SUBSURFACE TRICKLE IRRIGATION FOR ROW CROPS[1]

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Most row-crop irrigation in South Carolina and other southeastern states is applied by sprinkler systems. Water use and energy operating costs for these systems are often high enough to make irrigation unprofitable, even with the use of lower-pressure sprinklers. On the other hand, trickle irrigation offers lower water use and lower energy operating costs. However, because much of the system must be replaced annually when it is used in row crops, the cost is high. Consequently, it has been used primarily in high value crops such as vegetables, fruits, and nuts. Recent research efforts have been directed toward developing ways to reduce this annual cost by using the trickle tubing for more than one year or at wider spacings. This should make trickle irrigation technology feasible for use in lower-valued row crops.

Procedure. An experiment has been conducted during the last two years (1985-86) in which treatments consisted of three trickle tubing placements and two modes of application. The three tubing placements were (1) subsurface, 12 inches below twin rows which were 30 inches apart, (2) surface, between the drills of the twin row, and (3) surface, in alternate middles, providing a 60-inch spacing. The two application modes were continuous, where all water for each irrigation was applied continuously, usually a total of 0.25 inch, and pulsed application, where water was applied in a series of pulses (e.g. 20 min. on, 20 min. off, 20 min. on, until the total irrigation amount was applied). Results for the application mode treatments will not be discussed here, since no difference in yield for these two application modes was found.

The experimental design consisted of a completely randomized block with six treatments and four replicates. The entire area was cross subsoiled prior to planting the first year; subsequent tillage consisted of disking only. The plots were 40 feet long and four twin rows wide (8 row drills), each spaced 30 inches apart. Subsurface trickle tubing was installed about 12 inches deep prior to planting the first year using a subsoiler shank. Surface trickle tubing was installed after stand was established and was removed before harvest each year. The trickle tubing was a turbulent-flow (labyrinth) type with in-line emitters located inside 0.5-in. dia. polyethylene tubing (Lake Drip-In[3]). Emitters were spaced 24 inches apart and delivered 0.5 gal/h. There were either four or eight laterals per plot depending upon tubing placement for each treatment. Irrigation water was distributed through PVC manifolds with individual pressure regulators and solenoid valves for each plot. The water source was chlorinated and filtered through a 100-mesh cartridge type filter. Tensiometers were placed in two plots for each treatment at several soil depths and either three or four positions perpendicular to the row, depending upon tubing placement.

Irrigation was normally applied in increments of 0.25 inch/day unless rainfall greater than 0.25 inch occurred. If a tensiometer at the 12-inch depth exceeded 25 cbar, an additional 0.25 inch was applied that day. The goal was to replace the water lost through ET each day, but more than 0.25 inch was lost during days with high evaporative conditions. Every time irrigation was applied, an equal volume of water was applied to the plot, meaning alternate middle treatments were operated twice as long during irrigation because they had half as many laterals and emitters. Irrigation was controlled and switched sequentially among the various plots with a programmable, microprocessor-based controller that also timed the pulses, monitored and recorded water volume delivered to each plot, and monitored water flow to assure accurate delivery and to avoid water waste and flooding in case of leaks.

Fertilizer was broadcast in granular form (500 lbs 5-10-30 in 1985, 500 lbs 10-10-10 in 1986) and incorporated with preplant herbicide. Additional nitrogen was injected through the irrigation system in 3 or 4 applications beginning 3-4 weeks after emergence and at 2-week intervals. A corn hybrid (Asgrow/O's Gold 5509) was planted in late March. Target plant population was 30,000 plants/acre, but the population was higher in 1985. A population nearer the target was achieved in 1986 by hand thinning, but there were no population differences among treatments either year. Total plant nutrients added each year included 225 - 235 lbs N, 22 lbs P, and 42-124 lbs K; boron and sulfur were also added in 1986 through the irrigation system. Soil testing was used to guide fertilizer rates.

Results. In 1985, rainfall was fairly uniform, but slightly less frequent during the latter part of the season. Irrigation amounts were very similar for all treatments, except for differences in irrigation volume applied on some days. In 1986, there was much less rainfall, particularly during the early part of the season. A severe drought occurred in 1986, beginning early in the growing season. Again, irrigation patterns were similar for all treatments, except for a few more irrigations late in season for the alternate-middle treatment. All treatments required much more early-season irrigation because of drought. As in 1985, there were small differences in irrigation volume applied on some days. Total rainfall during the growing season was 10.6 inches in 1985 and 6.2 inches in 1986. The irrigation frequency and amount were not very different among the treatments either year; however, the subsurface treatment required less (0.4 - 2 inches) irrigation water both years. An average of 3 inches more irrigation water was required in 1986 for all treatments (15.6 vs 12.5 inches, based on means of all irrigated treatments).

Mean corn grain yield was 202 bu/acre in 1985, and there were no differences among treatments. Severe lodging, caused by Hurricane Bob which occurred shortly before maturity, probably reduced overall yield. The corn had to be harvested by hand and at a very high moisture content in order to collect yield samples; otherwise, much of the corn would have rotted. In 1986, the mean corn grain yield was lower (171 bu/acre), and the surface, alternate-middle treatment produced significantly lower yields than the two in-row tubing-placement treatments (155 vs 178 bu/acre). The overall decrease in yield was probably caused by the hot, dry weather in 1986. Moderate lodging caused by a thunderstorm in 1986 was not severe enough to warrant harvesting early.

The lower yield for the surface, alternate-middle treatment in 1986 was probably caused by poor growth of the outer row of the twin-row drill (away from the irrigation source) during the early season when severe drought occurred. Observations at 35 days after emergence indicated shorter plants with a lighter green color. Whole plant samples were collected for tissue analysis and biomass determination in an attempt to verify these observations. Mean biomass was 0.23 oz/plant for the inner row and 0.19 oz/plant for the outer row of the two-row drill in this treatment. This confirmed that plants nearer the irrigation tubing were larger. However, plant-tissue analyses indicated that there were no difference in nutrient concentrations between the two rows and that all nutrient concentrations were in the sufficient range. Therefore, the difference in plant size was caused by insufficient water uptake (and availability). Either the irrigation system did not supply enough water or the water was unable to move through the soil to the small root system. In this situation, when drought occurred early in the season and the corn plants had small, poorly developed root systems, trickle-tubing placement in alternate middles did not provide proper water distribution for good plant growth and development and caused a reduction in grain yield. Nutrient concentrations and DRIS (Diagnosis and Recommendation Integrated System) ratios for ear leaf samples indicated that plants in all treatments were in the normal range both years. This indicates than the fertilizer program was adequate and that yield reductions were caused by other factors. No emitter plugging problems were observed, although buried emitters have not yet been excavated and examined. No emitter plugging was indicated by deviations from expected water flow during irrigation, which was monitored closely.

Conclusions. Subsurface trickle irrigation provided corn grain yields comparable to those for other trickle irrigation treatments. The subsurface trickle treatment required slightly less irrigation water than the other treatments, probably because of a smaller wetted soil surface area and less evaporation from the soil surface. The profitability of subsurface or alternate-row trickle irrigation for row crops will depend on system longevity and operational cost, if alternate row trickle is removed and reused each year. All systems will be evaluated for one more year in the present study, and the subsurface trickle system, at least, will then be used in another study for further evaluation of system longevity. Based on the 1986 results, it appears that the alternate-middle placement of trickle tubing could be risky, if early-season drought occurs. On the other hand, the risk may be worth taking in view of the lower cost of materials (about 30%) and the fairly low probability of having an early-season drought. The alternate-middle system provides a larger area of dry soil for the capture of rainfall that might occur immediately following irrigation. Also, even with reduced yield, the alternate-middle placement may be more profitable, some or all years, depending upon economic conditions and operating costs. Overall, it may provide a lower level of risk because of the lower initial cost, the reduced potential for soil saturation caused by rainfall following irrigation, the reduced cost of removing tubing each season (when compared to surface, every-row placement), and reduced operating costs because of better capture of rainfall in dry soil areas.