K·STATE
Research and Extension

Kansas Soybean Management 2017

MF3154 Crop Production

How to Use This Guide

This publication offers advice to producers, crop consultants, and agronomists to manage soybean crops as efficiently and profitably as possible in Kansas. Recommendations provide guidelines and must be tailored to the diverse conditions found 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 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) vs. continuous monocrop (5 to 10 bushels per acre) in a no-till system. Crop rotation also promotes lower pest pressure.

Variety Selection

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

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

Look for varieties with resistance to diseases in your production area and varieties that perform well over several locations in your state and nearby states. The performance of soybean varieties depends on factors such as weather and management practices. When selecting varieties or brands, analyze variety performance for two or more years across locations. 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). The distribution and amount of rainfall during pod formation and grain-filling have a large influence in defining yield potential. Under high risk of drought and heat stresses, diversifying planting dates may be a good approach.

Row width. 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). For the 2015-16 seasons, on-farm studies showed slight yield improvement (+2 bushels per acre) on narrow rows (15-inch; Figure 1) with yields averaging 48 bushels per acre. Narrow rows benefits include early canopy cover, light capture, weed control, and reducing erosion. Poor stands, however, are more common with narrow than with wider row spacing.

Seeding rate (Table 1). 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 (soybean plants tend to produce fewer branches). Dry, hot environments

Figure 1. *Soybean yield (bu/a) to row spacing for conventional (30-inch) versus narrow (15-inch) configuration.*

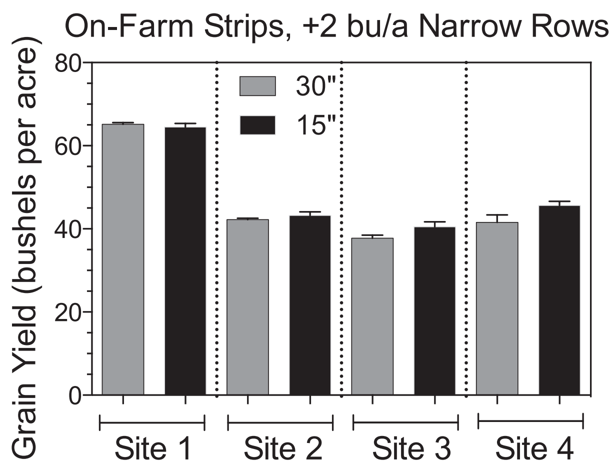


Table 1. *Recommended soybean plant density and seed spacing.*

	Target plants per acre (1,000s of plants)					
	<45	45-70	70-90	90-115	115-140	>140
	Seeds per acre (1,000 seeds; 85% emergence)					
	<50	50-80	80-100	100-130	130-160	>160
Row Spacing (inches)	**Seeds per linear foot (assuming 85% field emergence)**					
8	<1	1	1	1-2	2	>2
10	<1	1	1-2	2	2-3	>3
15	<1	1-2	2-3	3	3-4	>4
20	<2	2-3	3-4	4	4-5	>5
30	<3	3-4	4-5	5-7	7-8	>8

require lower optimum plant densities, while favorable environments, such as under irrigation, require greater plant density for capturing greater yield potential.

Planting depth. Optimum planting depth is from 1 to 1.5 inches. Late planting under dry conditions requires deeper seed placement to place the seed in contact with moisture. For early planting, seed can be placed slightly shallower to shorten time until emergence (related to soil temperature). Soil crusting results in poor stands, exacerbated by deeper seed placement (> 2 inches), and greater disease pressure.

Inoculation. Planting soybeans without inoculation in fields out of soybeans for more than 2 to 3 years or in Conservation Reserve Program (CRP) land can result in poor nodulation and nitrogen deficiency. Similar problems occur when inoculation fails, or if soybeans are planted on severely acidic soils that limit nodulation. Inoculate soybeans in fields not planted to soybeans for more than 2 to 3 years.

Double cropping. Double-cropped soybeans can achieve high yields with a comparable or slightly quicker maturing variety as compared with a full-season soybean crop. As compared to early planting, double cropping often benefits from narrow rows and increasing seeding rates under adequate moisture conditions.

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.

Example:

$$43{,}560 \text{ sq. ft. /a} \times \frac{\text{12-inch row}}{\text{(30) row spacing in inches}} \times 6 \text{ plants/row-foot} = 104{,}544 \text{ plants/a}$$

Estimation of yields before harvest. Estimate yields at the full pod stage (pods are ¾ inch long on one of the top four nodes), although the precision increases as the crop is approaching maturity. When estimating yields, sample a 21-inch row length in several sections of the field for one (30-inch row), two (15-inch rows), or four rows (7.5-inch rows). Within that section, count the total number of pods, count the seeds per pod, and estimate seed size as related to the conditions in that particular growing season. For the seeds per pod factor, a common average is 2.5 seeds per pod (ranging from 1 to 4). For the seed size, normal to large seed weight (2,500 seeds per pound) uses a seed size conversion factor of 15 units; while for smaller weight (3,500 seeds per pound) the factor is 21 units. Dry, hot conditions later in the crop season reduce both seed number and size. Scout more areas to represent natural variation within a field.

Example A — *Favorable Season:*

$$\frac{\text{264 pods (12 plants} \times \text{22 pods/plant)} \times \text{2.5 seeds/pod}}{15} = \text{44 bu/acre}$$

Example B — *Drought Season (late-drought during grain-filling period):*

$$\frac{\text{264 pods (12 plants} \times \text{22 pods/plant)} \times \text{1.5 seeds/pod}}{21} = \text{19 bu/acre}$$

Weed Control

Weed control in soybeans was relatively simple for several years following the introduction of Roundup Ready soybeans. Glyphosate was inexpensive and generally provided a high level of control of most weed species; so, many producers relied primarily on glyphosate treatments for weed control. Unfortunately, the heavy reliance on glyphosate has resulted in the development of glyphosate-resistant weeds. Consequently, glyphosate-only weed control programs can no longer be relied on for weed control and will only make glyphosate-resistant weed problems worse.

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, and a diversified herbicide program. One of the keys to planning an effective weed-management program is to be aware of what weed species are present in the field and have a good understanding of the biology of those weeds. Annual field records of weed species present, relative abundance, and problem spots are helpful when designing an effective 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, and mustards that emerge in the fall can be problematic in no-till systems if not controlled early enough in the spring. Uncontrolled winter annual weeds can use nutrients and moisture, interfere with planting, and be difficult to control at planting because of their advanced growth stage.

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 control and help prevent the development of herbicide-resistant weeds. Glyphosate, 2,4-D, dicamba, metribuzin, Canopy EX, and Autumn Super 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 more costly and 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 planted in the fall and then controlled in a timely manner in the spring also may help suppress weeds. There are many potential cover crop combinations, but to be effective for weed suppression, they need to establish quickly and be competitive. Another key component of using cover crops is to be able to terminate them effectively and in a timely manner to prevent seed production, avoid excessive moisture use, and facilitate good planting conditions.

Summer annual weeds are best managed using a combination of cultural practices (i.e. 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 the presence of herbicide-resistant weed populations.

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 control, especially if glyphosate-resistant populations are present. Consequently, 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 on into the growing season. Waterhemp and Palmer amaranth are both pigweed species that can be competitive with soybeans, have developed resistance to glyphosate, and are difficult to control postemergence with other herbicides. Preplant and preemergence herbicides with good residual pigweed activity are critical to help manage pigweeds, especially if glyphosate-resistant populations are present. The best approach for pigweed control is to use overlapping residual herbicides as preplant, preemergence and/or postemergence treatments. Relying solely on early preplant herbicides too early in the spring creates a situation where herbicides will not persist long enough to control later germinating pigweeds. The only postemergence herbicides that provide control of the pigweeds are Cobra, Flexstar, Marvel, Prefix, and Ultra Blazer. All of these products can provide good control when applied to small pigweeds, but control decreases dramatically after pigweeds exceed 3 inches in height, especially Palmer amaranth. Residual herbicides like Zidua, Outlook, Warrant, and Dual Magnum can be added to the postemergence applications, but will not control any emerged weeds.

Where extensive populations of glyphosate-resistant weeds have developed, alternative technologies like Liberty Link soybeans may be warranted. Liberty can provide good broad-spectrum weed control with proper timing and application techniques. Liberty works best when applied to small actively growing weeds and with thorough spray coverage. The most successful Liberty Link programs use a residual preemergence herbicide program at planting time followed by timely postemergence Liberty treatments.

It is critical to keep accurate records and communicate clearly with your herbicide applicator regarding herbicide-resistant traits within fields. Roundup Ready soybeans were widely adopted by most farmers, but conventional soybean varieties and Liberty Link soybeans also are viable options. Roundup Ready 2 Xtend soybeans (dicamba resistant) and Xtendimax herbicide were recently approved and will be available for the 2017 growing season. Roundup Ready 2 Xtend soybeans also will be resistant to glyphosate. Xtendimax herbicide has reduced volatility potential compared to previous dicamba products, but will have specific application guidelines to minimize the potential for herbicide drift to sensitive sites. Fexapan and Engenia are also low-volatility formulations of dicamba that may be approved for use on Xtend soybeans, but older dicamba products more prone to vapor drift are not approved for use on Xtend soybeans.

Additional herbicide-resistant traits, including 2,4-D resistant soybeans (Enlist) and HPPD resistant soybeans (Balance GT and MGI) may be introduced in the next couple of years. Most of these soybeans will be stacked with more than one herbicide-resistant trait, but will not be stacked with all of the different traits. Regardless of the herbicide-resistant trait, the most effective weed control programs are integrated programs with multiple weed control methods and diversified herbicide programs.

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 taken into account in an overall nutrient management plan. A 40-bushel-per-acre soybean crop removes approximately 30 pounds of P_2O_5 and 50 pounds of K_2O with the grain; in addition, approximately 10 pounds of P_2O_5 and 40 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 130 pounds per acre and about 44 pounds with the stover for a 40-bushel-per-acre soybean crop. Soybeans use all the nitrogen they can fix plus nitrogen from the pool of available nitrogen in the soil. 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 like corn. Banding fertilizer at planting is an efficient application method for soybeans. 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 the grain is removed. As with phosphorus, a soil test is the best index of potassium needs. Soils testing very low or low should be fertilized with potassium, either as a banded starter at planting or broadcast and incorporated. Potassium should not be placed in contact with the soybean 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.

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 make iron chlorosis more or less prevalent. 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 the 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. Some micronutrients also can cause phytotoxicity if prevalent in large quantities.

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. 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 for more complete soybean fertilizer recommendations.

Diseases

Numerous soybean diseases attack soybeans throughout the growing season. Long-term estimates predict a 12.5 percent increase in soybean yields in Kansas if diseases could be eliminated. Approximately 25 different diseases might occur annually, a much smaller number are responsible for most disease losses.

Early in the season, seed rots and seedling blights reduce yields 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 *Soybean Seedling Diseases* (*www.soybeanresearchinfo.com/pdf_docs/Soybean_Seedling_Diseases_CPN1008.pdf*), *Soybean Seed Treatments: Questions that Emerge when Soybean Plants Don't* (*www.soybeanresearchinfo.com/pdf_docs/CPN1016._SoybeanSeedTreatments.pdf*) and *Fungicide Efficacy for Control of Soybean Seedling Diseases* (*www.soybeanresearchinfo.com/pdf_docs/Fungicide_seedlings_BP163W_2015.pdf*).

General recommendations for seed treatment are that all fields planted before May 15 should be treated with a fungicide. Use seed treatment in no-till fields at least through May 31. With the expense of high-tech seeds, many growers are now using seed treatment as insurance even on double-cropped soybeans.

Two other important diseases, soybean cyst nematode and soybean sudden death syndrome are best managed at planting; resistant varieties, are the best way to manage both diseases. Research shows that soybean cyst nematode is a predisposition agent to sudden death syndrome, that is, you rarely see a field infected with sudden death syndrome that does not already have soybean cyst nematode in it.

A recent 2-year survey indicated that approximately 20 percent of Kansas soybean fields are infested with soybean cyst nematode. In two counties, Cherokee and Doniphan, that number is near 100 percent. Unfortunately, fewer than 10 percent of growers indicate they test for soybean cyst nematode. While nearly all soybean varieties have some level of soybean cyst nematode resistance, recent research indicates some populations of soybean cyst nematode are able to overcome the current source of resistance used in most varieties. Growers should continuously monitor nematode numbers in infested fields to make sure appropriate varieties are being grown. Test all fields after every third soybean crop 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 has 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 Management Guide* (*soybeanresearchinfo.com/pdf_docs/SCNGuide_5thEd.pdf*), *Scouting for Sudden Death Syndrome* (*www.soybeanresearchinfo.com/pdf_docs/CPN1012_ScoutingSDS_2016.pdf*), and *Sudden Death Syndrome* (*www.soybeanresearchinfo.com/pdf_docs/CPN1011_SuddenDeathSyndrome.pdf*)

The most significant soybean disease in Kansas is charcoal rot. 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. While all soybean varieties are susceptible, some are more susceptible than others. Careful observation of varietal differences can be useful in management. Also, 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 still have the ability to branch and compensate for fewer plants per acre. See *Charcoal Rot in the North Central Region* (*www.soybeanresearchinfo.com/pdf_docs/CharcoalRotMgmt_A4037.pdf*).

In the past 2 years, Kansas has seen increased outbreaks of Phytophthora root rot due to soaking rains early in the 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, brown spot, 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 or not the diseases are likely to appear. Pod and stem diseases are favored 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* (*www.plantpath.k-state.edu/extension/publications/BP-161-W-1.pdf*).

Soybean rust has only occurred once in Kansas, in 2007, since its introduction into the United States in 2004. Each year, its spread is tracked through a national reporting network. Should it threaten Kansas in the future, numerous outlets will update growers as to the need for fungicide usage.

All other diseases, including bacterial blight, 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.

Figure 2. *Pillbug feeding damage on seedling soybean plant.*

Insects

Defoliation of soybeans by insects and mites causes serious concern every year throughout the state. There is a significant difference between full-season vs. double cropped soybeans as far as 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 while double-cropped beans are not as likely to be susceptible. All may be defoliated by adult bean leaf beetles, webworms, mites, green cloverworms, and woollybear 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.

Pillbugs are crustaceans, not insects, and therefore require a moist environment to be able to get oxygen through their gills (Figure 2). Populations only obtain 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 3). Adults can defoliate early-season plants by chewing round and/or oval holes in leaves. Females then oviposit in the soil around the base of plants where 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 seeds 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

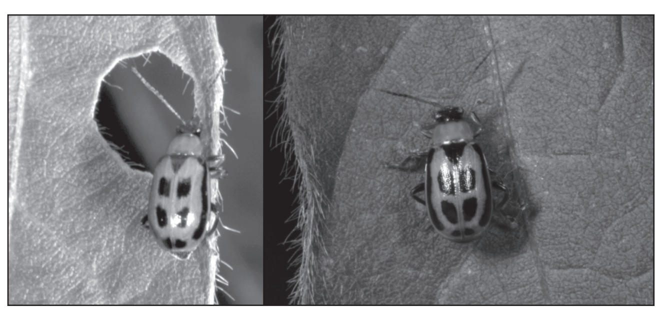


Figure 3. *Both color forms of the bean leaf beetle and characteristic round foliar feeding damage.*

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.

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 percent yield loss.

Soybean aphids have continuously migrated into Kansas since they were first detected in 2002. Rarely have these aphids reached infestation levels that warrant insecticide applications but that potential is always present for these prolific pests. Ants in soybean canopies indicate aphid infestations are present.

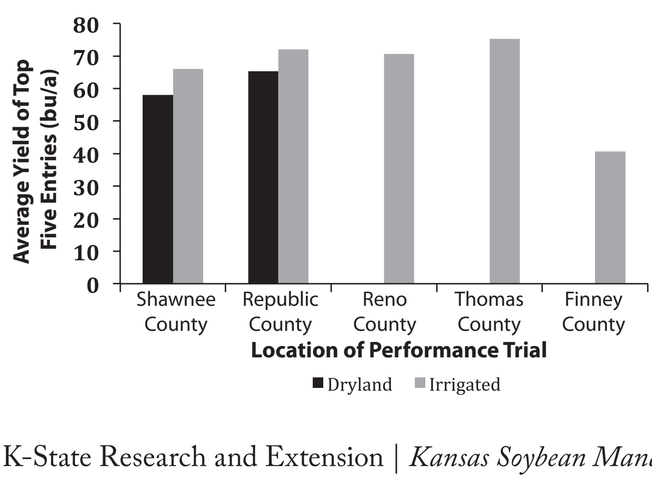
Dectes stem borers continue to be problematic throughout the western two thirds of Kansas. Yield losses from this insect's habit of girdling around the inside of the stem before harvest have been minimized by harvesting infested fields as early as possible.

Refer to K-State Research and Extension publications *Soybean Insect Management*, MF743, available online: *www.bookstore.ksre.ksu.edu/pubs/MF743.pdf* and *Crop Insects of Kansas* (S152) for more in-depth descriptions of soybean pests, damage, and management recommendations.

Irrigation

About 350,000 of the 3 million irrigated acres in Kansas are soybean. Approximately 10 percent 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 percent of irrigated soybean production occurs. The top ten 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 for the period of 1984 to 2009 as compared to 0.36 bushels per acre per year for dryland production. Figure 4 shows the average yield of the top 5 entries at various Kansas State University soybean performance trials across Kansas from 2008 to 2014. Two eastern counties also had dryland plots but at different sites than the irrigated sites.

Figure 4. *Soybean yield (bu/a) for the top 5 entries of various K-State performance trials across Kansas (2008 – 2014).*

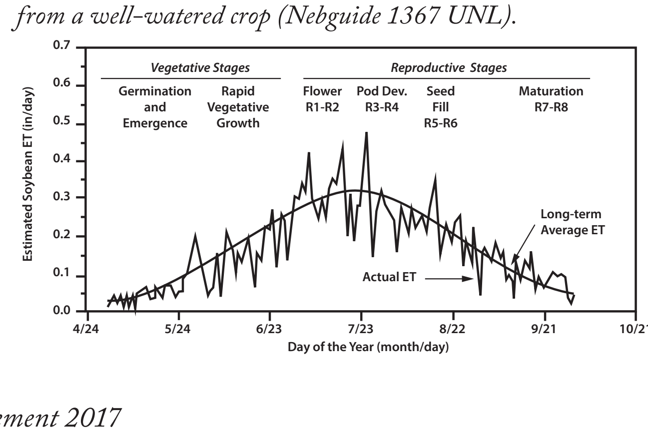


Plant Characteristics

Soybeans are a relatively deep-rooted crop. In deep, well-drained soils with no restricting layers, roots can penetrate 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 requirement, also known as evapotranspiration or ET, for soybeans ranges from 17 to 28 inches depending on climatic conditions.

Water use is generally slightly higher in the west than the east. A value 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 5). 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.

Figure 5. *Soybean water use or daily evapotranspiration (ET) from a well-watered crop (Nebguide 1367 UNL).*



Various research studies across the state and throughout the High Plains confirm the general rule 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 amounts of rainfall and stored soil water. When full irrigation is possible, a managed allowable depletion level of 50 percent in the managed root zone is the recommended management guideline; the typical managed allowable depletion for most field crops. Since soybeans do not have an extremely critical stage of growth, they also do well under deficit irrigation. The peak water use rate is generally later in the growing season than corn, which means soybeans may sometimes be used as a field acreage split with corn as a way to reduce water stress potential at the critical growth stage of corn at tasseling.

Research results from the K-State Research Experimental Field at Scandia, Kansas, illustrated that scheduling by soil water depletion (30 or 60 percent), which did not limit the total season application amount, uses less water to provide similar yields (53 vs. 52 bushels per acre). The 30 percent depletion also occasionally had increased lodging. In some years, 60 percent 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 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 percent depletion criterion (52 bushels per acre), which used less water than the three-application treatment (51 bushels per acre).

This enforces 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 or climatic-based (also known as evapotranspiration-based) irrigation scheduling. This latter method can be accomplished by using the K-State Research and Extension KanSched irrigation scheduling program; available at *www.bae.ksu.edu/mobileirrigationlab/* along with other free irrigation decision support software.

Crop Rotation

The potential benefit of crop rotation may be a consideration. From an irrigation standpoint, irrigators with limited irrigation water capacity usually find soybeans complement corn irrigation when water can be shared between fields or the two crops split acreage within a field since soybean critical water period is usually later in the season versus the earlier critical tasseling period for corn. Often both crops benefit from the rotation. Soybeans also can be used as a late-season double crop with wheat.

Irrigation Summarized

Soybeans are a good irrigated crop option with great yield potential for both full and limited irrigation regimes. Peak daily water use rates are about 0.35 inch per day with seasonal water needs ranging from 17 to 28 inches. When limited water is available, late-season irrigation is generally most important.

Ignacio A. Ciampitti
Agronomy
Crop Production and Cropping Systems

Dorivar Ruiz Diaz
Agronomy
Soil Fertility and Nutrient Management

Douglas J. Jardine
Plant Pathology
Field Crop Diseases

Dallas E. Peterson
Agronomy
Weed Science

R. Jeff Whitworth
Entomology
Integrated Pest Management

Danny H. Rogers
Agricultural Engineer
Irrigation

Douglas E. Shoup
Southeast Area
Crops and Soils Specialist

Publications from Kansas State University are available at: *www.ksre.ksu.edu*

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF3154 January 2017

K-State Research and Extension is an equal opportunity provider and employer. Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, as amended. Kansas State University, County Extension Councils, Extension Districts, and United States Department of Agriculture Cooperating, John D. Floros, Director.