Chapter 8

Irrigation

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Adequate drainage is essential for maximum soybean production and becomes even more important with irrigation. The benefits of irrigation are usually reduced if a field is poorly drained. Little can be done to improve internal soil drainage, so efforts should be directed to improving surface drainage. Drainage recommendations are covered in more detail in Chapter 6, "Drainage and Tillage."

> **Management Tip**
>
> An irrigated crop will not achieve its full potential if adequate surface drainage is not provided.

Why Irrigate?

When growth and yield factors are rated according to importance, the availability of moisture always ranks near the top. Yields, up to a point, are determined by the availability and use of moisture. Irrigation is a means by which an adequate moisture supply to the crop can be better assured. This provides a potential for increased yields over dryland production and the opportunity to stabilize year-to-year fluctuations in yield and seed quality. This yield stabilization can allow a more aggressive marketing program. In addition, loaning agencies in some areas are evaluating the percentage of a grower's soybean acreage that can be irrigated before they issue a crop production loan. By the reproductive growth period, when irrigation is often first needed, approximately 50 to 60 percent of the production costs are already invested in the crop. Irrigation serves as insurance against a drought that can result in yields that do not even cover production costs, especially for double-crop soybean production.

Yield

Irrigated yields are well documented in many research and Extension studies. The Arkansas Soybean Performance Tests include several varieties that consistently produce in the 50 bu/ac range when irrigated. These same varieties average 10 to 20 bu/ac less without irrigation. The SRVP (Soybean Research Verification Program) 16-year (1983-98) average irrigated yield for 140 full-season production fields is 47 bu/ac. During this same period, there were also 57 irrigated double-crop fields that averaged 44 bu/ac. Many soybean producers are consistently harvesting 50 to 60 bu/ac on well-managed, irrigated fields. This indicates that irrigated yields can vary due to various production factors, but a realistic irrigated yield for most acreage is in the 45 to 50 bu/ac range. However, the 16-year (1983-98) state average irrigated yield is only 33 bu/ac according to data from the Arkansas Agricultural Statistics Service. Even though this is 10 bu/ac greater than the 23 bu/ac state dryland average over the same period, it indicates that many producers are not achieving the full yield potential from irrigation. The information presented in the remainder of this chapter is intended to help producers increase and stabilize irrigated yields.

> **Management Tip**
>
> A realistic irrigated yield goal for most acreage is 45 to 50 bu/ac.

Water Needs

A soybean crop will produce approximately 2 bu/ac for every inch of water it uses through the season. Yields in the 40 to 50 bu/ac range require 20 to 25 inches of available soil moisture during the growing season. The irrigation water needed will vary depending on the beginning soil moisture and the rainfall received during the growing season. An irrigation system needs to be capable of providing 10 to 15 inches of water during the season to assure an acceptable yield.

Daily water use varies as the crop develops. Table 8.1 shows the general growth and daily water use relationship for soybeans.

Table 8.1. General Soybean Growth and Water Use

Crop Development	Water Use (in/day)
Germination and seedling	0.05 - 0.10
Rapid vegetative growth	0.10 - 0.20
Flowering to pod fill (full canopy)	0.20 - 0.30
Maturity to harvest	0.05 - 0.20

Moisture stress anytime after planting can reduce growth and yield. The goal of early irrigation (prior to bloom) is to promote adequate vegetative growth and node development. Prebloom irrigation is almost always needed on late-planted and double-crop soybeans. The crop should be irrigated as needed to avoid moisture stress and to provide good soil moisture at seed fill (R5-R6 growth stage), ensuring that the seeds achieve their maximum size. Most growers realize the need to irrigate when the crop is blooming and setting pods. Experience indicates, however, that many growers tend to be late with the first irrigation and then quit before the crop can reach its full potential. The lack of early and late season irrigation is often responsible for a soybean crop not reaching its irrigated yield potential.

Management Tip

Adequate moisture is essential throughout the growing season for maximum yields.

Irrigation Scheduling

The timing of irrigation is commonly referred to as irrigation scheduling. Correct timing is critical to maximizing yield. Having the ability to irrigate is important, but it is also essential that a grower have a commitment to apply irrigation in a timely manner. Too often growers irrigate by the appearance of the crop. Visual stress, especially during bloom and pod set, results in yield loss. Also, once irrigation is started, the time required to finish a field will result in part of the crop suffering even greater stress. If the soil moisture can be determined, then irrigation timing decisions can be improved.

Determining the soil moisture by visual observation or by kicking the soil surface is difficult and can be misleading. The "feel" method can be used to more accurately determine the soil moisture condition. This method involves using a shovel or soil probe to pull a soil sample from the root area. In general, if the soil forms a hand-rolled ball, the soil moisture is adequate. A key to this method is to take samples across the field at different depths to better determine the soil moisture for the field. The challenge is to determine when to begin irrigation so the entire field can be irrigated before any part becomes too dry, but satisfactory results can be achieved with experience.

A more precise method employs tensiometers, a sealed, water-filled tube with a vacuum gauge on the upper end and a porous ceramic tip on the lower end. The tensiometer is installed in the seedbed at a depth where the majority of the roots are located. A 12-inch depth is commonly used for surface irrigation, except where a hardpan exists, and there it is placed just above this layer. Shallower settings at about 8 inches deep are recommended for center pivots. Two or three tensiometers per field are recommended to avoid a problem if one of the tensiometers quits working. Starting irrigation at a vacuum gauge reading of 50-60 centibars on silt loam and clay soils, and 40-50 centibars on sandier soils, is recommended. *Tensiometers are fairly reliable and effective when checked and maintained properly. However, the time and effort required usually results in most producers not being able to use them very effectively.*

Soil moisture accounting is used to calculate the soil-water balance in the root zone throughout the growing season. This method is sometimes called checkbook irrigation scheduling because a record is kept on the water that enters and leaves the soil like an account balance is maintained in a checkbook. Two forms of the checkbook procedure are available through county Extension offices in Arkansas – the Checkbook User's Guide and the Irrigation Scheduling Computer Program.

The Checkbook User's Guide is used to keep a written record of the soil moisture balance when a computer is not available. It is a three-page handout that shows how to use a water use chart and a water balance table to monitor the soil moisture. The water use chart shows an estimate of how much water the crop uses each day based on the maximum temperature and the age of the crop. Daily water use and rainfall amounts are entered into a water balance table. Maximum temperature data can be taken from the weather, newspaper, etc., but the rainfall should be measured with a gauge at each field. Adding and subtracting these numbers in the table determines the soil moisture deficit. Table 8.2 shows the recommended allowable deficits that are included in the User's Guide to help determine when to irrigate. The allowable deficits vary depending on the soil type, crop and irrigation method.

The Checkbook User's Guide, water use charts and water balance tables are available through your county Extension office at no cost. This method does require some record keeping, but it can be helpful in deciding when to irrigate.

Table 8.2. Recommended Allowable Deficits – Soybeans

Predominant Soil	Flood, Furrow or Border Irrigation (Inches)	Pivot Irrigation (Inches)
Clay	2.00	1.50
Silt Loam w/pan	1.75	1.25
Silt Loam wo/pan	2.50	2.00
Sandy Loam	2.25	1.75
Sandy	2.00	1.50

w/pan – with shallow (<10") restrictive layer
wo/pan – without shallow restrictive layer

If a computer is available, then the Irrigation Scheduling Computer Program can be used for the record keeping. This program operates much like the Checkbook method just described except that the computer does the calculations. It also uses local daily maximum temperatures and rainfall measured at the field to determine a soil moisture deficit for the field. The program is being successfully used by growers in Arkansas, Mississippi, Louisiana, Tennessee and Missouri. It is also being used in numerous irrigation studies and demonstrations conducted in Arkansas. A three-year (1994-96) demonstration of the program at the Southeast Branch Experiment Station (SEBES) in Rohwer indicated that it successfully scheduled irrigations in a field situation very comparable to growers' fields (Table 8.3).

In field studies using both tensiometers and the scheduler program it was found that they are usually within one or two days of each other on indicating when to irrigate. However, the program is much easier to use and maintain than tensiometers. The program also has the option to predict when irrigation will be needed in the next 14 days if no rainfall occurs. This offers a real benefit to managing irrigation labor and sharing irrigation water with other crops. The program is available through the county Extension office.

Table 8.3. Irrigation Scheduler Demonstration SEBES – Rohwer, Arkansas

Treatment	Avg. 1994 Yield (bu/ac)	Avg. 1995 Yield (bu/ac)	Avg. 1996 Yield (bu/ac)	Avg. 3-Yr. Yield (bu/ac)
Irrigate at:				
2 inch deficit	62	63	61	62
3 inch deficit	58	57	57	57
4 inch deficit	51	52	50	51
Nonirrigated	25	16	22	21

Variety NK S59-60, emergence mid-May, furrow irrigated, 19 inch x 1,000 ft. rows, silty clay, 0.1-0.15% slope

Management Tip

Commitment to irrigation scheduling helps a producer better achieve the benefits of irrigation.

Irrigation Termination

Growers are also faced with making the decision on when to stop irrigating soybeans. The goal is to have adequate soil moisture to ensure that the seed will obtain its maximum weight. Field experience indicates that inadequate moisture for full seed development can result in as much as 10 bu/ac yield loss. A practical rule of thumb for terminating irrigation is to determine if 50 percent or more of the pods have seeds that are touching within the pod. (The upper two pods in Figure 8.1.)

Figure 8.1. Seeds touching in the pod and ready for irrigation termination (upper two pods) along with pods needing at least one more irrigation (lower two pods).

If there is good soil moisture at this point, then irrigation can be ended. If the soil is becoming dry, an additional irrigation is needed to assure maximum seed weight. A final irrigation at this stage should be as quick a flush as possible if flood (levee) or border irrigating, or every other middle with furrow irrigation. About 1 inch should be applied with a pivot at this time, and in five to seven days the soil moisture and crop development should be checked again to determine if an additional irrigation is needed.

Irrigation Methods

Surface and sprinkler irrigation methods are used on soybeans. Each method has different characteristics that could make it the best for a particular situation. No one method can be labeled as the best – each has its place. The SRVP has included the four primary soybean irrigation methods. Table 8.4 shows that the four methods averaged essentially the same yield over a 16-year period.

Table 8.4. SRVP Yields by Irrigation Method (1983-98)

Irrigation Method	Avg. Yield (bu/ac)	Number of Fields
Center Pivot	47	41
Flood	46	68
Furrow	49	86
Border	51	8

Levee Irrigation

Flood irrigation with levees should really be thought of as flush irrigation. The challenge is to get the water across the field as quickly as possible. It is also important that irrigation is started before the crop experiences drought. If plants are drought stressed and then subjected to an extended wet soil condition, plant development can be delayed and some plants may die.

Levees should be marked early to strengthen the commitment to pull levees and irrigate when needed. The levee spacing depends on the slope, but spacing on a vertical difference of 0.3 to 0.4 feet is common. A narrower spacing on a 0.2- to 0.3-foot vertical difference may be necessary on very flat fields or when trying to irrigate small beans (less than 8 inches tall). Levees are often broken in several places or completely knocked down to get the water into the next bay. Rebuilding the levee in time for the next irrigation is often difficult because the levee area tends to stay wet. Some growers install gates or spills in the levees to avoid irrigation delays due to rebuilding the levees between irrigations. When possible, it is recommended that gates or spills are also installed in the outside levee. This provides better drainage of a field in a situation where a rain occurs during or soon after the irrigation.

Figure 8.2. Levee irrigation with flume ditch for multiple inlets into field.

It is recommended that water not be allowed to stand on any area for longer than two days. This can be difficult on big, flat fields. Some growers are able to divide these type fields into two smaller fields when they start irrigating so they can better manage the water. If this isn't practical, then providing multiple water inlets to the field can be helpful. Multiple inlets help avoid running water too long at the top of the field in order to get water to the bottom of the field. One multiple inlet method is to water the upper half of the field from the pump discharge or riser and then run irrigation pipe or tubing from the discharge down the field to water the lower half. A canal or flume ditch alongside the field can also be used for multiple inlets. The water can be directed from the ditch through cuts or spills into individual bays down the length of the field.

Another possibility is to run tubing the full length of the field and install several of the 2 1/2-inch plastic gates in each bay. These slide gates are adjustable from completely closed to fully open, where they deliver 65 to 75 gpm and they are reusable from year to year. This method is well suited to fields that have a permanent outside levee or road that the tubing can be laid on. However, the heavier tubing (9 to 10 mil) has been run up and over levees successfully as long as it is going down slope. The 9- to 10-mil tubing is better suited for these multiple inlet-type applications than the 6- to 7-mil tubing.

> **Management Tip**
> It is recommended that water not be allowed to stand on any area for longer than two days.

If the soil cracks readily, then levee irrigation becomes even more of a challenge. Multiple inlets can help, but it is still important to irrigate on time. Planting on a raised bed can also provide extra drainage and help avoid some of the water management challenges of levee irrigation.

A minimum irrigation capacity of 15 gpm per irrigated acre is recommended for levee irrigation. At that rate, about four days would be required to complete an irrigation. Starting late would increase the time required, resulting in severe drought stresses in the last portion to get water. The more pumping capacity available for levee irrigation, the better. Opportunities for getting more pumping capacity to a field should be explored and developed whenever possible so the pumping time required to irrigate a field can be reduced. Although levee irrigation presents a challenge, it can be done successfully. There are many producers who consistently produce high yields by paying close attention to the precautions and recommendations that have been presented.

Furrow Irrigation

Furrow irrigation can be a very effective irrigation method. *One of the biggest requirements for furrow irrigation is that the field must have a positive and continuous row grade.* This usually requires precision land grading which can be rather expensive. However, the grading results in positive field drainage that greatly enhances production. The row grade should be a minimum of 0.1 percent and no more than 0.5 percent; row grades between 0.15 and 0.3 percent are especially desirable.

The row length to be furrow irrigated is another key consideration. Row lengths of 1/4 mile or less generally water more effectively than longer rows. Row lengths less than 1/4 mile are usually required if sandy soils are to be irrigated effectively.

When row lengths cannot be altered, it may be necessary to control the furrow stream flow by adjusting the number of rows that are irrigated at one time. Experience shows that in most situations it is desirable to get the water to the end of the row in 10 hours or less. Watering much longer than this can cause overwatering at the top of the row and cause problems, especially if it rains and stays cloudy soon after the irrigation. This has become more of a concern with the expanded use of irrigation tubing with punched holes for furrow irrigation. The tendency with the tubing is to punch holes as long as water still comes out of them without much concern for how long it will take to water out the row. This is desirable from the standpoint of not having to plug and open holes and operate the tubing in sets. However, the caution is to water according to what is more effective for the field and crop rather than what is easiest.

Figure 8.3. Furrow irrigation with gated pipe.

Furrow irrigation requires a water supply of at least 10 gpm per irrigated acre, and more capacity is desirable if available. At 10 gpm/acre, about five to six days should be expected to complete an irrigation. Practices like waiting until morning to change sets when rows water out at night can add significantly to the time, making it difficult to finish the field much before it is time to begin the next irrigation. A well-defined furrow is needed to carry the irrigation water. Planting on a good bed is the most desirable option for having a good water furrow. If a bed is not used, then it is necessary to cultivate with a furrow plow that moves enough soil from the middle of the rows so that a good furrow is created. Plowing out a furrow is probably not an option on rows less than 19 inches wide, so the border method may be a better option on those fields.

> **Management Tip**
> Furrow irrigation requires a water supply of at least 10 gpm per irrigated acre.

Some producers prefer to water alternate middles under certain conditions. This is especially true on row spacing of 20 to 30 inches. Watering alternate middles can result in getting across the field quicker and not leaving the soil as saturated as it might be if every middle were irrigated. Then, if rain comes soon after the irrigation, it is possible for it to soak into the soil rather than run off or collect and stand in low spots. However, with alternate middles on narrow rows and/or cracking soils, the skipped middle is sometimes saturated.

Producer preference and experience, along with the crop and field condition, will determine whether it is best to water every middle or alternate middles. Alternate middle irrigation will result in having to come back with the next irrigation somewhat sooner than when every middle is watered if the water doesn't soak across the dry rows.

Furrow irrigation by necessity requires that there be some amount of tail water runoff from the end of the rows. All the middles will not water out at the same rate, especially those that are wheel middles. Also, cracking soils can make furrow irrigation management more challenging. However, irrigating on the appropriate schedule will reduce the problems associated with too much cracking.

Border Irrigation

This is an old irrigation method that is relatively new in Arkansas. The concept is to flush a large volume of water over a relatively flat field surface in a short period of time. Borders are raised beds or levees constructed in the direction of the field's slope. The idea is to release water into the area between the borders at the high end of the field. The borders guide the water down the slope as a shallow sheet that spreads out uniformly between the borders.

Border irrigation is best suited for precision graded fields that have slope in only one direction. The soybeans need to be flat planted in the direction of the field slope or possibly at a slight angle to the slope. Planting across the slope tends to restrict the water flow, especially on fields with less than 0.1 ft. fall per 100 feet. Fields with slope in two directions are not as well suited to border irrigation, but it may still be possible if the borders spacing is relatively narrow.

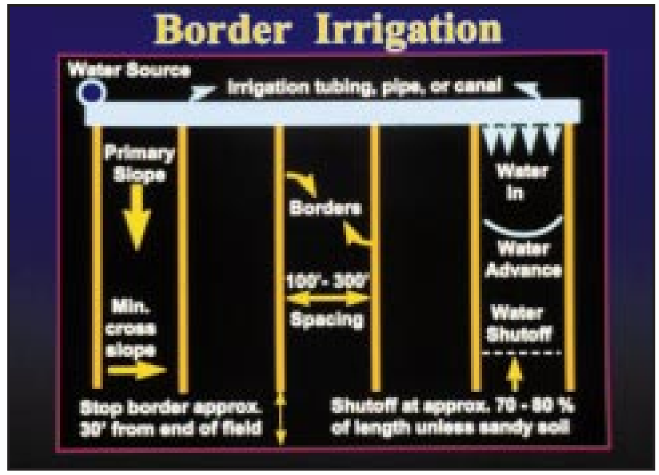

Figure 8.4. Border irrigation system general layout.

The spacing between borders is dependent on soil type, field slope, pumping capacity, field length and field width. A clay soil that cracks is sometimes difficult to irrigate, but with borders the cracking actually helps as a distribution system between the borders. This factor also makes it possible to use borders on clay fields that have a slight side or cross slope. The tendency on fields with side slope is for the water to flow to the lower side and not spread out uniformly between the borders. The soil cracks lessen this effect because the water will spread laterally as it follows the cracking pattern. The border spacing on clay soil will generally be between 200 and 300 feet with the narrower spacing on fields with side slope.

The border spacing on sandy and silt loam soils that tend to seal or crust over is more of a challenge than with the cracking clays. Side slope on these soils results in the border spacing having to be narrower in order for the water to spread uniformly between the borders. The border spacing on these soils will generally range between 100 and 200 feet with the narrower spacing on fields that have side slopes.

The pumping capacity and field dimensions (length and width) are used to determine the number of borders needed and how many can be irrigated in a reasonable time. Calculations can be made to estimate the time required to irrigate a border, and it is usually possible to work toward approximately 12-hour set times. The 12-hour time set is very desirable because it fits very well for managing water and labor. The border can be constructed in a variety of ways and with different types of equipment. The method used is partially determined by whether or not soybeans are to be grown on the border. A settled border height of 2 to 4 inches is all that is needed on ideal fields with no side slope, but a 4- to 6-inch settled height is required if the field has side slope or if the field has potholes. *If the border is constructed with a disk-type implement, an effort must be made to fill the ditch left at the base of the border so it will not act as a drain furrow.* The borders need to stop at least 30 feet from the low end of the field so they will not restrict drainage.

The water can be delivered into the area between the borders from a canal, gated pipe or gated irrigation tubing. If irrigation tubing is used, it is recommended that it be the heavier 9- to 10-mil tubing. The 2 1/2-inch plastic gates that deliver 65 to 75 gpm each can be installed in the tubing, reducing the number of holes needed and simplifying closing gates at the end of a set.

If border irrigation can be used on a field that is usually flood irrigated, then it can provide certain advantages:

1. Less production area lost with border than with levees.
2. Improved ability to irrigate small beans.
3. Don't have to repair or rebuild border between irrigations, thus a potential for time and labor savings.
4. Field drainage is not restricted by borders.
5. There is better possibility of growing soybeans on the border.

Border irrigation will not work on all fields and is not necessarily a better method where soybeans are already grown on good beds and furrow irrigated. However, if a grower wants to move toward flat planting and reduced tillage on these fields, then border irrigation may be more appealing than flood. There is not adequate space in this publication to cover all of the details associated with border irrigation. However, more information is available through your local county Extension office.

Center Pivot Irrigation

Center pivots offer the ability to irrigate fields that have surface slopes that make it impossible or impractical to irrigate with surface methods. They also offer more water management options than surface irrigation. *The need for good surface drainage still exists with pivot irrigation and should not be overlooked.*

Pivots are best suited for large square-, rectangular- or circular-shaped fields free of obstacles such as trees, fences, roads, power poles, etc. Field ditches are also a concern if the pivot towers must be able to cross them. Pivots can cover a range of acreage depending on the allowable length, but the common 1/4-mile system will cover approximately 130 acres of a 160-acre square field. It is also possible to tow a pivot from one field to another. *It is usually best for a system not to be towed between more than two points during the season.*

Figure 8.5. Center pivot sprinkler system.

Pivots provide the ability to control the irrigation amount applied by adjusting the system's speed. This gives the operator advantages for activating chemicals, watering up a crop and watering small plants. These advantages are especially important for double-crop soybeans, since they are more likely to encounter a drought soon after planting. It is also possible to apply liquid fertilizer and certain pesticides through the system if the necessary precautions are taken. One of the biggest advantages of pivot irrigation is the limited labor required for operating the system.

It is recommended that a pivot have a water supply of at least 5 gpm per acre that is irrigated. At that rate, nearly four days are required to apply a 1-inch irrigation. A water supply less than this leaves little room for breakdown time without the risk of getting behind in meeting the crop water needs. The capacity for a towable system should be greater to account for the added time needed to move the system. Most new pivots are being equipped with low-pressure sprinkler packages. Many of these are mounted on drops so that the water is released closer to the soil surface. This is desirable as long as the system application rate is matched to the soil and field characteristics so that excessive runoff is avoided. If a field has a rolling surface and a soil that tends to crust or seal over, this should be taken into account in the sprinkler package selection. The application amount can be adjusted to reduce runoff to some degree, and most producers find that applying approximately 1 inch works best.

The biggest challenge with center pivots is the initial cost. However, it does offer some advantages that can justify the initial cost, especially when surface irrigation is not possible and the cost is spread over an expected service life of at least 15 years.

When considering the different irrigation methods, it is important to remember that any method that is well planned and is properly installed, operated and maintained can give the results desired. *Every method requires time to irrigate the whole field, so it is very important that irrigation be started early enough that no part of the field suffers moisture stress.*

Arkansas Situation

Consistent and profitable soybean production is difficult without irrigation. Fortunately, once irrigation is in place, the energy cost for pumping water is relatively cheap at $2 to $5 per acre for each irrigation. This cost is easily justified by the yield increase that can result from the irrigation. The maximum profit usually results when the maximum yield is obtained, so the irrigation goal is to obtain the maximum yield by preventing crop moisture stress. *Irrigation is not a cure-all. Maximum yield and profit will be achieved only when irrigation is coupled with other production practices that establish profitable yield potentials.*