# Report for 2003WY11B: Subsurface Drip Irrigation Systems: Assessment and Development of Best Management Practices

Publications

- Articles in Refereed Scientific Journals:
  - Hao, X., R. Zhang, and A. Kravchenko, 2005. Effects of Root Density Distribution Models on Root Water Uptake and Water Flow under Irrigation. Soil Science,170:167-174.
  - Hao, X., and R. Zhang, 2005. A Mass-Conservative Switching Method for Simulating Water Flow in Saturated-Unsaturated Soils. J. Hydrology (in press).
  - Youquan Jiang, Drew W. Johnson, George F. Vance and David E. Legg. Subsurface Drip Irrigation for Alfalfa Production in Wyoming, Transactions of the ASAE, planned submission for August 2006.
- Conference Proceedings:
  - Hao, X. and R. Zhang, 2004. A hybrid mass-conservative scheme for simulating variably saturated flow in soils with large outflow flux. Proceedings of Computational Methods in Water Resources 2004 Conference. UNC-Chapel Hill, North Carolina.

Report Follows

**Problem and research objectives:**

Agriculture is the major consumptive use of water resources in the United States, especially in the arid and semi-arid areas in western U.S. The predominant method of irrigation is flood irrigation. With flood irrigation techniques, water is not effectively used by plants, and fertilizer components are often carried into ground and surface waters with waste runoff generated during water applications (Ayers et al., 1999). Improving irrigation techniques can benefit agricultural and environmental activities. In recent years, best management practices (BMP) for irrigated agriculture has become a focus of research in regions experiencing water shortages and water quality degradation because of agricultural activity. Micro-irrigation, such as subsurface drip irrigation (SDI), offers the opportunity for precise application of water and fertilizers.

Alfalfa is one of the most important forage crops in Wyoming and is Wyoming's largest cash crop. The harvested area of alfalfa hay in Wyoming in 2005 was 250,000 hectares, with a production value of $112.5 million dollars (Wyoming Agricultural Statistics, 2005).

Efficiency of SDI systems is closely related to its design and layout (Fig. 1), which is mainly determined by factors such as soil properties, crops, and local climate. Design parameters of dripper line lateral spacing, emitter spacing, depth and scheduling of irrigation are manageable factors to control the overlap of wetting fronts. Combinations of these parameters will generate different wetting patterns for a specific field application with different soil properties.

Objecitve of this study were to: (1) evaluate alfalfa biomass production using SDI as compared to sprinkler irrigation (SPK) and (2) to determine SDI system (spacing and depth of driplines) parameters for optimal alfalfa production.

**Materials and methods:**

A field study was conducted to evaluate various subsurface drip irrigation (SDI) parameters on alfalfa production. The study evaluated water use for different SDI system characteristics to better understand the utilization of SDI for improving alfalfa yields in Wyoming. Parameters studied included SDI dripper depth placement (30, 50 and 70 cm) and dripper spacing (60, 90 and 120 cm) on alfalfa yield using 9 treatments in a 2 factorial complete randomized (CRD) design. Biomass of alfalfa and non-alfalfa plants was determined from harvests of individual treatment plots. A comparison was made using sprinkler irrigation (SPK) as a control.

The project site is located on the UW's Experimental farm in west Laramie. Study site is approximately 90x30 m in size, and has a gently 1 degree southeast slope. The study site was divided into two large zones - a SDI zone of 60x30 m, and a sprinkler irrigation zone (SPK) of 30x30 m. The SDI zone was divided into 9 equal sized plots and the SPK zone was divided into 2 plots (Fig. 1). Trenches were dug at three depths and three lateral spacings. Alfalfa was seeded in mid May 2005 after plowing, rototilling and leveling the study site; seeding density was 20 kg/ha. Sprinkler irrigation was used for initiating seed germination. Alfalfa resulted in excellent germination and crop growth. In addition to the use of herbicides for weed control, weeds were routinely removed by hand throughout the experimental site.

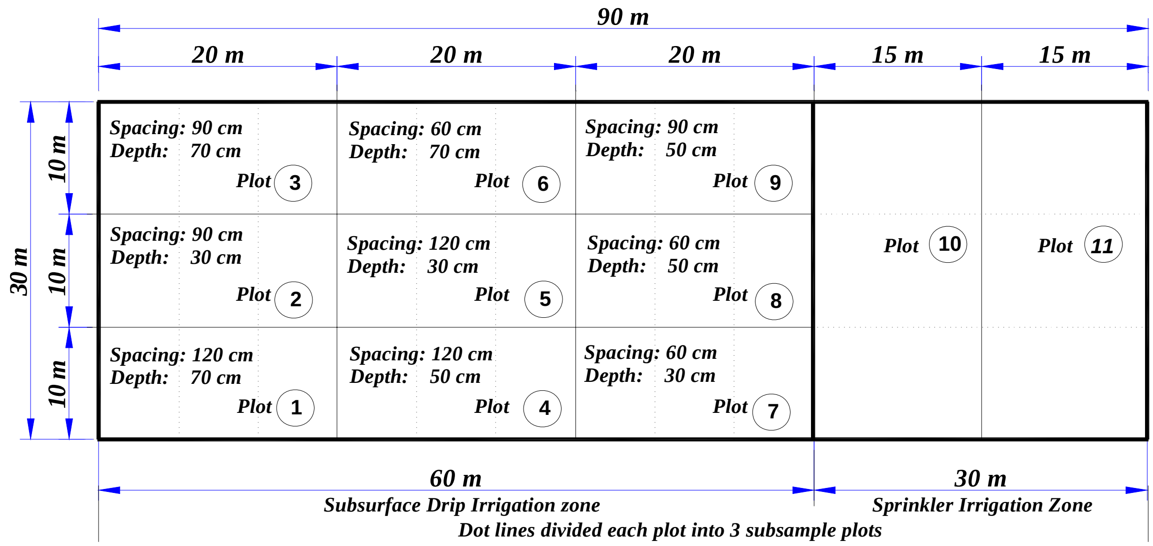


**Figure 1. Study site design including SDI and sprinkler treatment plots.**

Water supplies were measured by flow meters, and quantitatively controlled by a computer module. Amount of water supplied was based on historical monthly evaportranspiration (ET) rates for alfalfa production in Laramie (Pochop et al., 1992). Water was supplied equally to all plots until mid-August 2005. After which, three irrigation levels of 0.8, 1.0 and 1.2 ET water supply were applied to the 9 SDI plots, and 1.0 ET continued to be applied in sprinkler plots for the later half of August and early September.

Plants were harvested in September 2005. Each plot was divided into 3 subplot replicates, and 7 to 9 samples were randomly collected by hand clipping from each subplot. A total of 240 samples were collected from the 11 plots (9 SDI plots and 2 sprinkler plots). Alfalfa and non-alfalfa plants were separated by hand and individually packed into paper bags. All samples were oven-dried at 75oC for two weeks. After which the dry biomass weight of alfalfa and non-alfalfa sample bags were weighted and recorded.

SAS statistical analyses were conducted on the biomass using an alpha = 0.05 level of significance. Regression was used to evaluate the effect of water supply on biomass, and a 2-factorial CRD was used in order to determine the best SDI placement. All data were subjected to one-way ANOVA, and means was separated using Fisher's protected LSD test for the comparison of SDI and SPK. The statistical experiment design is shown in Table 1.

**Table 1. Statistical experiment design.**

| Location | | Factors | | | Replicates |
|---|---|---|---|---|---|
| | | Water supply | Spacing | Depth | |
| SDI | Plot1 | 1.0ET | 120 | 70 | 3 |
| | Plot2 | 1.2ET | 90 | 30 | 3 |
| | Plot3 | 1.2ET | 90 | 70 | 3 |
| | Plot4 | 1.0ET | 120 | 50 | 3 |
| | Plot5 | 1.0ET | 120 | 30 | 3 |
| | Plot6 | 0.8ET | 60 | 70 | 3 |
| | Plot7 | 0.8ET | 60 | 30 | 3 |
| | Plot8 | 1.2ET | 60 | 50 | 3 |
| | Plot9 | 0.8ET | 90 | 50 | 3 |
| SPK | Plot10,11 | 1.0ET | 0 | 0 | 6 |

In addition to field equipment installation, percolation tests and permeability spatial variability measurements were made at the site. These measurements were used when modeling water distributions and when relating system design to site productivity values. Software CHAIN_IR (Zhang, 1997) was used when modeling the water distribution patterns.

**Principal findings and significance:**

Based upon measured site permeability values, modeling results indicated the maximum lateral movement of water between drip lines to be approximately 36 cm. Movement varied little with emitter placement depth and irrigation duration greater than 0.5 day. Based upon these values, it was anticipated that our narrow spacing drip lines would perform better than widely spaced emitters.

Production of alfalfa and total biomass were significantly higher in SDI vs. SPK treatments. The 2-factorial CRD results found a statistically significant interaction between spacing and depth. Water supply did not have a significant effect on biomass production because adequate irrigation and rainfall resulted in total water supplied at a level greater than the required ET.

Both SDI dripper spacing and depth have significant effects on biomass production; however, an interaction between spacing and depth was determined based on the study design. Data suggests SDI with drippers spaced 90 - 120 cm on the drip tubing placed at a depth of 30 cm may be the best combination for alfalfa production. Results did not agree well with model predictions for effect of emitter spacing. Differences may be due to the root uptake effects not accounted for in the modeling work.

Additional studies are planned to study the effect of reduced water supply. Similar data for alfalfa production is being collected for the 2006 growing season with water supplied at a rate of 0.7 ET. Additional modeling work with modifications to include root uptake and precipitation is also planned.

**Meetings and Presentations:**

Youquan Jiang, Drew W. Johnson, George F. Vance and David E. Legg. Subsurface Drip Irrigation for Alfalfa Production in Wyoming, University of Wyoming Graduate Research Symposium, April 2006.

**Student Support:**

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**Selected References:**

Ayers, J.E., C.J. Phene, R.B. Hutmacher, K.R. Davis, R.A. Shoneman, S.S. Vail and R.M. Mead. 1999. Subsurface drip irrigation of row crops: A review of 15 years of research at the Water Management Research Laboratory. Agricultural Water Management 42:1-27.

Pochop, L., T. Teegarden, G. Keer, R. Delaney and V. Hasfurther. 1992. Consumptive Use and Consumptive Irrigation Requirements in Wyoming. Report to the Wyoming Water Resources Center. WWRC 92-06. 59 pp.

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Zhang, R. 1997. CHAIN_IR, Irrigation simulations of water flow and solute transport with nitrogen transformation. Research Bulletin No. B-0888, College of Agriculture, University of Wyoming, 34pp.