3 - Drainage and Irrigation

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Drainage

Adequate drainage is necessary for maximum corn production. It is highly recommended that corn be planted on raised rows or beds, especially on fields that are relatively flat. Corn is typically planted early when low temperatures and significant rainfall are likely. Raised rows or beds reduce the effect that cold, wet soil conditions have on planting and early crop development. Rolling fields that have significant slopes may not need raised rows or beds for drainage, but may still benefit from the beds warming up faster than flat seed beds. Poor drainage hampers field operations from field preparation through harvest and limits the effectiveness of irrigation. Eliminating poorly drained areas preserves natural soil productivity by reducing field rutting that requires additional tillage. Poorly drained areas reduce yields and often require the most tillage. Water infiltration is also reduced if soil is tilled when it is too wet. Good field drainage complements all crop production practices and makes it possible to consider reduced or no-till corn production. **The goal for drainage is to have minimal standing water on a field 24 hours after a rainfall or irrigation.**

Surface Drainage

Field surface smoothing and forming, prior to bedding, can improve the surface drainage of a field. Use land planes to smooth out the high spots and fill in the low areas so that the field has a more uniform slope toward drainage outlets. Low areas that are larger than 100 feet across or that require more than 6 inches of fill should be overfilled and compacted before being planed. Make an effort to accurately determine a field's drainage flow pattern. Deciding where water will drain by simply looking at the field is not always easy. Some limited surveying of field elevations can be very helpful in determining where to place tail water furrows and field drain outlets.

Precision grading of a field provides a positive method of improving surface drainage as well as making furrow irrigation possible. If a field is being considered for precision grading, the soil should be evaluated to determine what problems might occur if deep cuts are made in some areas. The cut areas may expose soil with reduced production capability. County soil survey reports, published by the Natural Resources Conservation Service (NRCS, formerly SCS), can help identify soils with unproductive subsoils. Taking several deep (more than 6 inch depth) soil cores or samples may be beneficial if a problem soil is suspected. Poultry litter application may improve the productivity of cut soils. An Extension publication, *Soil and Fertilizer Information Article 2-90*, Poultry Litter as an Amendment for Precision Graded Soils, reports on results of litter application studies.

Precision grading is limited to fields with slopes of less than 1 percent, or the cost can be prohibitive. **If possible, the finished grade in the primary slope direction should range from 0.1 to 0.5 percent (% 0.1 to 0.5 ft. per 100 ft.).** This range provides good surface drainage without increasing erosion potential. Slopes of less than 0.1 percent are suitable for cross slopes but should be limited to slope lengths of a quarter mile or less. Slopes less than 0.1 percent are more difficult to construct with precision, and they tend to develop more low areas and reverse grades. It is also recommended to consider putting a field to grade in only one direction (i.e., zero cross slope) if it doesn't require a significant amount of extra cost. Building a permanent pad or elevated road on one or more sides of a field should also be considered in the grading plan. Settling often occurs in deeper fill areas and should be "touched up" before bedding if possible. The land grading design should consider the type of drain outlets and the number required for the field. If possible, it is best to provide an outlet point for every 20 acres.

An elevation survey of the field is required before any design work can be done. Survey information can be entered into a computer program that evaluates possible drainage options for a field and determines the cuts and fills required. Most land grading contractors offer the computer program design, and it is sometimes available through NRCS. The lowest expected elevation of the field should be determined before grading begins to assure that water will drain into the surrounding ditches adequately and not back up onto the field. It may be necessary to divide the field into shorter segments to ensure that the runoff leaves the field. Precision grading is usually expensive and is a long-term investment for increasing production efficiency and potential and the market value of the land. Government funded conservation programs sometimes offer cost sharing on precision grading and/or other conservation best management practices. Information on these programs can be obtained through NRCS.

Good surface drainage is even more important if corn is planted flat rather than on raised rows or beds. Low areas in a flat-planted field are likely to have poor production for obvious reasons. Drain furrows to these areas can be used to reduce the effect on the crop. Shallow and narrow drain furrows can be constructed with several different types of equipment. The equipment should spread the soil evenly away from the drain furrow, so flow into the furrow is not restricted. Construct drain furrows in the low areas of a field rather than putting them in randomly. They should generally run with or at a slight angle to the natural slope of the field but not across the direction of the slope. Furrows should have continuous positive grade to assure that the water will be directed off the field. A drain furrow is not complete until it is connected to a ditch or pipe of adequate size to carry excess water away from the field.

An important component of field drainage is the ditch system that receives the excess water and carries it away from the field. Flow restrictions in these ditches can cause excess water to remain on a field. Drainage ditches should be maintained and routinely cleaned out to effectively handle the drainage water from a field. **No tillage or reducing tillage limits the sediment leaving fields and minimizes the sedimentation that occurs in drainage ditches.** Ditch outlets and drainage structures should also be checked to assure that they are functioning properly and are not becoming restricted. Beavers often cause problems by damming ditches, culverts and drainage pipes. A Beaver Pond Leveler pipe has the potential to reduce these problems in certain situations. This device is described in Extension publication FSA-9068, *Flood Water Management With a Beaver Pond Leveler*. It may be necessary to work with neighboring farms and/or the Drainage District to correct common drainage problems. Planned drainage improvements could impact areas classified as wetlands. If this possibility exists, contact the local NRCS staff to see what help they can provide. Typically, they can visit the site and determine if there are drainage restrictions.

Internal Drainage

Many Arkansas soils, with the exception of the sandier (coarse) soils, have limited infiltration and/or internal drainage. Some clean-tilled silty soils tend to seal or crust over at the surface after rainfall or irrigation, restricting the movement of water into the soil surface and the root zone. Infiltration may be improved through crop residue management. Maintaining crop residue reduces surface sealing and crusting so water moves into the soil more freely. This improves the infiltration and water-holding capacity of the soil.

Naturally occurring restrictive soil layers and those formed by tillage equipment restrict internal soil drainage. The restrictive soil layers reduce the rooting depth and water reservoir available to the corn plant. Shattering these layers prior to planting a corn crop is recommended to improve plant root development and internal drainage. A soil probe or shovel can be used in several areas of a field to determine if restrictive soil layers are a problem.

Digging up root systems and observing the rooting depth and pattern can also help determine if there is a restriction. Restrictive soil layers are commonly shattered by using a subsoiler or ripper-hipper in the field. The depth and thickness of the restrictive layer usually determines which implement should be used. **The restrictive layer must be dry enough for the deep tillage implement to extend just below the bottom of the restrictive layer so it is effectively lifted and shattered.** If the restrictive layer begins at 8 inches and is 2 to 3 inches thick, the tillage shank must penetrate 10 to 12 inches deep. In-row subsoiling is more effective than random subsoiling paths due to the re-compaction caused by subsequent trips of the implement. The in-row pattern also reduces the likelihood the field will be too soft in the spring to support equipment and delay early field preparations. High-residue subsoilers or ripper-hippers are suggested for maintaining the same row location year to year. Surface tillage, especially disking, quickly reforms restrictive layers and should be avoided, if possible.

Irrigation

Corn production in Arkansas is only recommended with irrigation. All five locations for the Arkansas Corn Hybrid Performance Tests are irrigated, even though there is still a small percentage (estimated 20 percent or less) of corn in Arkansas that is not irrigated. Reasonable corn yields may be obtained without irrigation in some years that have good rainfall patterns and growing conditions. However, if adequate rainfall does not occur, yields can be a disaster and the drought stress can contribute to charcoal rot and aflatoxin, which can result in crop failure. These potential risks are the basis for the strong recommendation to irrigate corn in Arkansas.

Yield

Several hybrids in the Arkansas Corn Performance Tests have 2- and 3-year irrigated average yields of 175 bushels per acre or greater. In the 3 years (2000-2002) of the Corn Research Verification Program, the average yield for the 26 irrigated fields was 175 bushels per acre. Most Arkansas corn producers report irrigated yields of 150 to 200 bushels per acre, and many experienced corn growers are consistently harvesting 175 to 200 bushels per acre on much of their acreage. **Irrigated corn should yield approximately 175 bushels per acre with good production practices and management on productive soils.**

Water Needs

The total amount of water that a corn crop needs during the growing season may vary from 20 to 30 inches depending on factors such as weather conditions, plant density, fertility, soil type and days to maturity. In most seasons, the amount of water needed will be about 20 to 24 inches. The inches of irrigation water required will vary depending on the beginning soil moisture and the rainfall received during the growing season. The irrigation system needs to be capable of providing 12 to 16 inches of irrigation water to assure a good yield potential.

Moisture stress anytime after planting can affect plant development and reduce yield potential. The amount of yield loss is dependent on the growth stage of the corn when moisture stress occurs. Table 3-1 shows the general relationship of potential yield reduction due to moisture stress at different growth stages.

Table 3-1. Potential Yield Reduction From Moisture Stress at Different Growth Stages of Corn

Growth Stage	% Yield Reduction
Prior to tasseling	10-20
Tasseling to soft dough	20-60
Soft dough to maturity	10-35

Corn's daily water needs are relatively low in the first 3 to 4 weeks of vegetative growth, and rainfall is usually adequate to meet the water demand during this period. However, if it is relatively dry when the crop emerges and rainfall doesn't occur in the first 2 to 3 weeks, irrigation may be needed. When the corn has approximately 8 fully developed leaves, its growth rate greatly increases. The number of kernel rows per ear is determined at this time so plant stress needs to be avoided during this period. A sidedress fertilizer application is usually made prior to this time. The plant's nutrient and water uptake increases, and irrigation is often needed at this time to activate the fertilizer and avoid moisture stress.

If nutrient and water needs are met, rapid plant growth continues. The number of kernels on each ear and the size of the ear are being determined when the plant has 12 leaves. The number of kernels is determined by the 17-leaf stage, which is about one week from silking. At this time the crop is very near the start of the reproductive growth stage, when its water needs are greatest. **During the period from about 2 weeks prior to silking until 2 to 3 weeks after silking, the water use on days with temperatures in the upper 90s can be 0.3 inches. This 4 to 5 week period is the most critical time to make sure irrigation is applied as needed to satisfy the water needs.** Moisture stress during the silking stage may delay development so that the pollen is shed before the silks emerge. This can result in poor or no pollination and extremely low yields. Most corn producers report that if it is hot and dry and you are late starting irrigation going into this period, it is very difficult to irrigate often enough to keep up with the crop's water needs. Once the grain is developed, the water use begins to decrease because the kernels start to progressively harden as they dry and the crop approaches maturity. Table 3-2 shows the estimated range for daily crop water use as the crop develops.

Table 3-2. Estimated Corn Water Use in Arkansas*

Days after planting	Inches per day
0-30 (early plant growth)	0.05-0.10
30-60 (rapid plant growth)	0.10-0.20
60-100 (reproductive stage)	0.20-0.30
100-120 (grain fill to maturity)	0.25-0.10

*Based on planting date of April 1

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 the ability and commitment to apply irrigation in a timely manner.** Too often, growers irrigate by the appearance of the crop. Visual stress, especially during reproductive growth, results in yield loss. Even if irrigation is started at the first sign of visual stress, there is still some amount of time required to finish irrigating a field. The result is that the crop in the last area of the field to be irrigated suffers even greater yield-limiting stress.

Irrigation timing decisions can be improved if the soil moisture can be determined. 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 determine the soil moisture condition more accurately. 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 in order 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. Satisfactory results with the "feel" method can be achieved with experience.

Soil moisture can be determined more precisely with tensiometers. A tensiometer is 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, but if a hardpan exists then the tensiometer is placed just above the restrictive 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 should one of the tensiometers quit working. Starting irrigation at a vacuum gauge reading of about 50 centibars on silt loam and clay soils, and at approximately 40 centibars on sandier soils, is recommended. In addition to tensiometers, there are other soil measurement devices that are fairly reliable and effective when checked and maintained properly. However, the time and effort that this requires 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 – 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 usage chart and a water balance table to monitor the soil moisture. The water usage 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 3-3 shows the recommended allowable deficits that are included in the User's Guide to help determine when to irrigate.

Table 3-3. Allowable Deficits – Corn

Predominant Soil	Flood, Furrow or Border Irrigation (Inches)	Pivot Irrigation (Inches)
Clay	1.75	1.25
Silt Loam w/pan	1.50	1.00
Silt Loam wo/pan	2.00	1.50
Sandy Loam	1.75	1.25
Sandy	1.50	1.00

w/pan – restrictive layer at 10 inches or less below soil surface
wo/pan – without shallow restrictive layer

The Checkbook User's Guide, water usage 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.

If a computer is available, 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 uses daily maximum temperatures and rainfall measurements at the field to determine the field's soil moisture deficit. **The program also has the option to predict when irrigation will be needed in the next 10 days if no rainfall occurs.** This offers a real benefit to managing irrigation labor and sharing irrigation water with other crops. The program is used in research and Extension irrigation studies and demonstrations conducted in Arkansas. Growers in Arkansas, Mississippi, Louisiana, Tennessee, Kentucky and Missouri are successfully using the program on their farms. **The program is downloadable from the following Extension web page address: http://www. aragriculture.org/computer/schedule/default.asp.**

Irrigation Termination

As the crop approaches physiological maturity, a decision on when to stop irrigating has to be made. **The goal is to maintain adequate soil moisture until the corn reaches black layer, which indicates physiological maturity.** This ensures that the kernels can obtain their maximum weight so the crop's full yield potential will be achieved. The decision is best made toward the end of the season by a field determination of the maturity of the crop and the soil moisture status. An initial consideration is how many days it has been since planting. If it has been 90 days since planting and the corn is a 112-day corn, then it may be within 3 weeks of maturity and a field check should be made.

Determining how developed the starch is in the kernel is helpful in making the decision on when to terminate irrigation. The starch begins forming as a line from the top of the kernel and moves toward the tip of the kernel where it is attached to the cob. The progress of the starch line can be checked by taking approximately six (6) representative ears from the field and removing the shucks. The ears can then be broken in half and some of the kernels taken from where the ear was broken. These kernels can be sliced lengthwise so the starch development can be observed. The goal is to determine if there is at least 50 percent starch development inside the kernels sampled. If there is 50 percent starch and good soil moisture exists from a recent surface irrigation or rain, then irrigation can be terminated. However, if the soil is becoming dry at this point, then additional irrigation is needed to assure maximum seed weight and yield. A final irrigation at this stage should be as quick a flush as possible with flood (levee) or border irrigation. If the corn is irrigated with a center pivot, then it is recommended that the starch development be at 75 percent with good soil moisture before stopping irrigation.

Irrigation Methods

The surface and sprinkler irrigation methods used on corn have different characteristics that determine which would be the best for a particular situation. No one method can be labeled as the best – each has its place.

Flood (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. This is especially important if the corn is small and planted flat rather than on a raised row or bed. **It is also critical that irrigation is started before the crop experiences drought stress. 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. If the corn in the levee mark has been allowed to grow very much, it may be necessary to bush-hog the levees before they are pulled. This helps avoid problems caused by having too much plant material in the levee. Spacing of the levees depends on the field slope, but spacing on an elevation difference of 0.3 to 0.4 feet between levees is common. A narrower spacing of 0.2 to 0.3 feet elevation difference may be necessary on very flat fields or when trying to irrigate flat planted corn that is less than 6 inches tall. Levees are usually 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 a few gates or spills be installed in the outside levee to provide better field drainage when a big rain occurs during or soon after the irrigation. The outside spills can be opened to avoid the “blowing out” of levees.

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 a big field into two smaller fields so they can better manage the water when they start irrigating. 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 2.5-inch plastic gates in each bay. These slide gates are adjustable from completely closed to fully open. When fully opened they deliver 65 to 75 gallons per minute (gpm) and they are reusable from year to year. The decision can then be made on how many bays to water at one time based on the available flow and the size of the bays. This method can be used by laying the tubing on a permanent outside levee or road along-side a field. However, with this installation, all of the water will tend to go to the low end of the tubing. When this occurs, some type of restriction has to be put on or under the tubing (choke-rope, barrel, etc.) in order to hold water back up the slope. Another option is to run the tubing over the levees. Heavier tubing (9 to 10 mil) has been laid over levees successfully as long as it is going down slope. The 9 to 10 mil grade tubing is better than the 6 to 7 mil in multiple-inlet-type applications.

Levee irrigation becomes even more of a challenge if the soil is allowed to crack severely before irrigation is started. Multiple inlets can help offset this challenge, but it is still important to irrigate on time. Planting on a raised bed or row as recommended provides improved drainage and helps avoid some of the water management challenges of levee irrigation. Planting on beds and using multiple inlets with spills installed in the levees may provide the best water management capability with flood (levee) irrigation.

A minimum irrigation capacity of 15 gpm per irrigated acre is recommended for levee irrigation. At this 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 of the field to get water. 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. As discussed earlier, the row grade should be in the range of 0.1 to 0.5 percent, and row grades between 0.15 and 0.3 percent are especially desirable for furrow irrigation. The row length to be furrow irrigated is another key consideration. Row lengths of 1,500 feet 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 about 12 hours. Watering so long that the top of the row is over-watered can cause problems in this area, especially if it rains and stays cloudy soon after the irrigation. This is a concern with the expanded use of irrigation tubing with punched holes for furrow irrigation. The tendency is to punch holes in the tubing as long as water still comes out of them without much concern for how long it will take to water out the row.

Growers find that on some fields with good beds, they can use small holes with small furrow streams for up to 24 hours on a furrow irrigation set without risk of over-watering or damaging the crop. This is desirable from the standpoint of operating the tubing in sets without having to plug and open holes. The caution is to water according to what is more effective for the field and crop rather than what is easiest.

Another approach that can limit or avoid the opening and plugging of holes and the tendency to irrigate for too long is to run parallel tubing across the field. One run of tubing would go across the first half of the rows and have holes punched for each middle to be irrigated. A longer run of tubing is then laid behind the shorter tubing. Beginning where the shorter tubing ends, holes are punched in the longer tubing for the middles irrigated across the remainder of the field. This allows row sets to be changed by unhooking one run of tubing from the irrigation well or riser and hooking up the other run. If more than two sets are required for a field, then alternate rows may be irrigated to avoid the laying of additional tubing. It is also possible to get multi-valved fittings that can accommodate three or more sets and reduce the amount of tubing needed to avoid the plugging and unplugging of holes.

Furrow irrigation requires a water supply of at least 10 gpm per irrigated acre, and more capacity is desirable if available. At 10 gpm per acre, about five 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 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. Some producers prefer to water alternate middles under certain conditions. 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. 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 usually result in having to come back with the next irrigation somewhat sooner than when every middle is watered.

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

Border Irrigation

Border irrigation may be a method to consider on fields that are planted flat rather than on raised beds or rows. 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, flushing a large volume of water over a relatively flat field surface in a short period of time. 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. All field preparations should be done with the field's primary slope, and planting should be with or at a slight angle to the primary slope. Planting across the slope tends to restrict the water flow, especially on fields with less than 0.1 percent slope. Fields with slope in two directions are not as well suited to border irrigation, but it may still be possible if the spacing between borders is relatively narrow.

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 border irrigation, 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 affect 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 soils that seal or crust over 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. **The desired pumping capacity for border irrigation is 12 gpm per irrigated acre. 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, which fit very well for managing water and labor.**

The border can be constructed in a variety of ways and with different types of equipment. It is also possible to plant on the borders if they are constructed before planting. A settled border height of 2 to 3 inches is all that is needed on ideal fields with no side slope, but a 3 to 6 inch settled height is required if the field has side slope or if the field has shallow depressions or 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 irrigation tubing. The 2.5-inch plastic gates that deliver 65 to 75 gpm each can be installed in the tubing so sets can be changed by opening and closing the gates. If gates are installed in the irrigation tubing, the heavier 9 to 10 mil tubing should be used. When holes are punched in the tubing, the parallel tubing layout discussed with furrow irrigation may need to be used in order to avoid plugging and unplugging holes.

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 borders than with levees,
2. improved ability to irrigate small corn,
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 and
5. possibility of planting on the borders.

Border irrigation will not work on all fields, and it should really only be considered when the corn is planted flat. 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 cross them. Pivots can cover a range of acreage depending on the allowable length, but the common 1/4-mile, full circle system will cover approximately 130 acres of a 160-acre square field. **It is possible to tow a pivot from one field to another, but it is usually best for a system not to be towed between more than two points during the season.**

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. It is also possible to apply liquid fertilizer and certain pesticides through the system. This is called chemigation, and it can be especially applicable to corn for sidedress or late-season applications of fertilizer. **Any chemicals that are to be applied through the system must be specifically labeled for chemigation.** The label will give fairly specific application requirements and recommendations if a chemical is approved for chemigation application. Any pivot system used for chemigation must have some specific equipment and safety devices installed. Information on equipment requirements and chemigation is available through most center pivot dealers or companies. General information on chemigation can be obtained through the local county Extension office.

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 no room for break down 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. It is recommended that pivot irrigation be applied early enough to avoid the deeper soil moisture being extracted early in the season. If the deeper moisture is used early in the season, it becomes difficult for a pivot to keep up with the water demand unless rainfall replenishes the deep moisture. A pivot irrigation will typically soak about 8 inches of the root zone and has very little chance of replacing moisture any deeper. The goal is to save the deeper moisture for when irrigation is terminated and the crop uses the deeper moisture to take it to maturity.

Most pivots are equipped with low-pressure sprinkler packages, and many are mounted on drops that release the water closer to the soil surface. This is desirable as long as the system application rate is matched to the soil and field characteristics so 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. Minimum tillage that leaves crop residue on the surface can help reduce runoff problems. It might also be possible to put in narrow width (1 inch or less) slots at a depth of about 8 inches in some of the middles. This can be done with something like anhydrous shanks in order to give the water a path for soaking in rather than running off a sealed or crusted-over soil surface.

One of the biggest advantages of pivot irrigation is the limited labor required for operating the system. The biggest challenge with center pivots is the initial cost. However, they 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 corn production in Arkansas is difficult without irrigation. Once irrigation is in place, the irrigation operating cost for each irrigation is typically $3 to $6.50 per acre. 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.**

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