IRRIGATION MANAGEMENT SERIES

Subsurface Drip Irrigation for Alfalfa

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The demand for alfalfa remains strong in Kansas due to the needs of the cattle feeding industry and the influx of large-scale dairy operations. These industries are largely located in western Kansas. Alfalfa production is increasing in the United States. More than a million acres of alfalfa have been added during the last decade, with the highest increase taking place in 13 western states. Because alfalfa water-use can exceed 46 inches per year, producers in arid western states depend on irrigation supplied by surface water diversions or groundwater from wells.

In general, water supplies for irrigation and other uses are under increasing pressure due to increasing demands. In many areas, water supplies are insufficient to meet current needs or allow for expansion. In Kansas, most irrigation water is supplied by the Ogallala Aquifer, which is experiencing decline. Pumping costs are increasing due to increased pumping lifts and higher energy costs. Therefore, available water needs to be used efficiently to produce a high water-use crop such as alfalfa.

Subsurface drip irrigation (SDI) may be an option alfalfa producers should consider, since SDI systems can be highly efficient. SDI systems reduce water loss from evaporation, runoff, and deep percolation and may offer some alfalfa production advantages during harvest and regrowth after cutting.

Subsurface Drip Irrigation

In Kansas, research shows that SDI is a feasible irrigation system for field crops such as corn. Kansas State University research (Lamm et al., 1995) shows possible irrigation water savings of as much as 25 percent because of increased efficiency in application, elimination of run-off, avoidance of deep percolation and improved capture of precipitation. A previous study (O'Brien et al., 1998) on irrigated corn shows that SDI is economically competitive to flood and center pivot irrigation systems for small fields and potentially competitive for larger fields.

More efficient irrigation for a high water-use crop such as alfalfa helps to conserve water without a loss in production during the relatively long growing period. A study in California shows increased alfalfa yields when using SDI, as compared to furrow irrigation (Hutmacher et al., 1992). Subsurface drip irrigation also shows improved crop yield because it eliminates leaf scalding in alfalfa, which may occur when using sprinkler irrigation (Henggeler, 1995).

SDI Systems Considerations for Alfalfa Production

SDI Water Use

Total water needs for alfalfa production, approximately 3 to 5 inches of water per ton of production, will be same regardless of the system type. Properly designed and operated SDI systems can be highly efficient, and the SDI system used for alfalfa production will need to meet all the design criteria as systems used for row crops. (See the reference list on page 6 for K-State Research and Extension bulletins that discuss SDI system components, water quality considerations, filtration, and general maintenance needs.)

With SDI, alfalfa can be irrigated during and immediately after harvest. This eliminates the dry down period required before harvest, as in the case of flood or sprinkler irrigation. Just before harvest, the alfalfa crop is in the peak production stage and optimum soil water conditions help maintain the production at a high level. Soil water conditions are field specific and may be influenced by the depth of dripline placement.

Some fields may have occasional surface wetting that can cause harvest problems, as reported by Hutmacher et al., 1992; but even in systems where irrigation was suspended for harvest, it was for a shorter period than for sprinkler or surface irrigation systems. Field

Figures 1a and 1b. The top picture shows a field irrigated by center pivot sprinkler; the bottom picture is a field irrigated by SDI (subsurface drip irrigation). The fields were planted at the same time in the fall.

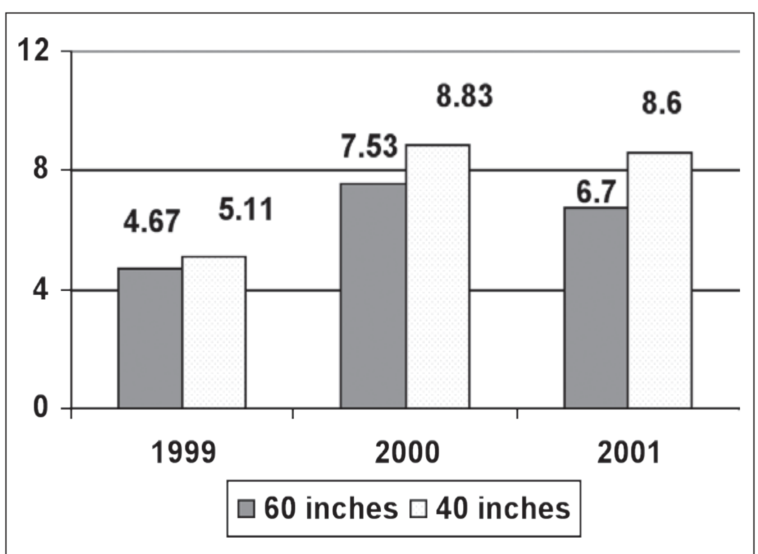

Figure 2. Dry matter yield as affected by dripline spacing.

observations on systems in Kansas have shown harvest during irrigation to be possible.

Since suspended irrigation time for harvest is less of an issue for SDI systems, the irrigation capacity of the system is less affected. Irrigation capacity is normally considered to be the effective application depth that the system can supply to a field if the entire field was watered daily.

For example, a 128-acre center pivot system with a flow rate of 700 gpm has a gross irrigation capacity of 0.29 inches per day, which on good soils would be considered a high irrigation capacity. This system could apply 8.7 inches of water in a 30-day typical harvest cycle for alfalfa; if seven days are required to have the field surface dry enough for harvest operations, only 6.67 inches can be applied. This will mean that the effective irrigation capacity is only 0.22 inches per day, which would be regarded as low irrigation capacity. Because alfalfa yield is linearly related to water use, if the amount of irrigation is insufficient to keep the soil water levels in the appropriate range for crop growth, yield will be reduced.

The most critical period of growth for alfalfa is after cutting when regrowth starts. Availability of adequate soil water after harvest is essential when alfalfa hay is drying in the field and baled after drying. Irrigation using flood or sprinkler method is not possible when the hay is being cured before baling. On the other hand, SDI irrigation can provide the water needed to start the regrowth and get ahead of surface germinating weed seeds that may be encouraged by flood or sprinkler irrigation.

The lack of surface wetting from SDI eliminates evaporation loss and helps reduce the competition from annual weeds that may germinate due to soil surface wetting from sprinkler or surface irrigation. This is illustrated in Figure 1, which shows an alfalfa field irrigated by a center pivot and another irrigated by SDI. The fields were operated by the same individual. Less weed pressure is noted in the SDI field.

SDI Dripline Spacing

The largest expense of an SDI system is the cost of dripline. The closer the spacing of the dripline, the more driplines are needed to irrigate a given area and the higher the cost for the system. The typical recommended spacing for row crops spaced at 30 inches is 60 inches (Lamm et al., 1997). Since alfalfa is a distributed crop, closer dripline spacing would have a production advantage.

There is not an extensive research database on SDI irrigated alfalfa, so a field demonstration project on a producer's field was established in southwest Kansas to generate information. The site was on sandy loam soils. Seven test plots were established using various dripline spacing and depth configurations. The plots were not replicated, so a statistical comparison of the results is not possible. A center pivot system operated by the farmer cooperator adjacent to the SDI system was planted to alfalfa at the same time as the SDI system and was used as a sprinkler comparison field.

The yields from the sprinkler-irrigated field were 8.38 and 8.32 tons per acre for years 2000 and 2001 respectively, with an application of 25 inches of irrigation water. The yields for the 40-inch dripline spacing SDI field were 9.02 and 8.50 tons per acre for the corresponding years with an application of 20 inches of irrigation water. However, the yields from 60-inch dripline spacing SDI field were lower at 7.98 and 6.56 tons per acre for the same period.

The result from the demonstration site for dripline spacing is shown in Figure 2. The yield advantage from a 40-inch dripline spacing over 60-inch dripline spacing ranged from 0.44 to 1.9 tons per acre. Yield disadvantage for 60-inch spacing was greater for 2001.

As noted, there is an additional installation cost incurred to install a 40-inch dripline spacing as compared to a 60-inch dripline spacing. The total length of dripline required for the 40-inch spacing increases by 4,356 feet per acre. The number of fittings also increases proportionately. A net present value (NPV) analysis was used to evaluate whether the closer spacing was cost effective. The NPV indicated that the 40-inch spacing would need to yield about 0.75 tons more per acre than 60-inch spacing in order to have an equal NPV. The calculation is based on a 15-year life span of the system and an alfalfa price of $70 per ton. These assumed values are conservative. If either the useful life of the SDI system or alfalfa price increases, the additional yield needed to make the 40-inch spacing economical decreases.

Another observation from the demonstration site was the effect of spacing on the alfalfa establishment. Figure 3a shows a "striping" appearance that was visible during germination for the plots with 60-inch spacing, which was less evident in the 40-spacing plots (Figure 3b). The 60-inch plots were also observed to have some alfalfa water stress during the growing season during hot dry periods, which was also verified by soil water sensors placed at the mid-point between the driplines at several locations (Alam et al., 2002).

Figures 3a and 3b. The top picture shows alfalfa germination in a 60-inch spaced dripline plot. The bottom picture shows alfalfa germination in a 40-inch spaced dripline plot.

SDI Dripline Depth of Placement

Most K-State Research and Extension studies on row crops use a placement depth of 16 to 18 inches. In a depth of placement study on corn (Lamm and Trooien, 2005), depths ranging from 8 to 24 inches indicated no yield differences for corn when germination was not limited. The rationale for deeper placement is to minimize potential dam-

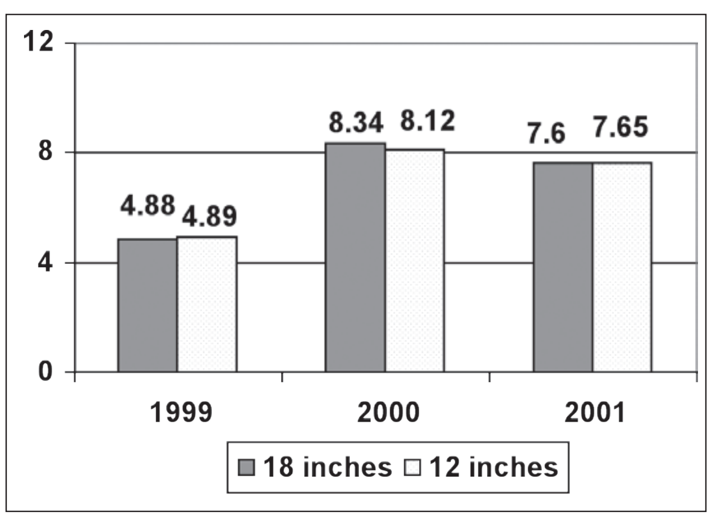

Figure 4. Dry matter yield as affected by depth of dripline placement.

age from tillage operations and rodent damage. However, the study results showed no damage from either rodents or tillage equipment for shallower placement.

Row crop producers have tended towards shallower placement (12 inches) in the hopes of aiding row crop germination or early stand establishment in dry springs. Deeper placement would require more power to install the driplines but this would not be a major cost in comparison to other materials and installation labor. However, uniform placement depth is critical.

The yield from the K-State demonstration site for the two different placement depths for alfalfa showed similar dry matter yields, as illustrated in Figure 4. The placement depth had little effect on the yield. In a perennial crop, like alfalfa, there is increased concern about rodent damage to the driplines, which could be minimized with deeper placement.

KSU SDI Demonstration Site Hay Quality

The 40-inch spacing produced a larger crop yield and improved hay quality when compared to 60-inch spacing, especially in dry years. The hay quality analysis was conducted at an independent laboratory certified annually by the National Hay Testing Association. Four random hay samples from each plot were ground to prepare a composite sample, and a composite sub-sample was used for analysis. The average RFV (relative feed value) for 40-inch spacing was 164 (good dairy quality hay) compared to 134 (dairy quality hay) for 60-inch spacing. (Although the samples were obtained randomly, the irrigation trial was non-replicated and, therefore, the results cannot be statistically compared.)

Water Quality for SDI Irrigated Alfalfa

The water quality to ensure SDI system longevity is discussed in detail in the K-State Research and Extension bulletin MF-2575. (See reference list.) Water quality can also affect crop productivity. Expected yield gains due to irrigation may be lost with poor water quality. Alfalfa is rated as being moderately sensitive to salinity. Alfalfa can be susceptible to foliar burn caused by wind-drifted water with sufficiently high sodium or chloride content. Alfalfa production can also be adversely affected by scalding, which can occur with surface-ponded water in hot weather. These two conditions are eliminated with the use of SDI.

Root Intrusion in SDI Irrigated Alfalfa

Root intrusion into the emitters of the dripline can be a concern because alfalfa is a perennial crop. However, no root intrusion was observed in the K-State demonstration plots that were discussed previously. Observations in this trial occurred over three years. It is generally thought that fully irrigated alfalfa would be less likely to be affected by root intrusion than deficit irrigated alfalfa.

The Microirrigation Forum, a Web-based information source, lists prevention methods for root intrusion including the use of chlorine, acid, Trifluralin, and copper sulfate (CuSO4). However, it is important to check the product label to see if dripline injection is permissable. The *California Farmer* reported in 1995 that chlorine injected at 100 ppm has helped prevent root intrusion from walnut trees.

Richard Mead, owner/operator of Microirrigation Forum, states that research at their Water Management Research Laboratory showed that the use of acid at 10 to 15 ppm has eliminated root intrusion. There is a product line that has emitters impregnated with herbicide to discourage root intrusion.

Rodent Control for SDI Irrigated Alfalfa

Although SDI is ideally suited for alfalfa from a production standpoint, the permanent crop cover also enhances the potential for rodent infestations within the field. Currently, there are no recommended or labeled chemicals to use as rodent repellents. The best management practices for rodent control are site selection, field border habitat control, and field border baiting.

Soils should be considered in site selection. Sandy and sandy loam soils tend to have more rodent problems than other soil types.

Producers are discouraged from injecting pesticides into the system. Although this might be effective in killing rodents biting the driplines, damage to the driplines has already been sustained. The repair process would expose the repairman to the chemical. Alfalfa fields located next to ditch banks or other natural habitat areas for rodents have sustained damage from rodents that chew the driplines. An effort must be made to control rodents. Damaged driplines can be repaired by the use of quick couplers, but damage repairs require locating the damaged area and digging to the dripline's placement depth.

Conclusion

Proper management of the SDI system is important to ensure a long life span for the system. A producer considering the use of subsurface drip irrigation for alfalfa should become familiar with the requirements for design, installation, and maintenance. Water quality should be determined and action taken to remedy any adverse condition as appropriate, usually by the injection of chlorine or acid or both. Periodic flushing is essential in all cases to avoid buildup of any sediment or bacterial slime.

SDI systems can be successfully used to irrigate alfalfa. SDI systems may have some production advantages over sprinkler and surface irrigation systems, such as minimizing or eliminating irrigation interruption during alfalfa harvest, and reduced weed seed germination since SDI systems do not wet the soil surface. A potential drawback for SDI on alfalfa, as opposed to row crop production, is increased rodent activity within an alfalfa field.

Recommended K-State Research and Extension Bulletins on SDI:

MF-2575 *Water Quality Assessment Guidelines for Subsurface Drip Irrigation.*

MF-2578 *Design Considerations for Subsurface Drip Irrigation*

MF-2576 *Subsurface Drip Irrigation (SDI) Components*

MF-2361 *Filtration and Maintenance Considerations for Subsurface Drip Irrigation Systems*

MF-2590 *Management Consideration for Operating SDI*

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