Horizontal dashed lines marked the 35 percent grain moisture at black layer formation and 13 percent grain moisture around harvest time.*



Dry down grain moisture rate, 23 days
↓ 22% moisture
Final estimated rate ~ 1% drying down per day after black layer formation

A detailed review of a database from Dupont Pioneer helped synthesize the yield response to plant population under different yield environments. Overall, yield response to plant density was: slightly negative in the low-yielding environment with average yields below 100 bushels per acre; flat when yield productivity environment was between 100 to 150 bushels per acre; positive and quadratic with yield improving as plant number increased until an optimal point and then plateauing, with a productivity environment potential ranging from 150 to 180 bushels per acre; and in the last scenario, yield increased almost linearly relative to the plant number factor but with a less than proportional yield improvements as maximum yield value approached 210 bushels per acre.

Rate of Dry Down in Corn before Harvest

Grain water loss occurs at different rates but with two distinct phases: 1) before "black layer" or maturity (Figure 1), and 2) after black layer. For the first phase, Table 1 contains information on changes in grain moisture from dent until maturity of the corn. For the conditions experienced in 2017 (from late August until mid-September), the overall dry down rate was around

Table 1. *Growth stages, moisture content, and total dry matter progression for corn during the reproductive period.*[1]

R Stage	Moisture %	Dry Matter (% of Total Dry Weight)	Average per Substage: Growing Degree Days, °F	Average per Substage: Days
5.0	60	45	75	3
5.25 (¼ milk line)	52	65	120	6
5.5 (½ milk line)	40	90	175	10
5.75 (¾ milk line)	37	97	205	14
6.0 (Physiological maturity)	35	100		

[1] Abendroth, L.J., R.W. Elmore, M.J. Boyer, and S. K. Marlay. 2011. *Corn Growth and Development*. PMR 1009. Iowa State Univ. Extension. Ames Iowa.

1 percent per day (from 35 percent to 13 percent grain moisture) – taking an overall period of 23 days (Figure 1). The dry down process can be delayed by low temperatures, high humidity, and high grain moisture content at black layer (38 to 40 percent). It is expected that the dry down rate will decrease to less than 0.5 percent per day for late-planted corn entering reproductive stages later in the growing season. A similar decrease is also expected 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. These main factors should be considered when the time comes to schedule corn harvest.

Weed Management

There are several preplant and preemergence residual herbicides as well as postemergence herbicides available for corn. Two-pass herbicide programs using multiple modes of action are key to managing glyphosate-resistant and other difficult-to-control weeds. Starting with a clean seedbed is especially important for managing glyphosate-resistant weeds. Early spring burndown applications in a no-till system using glyphosate and a product containing dicamba or 2,4-D helps manage weeds. The choice between 2,4-D and dicamba depends on weed species present. Dicamba products are more effective on kochia and marestail. 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. With the development of glyphosate-resistant weeds, it is essential to use preemergence herbicides.

Acetamides and acetamide/atrazine premixes. The main acetamide products used in corn contain acetochlor, S-metolachlor, dimethamid-P, pyroxasulfone, or flufenacet. Many premix products contain one of these five active ingredients. In general, these products are effective in controlling annual grasses (except shattercane and perennial Johnsongrass) and small-seeded broadleaf weeds such as pigweeds. The products have little postemergence activity but may be tank mixed with postemergence products to provide extended residual control of problem weeds like Palmer amaranth or waterhemp. The acetamide products are most effective when applied with atrazine.

HPPD-inhibitors. Examples of HPPD-inhibitors are isoxaflutole (e.g., Balance Flexx, Corvus, and Prequel), and mesotrione (e.g., Callisto and many generic mesotriones, Callisto Xtra, Acuron, Acuron Flexi, Lexar EZ, Lumax EZ, Revulin Q, and Zemax). These products either contain atrazine or should be applied with atrazine and provide control of kochia, pigweeds, velvetleaf, and many other broadleaf weeds. Acuron and Acuron Flexi also contain the HPPD inhibitor bicyclopyrone, which enhances control of large-seeded broadleaf weeds. Some of these products may be applied preemergence or early postemergence. Other effective postemergence HPPD products include tembotrione (Laudis and Capreno), topramezone (Armezon, Impact), and mesotrione (Callisto, generics, and Halex GT). Halex GT also contains S-metolachlor and glyphosate. Resicore is a new product containing mesotrione, clopyralid, and acetochlor that provides excellent broad spectrum weed control. All HPPD inhibitors should be applied with at least 0.5 pound atrazine. HPPD herbicides effectively control pigweed, kochia, and many other broadleaf weeds, but vary on their effectiveness on annual grasses.

Triazine. 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. March 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 weeds like kochia. Add glyphosate to the mix if winter annual grasses are present. Postemergence atrazine is often included in the tank of postemergence programs to broaden the spectrum of broadleaf weed control and often synergizes various groups of herbicides.

PPO-inhibitors. Examples of PPO-inhibitors include flumioxazin (e.g. Valor, Fierce), and saflufenacil (e.g. Sharpen, Verdict). Valor or Fierce must be applied 7 to 30 days before corn planting in no-till systems, and these products provide excellent control of pigweeds; however, they are marginal on kochia. Sharpen and Verdict herbicides have excellent activity on pigweeds, kochia, and large-seeded broadleaf weeds. Length of residual of Sharpen and Verdict is relatively short compared to other preemergence products at full rates. POST PPO-inhibitor products include Aim, Cadet, and Resource, which are most effective on velvetleaf.

ALS-inhibitors. Several ALS-inhibitors are used both postemergence and soil-applied. Postemergence herbicides for corn are often premixed with herbicides having different modes of action. The ALS actives include flumetsulam (Python, Hornet WDG, SureStart II, TripleFLEX II, Trisidual), rimsulfuron (Solida, Resolve Q, Instigate, Prequel, Basis, Basis Blend, Harrow, Crusher, Realm Q, Require Q), and thiencarbazone-methyl (Corvus, Capreno, Autumn Super). Many of these products have preemergence and postemergence activity on many broadleaf and grass weed species when the weeds are not ALS resistant. ALS inhibitors are often premixed with other classes of herbicides to broaden the spectrum of weeds controlled and to help control ALS-resistant weeds.

Other postemergence herbicides. Key postemergence products include glyphosate and glufosinate (Liberty 280), which control grass and broadleaf weeds, while the growth regulators including dicamba, 2,4-D, and fluroxypyr (Starane products) all provide broadleaf weed control at varying levels of effectiveness depending on species treated.

See K-State's *2018 Chemical Weed Control of Field Crops, Pastures, Rangeland, and Noncropland,* SRP1139 for more details regarding herbicide options for corn.

Nutrient Management

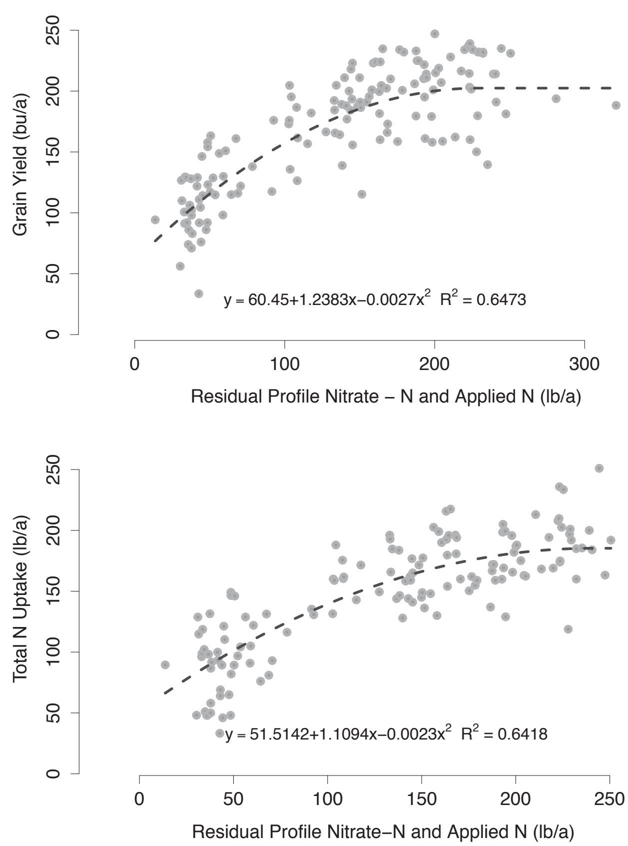
With continuing low grain price for the corn crop, many growers continue to focus on producing good yields as efficiently as possible. Since fertilizer and nutrient inputs are a key component of corn production costs, consider these points when making 2018 production plans.

Soil test to determine your 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 and sulfur. Nutrient levels vary from field to field, and in different areas of fields, so determine nutrient needs before investing in fertilizer. 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 over the past decades has shown that 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 2 shows the relationship between soil test nitrate and fertilizer-applied nitrogen and grain yield and total nitrogen uptake in a number of 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. But nitrogen recommendations are strongly improved when the soil test nitrate nitrogen level is considered. Profile soil test is probably the single most important thing a farmer can due to reduce fertilizer costs and maximize nitrogen use efficiency in

Figure 2. *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.*



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. The use of an active crop sensor such as a Greenseeker or AgLeader OpTrix 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 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. In many cases yields were high during 2017 leaving low residual nitrogen, and additional fertilizer may be required in 2018 to reach optimum yields. This adjustment can be made based on profile soil nitrogen test values.

Diseases

Yield losses from disease in Kansas average an estimated 17.8 percent. Of the total, approximately 5.3 percent is attributable to soilborne pathogens. Another 1.7 percent comes from foliar diseases, and 0.3 percent from ear rot diseases. The largest contributors to yield loss are stalk rots, accounting for 10.5 percent of losses.

All commercial seed corn comes pretreated with fungicides and outbreaks of seed rot or seedling blight are not common. The bulk of the yield loss from soilborne organisms is from nematodes. The most common nematode is the root lesion nematode. It is present at some level in nearly all corn fields in the state. Yield losses in individual fields from root lesion nematodes can exceed 40 percent. There are several commercially available seed treatment nematicides currently marketed, but in university trials, results have been inconsistent. Since root lesion nematode has a wide host range, crop rotation has limited benefits. Other plant-parasitic nematodes that occasionally cause losses include the sting, stunt and stubby-root nematodes.

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 its historical 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 10 to 30 percent.

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 new disease. It is not known at this time if it is yield limiting. The primary issue with bacterial streak is that its symptoms are easily confused with gray leaf spot, resulting in the misapplication of fungicides.

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 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 ear rot. Severity of any particular ear rot disease is usually dependent 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. 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 two- to three-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.

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 a number of options available for managing both above-ground corn pests, like ear-feeding caterpillars, stalk borers and foliage feeders, as well as below-ground 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 when 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 helps minimize this potential problem.

Recently, 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. A number of ear-feeding caterpillars are starting to show 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 reducing 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 is supposed to work helps producers make more informed decisions about spider mite management (see Table 2).

See K-State's *2017 Corn Insect Management Guide*, MF810, (*www.bookstore.ksre.ksu.edu/pubs/MF810.pdf*) for more details about insect management options for corn and visit *http://myfields.info/pests* for more information about specific pests in your area.

Risk Management and Corn Markets

U.S. and World supply-demand situation. After producing the five largest U.S. corn crops on record through the 2013-2017 period following the drought of 2012, U.S. corn ending stocks of 2.487 billion bushels in the new crop 2017/18 marketing year have risen to a 30-year high, while percent ending stocks-to-use of 17.2 percent have risen to a 12-year high. In this "large supply - low price," "buyer's market," the USDA has projected U.S. average corn prices in market year 2017/18 in the $2.80 to $3.60 range — down for five consecutive years from a record high of $6.89 per bushel in drought-stricken market year 2012/13 to the lowest level since $3.04 per bushel in market year 2006/07. Foreign coarse grain ending stocks of 166.3 million metric tons in new crop marketing year 2017/18 are down 17.6 percent from record high levels of a year ago. This reduction offers marginal relief from the "large crop - low price" scenario that currently exists in the U.S. and world coarse grain markets.

Corn price expectations and contingencies. Lower U.S. corn prices are likely to prevail through the winter months until at least mid-spring to early summer 2018 unless unexpected and substantial crop production problems occur in other major coarse grain production regions of the world, such as Argentina, Brazil, China,

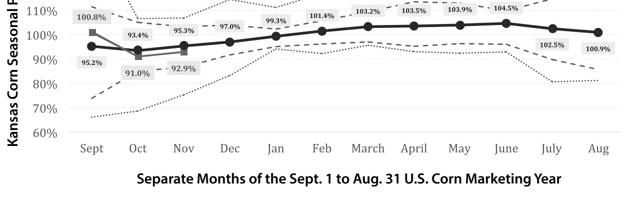
Table 2. *Miticides available for controlling spider mites in corn. All product data in this table is directly from the manufacturer.*

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

or the Ukraine. If tangible evidence of crop production problems in South America, China or elsewhere do not occur until February-April 2018, and later during the summer months in the United States, then U.S. corn prices are likely to remain at current low-to-moderate price levels. Financial market volatility, trends in the value of the U.S. dollar relative to other world currencies, and other economic factors may affect the U.S. corn market and other agricultural and energy commodity prices in coming months. Absent any of these surprises to the U.S. and Kansas corn markets in 2018, in-state corn prices will likely follow the average normal seasonal price pattern since the 1998/99 marketing year. This would include harvest-time lows followed by at least moderate seasonal increases through spring-early summer 2017, with weather-based market volatility influencing U.S. corn prices through the mid-to-later summer months (Figure 3).

Kansas irrigated and non-irrigated corn cost of production for 2009-2016. On Monday, November 13, 2017 Kansas cash corn prices of $2.92 to $3.37 per bushel at major grain elevators throughout the state, with some ethanol plant bids up so $3.63, were substantially below Kansas State University estimates of average full cost of production from Kansas Farm Management Association enterprise records for the 2011-2016 period. The statewide average irrigated corn cost of production was $3.96 per bushel in 2016, and $4.69 per bushel on average over the 2011-2015 period. For non-irrigated corn, Kansas State University estimates of statewide average full cost of production were $3.76 per bushel in 2016 (with much larger than normal yields) and $6.25 per bushel on average over the 2011-2015 period. Total variable cost of production (excluding machinery depreciation, unpaid operator labor, interest expense, and the charge for owned farmland) in 2016 were $3.04 per bushel for irrigated corn and $2.68 per bushel for non-irrigated.

Figure 3. *Kansas Corn Seasonal Price Index – Last 15 Marketing Years (MY 1999/00 – "Old Crop" marketing year 2014/15) plus "New Crop" marketing year 2015/16 Estimate (Source: K-State www.AgManager.info).*



What signals about 2018 are the CME corn futures markets providing? As of November 13, 2017, the structure of futures contract prices over the remainder of the 2017/18 marketing year (i.e., through August 31, 2018) provides a price-neutral incentive for commercial storage of grain (i.e., $0.04 to $0.05 per bushel per month), and is modestly positive for on-farm storage at 50 to 65 percent of commercial costs. On November 13, 2017, CME DEC 2017 corn futures closed trade at $3.42¼ per bushel, followed by MARCH 2018 CME corn at $3.55, MAY 2017 at $3.63½, JULY 2018 at $3.71¼, and SEPT 2017 CME corn at 3.78 per bushel. Per month futures carrying charges for DEC-MARCH were $0.0425 per bushel, MARCH-MAY were $0.0425 per bushel, $0.03875 per bushel per month for MAY-JULY, and $0.03375 per bushel for JULY-SEPTEMBER.

Restated, if commercial storage costs before interest are commonly $0.04 to $0.05 per bushel per month, then mid-November 2017 CME corn futures carrying charges offer a "break-even" incentive for storing grain — with the possibility that local cash basis levels may narrow or strengthen enough to make storage profitable. If on-farm storage cost is approximately $0.02 to $0.0260 per bushel, then on-farm storage (before cost of interest) appears to be a "modestly profitable" marketing strategy — with the possibility of any rally in corn futures or narrowing of basis in spring-early summer 2017 adding to potential returns.

Concerning new crop 2018 acreage prospects for corn and other major competitive crops, on November 13, 2017 CME NOV 2018 soybean futures closed at $9.88 with CME DEC 2018 corn futures at $3.87¼, with a ratio of 2.55. Over time this ratio of soybean to corn prices would be considered to be "favoring soybeans" from an expected profitability standpoint (i.e., being markedly larger than the customary 2.2 to 2.3 break-even level). It is likely prospects for the South American soybean crop during March-April 2018 will affect both old crop and new crop soybean and corn futures prices in the United States at that time. This could lead to significant changes in relative 2018 futures prices and expected profits between U.S. corn and soybeans, and ultimately affect U.S. farmers' 2018 planted acreage decisions.

Machinery

Planting systems have transformed over the last 3 to 5 years. More and more producers managing large farming operation 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 (Figure 4) or the seed plate has gears that mesh with another gear on the electric motor to run the seed plate. A motor control module, either integrated with the electric motor or standalone receives key control parameters from field computer. The control parameters like target population, planting speed (speed radar or GPS), and variety are sent over the controller area network (CAN) to each row motor control module to generate target motor rpm. The operational parameters implemented over the CAN network realize 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 low maintenance, electric seed meters provide technologies like automatic row shut-off; turn compensation; any population any row; and two hybrid planting options. The seed tube sensor on each row unit provided feedback on seed simulation, doubles and misses, to field computer. New seed tube also has positive seed delivery using motorized brush or slot belt with sensor to sense and feedback seed simulation. 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 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 8 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. Planter typically uses 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, row unit ride quality to optimize performance, increase efficiency, and enhance productivity.

Figure 4. *Planter row unit with electric seed meter.*

Irrigation

Corn is the most commonly irrigated crop in Kansas with nearly one-half of the approximately 3 million irrigated acres in Kansas producing corn. The statewide, irrigated corn yield has steadily risen at 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.

Water use requirements. Corn grown in Kansas has reported growing seasonal 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

Table 3. *Crop water use rates from 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

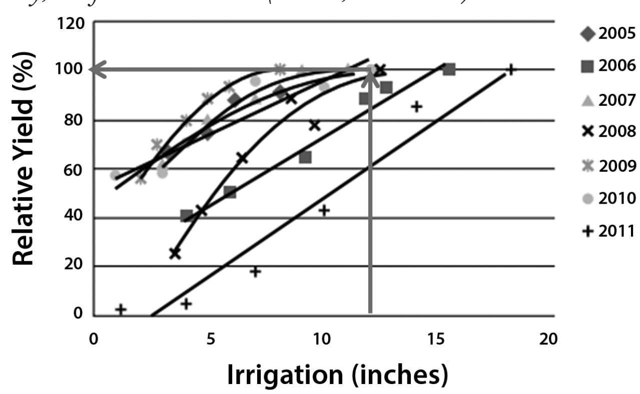
**Value appears low; see Agricultural Crop Water Use, L934 for more discussion.*

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 the 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, but a 3-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.

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 percent chance rainfall (80 percent chance rainfall is a dry year value, 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. However, to achieve high crop-water productivity, irrigation systems must be efficient and irrigation water should be scheduled. Scheduling can be achieved by a variety of methods; the most common are either soil based or climate based. Climate based is often referred to as evapotranspiration (ET) based scheduling. ET is a scientific word for crop water use. A combination of soil and ET based scheduling is also complimentary 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.bae.ksu.edu/mobileirrigationlab/.*

Figure 5 illustrates the importance of scheduling irrigation water. 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 percent 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 6 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.

Figure 5. *Corn relative yield response to irrigation at Garden City, KS for 2005 – 2012 (Klocke, et al. 2015).*



Ignacio A. Ciampitti
Crop Production and Cropping Systems
Agronomy

Curtis R. Thompson
Weed Scientist
Agronomy

Dorivar Ruiz Diaz
Soil Fertility and Nutrient Management
Agronomy

Daniel M. O'Brien
Agricultural Economist
Agricultural Economics

Danny H. Rogers
Agricultural Engineer – Irrigation
Bio and Ag Engineering

Ajay Sharda
Agricultural Engineer – Planting Systems
Bio and Ag Engineering

Doug Jardine
Plant Pathologist – Row Crops
Plant Pathology

Sarah Zukoff
Entomologist
Entomology

Brian McCornack
Entomologist
Entomology

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