K·STATE
Research and Extension

Kansas Soybean Management 2025

MF3154 Crop Production

This publication offers advice to producers, crop consultants, and agronomists to help manage Kansas soybean crops as efficiently and profitably as possible. Recommendations provide guidelines and must be tailored to the diverse conditions in cropping systems across the state.

Tillage and Rotations

Uniform residue distribution, effective weed control, proper seed placement, correct planter adjustment, soil testing, and fertilizer management are important for success in conservation-tillage systems.

Crops in a rotation with soybeans usually receive a benefit compared with continuous monocrop systems. Additionally, yields are greater when soybeans are grown in a rotation (e.g., followed by wheat or sorghum), reducing pest pressure, versus continuous monocrop (5 to 10 bushels per acre) in a no-till system. The factors affecting double-crop soybean yield are related to the yield of the previous crop, soil moisture after crop harvest, soybean planting date, and maturity group.

Variety Selection

Variety selection should be based on plant traits such as yield potential, maturity, lodging, disease resistance, stem termination type, and iron chlorosis tolerance. Varieties adapted to Kansas are generally classified as maturity groups III, IV, and V (from northwest to southeast). Maturity groups late II and late III are recommended for northern Kansas and under irrigation; while early IV has gained significant acreage in north central and northeastern soybean regions based on yield results; group IV (early and late) performs well in the east central and southern parts of the state; and maturity group V is recommended in southeast Kansas. Stem termination type is related to the growth habit. Indeterminate varieties are common for maturity groups III and IV, while determinate varieties are mostly for group V or later.

Varieties that stand well under diverse conditions, such as irrigation, soil fertility, and high plant density, are preferred to avoid reductions in harvest efficiency.

Look for varieties with resistance to diseases in your area that perform well over several locations in Kansas and nearby states. The performance of soybean varieties depends on factors such as weather and management practices. When selecting a variety or brand, consider its performance for two or more years across locations. Soybean crop performance tests are available at: *www.agronomy.k-state.edu/outreach-and-services/crop-performance-tests/soybeans/*.

When faced with limited years of data, evaluate performance averaged over several years and sites to provide a better estimate of genetic potential and stability. A variety that performs well across a range of sites is more likely to perform well on your farm.

Planting Practices

Planting date. Soybeans can be planted over a wide range of dates under good soil moisture availability, although emergence could be reduced under wet and cool soils (lower than 50 degrees Fahrenheit). Planting date will define the time frame of pod formation and grain-filling; the distribution and amount of rainfall have a large influence on defining the attainable yield. Under high risk of drought and heat stresses, diversifying planting dates may be a good approach.

Row spacing. Narrow rows result in equal or greater yields compared to 30-inch rows in conditions with yields greater than 50 bushels per acre (regardless of planting date, seeding rate, or maturity). Benefits of narrow rows include early canopy cover, light capture, weed suppression, and reduced erosion. Poor stands can occur more often with narrow row spacing than with wider row spacing when a similar seeding rate is used. Reduced planting uniformity can negatively affect yields, especially in conditions with plant densities lower than 80,000 plants per acre and yields lower than 45 bushels per acre. Proper planting speed, planter unit down pressure, and adequate press wheel pressure may help reduce or eliminate narrower row stand issues.

Seeding rate. The number of seeds or plants per linear foot of row decreases as the row spacing becomes narrower and increases with the plant density. Late planting dates may require increasing plant density to compensate for the reduction in the length of the growing season by compensating for fewer nodes per individual plant. Low-yielding environments (less than 35 bushels per acre) may need an increase in plant density. For environments with yields greater than 35 bushels per acre, changes in plant density might not be required.

Planting depth. Optimum planting depth is from 1 to 1½ inches. Late planting under dry conditions requires deeper seed placement to place the seed in contact with moisture. For early planting, place the seed slightly shallower to shorten the time until emergence (related to soil temperature). Soil crusting can result in poor stands, and it

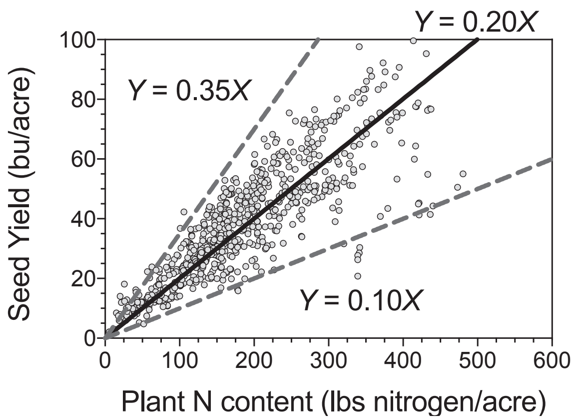

Figure 1. *Relationship between seed yield and plant nitrogen content at maturity for soybean plant.*

can be worsened by deeper seed placement (deeper than 2 inches) and greater disease pressure.

Seed treatment. A good fungicide seed treatment package is recommended when planting into cold (cooler than 58 degrees Fahrenheit), damp seedbeds. Study results have shown stand and yield benefits when using treated seed when planting before mid-May, and as late as late May in northern Kansas no-till fields.

Inoculation. Planting soybeans without inoculation in fields out of soybeans for more than two to three years or in Conservation Reserve Program (CRP) land can result in poor nodulation and nitrogen deficiency. From the total nitrogen demand of the crop, the nitrogen-fixation process provides, on average, 50% to 60% of the total nitrogen demand of the crop — typically about 5 pounds of nitrogen per bushel of yield (Figure 1). For further details check: *Biological Nitrogen Fixation and Soybean Productivity in the Midwest*, MF3462 (*www.bookstore.ksre.ksu.edu/pubs/MF3462.pdf*).

Double cropping. Double-cropped soybeans can achieve high yields with a similar maturing variety compared to a full-season crop. Double cropping often benefits from narrow rows and increasing seeding rates (under adequate moisture), as these may help compensate for the late planting date.

Calculation of plant density. Soybean seed size varies among and within the same variety grown under diverse climatic conditions. Thus, planting rates need to be calculated as the total number of seeds per acre (Figure 2).

Trend On Yield and Seed Protein Concentration Over Time

Over the past decades, breeding efforts increased soybean yield potential. The varieties released from 1980 to 2014 demonstrated a realized yield gain of approximately 0.6 bushels per acre per year (Figure 3); an estimated increase of 50% for the entire period (35 years). Unfortunately, yield improvement was linked to a reduction of seed protein concentration. During the same period, protein concentration in seeds decreased at a rate of 1.22% per year, increasing carbohydrates and other compounds. Lastly, the decrease in protein concentration was not linked to an overall greater nitrogen demand by the crop due to the high yields.

Seed Quality Management and Potential Uses

The commercial value of soybeans lies in both protein and oil concentrations. After seed crushing and oil extraction, the soybean meal is primarily used as a protein and amino acid source in the livestock industry. Although protein concentration is the most critical trait for the industry, the amino acid profile is also a determining factor of seed and meal quality. Among the 18 amino acid constituents of the soybean protein, the decreasing trend of each component is not always like the trend observed in protein itself. Some amino acids have decreased at a slower pace. This is the case of the essential ones: lysine, threonine, and tryptophan, and potentially could indicate an advantage for the poultry and swine industries. Others such as the essential sulfur amino acids cysteine and methionine, present a concerning greater decreasing trend relative to protein.

The good news is that sulfate fertilization can improve the seed concentration of sulfur amino acids in soybean seeds under certain environmental conditions. Consistent responses were observed with yield environments up to roughly 90 bushels per acre. However, excessively high or low (nonoptimal) temperatures during seed

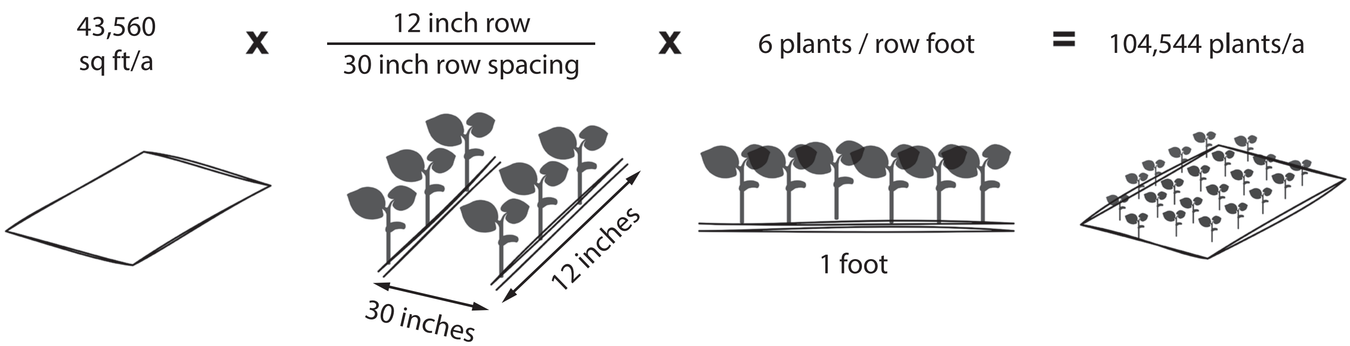

Figure 2. *Seeding rate calculation.*

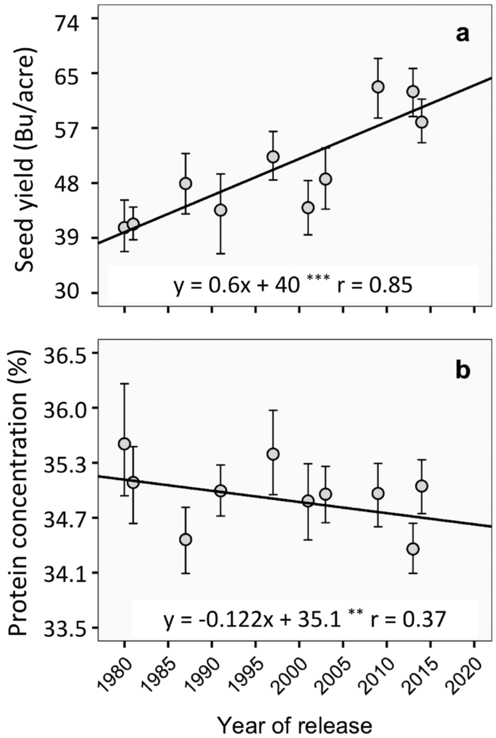

Figure 3. *Relationship between yield (A) or protein concentration (B) with year of release of soybean varieties from 1980 to 2014.*

filling are likely to impair responses to sulfur fertilization regarding this seed-quality trait. Soluble sources of sulfate fertilizer such as ammonium sulfate or magnesium sulfate applied in preplanting or top-dressing are the most recommended fertilizers for achieving the goal of improved seed quality.

Weed Management

The most effective way to manage weeds in soybeans is to use an integrated weed management program that includes crop rotation, good crop production practices, cultural weed control practices, vigilance to prevent spreading weeds, and a diversified herbicide program. A key to planning an effective weed-management program is to be aware of what weed species are present in the field and understand the biology of those weeds. Annual field records of weed species present, relative abundance, and problem spots are helpful when designing a management plan.

Early emerging weeds are the most competitive with crops and can be the most difficult to control. It is important to have a weed-free seedbed at planting. This can be accomplished with tillage in conventional tillage systems or with herbicides in no-till. Winter-annual weeds generally are not a problem in conventional tillage because they are controlled with spring tillage before planting; however, winter-annual weeds such as henbit, marestail, mustards, and weedy bromes that emerge in the fall or early in the spring can be problematic in no-till systems if not controlled early enough. Winter annual weeds are generally easier to control before they flower; and uncontrolled winter-annual weeds can use nutrients and moisture and interfere with planting.

Fall herbicide treatments from late October through early December, or early-spring treatments in March and April can provide good control of winter-annual weeds and help facilitate better planting conditions. Herbicide combinations with different modes of action provide the broadest spectrum of weed control and help prevent the development of herbicide-resistant weeds. Glyphosate (Group 9), 2,4-D (Group 4), dicamba (Group 4), metribuzin (Group 5), flumioxazin (Group 14), and Autumn Super (Group 2) are some of the more commonly used fall and early-spring burndown treatments in soybeans. Longer residual herbicides also can be used in fall and early-spring treatments but tend to be costlier and probably will not provide much weed control into the soybean-growing season. Consult herbicide labels for required preplant intervals ahead of soybeans and any guidelines regarding soil texture, soil pH, precipitation requirements, or geographical use restrictions.

Cover crops may help suppress weeds. There are many potential cover crop combinations, but to be effective for weed suppression, they need to establish quickly and produce sufficient biomass. Winter cereals, such as cereal rye, winter wheat, or triticale, generally have the greatest potential for weed suppression. Another key component of using cover crops is to terminate them effectively and in a timely manner to prevent seed production, avoid excessive moisture use, and facilitate good planting conditions. In some situations, chemical termination of cover crops may be accomplished when residual herbicides are applied at planting.

Summer annual weeds are best managed using a combination of cultural practices (e.g., cover crops and narrow soybean rows), residual herbicides as preplant or preemergence treatments, and timely postemergence treatments. The most appropriate herbicide program depends on the weed species present and herbicide resistance that has developed in the weed population. Applying two or more effective herbicides is important to slow the selection of herbicide-resistant weeds.

Kochia, giant ragweed, and common ragweed are summer annual weeds that primarily germinate early in the spring before soybean planting. In addition, few postemergence herbicides are effective for kochia and ragweed control, especially if herbicide-resistant populations are present. The key to managing these species is to control them with preplant herbicides.

Conversely, most waterhemp and Palmer amaranth do not germinate until later in the spring and into the growing season. Waterhemp and Palmer amaranth are both pigweed species that can be competitive with soybeans, have developed resistance to several different herbicides, and are difficult to control postemergence. Preplant and preemergence herbicides with multiple effective sites of action and good residual pigweed activity are critical for their management. The best approach for pigweed control is to use residual herbicides as both preplant or preemergence and postemergence treatments. Relying solely on preplant herbicides too early in the spring creates a situation where herbicides will not persist long enough to control later-germinating pigweeds.

The primary postemergence herbicides that provide control of pigweeds in conventional soybeans are Cobra (lactofen), Flexstar (fomesafen), and Ultra Blazer (acifluorfen) (all Group 14). These products can provide good control when applied to small pigweeds, but control decreases dramatically when pigweeds exceed 3 inches in height, especially Palmer amaranth. Pigweed resistance to the postemergence Group 14 herbicides is also present in some populations, so pigweed control with these herbicides can be inconsistent. Residual herbicides like Zidua (pyroxasfulfone), Outlook (dimethenamid-P), Warrant (acetochlor), and Dual Magnum (S-metolachlor) (all Group 15) can be added to postemergence applications for extended control of pigweeds and small-seeded grasses but will not control any emerged weeds.

Herbicide-resistant soybean technologies should be used as part of a diversified weed-management program with effective residual herbicides to achieve acceptable weed control and sustain the technologies. Glyphosate-resistant soybeans allow the use of the broad-spectrum herbicide glyphosate (Group 9) to control many weed species; however, glyphosate-resistant populations of many weeds have developed. Liberty (Group 10) and other glufosinate products can also provide good broad-spectrum weed control. Glufosinate works best when applied to small, actively growing weeds, and with higher spray volumes and thorough spray coverage. A second application of glufosinate 1 to 2 weeks after the first application generally provides the most consistent control.

XtendFlex soybeans are resistant to dicamba, glyphosate, and glufosinate. At the time of this writing (November 2024) there are no dicamba products labelled for use in Xtend soybeans during 2025. T

Enlist E3 soybeans are resistant to 2,4-D, glyphosate, and glufosinate. Only specific, reduced volatility 2,4-D products are labeled for use in this system. These products are Enlist One and Enlist Duo, which contains glyphosate in addition to 2,4-D. Careful attention to application guidelines is necessary to avoid off-target movement of 2,4-D.

It is critical to keep accurate records and communicate clearly with your herbicide applicator and neighbors regarding herbicide-resistant traits to avoid misapplication and reduce the potential for nontarget herbicide injury. “Flag the Technology” is a program that consists of different colored and patterned flags to represent different herbicide trait technologies. Flags can be purchased online and should be placed at the entrance and/or visible locations in fields for applicator and neighbor awareness of what traits are planted.

See K-State’s *2025 Chemical Weed Control of Field Crops, Pastures, Rangeland, and Noncropland*, SRP1190 for more information regarding herbicide use in soybeans.

Fertilizer Requirements

Compared to corn, wheat, and sorghum, soybeans remove significant amounts of nutrients per bushel of grain harvested. Nutrient uptake in soybeans early in the season is relatively small; however, as they grow and develop, nutrient uptake increases. Soybeans need an adequate nutrient supply at each growth stage for optimum growth.

High-yielding soybeans remove substantial nutrients from the soil. This should be considered in an overall nutrient management plan. For example, a 60-bushel-per-acre soybean crop removes approximately 48 pounds of P_2O_5 and more than 80 pounds of K_2O with the grain; in addition, approximately 15 pounds of P_2O_5 and 60 pounds of K_2O can be removed with the stover.

Nitrogen is supplied to soybeans mainly by nitrogen fixation. Fertilizer nitrogen application is not recommended if the plants are well nodulated. Soybeans are heavy users of nitrogen, removing a total of 195 pounds per acre and about 66 pounds with the stover for a 60-bushel-per-acre soybean crop. Soybeans use all the nitrogen they can fix plus nitrogen from the pool of available nitrogen in the soil. A nitrogen fertilizer application to soybeans seldom results in any yield benefit, and efforts should focus on proper inoculation.

Phosphorus applications should be based on a soil test. Responses to direct phosphorus fertilization is generally consistent in soils testing very low or low in soil test phosphorus. Response to starter phosphorus fertilizer application in soybeans can occur, but it depends on several factors. The most important factor is the soil test level. Generally, warmer soils at soybean planting, compared to corn, also may contribute to typically lower response to starter fertilizers in soybeans. However, starter fertilizer in soybeans can be a good way to complement nutrients that may have been removed by high-yielding crops in the rotation such as corn. Banding fertilizer at planting is an efficient application method. Soybean seeds are easily injured by fertilizer, therefore, no direct seed contact with fertilizer is advised.

Potassium — Soybean seeds are relatively high in potassium and removal of potassium by soybeans is greater than for other crops on a per-bushel basis when only grain is removed. As with phosphorus, a soil test is the best index of potassium needs. Fertilize low-testing soils with potassium, either as a banded starter at planting or broadcast and incorporated. Potassium should not be placed in contact with the seed because of possible salt injury. Yield increases from potassium can be comparable to those with phosphorus under very low and low soil-test levels.

Sulfur is mobile in the soil (leaching is common) but fairly immobile in the plant. High soil-test variability along with significant uptake by crops generates the need for proper sulfur management — especially in sandier soils and fields with several different soil types. Deficiency symptoms in soybeans are pale green to yellow leaf color without prominent veins or necrosis in the youngest trifoliate leaves. Recent Kansas studies suggest a low probability of soybean response to sulfur application; however, sulfur removal with soybeans can be significant, and more sensitive crops in the rotation such as wheat may require sulfur fertilization after a soybean crop.

Iron deficiency symptoms appear in irregularly shaped spots randomly distributed across a field, primarily in fields with a previous history of iron deficiency. Different annual weather patterns can increase or decrease the prevalence of iron chlorosis. Iron chlorosis also differs under different soil conditions. In general, high soil pH and high carbonates (free lime) can increase the incidence of iron deficiency. Iron chlorosis can be a big limitation in some regions of western Kansas. Iron fertilizer using chelated sources and in direct contact with the seed (in-furrow) has shown significant yield responses in soils with history of iron chlorosis. If iron chlorosis has been a common problem in the past, producers should select a soybean variety tolerant to iron chlorosis. It may be beneficial to use a chelated iron in-furrow application. Foliar iron treatments seldom result in a yield increase.

Others — Zinc, manganese, and boron are other nutrients that can be limiting in soybeans. The need for zinc should be determined by soil tests. Zinc fertilizer can be either banded at or broadcast preplant with little difference in response when applied at an adequate rate. Both organic and inorganic zinc sources (chelates and nonchelates) can be used, but chelates are considered more effective than inorganic sources. Manure applications also are effective at eliminating micronutrient deficiency problems, including iron.

Monitoring nutrient levels with tissue analysis along with soil tests conducted during the crop season should be used to diagnose potential nutrient deficiencies. Stresses such as drought, heat, and pest pressure can influence tissue test results.

Nutrient removal by soybean is very high in high-yielding environments, so fertilizer application rates will be high, or soil test levels will drop. Regular soil testing (every 2 to 3 years) is essential for optimum nutrient management. Having soil test information on hand allows for significant savings on fertilizer, resulting in a substantial increase in profitability, given the current record high fertilizer prices.

Soybeans take advantage of residual phosphorus and potassium, but keep in mind the total nutrient needs in the rotation. See K-State Research and Extension publication *Soil Test Interpretations and Fertilizer Recommendations*, MF2586 (*www.bookstore.ksre.ksu.edu/pubs/MF2586.pdf*) for more complete soybean fertilizer recommendations.

Diseases

Numerous diseases attack soybeans throughout the growing season. Long-term estimates predict a 12.5% increase in soybean yields in Kansas if diseases could be eliminated.

Early in the season, seed rots and seedling blights reduce yields by an average of 2.5 bushels per acre. The responsible pathogens primarily include Pythium, Rhizoctonia, and Fusarium, although occasionally others can be involved. Seed treatment is an effective means of dealing with seedling blights. Numerous products are available that provide good to excellent control of these early-season problems. Use products containing two or more active ingredients to broaden the spectrum of control. See *An Overview of Soybean Seedling Diseases, Soybean Seed Treatments: Questions that Emerge when Soybean Plants Don't,* and *Fungicide Efficacy for Control of Soybean Seedling Diseases*.

Two other important diseases, soybean cyst nematode (SCN) and soybean sudden death syndrome (SDS), are best managed with resistant varieties. The pathogens causing these diseases frequently co-occur in the same fields, and research has shown that SDS is often more severe in the presence of the nematode.

A recent two-year survey indicated that approximately 35% of Kansas soybean fields are infested with soybean cyst nematode. The infestation rate exceeded 50% in several counties, including Cherokee, Doniphan, and Douglas. Unfortunately, fewer than 10% of growers indicate that they test for soybean cyst nematode. While nearly all soybean varieties have some level of soybean cyst nematode resistance, recent research indicates more than half of the SCN populations in Kansas can overcome the current source of resistance (PI 88788) used in most varieties. For this reason, it is advisable to rotate soybean varieties with sources of resistance other than PI 88788 when available. Growers should continuously monitor nematode numbers in infested fields to make sure appropriate varieties are being grown. Fields should be sampled regularly (e.g., after every two to three soybean crops or whenever yield suppression is observed) to confirm that the nematode has not become established, or that it is being properly managed.

Recently, seed treatments have become available for soybean cyst nematode control, but results in university trials have been inconsistent. The use of a newly registered product, ILeVO, has resulted in significant reduction in losses from sudden death syndrome. For more information, see *Soybean Cyst Nematode Coalition* (*www.thescncoalition.com/partners/university-partners/kansas-state-university*), *Scouting for Sudden Death Syndrome, Sudden Death Syndrome of Soybean, and Using ILeVO with Preemergence Herbicides*.

The most significant soybean disease in Kansas is charcoal rot (see *Charcoal Rot of Soybean*). While this pathogen infects soybean roots early in the season, it does not make itself known until the reproductive stages of growth when hot, dry weather occurs. Under heat and drought stress, the fungus becomes active and slowly kills the plant. Plants that die prematurely typically have smaller seeds and reduced yields. Shorter maturity group varieties tend to express disease symptoms more than late-maturity group varieties. Irrigation and any type of moisture-saving cultural practices can reduce disease losses. The most effective management strategy is to reduce seeding rates to approximately 100,000 seeds per acre. At this rate, there are fewer plants competing for moisture in a dry year. In wet years, plants can still branch and compensate for fewer plants per acre.

Kansas has continued to see increases in outbreaks of Phytophthora root rot due to soaking rains in early-mid-season. Resistant and field-tolerant varieties are the best means of management.

There are several foliar and late-season stem and pod diseases that reduce soybean yields. These include frogeye leafspot, pod and stem blight, anthracnose, and Cercospora leaf blight/purple seed stain. Fungicides can be profitable in certain instances, most notably for frogeye leafspot control. Pod and stem diseases are tricky to manage because at the time fungicides need to be applied, it is not apparent as to whether the diseases are likely to appear. Pod and stem diseases are caused by late-season rains.

When a fungicide is necessary, it should be applied at the R3 to R5 growth stage for maximum effectiveness. Growers should be cautious about overuse of strobilurin fungicides. Strobilurin-resistant frogeye leafspot has already been reported in 11 states; fortunately, Kansas is not yet one of them. See *Fungicide Efficacy for Control of Soybean Foliar Diseases*.

All other diseases, including bacterial blight, brown spot, downy mildew, aerial blight, Sclerotinia white mold, stem canker, bean pod mottle virus, bud blight, and soybean vein necrosis virus occur too infrequently to warrant control or there are no effective control measures.

Publications in the *Diseases* section of this document without a listed web address can be found by searching at: *cropprotectionnetwork.org*.

Insects

Defoliation of soybeans by insects and mites causes serious concern every year throughout the state. There is a significant difference between full-season versus double-cropped soybeans relative to which pests attack them, when they attack, and the effect they have. Full-season soybeans may be susceptible to wireworms and white grubs early on, but double-cropped beans are not as likely to be attacked. Both may be defoliated by adult bean leaf beetles, webworms, mites, green cloverworms, and woollybear and thistle caterpillars, but usually not to the extent that requires treatment. Some of the perennial pests in soybeans across the state are:

Wireworms and white grubs may attack the seed and seedlings of full-season beans, but insecticide seed treatments can protect stands for 21 to 28 days after planting.

Pillbugs are crustaceans, not insects, thus require a moist environment to be able to get oxygen through their gills (Figure 4). Populations only reach densities sufficient to reduce soybean stands in no-till fields. They have been serious pests in south central Kansas because they bite off the small, succulent seedlings, causing stand losses. Insecticide seed treatments are not effective, and foliar applications only work if there is no residue to block the spray from contacting the pillbugs.

Bean leaf beetles have historically been a serious pest of soybeans throughout all soybean-producing regions (Figure 5). Adults can affect early-season plants by chewing round and/or oval holes in leaves. Females then oviposit in the soil around the base of plants where

Figure 4. *Pillbug feeding damage on seedling soybean plant.*

the white larvae feed on roots. Emerging adults feed on leaves but also may feed on green pods, which can cause yield loss relatively quickly. Foliar insecticide applications usually work well to control bean leaf beetle adults and prevent this pod feeding.

Soybean podworms are called corn earworms in corn. Adults fly from corn to soybeans where females oviposit on leaves and larvae often feed on the beans through the pod. Adult bean leaf beetles feed on the pods, whereas podworms chew through the pods to feed on the seeds within. Early detection, while the larvae are still small, is the key to good control. Ensure proper identification of larvae as other worms commonly found in soybeans do not feed on seeds. Small, hair-like microspines on podworms are the key to identification. Use enough gallonage to ensure any insecticide applied for pest control penetrates through the foliage to contact the targeted pest.

Green cloverworms caused some defoliation in 2021, but not as much as in the three previous years, and none since.

Thistle caterpillars were not as abundant but as usual, did complete two generations in Kansas soybean fields. Painted lady butterflies emerged from the last generation and headed south to overwinter, although there were not nearly as many as in 2017-2019.

Stinkbugs may insert sucking mouthparts into soft, succulent seeds as they develop inside pods. This can result in shrunken seeds with wrinkled coats and 30 to 50% yield loss. It only takes one bug per row foot at the right time to cause this yield reduction.

Soybean aphids have migrated into Kansas every summer since they were first detected in 2002. Ants in soybean canopies indicate aphid infestations are present; however, few have been reported in the last 15 years.

Dectes stem borers continue to be problematic throughout the western two thirds of Kansas and are expanding as an economic pest down the Kansas River Valley. Yield losses from this insect's habit of girdling the inside of the stem before harvest, potentially leading to plant lodging, can be minimized by harvesting infested fields as early as possible.

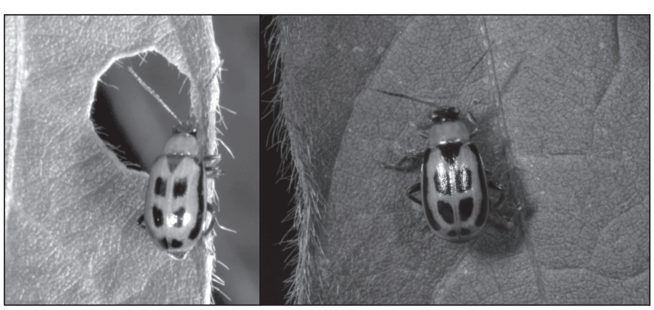

Figure 5. *Both color forms of the bean leaf beetle, and characteristic round foliar feeding damage.*

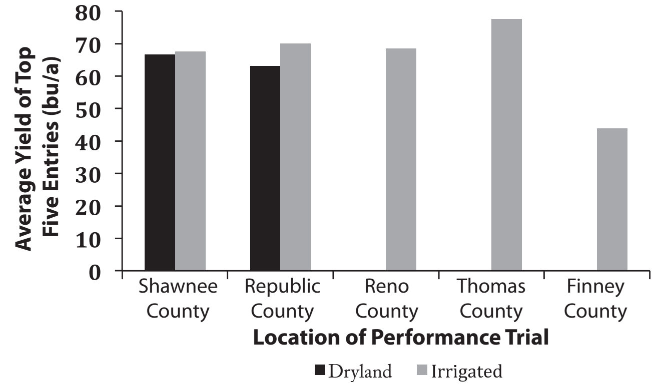

Figure 6. *Soybean yield (bu/a) for the top 5 entries of various K-State performance trials across Kansas (2008 - 2017).*

Refer to K-State Research and Extension publications *Soybean Insect Management*, MF743, (*www.bookstore.ksre.ksu.edu/pubs/MF743.pdf*) and *Crop Insects of Kansas*, S152 (*bookstore.ksre.ksu.edu/Item.aspx?catId=526&pubId=13159*) for more in-depth descriptions of soybean pests, damage, and management recommendations.

Irrigation

In 2017, more than 340,000 of the 3 million irrigated acres in Kansas were soybeans. Approximately 11% of the harvested soybean acres are irrigated. Irrigated soybean production is concentrated in the central third of Kansas; particularly in south central Kansas where more than 60% of irrigated soybean production occurs. The top 10 counties in irrigated soybean production are within the boundaries of groundwater management districts 2 and 5.

Soybeans are a relatively drought-tolerant crop but respond well to irrigation. In 2009, the last year of irrigated soybean yield information, irrigated soybeans averaged 59 bushels per acre statewide as compared to 42 bushels per acre for dryland soybeans. Irrigated soybean yields were increasing at a rate of about 0.57 bushels per acre per year from 1984 to 2009 as compared to 0.36 bushels per acre per year for dryland production. Figure 6 shows the average yield of the top five entries at various Kansas State University soybean performance trials across Kansas from 2008 to 2017. Two eastern counties also had dryland plots but at different sites than the irrigated sites.

Plant Characteristics

Soybeans are a relatively deep-rooted crop. In deep, well-drained soils with no restricting layers, roots can penetrate up to 6 feet. As with all crops, most of the roots are concentrated in the upper half of the root zone. Managing a root zone of 3 feet is the general irrigation recommendation. Water use requirements, also known as evapotranspiration or ET, for soybeans range from 17 to 28 inches depending on climatic conditions.

Water use is generally slightly higher in the west than the east. A value of around 22 inches is a good average estimate for the state. Daily water use varies with the stage of growth and weather conditions. The typical peak water use rate is about 0.35 inch per day as typical for all summer-grown field crops, which normally occurs near the beginning of the pod fill stage (Figure 7). Single-day peak water use rates can approach 0.5 inch per day. Water use is low at the germination and seedling stages, peaks at or near the full-bloom stage, and then declines with maturity. The most critical time for adequate soil water availability is during the end of the reproductive period when pod fill begins. Soybeans produce many flowers relative to the final number of pods, so losing a few flowers to light water stress earlier in the reproductive cycle is not as critical to final productivity as the same water stress during pod fill. Net irrigation requirements for soybeans in dry years range from around 14 inches in western Kansas to less than 5 inches in the east. Requirements in an average year will be 2 to 4 inches less.

Research studies across Kansas and throughout the High Plains confirm that the most beneficial timing for a limited amount of irrigation is during the latter part of the reproductive growth stages rather than earlier. This is generally true because early-season growth and development can be satisfied by typical rainfall and stored soil water. When full irrigation is possible, a managed allowable depletion level of 50% in the managed root zone is the recommended management guideline; the typical managed allowable depletion for most field crops. The peak water use rate is generally later in the season than corn, which means soybeans may be used as a field acreage split with corn to reduce water stress potential at tasseling for corn crop.

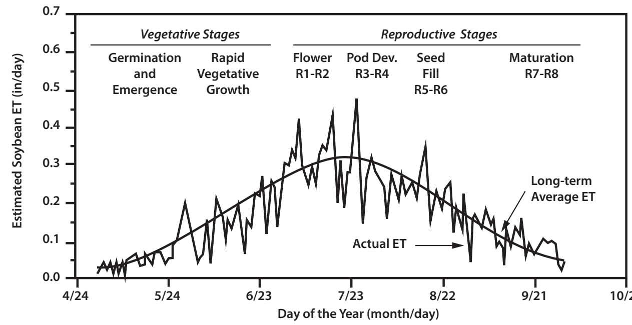

Figure 7. *Soybean water use or daily evapotranspiration (ET) from a well-watered crop (Nebguide 1367 UNL).*

Research results from the K-State Research Experimental Field at Scandia, Kansas, illustrate scheduling by soil water depletion (30 or 60%), which did not limit the total season application amount, uses less water to provide similar yields (53 versus 52 bushels per acre). The 30% depletion also occasionally had increased lodging. In some years, 60% depletion had only one irrigation application. For the 2011 soybean season at Scandia (rainfall was 8.3 inches below the 30-year average), a strong yield increase was documented from a single in-season irrigation as compared to non-irrigated. Yield also increased as the number of irrigations increased; however, the maximum yield of the trial occurred using a 50% depletion criterion (52 bushels per acre), which used less water than the three-application treatment (51 bushels per acre).

This confirms that irrigation scheduled by using planned depletion is a best management practice. Irrigation scheduling in this form can be accomplished using either soil water measurement devices (sensors/probes) or climatic-based (known as evapotranspiration-based) irrigation scheduling. This latter method can be executed by using the K-State Research and Extension KanSched irrigation scheduling program; available at *www.bae.ksu.edu/mobileirrigationlab/* along with other free decision support software.

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