EXPERIENCES WITH MICROIRRIGATION FOR AGRONOMIC CROPS IN THE SOUTHEASTERN USA

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ABSTRACT

Microirrigation offers several advantages over sprinkler irrigation in humid areas, including ease of automation; lower water pressure and flow rate; improved management of water and nutrients; and easy seasonal start-up, especially for subsurface placement. Microirrigation system cost could be reduced and made more profitable for agronomic crops by using wider spacing and subsurface placement of microirrigation laterals. Results are reviewed from five experiments involving microirrigation of agronomic crops (corn, soybean, and cotton) and including 14 site-years of data. Agronomic crops can be effectively and efficiently irrigated in the southeastern Coastal Plain with microirrigation systems. In three experiments involving nine site-years of data, both normal (0.76 - 1.0 m) and wide (1.5 - 2.0 m) lateral spacings were used to irrigate corn and cotton; yields were equal except in one year when corn yield was reduced by about 10% for the wide spacing. With corn, there was no yield difference between surface and subsurface placement of laterals at the normal spacing (every row). Other data indicate that wider spacing of laterals in subsurface installations produces cotton lint yields similar to those for the same spacing in surface placements. Consequently, it appears that surface or subsurface placement of laterals at wider spacings (alternate furrow, 1.5 - 2.0 m) has significant potential for profitable irrigation of agronomic crops such as corn, cotton, and soybean in the southeastern USA.

Keywords: Lateral-placement, Trickle-irrigation, Lateral-spacing, Corn, Cotton, Soybean

INTRODUCTION

n humid areas, such as the Coastal Plain in the southeastern USA, seasonal rainfall is ometimes sufficient to satisfy evapotranspiration (ET) requirements. However, the combina-ion of short drought periods (5-20 days) and low water storage capacity (about 5-10 days torage) of the coarse-textured soils often results in periods of yield-reducing plant water tress. Shallow crop rooting, often caused by compacted soil layers, further aggravates the roblem. Periods of 5-20 days without rainfall occur during most growing seasons. The onsequences of these drought periods depend upon crop, soil, timing, and the antecedent soil vater conditions. Irrigation can alleviate these problems, but profitability of irrigation is xtremely variable. Because irrigation is often not required at regular intervals or in all ears, managers seldom plan for irrigation-related needs along with other farm operations. Consequently, irrigation systems in humid areas should be designed with low labor require-nents (preferably automatic control), easy annual start-up/convenience, multiple-year life, and dequate capacity to sustain crops during drought.

lthough sprinkler irrigation is most often used for agronomic crops, microirrigation offers everal advantages—including low application rates, precise water placement, and low ressure requirements. When used in the conventional manner, the major disadvantage of nicroirrigation is high cost. This is partially caused by annual replacement and disposal of nany system components. A microirrigation system that reduces the amount of material needed and uses materials for multiple seasons would reduce system cost. Possible solution include wider lateral spacing and deeper placement (below tillage depth). Wider spacings were used on a coarse-textured soil in Arizona, where cotton yields were similar for laterals placed every row (1-m spacing) and every other row (2-m spacing) but were much lower fo laterals placed every third row (3-m spacing) (French et al., 1985). Deeper placement of microirrigation tubing (0.2 - 0.3 m deep) allowed shallow tillage and cultivation for cotton (Tollefson, 1985), potato (Sammis, 1980), and fruits and vegetables (Bucks et al., 1981; Phene et al., 1987; Camp et al., 1993a) and obviated the need for annual removal/replacem of system components.

A possible microirrigation system for humid areas includes wider tube spacing (about 2 m), multiple-year life, and subsurface installation (below tillage zone) to reduce labor and materi costs; however, the system should have the capacity to sustain a crop during short- to mid-term drought periods, possibly with limited yield reduction during severe drought. To investigate the feasibility of this irrigation system, results are reviewed from several experi-ments that used various microirrigation lateral placements both on the soil surface and subsurface.

MATERIALS AND METHODS

Five experiments were conducted over a 12-year period, 1980-92, using various microirrigation lateral spacings and placements relative to the crop row and/or soil surface fo corn, soybean, or cotton. Experiments are described briefly, either individually or collec-tively if the same irrigation system was used. In all experiments, water was supplied from either a well or a municipal supply and was filtered via a 100-mesh cartridge filter, pressure was regulated at each plot manifold using a pressure regulating valve, and water flow was controlled via solenoids on a volume basis.

Corn Row Spacing (CRS)

Treatments in a corn experiment were two plant populations, two N side-dress rates, single rows or twin-row pairs with rows and row-pairs spaced about 1 m apart, and three water management regimes (two irrigation scheduling methods and rainfall only) during the 3-year period, 1980-82. The overall objective of the experiment was to identify the combination of cultural practices that would produce maximum corn grain yield in the southeastern Coastal Plain. Irrigation was provided using 380-μm-thick double-wall (Bi-Wall**) microirrigation laterals spaced 0.5 m apart on the soil surface and equidistant from crop rows. Emitters were spaced 0.3 m apart along the lateral and delivered 4.3 L/h/m at 85 kPa pressure. New laterals were used each year. Additional details regarding this experiment were reported by Camp et al. (1985).

Soybean Row Spacing (SRS)

During 1980-81, soybean was grown in treatments consisting of four row spacings (0.36, 0.51, 0.76, and 1.02 m), two row orientations (N-S and E-W), two cultivars (Davis and Coker 338), and two water management regimes (rainfall only and irrigation). Irrigation was provided by 380-μm-thick double-wall (Bi-Wall) microirrigation laterals installed on the soil surface at a spacing of 0.36 m. Emitters were spaced 0.3 m apart along the lateral and

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delivered 4.3 L/h/m at 85 kPa pressure, and new laterals were used each year. Irrigation applications were managed using tensiometer data, primarily at the 0.30-m soil depth.

Corn and Lateral Placement 1 (CLP1)

A microirrigation system was installed in the fall of 1984 to evaluate subsurface and surface placement of laterals, especially with respect to longevity of laterals used for several seasons. Three placements included laterals buried 0.3 m under each row (0.76-m spacing), laterals on the soil surface adjacent to each row (0.76-m spacing), and laterals on the surface in alternate furrows (1.52-m spacing). The first experiment (1985-87) also included two irrigation application modes, continuous or pulsed. Corn was grown in twin-row pairs spaced 0.24 m apart with each pair spaced 0.76 m apart. The microirrigation laterals (Drip-In) had in-line, labyrinth-type emitters spaced 0.61 m apart, each delivering 2.5 L/h at 115 kPa pressure. Additional details regarding this experiment were reported by Camp et al. (1989).

Corn and Lateral Placement 2 (CLP2)

Following the CLP1 experiment, a vegetable experiment was conducted on the site during 1988-89, and a second corn experiment was conducted during 1990-92. While the primary objective was to evaluate system longevity, the same lateral placements used in the first experiment were used in this experiment, and two irrigation scheduling methods were evaluated during 1990. Cultural practices were similar to those in the previous corn experiment.

Cotton and Lateral Spacing (CLS)

Cotton was grown during the period 1988-90 in an experiment that evaluated two microirrigation lateral spacings on the soil surface (adjacent to each row, 1.0 m apart, or in alternate furrows, 2.0 m apart) in relation to a rainfall-only treatment; three irrigation scheduling methods (GOSSYM/COMAX, water balance model, and tensiometer); and three cultivars (Coker 315, DPL 90, and PD 3). The microirrigation laterals (Netafim Dripperline) had in-line, turbulent-flow emitters spaced 0.6 m apart, each of which delivered 1.9 L/h at 100 kPa pressure. The same laterals were used for the 3-year period. Additional details regarding this experiment and the irrigation system were reported by Camp et al. (1993c).

RESULTS AND DISCUSSION

Seasonal rainfall and irrigation and agronomic crop yield for all experiments and all years are reported in Table 1. Although several crop management practices were included as treatments in the CRS and SRS experiments, yields for all variables except spacing are pooled because the microirrigation system was not varied in subtreatments. In both experiments, microirrigation was used to provide uniform surface irrigation in the canopy floor, not band irrigation near the row only, as in traditional microirrigation. There was substantial variation in seasonal rainfall years for CRS but not SRS. Irrigation amount varied between years for both CRS and SRS. Seasonal irrigation volume, however, was more closely related to seasonal ET for corn than for soybean. Corn grain yields for the irrigated, twin-row configuration were very high (11.50 - 14.06 Mg/ha) and were significantly greater than the rainfall-only treatment all three years (1980-82). Likewise, in the soybean experiment (SRS), mean yields were significantly greater for the irrigated treatment than for the rainfall-only treatment both years (1980-81). While yield differences sometimes resulted from other crop management variables, the greatest yield effect resulted from irrigation.

Table 1. Seasonal rainfall, irrigation, and agronomic crop yield for microirrigation experime conducted during the period 1980-1992 in the southeastern Coastal Plain of the USA.

Experiment/Crop*		Year	Treatment†	Rainfall	Irrigation	Yield	
						Rainfed	Irriga
				--------- mm ---------		--------- Mg/ha ----	
CRS	Corn	1980	Twin/T	297	448	5.28 c‡	14.0
CRS	Corn	1981	Twin/T	330	252	4.82 c	12.14
CRS	Corn	1982	Twin/T	485	155	10.49 b	11.5
SRS	Soybean	1980	Mean/T	461	382	1.51 b	3.10
SRS	Soybean	1981	Mean/T	453	202	2.57 b	3.01
CLP1	Corn	1985	ER/C	274	312	--	12.8
CLP1	Corn	1985	AF/C	274	331	--	13.1
CLP1	Corn	1986	ER/C	161	400	--	11.0
CLP1	Corn	1986	AF/C	161	387	--	9.8
CLP1	Corn	1987	ER/C	202	348	--	11.8
CLP1	Corn	1987	AF/C	202	373	--	11.4
CLP2	Corn	1990	ER/T	276	286	--	11.1
CLP2	Corn	1990	AF/T	276	286	--	10.2
CLP2	Corn	1991	ER/T	370	248	--	7.8
CLP2	Corn	1991	AF/T	370	248	--	7.8
CLP2	Corn	1992	ER/T	266	330	--	6.9
CLP2	Corn	1992	AF/T	266	330	--	6.4
CLS	Cotton	1988	ER/T	544	173	0.98 B	1.28
CLS	Cotton	1988	AF/T	544	175	0.98 B	1.16
CLS	Cotton	1989	ER/T	485	108	0.81 B	0.96
CLS	Cotton	1989	AF/T	485	96	0.81 B	0.83
CLS	Cotton	1990	ER/T	313	162	0.82 B	0.96
CLS	Cotton	1990	AF/T	313	127	0.82 B	0.86

* Experiment abbreviations are as follows: CRS = Corn Row Spacing; SRS = Soybean Row Spacing; CLP1 = Corn Lateral Placement 1; CLP2 = Corn Lateral Placement 2; and CLS = Cotton Lateral Spacing.

† Treatment abbreviations are as follows: AF = alternate furrow lateral placement; ER = ever row lateral placement; T = irrigation scheduled by tensiometer; Twin = twin-row configuratio Mean = mean values for soybean cultivar, row spacing, and row orientation treatments; and C continuous irrigation mode.

‡ Means followed by the same letter within row(s) or column(s) for an experiment-year combina tion are not significantly different at P = 0.05. In the CLS experiment, cotton lint yields are reported and capital letters are used because mean comparisons are valid only within a row (Irrigated vs. Rainfed).

Seasonal rainfall and irrigation varied considerably during the two 3-year periods of the corn experiments (CLP1 and CLP2) with different microirrigation lateral placements (ER and AF and irrigation volume was generally related to seasonal rainfall volume. All values reported for the ER placement are means of values for surface and subsurface placement because seasonal irrigation volumes were equal or very similar in all years. Again, corn grain yield was high to very high, especially during the first 3-year period, and there was no significant yield difference between the two placements except in 1986. Seasonal rainfall in 1986 was least of the six years because of a drought period that was one of the worst in the century. The drought was especially severe during the first half of the growing season, when corn plants were very small and had poorly developed root systems. Plant biomass and yield measurements indicate that corn in the row farthest from the irrigation lateral in the twin-row drill was shorter, had less biomass, had a lighter green color, and yielded less than rows closer to the irrigation source. There was a general decline in corn grain yield during the 6-year period, especially during the final 3-year period. This cannot be fully explained, but one reason for the lower yields in 1991 and 1992 was severe damage caused by birds. The damage appeared to be random and unrelated to treatment; consequently, comparisons among treatments should remain valid. There was no rainfall-only treatment in these experiments.

In the cotton experiment (CLS), seasonal rainfall varied considerably, decreasing each year of the 3-year period. Seasonal irrigation volumes were not closely related to seasonal rainfall volume during this experiment. A large range of irrigation volume was applied for the various irrigation scheduling methods during the 3-year period, but lint yield was not closely related to irrigation volume (all data not reported here). Using orthogonal contrasts, cotton lint yields (mean of three cultivars) were significantly greater for four of the six lateral placement-year combinations in the irrigation treatment than yields for the rainfall-only treatment. Using analysis of variance (SAS, 1990), the lateral placement effect was significant at P = 0.09. Because of inconsistent differences and a relatively low level (P=0.09) of statistical significance for the lateral placement treatment, we concluded that the wide and normal lateral spacings produced similar results.

All Experiments

Fourteen site-years of data from five different experiments using microirrigation systems indicated that they provided adequate irrigation for production of agronomic crops (corn, soybean, and cotton) in the southeastern U. S. Furthermore, nine site-years of data from three experiments indicated that wide lateral spacings in alternate furrows (1.5 - 2.0 m) produced yields comparable to those for normal lateral spacings (every row, 0.76 - 1.0 m) for these crops in this region. A wider lateral spacing should result in a savings of about 30% in initial irrigation system cost. Small yield reductions (10 to 20%) with wider lateral spacings during extreme drought can occur, but would be acceptable, especially when both reduced system cost and high humid-area rainfall probabilities are considered. In two experiments, with six site-years of data, corn yield for subsurface placement of laterals under every row was not significantly different from yield for laterals on the surface adjacent to every row. This indicates great potential for placing the irrigation lateral below the tillage zone where it can remain undisturbed for several years before replacement is required. This would significantly reduce system cost because of savings in annual material removal and replacement cost. Recent results indicate that subsurface systems can provide efficient, uniform irrigation for periods of at least 10 years in southeastern Coastal Plain soils without serious plugging (Camp et al., 1993b). The combination of wider lateral spacings and subsurface placement to allow greater longevity would produce additive material savings and increase profitability for these systems with agronomic crops. This combination is now being evaluated in an experiment with a cotton/peanut rotation. Preliminary results (3 years) indicate no difference in cotton lint yield between the normal (1 m) and wide (2 m) subsurface lateral placements (Camp et al., 1995).

SUMMARY AND CONCLUSIONS

An irrigation system for humid areas should have a low labor requirement (preferably automatic control), easy annual seasonal start-up, and the capacity to sustain crops during drought. Wider lateral spacings and use of laterals for multiple seasons (as in subsurface installations) provide additive savings in system cost and could make this technology profitable for agronomic crops in the southeastern USA. Fourteen site-years of data from five experi ments that evaluated microirrigation for agronomic crops (corn, cotton, soybean) indicated that this irrigation technology will provide acceptable irrigation for this region. Nine site-years of data from three experiments indicated that wider lateral spacings (1.5 -2.0 m) can provide acceptable irrigation most years for agronomic crops, and the yield reduction durin extreme drought may be only 10% or less. This may be an acceptable risk for the humid where rainfall probability is usually moderately high. In two experiments with corn, there was no difference in yield between surface and subsurface lateral placements when both ha the same spacing. Other data indicate that wider lateral spacings in subsurface installations perform as well as normal spacings for cotton. From these data, it appears that surface or subsurface placement of laterals at wider spacings (alternate furrow, 1.5 - 2.0 m) offers significant potential for profitable irrigation of agronomic crops such as corn, cotton, and soybean in the southeastern USA. Subsurface lateral placement offers the potential to use same material for at least 10 years without having to remove and install it each season, fur reducing system cost.

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DRIP IRRIGATION OF FLUE-CURED TOBACCO

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ABSTRACT

Drip irrigation and plastic mulch were introduced to commercial production of tobacco to o
yields and quality. Using this highly controlled root zone management system resulted in ob
yields at the level of 5,100 Kg/Ha which nearly doubles the state of Georgia's average yield
2,500 Kg/Ha. High yields, together with improved quality, can generate an additional incon
$6,295/Ha which will pay for the total first year cost of a complete drip irrigation system an
an additional profit of about $3,000/Ha.

The data and experience obtained in the last two years are used to recommend a tentative irr
and fertigation schedule for drip irrigation of tobacco.

KEY WORDS: Drip Irrigation, Fertigation, Plastic, Mulch, Tobacco

INTRODUCTION

Chemical and physical properties, as well as the yields of flue cured tobacco, are mainly determined by the moisture and nutrient availability in the root zone. This fact has attracted researchers to investigate drip irrigation as a tool to control the root zone conditions in order improve yields and quality. Phene et al (1976) started a two year research plan to investigat effect of drip irrigation and fertigation on yield and quality of flue-cured tobacco in South Carolina. The highest yield increase of the drip irrigated and fertigated tobacco over the non irrigated was 255 Kg/Ha. The main support price reflected a 12% increase in quality, resulti 19% income increase.

McPeteres (1988) tested the effect of drip irrigated and fertigated tobacco over conventionally tobacco (non-irrigated, dry fertilized) in Halifax County, Virginia. The test resulted in yield increase of 982 Kg/Ha with 8% more quality smoking leaves. The improved yield and qualit resulted in additional gross income of $3,390/Ha.

Nevertheless, in the spring of 1991, Mr. Graham Cole, a tobacco and vegetable grower from Moultrie, Georgia, planted three beds of approximately 100 m each with tobacco at the edge pepper field, using the vegetable set-up of 1.8 m' bed spacing with plastic mulch, two rows o bed with a single drip tape (typhoon) in the middle. This was the first time that drip irrigated tobacco using plastic mulch was tried on a commercial level. Since the size of the plot was t small, no yield or quality measurements were taken. However, this tobacco showed vigorou growth, three week earlier maturity, and good quality. The yield was estimated at 4,545 Kg/ which was almost double the county and state average.

Based on these findings, a block of 8 Ha of drip irrigated and plastic mulched tobacco was se the season of 1992. Slides of the growing tobacco have been taken in the various growth sta including a comparison of the root system under drip irrigated, fertigated and mulched tobacc *versus* conventional drip, which was overhead irrigated and dry fertilized. Measurements of fertility, yield and leaf quality were taken as well.

The average yield was 4,248 Kg/Ha which exceeded the county average by 1,522 Kg/Ha - an increase of 56%. In addition to a sizable yield increase, tobacco quality improved - especiall bottom leaves which were free of ground injury, fully matured and sold for almost the same p as the middle stalk.

At the same time, Rideout and Gooden (1993) of Clemson University, set up a program to ev

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