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Border Irrigation System

Border irrigation is an old irrigation system used in the western part of the United States to irrigate alfalfa, wheat, other small grains, and sometimes row crops. The border idea is to flush a large volume of water over a flat surface in a short period. The borders are no more than a good, high bed or row. Depth of water flow is shallow and uniform down the bordered area. It is a system where a large volume of water is put in a defined border or bay at the top of the field and guided by the borders down the slope in a uniform wetting pattern to the end of the field.

Unlike rice/soybean rotations, where flooding is sometimes used as an irrigation system for soybeans, the borders have a shallow, uniform water flow and can be used to irrigate soybeans or other crops when they are small; you do not have a danger of submergence. Also unlike rice culture, when the water is turned off at the top of the field, there is little freeboard to carry water much farther through the field. Run the water until it reaches the end of the field or close to the end so the entire border is watered out.

Border irrigation is simple to use in the Mississippi Delta regions where rice culture is practiced and straight-levee rice fields are used. Straight-levee rice culture is a sloped field in one direction with a side slope of zero, flat in one direction, and sloped in the other direction. The soil types of many of the fields are often a cracking clay that actually helps distribute water. The cracks give random distribution of the water and help disrupt the potential for channeling through the border.

Border irrigation in the Midsouth is a straightforward concept on straight-levee rice fields for row crops. Border widths are easily designed based on a well's flow rate and length of the field. There is a design equation to determine the flow rate per unit width for a border, but some rules of thumb have proven effective in the cracking clays in the Midsouth. Use caution when considering border irrigation. This system is not a replacement or substitute for good beds and row irrigation of any crop. It is for flat-planted crops only. A border irrigation system is better than flood irrigation but it is not better than bedded crops that are row watered.

Border Design

The rule of thumb for border design, or at least a place to start on a field, is 5 gallons per minute (gpm) per foot of width for a 1,320-foot run length and 10 gpm per foot of width for a 2,640-foot run length (Figure 1). These flow rates give approximately a 12-hour set time, depending on field width, soil type, well yield, starting soil moisture deficit, and field roughness. Good field records where borders are installed can help "fine tune" the border widths in future years.

Design your border irrigation system for convenience (12- or 24-hour sets) to conserve the most water and labor during the irrigation season. This also benefits the crop by not allowing long, slow irrigation sets that often are counter productive to an irrigation response.

Sometimes 12-hour sets are not the most efficient for fitting an even number of borders into a field. If it is more convenient, or it fits the field better, use 24-hour sets. Irrigation times longer than 24 hours are not recommended; however, research shows 48 hours to be the maximum set time for flood irrigation of soybeans. For a starting point, design 24-hour sets at half the flow rate per unit width indicated (Figure 1).

The equation for designing borders in its simplest form:

$$Q_u = 0.000064 \times L \times \frac{S_0^{0.5}}{n}$$

Q_u = Flow rate per unit foot in cubic feet per second. Qu multiplied by 450 will give the flow rate per unit foot in gallons per minute per foot of width.

L = Length of the field in feet.

S_0 = Slope of the field in feet per foot.

n = Roughness coefficient between 0.15 and 0.25, with 0.25 being rougher.

$$Q_u \times 450 = \text{gpm/foot}$$

For example, if a field is 1,320 feet long with a 0.1 percent slope and a roughness coefficient of 0.25, the flow rate per foot of width is 0.01 cfs, or 4.8 gpm per foot of width (0.01 × 450). This is close to the 5 gpm per foot on the estimator (Figure 1). If your well yields 1,200 gpm, then place your borders 240 to 250 feet apart, which is 5.25 to 5.50 borders on a 1,320-foot width. Try to place an even number of borders in a field. From the example, you could go down to five-border spacings or up to six; either set is acceptable. Using the same field length and a slope of 0.05 percent, you can calculate the flow rate from the equation as 3.4 gpm per foot of width, giving a border width of 353 feet, which would be 3.7 borders on a 1,320-foot-wide field. In a case such as this, you would probably divide the field into four even borders of 330 feet. This indicates that, as the field gets flatter, the flow rate per unit foot does not need to be as high for even distribution. However, this will be a slow set time to move water through the field; this is a minimum value and does not take into consideration the effect of the cracks and the random distribution they will give. Figures 2 and 3 give calculated flow rates per unit width for four common slopes on quarter-mile and half-mile field lengths.

There has not been as much variability (as the equation may indicate) for flow rate versus slope on the cracking clay soils, but it may make a difference on soils that crust and do not crack. The cracking soils wet the cracks well ahead of the wetting front of the water on the surface; this indicates the cracks are giving some added slope characteristics that do not appear on a smooth soil surface. On cracking soils, the estimator chart works well, but on soils that don't crack, it may be more desirable to use the equation and try to fit an even number of borders into a field by staying closer to the design numbers. Also, the type of soil (especially intake rate) probably makes the most difference in the rate of advance and the total time to get water through the field. The higher the intake rate, the slower the water will move through the field. Trying to get water through in convenient set times of 12 or 24 hours has the biggest advantage since these sets are easier to change and are much more efficient. It is important to keep field notes from year to year on a particular field.

Another method to design border size is to determine the amount of water it takes to refill the profile and the losses on a per-acre basis. This is a volume balance based on water supply and demand of the soil and on losses to runoff. An example of this includes the following:

Assume a soil needs 2 inches of water to refill the profile and 1 inch will run off. That is a total of 3 inches per acre required to meet irrigation needs. A well pumping 2,400 gallons per minute equates to 5.33 acre-inches per hour (2,400 ÷ 450). The 5.33 acre-inches per hour divided by 3 inches per acre required gives 1.77 acres per hour that will be covered by the well replacing a gross of 3 inches. If 1.77 is multiplied by 12 hours, that equals 21.3 acres that can be covered in 12 hours, or a border size of 21.3 acres.

To determine the width, you can size border areas by dividing the length of field into the number of square feet in 21.3 acres. A 21.3-acre border has 929,280 square feet (21.3 × 43,560); divided by 1,320 feet (field length), it equals a 704-foot border width. This is significantly different from the 408-foot border width calculated using 5 gpm per foot of width (408 feet). The difference is that one is a flat rule of thumb and the latter one, using flow rate and replacement moisture, is based on a known deficit and runoff or loss value of

3 inches, as compared to a calculated deficit of about 4.5 inches. Either system works, replacement water or flow rate per unit foot of width. The main factor is that the assumptions being made are correct. The method of figuring replacement water may work easier for fields with parallel levees not parallel to a turn row (diagrams 3 and 4).

Border Levee Construction

Actual border construction is simple. Most producers use some form of a single-row hipper to build the borders. One or two passes with the hipper give enough height difference to contain the water in the bay. Only a slight height difference of 2 to 3 inches, from the top of a settled border dike to the top of the planted ground level, is needed to guide the water down the bay. The borders are not butted to the end of the field; make the borders short of the field end to leave open any drainage at the bottom of the field. Many producers are putting the border dike in the wheel tracks, since these tracks often are unplanted. You can use a levee plow, but it is much higher and wider than it needs to be, destroying production area. At most, the hipper will take out one row of beans or a 30-inch-wide area; a regular rice levee takes out about 10 feet of row if it is used.

You can install border dikes or borders almost any time during the growing season. (You can install early, before planting, just after planting, after emergence, or just before you need to irrigate.) If you install the borders early enough, the field is set up to irrigate whenever it is needed. If you put borders in too late, plant vegetation may become a problem. The borders are left in all season and typically melt or settle down enough they are not in the way for harvest. Most producers harvest with the borders still in the field then work the field down as one unit.

Water Distribution Systems for Bays

Producers have several ways to get water from the source to the borders. It is more desirable to inlet water into a border with multiple inlets across the top than to discharge all the water at one location in the top of the border. The multiple inlets give more uniformity of coverage and advance than a single inlet can.

Flume pads have been used as a conveyance system and inlet system for border irrigation. One method is to construct the flume at the top of the field and move the water to the far end of the flume. Several openings are cut in the flume to water the border; when the next border is to be irrigated, the flume is dammed with a backhoe and new openings are made in the flume at the top of the border to be watered. This method requires that the flume be rebuilt or repaired after each complete irrigation.

On more narrow fields, you can build a zero-grade flume and install rice gates as inlets to each border. Use a minimum of three gates per bay with a maximum spacing of 50 to 75 feet. When you use a zero-grade flume, make it wide enough for a tractor to run inside it to spray for grass and weeds. It will also need to have higher levees nearest the well to keep from overtopping the flume. Width helps some but depth helps more, since the water must develop a surface slope to overcome the lack of ground slope to move it.

Rice gates can then be installed at ground level and raised or lowered to outlet water into a bay or to stop the water entering a bay when another bay is to be irrigated. On wide fields, those more than a quarter of a mile, the depth required may be too much for a flume. The well volume and length of the flume are deciding factors in most cases.

You can use roll-out disposable irrigation pipe as a distribution system across the top of the border. If this is the case, you need to install large 3-inch-plastic gates in the pipe so you can switch water from border to border. When gates are used, the heavier mil pipe is more desirable to prevent gates from blowing out or tearing the gates out when they are opened and closed. The gates carry about 60 gpm each.

The rule of thumb for gate installation for a 12-hour set on a quarter-mile-field length is a spacing of about 15 feet; for a half-mile run and 12-hour sets, the gates are about 7.5 feet apart. For 24-hour sets, the spacing is half that of a 12-hour set time. You can also use solid-gated pipe by opening all the gates in a border all the way or enough gates to deliver all the water into the bay at one time without washing large holes in the ground next to the pipe. Two-inch gates in gated pipe deliver 25 to 30 gpm each.

Advantages

The border system (diagrams 1 and 4) has several advantages over conventional flood irrigation (diagrams 2 and 3) practices used on beans, especially beans following rice. One of the biggest advantages is that you can irrigate beans or other crops much earlier without the fear of submergence. It takes less labor to install borders than it does a conventional flood irrigation system.

Drainage is not blocked in the field due to cross levees or from levees that are butted at the bottom of the field, since the border levees are not constructed completely to the low end of the field. The borders do not have to be plowed out after an irrigation; they can be taken out after the last irrigation but preferably after harvest with regular field tillage. Row direction is not a factor in how well the borders work, so rows can run with the slope or across the slope and not impede the water movement or uniformity of water distribution.

Disadvantages

The water distribution system must be set up across the top of the field instead of one inlet point as is done with most flood irrigation systems. It does not work as well with a field that has side slopes (contour levees) because the borders must be narrower, and the border levees need to be taller to contain the water on the low side of the border.

Distribution is not as good on fields with side slope because of the tendency for water to stack up on the low side of the irrigated bay. Irrigation set times can vary, depending on soil type, stage of growth of the plant, and soil moisture levels.

Border irrigation is better and more flexible than flood irrigation, but do not use it to replace furrow- or row-watered crops. **Do not use beds in a border irrigation system; it is for flat planting only.**

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