

**SUBSURFACE DRIP IRRIGATION TO CONSERVE WATER AND
IMPROVE QUALITY OF SPECIALTY VEGETABLE AND FORAGE
CROPS IN THE EDWARDS AQUIFER REGION**

FINAL REPORT

to

Texas Water Development Board

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Summary

The Texas Water Development Board (TWDB) has provided the Texas Agricultural Experiment Station (TAES) at Uvalde a one-year grant award of \$40,601 to supplement the cost of a precision subsurface drip irrigation (SDI) monitoring system that is linked to a fertigation controller to be used for water conservation studies of vegetable crops (Task 1 - 70% of the grant). These funds were also used to offset the costs of land preparation and installation of 6 acres of SDI and associated components (filter, meters, valves) for a large-scale production of forage crops (Task 2 - 30% of the grant). Both SDI systems were installed, including a renewable low-pressure system (LPS) for vegetable crops. Our preliminary winter and summer evaluations on vegetable species showed positive results either in yield or quality in response to deficit irrigation (less than 100% crop evapotranspiration, ETc) in artichokes, watermelon, and spinach, while poblano peppers were too sensitive and reduced yield significantly at 50% ETc. A small experiment with Tifton 85 bermudagrass revealed that under limited irrigation (pre-watering only) the use of transplants was superior to using bare-rooted sprigs. We expect that integrating efficient irrigation systems with improved cultural strategies aimed at earliness, improved size and/or yield of vegetable and forage crops will contribute to water savings and improve profitability of growers in the region.

Problem and Research Objectives

Irrigated vegetable and forage crops are economically important in the Wintergarden region. However, regulations restricting water use, competition for water with large urban areas coupled with the continual increase of drought episodes have placed a large strain on water resources and on the livelihood of farmers in south Texas. Over the last 5 years, there has been an increased interest in the application of subsurface drip irrigation (SDI). The benefits of SDI to conserve water are well documented in vegetable crops, but less so in permanent forages. The benefits of SDI can be further emphasized with the use of monitoring tools that can provide control of irrigation and fertilization, and with soil moisture monitoring devices that can assist in management decisions during crop production. These technologies, when integrated with cultivars that possess drought tolerance, high nutritional components and adaptation to local environmental conditions, could provide 'branded products' for growers, and consequently create new opportunities to increase market shares and profitability. Our long-term goal is to develop efficient water conservation strategies to enhance quality of both vegetable and forage crops in order to obtain a minimum of 25% water savings in the Edwards Aquifer region. We expect our results will help farmers located primarily in the Wintergarden region and along the Rio Grande corridor to increase irrigation efficiency as well as giving them new estimates of water use of the specialty crops under investigation.

Water Savings

Approximately 19,300 acres of watermelons are grown in southern border regions of Texas. We estimate that a 25% reduction in water application (75% ETc) would represent 6,000 acre-feet savings (1.95 billion gallons). About 6,000 acres of spinach are grown in the Wintergarden-Laredo area. A 25% reduction in water application in spinach would save approximately 1,000 acre-feet (325 million gallons). We expect similar or greater savings for onions grown with SDI or low-pressure drip system (LPS) when using specific crop coefficients being developed by TAES Uvalde for our region. While there are no statistics available on the acreage of grass hay production in the Edwards Aquifer region, some very preliminary data suggest that SDI can

allow profitable production of high quality Tifton 85 bermudagrass hay using 50% ETc. This equates to a water savings of approximately 525,000 gallons per acre. Similar to vegetable crops, further savings would be obtained when new developed crop coefficients become available for both warm- and cool-season forage production in this region.

Methodology

Task 1- Vegetable Crops

Installation of SDI and LPS irrigation systems

We have established a new precision SDI and LPS system on a 5 acre-block at TAES, Uvalde. A fertigation control unit attached to a computer controller monitors these systems. The fertigation unit allows the application of two fertilizer sources as needed for the specific crop and stage of development. Generally the first source consists of a N fertilizer and the second a balanced N-P-K + micronutrients. In addition, the system allows the injection of an acid fertilizer to control the irrigation water to a pre-set electrical conductivity (EC) and pH rates (e.g. EC 1.2 dS/m and 6.0 pH). The field layout for the SDI consists of 24 zones, 12 on single 40" beds and 12 on double 80" beds. The drip lines were placed at 12 inches deep using a total 72 singles (12 zones with 6 rows each) or 36 double rows (12 zones with 3 rows each). This configuration can accommodate crops like cucurbits for the wider-double beds, or onion, spinach, and/or pepper for the narrow beds. We have also installed the basic components of the SDI system that include filtration, pressure regulators, air/vacuum relief valves, pressure gauges, automatic valves, main lines, sub-mains, laterals, connectors, and line end-caps.

Crop evaluations

Irrigation applications including deficit irrigation regimes are based on evapotranspiration rates (ETc). The ETc value was obtained by adjusting the reference evapotranspiration (ETo) determined by atmospheric conditions (Penman-Monteith equation) and available daily at the Uvalde web site. The reference ETo was then multiplied by a crop coefficient (kc), which was estimated by the canopy cover over time. For onion and spinach we utilized the kc's developed at TAES Uvalde.

Spinach and onion. Field blocks with SDI, LPS and furrow irrigation were seeded with spinach on December 2, 2004 to compare growth, leaf quality and water use efficiency of five processing cultivars (DMC 16, DMC 18, exp. 307, 308 and 403). In addition, a short-day onion 'Legend' and two mid-day onion cultivars 'Momiji' and 'Takii' were planted on December 1, 2004 in the SDI and LPS to evaluate bulb size and yield.

Artichoke. This is a new potential crop for Texas, with no growing history in the area. Our first step was to evaluate cultivars with different bolting requirements at two planting times and irrigation rates. Transplants of five seed propagated cultivars (Emerald, Experimental Red, Imperial Star, Green Globe, and Purple Romagna) were planted in the field on beds with black plastic mulch at 3 feet apart on 27 September and 3 December 2004, and evaluated at 100% and 75% crop evapotranspiration rates (ETc).

Watermelon and pepper. In the summer we evaluated triploid watermelon cultivars with red, orange and yellow flesh colors at 100% and 50% ETc rates, representing 15 and 9 inches of

irrigation, respectively. Fruits were harvested during summer at various stages of maturity. Yield, soluble solid content, firmness, rind thickness and fruit size were measured by standard methods. In pepper, deficit irrigation (50% ETC) was evaluated on poblano and jalapeno peppers established in the SDI during spring. In addition TAES breeding lines for improved fruit quality and drought tolerance were evaluated and screened during summer in the SDI blocks.

Task 2 – Forage Crops

Installation of SDI for Tifton 85 bermudagrass

The wet winter of 2004-2005 precluded the earlier installation of the six acres of subsurface drip irrigation that was the objective of this task. However, the whole six acres was installed by mid-summer and the whole area planted to Tifton 85 bermudagrass using transplants. The six acres is subdivided into 12 one half acre blocks that can be independently irrigated and fertilized. Half of the total area will be fenced to allow grazing by goats or cattle, the remaining area will be hayed.

Though not a part of the original proposal, a small study was conducted to examine the difference in successful establishment of transplants versus sprigs under varying irrigation regimens. Three blocks were planted to compare plant survival with 1) pre-irrigation only, 2) pre-irrigation plus irrigation immediately after planting or 3) pre-irrigation with irrigation immediately after planting and again 7 days later. Each block was irrigated for four hours using overhead sprinklers the day prior to planting. Each block was planted with four replicates each of transplants and sprigs. Transplants were planted 2 meters apart in three 4 meter long rows, with each row 2 meters apart. Sprigs were dug from an existing field of Tifton 85 Bermudagrass and were placed in 4-meter long shallow furrows. The sprigs were then covered with a thin layer of soil and well compacted. Blocks 2 and 3 were irrigated immediately after planting with overhead sprinklers. Block 3 was irrigated again one week after planting. Two weeks after planting a survey was conducted to determine survival of transplants and emergence of new growth from sprigs. Each transplant was checked to see if it had survived, and the presence or absence of a live sprig was recorded every 2 meters in each row. In addition, the longest new above-ground stolon emerging from each transplant or from the previously observed sprig was measured. The Tifton 85 is now in winter dormancy, but the hot dry weather has necessitated some limited irrigation.

Results

Task 1 - Vegetable Crops

Onions and spinach. Even though the onion crop started late due to a delay in completing the SDI system, the first evaluation showed that SDI produced higher total marketable yields (harvest on June 7, 2005) compared to onions grown under the LPS system. However, the large amount of total water applied in the SDI (25 inches) was due to the initial irrigations necessary to fill the soil profile prior for germination and seedling emergence. A new study is currently under way this spring. In spinach, there were significant differences among the three irrigation systems in terms of water use efficiency (WUE) and percent stem weight (preferred lower values), but not in yield. WUE was highest for spinach grown with the LPS system, while lower stem weight was measured in the SDI system compared to LPS or furrow. Across all irrigation systems, the

cultivar Exp. 403 had significantly higher yields and slightly higher WUE than DMC 16, F018, Exp. 307, and Exp. 308.

Artichokes. Harvests started on 24 March and 21 April 2005 for the first and second planting dates, respectively. Yield increased over 3-fold for the first compared to the second planting date. Irrigation rates did not affect yield, water use efficiency or head quality. Cultivars Emerald, Imperial Star and Experimental Red were earlier than Green Globe and Purple Romagna. The best yield was for cv. Imperial Star, while largest head weight was for cv. Green Globe. Head weight, percentage of heart and crude protein concentration decreased, whereas total fibers content increased as harvesting season progressed. We selected two cultivars with different climatic requirements. Our first year data showed that yield, water use efficiency or head quality were not reduced at 75% ETc. We expect that integrating environmental and irrigation strategies aimed at earliness and large head size will contribute to the potential production of globe artichoke in the region.

Watermelon and pepper. Deficit irrigation imposed after plants were fully established reduced yields by 6 to 33% compared to 100% ETc. A positive response was that fruit quality parameters (firmness and brix %) were similar compared to well-irrigated plots. Deficit irrigation (50% ETc) significantly reduced marketable yield in poblano and jalapeno pepper cultivars due a decline in the fruit number and in increase in the % of cull fruits. We screened and selected new individual plants of poblano and habanero peppers with improved size, high vigor, and virus/bacterial tolerance. They will be evaluated in the next growing cycle.

Task 2 – Forage Crops

The objective of installing six acres of sub-surface drip irrigation has been accomplished. A small experiment initially reported in the third quarterly report revealed that transplants had higher survival rates and tended to grow faster than bare-rooted sprigs under limited irrigation post planting. Transplants that were only pre-irrigated had an 83% survival compared to a 31% survival of sprigs. Transplants also produced more stolons than sprigs, but the longest stolons from transplants were shorter than those of sprigs. Transplants that were irrigated once after planting had a 100% survival compared to 75% survival of sprigs. Transplants again produced more stolons and this time they were considerably longer. Survival of sprigs and transplants was the same (100%) when plants were irrigated twice after planting. Transplants again produced longer stolons than sprigs. These results suggest that unless sprigs can be watered soon after planting, a large loss of material can be expected. Also, transplants seem better able to grow vigorously than sprigs.

Benefit to the region and Texas

It is expected that growers will improve the irrigation efficiency while saving water on economically important crops in the Wintergarden region. We are concentrating in spinach and onion as cool-season crops, and watermelon and pepper as warm-season crops. Specialty and novel crops like habanero and artichokes could also bring high income and provide new opportunities to farmers in the region. In collaboration with local partner agencies and industry, an increased interest is being placed in large-scale evaluations of the less expensive LPS being currently evaluated at the Center.

While SDI is more widely used by vegetable growers in south Texas, hay and livestock producers have little experience in using SDI to grow forages. This facility will allow us to conduct experiments that provide information on the water saving potential of SDI to hay and forage producers in this region. Currently, producers of forages for hay or livestock by center pivot irrigation apply up to (and in some cases more than) 1" of water per week during the summer months. SDI can probably reduce this amount by half while remaining as productive.

Future plans

The evaluation and development of deficit irrigation practices with nitrogen fertilization is important environmentally for our soils and groundwater resources as well as for the public impact since they may affect the nitrate levels in the final vegetable product. The continuation of water conservation projects will also enhance our understanding of how drip fertigation strategies affect growth, development, and final product quality while saving water in the region. For the SDI-forages, the twelve half acre blocks will be used to conduct replicated studies on hay and livestock production at reduced rates of water application in order to build up a bank of information that can be provided to producers and other interested individuals.

We are planning to have a field day to highlight the benefits of subsurface drip irrigation and water conservation programs for forages, vegetable and row crops. During the visit we will also present and discuss the application and validation of crop coefficients based on lysimeter data for irrigation scheduling in the Edwards Aquifer region. This information will also contribute to the PIN network addressing research demonstration and irrigation management for growers in the Edwards Aquifer region. We have requested K. White, Uvalde County Extension Office propose the Uvalde Crop Tour committee stop at the Center for the annual 2006 Tour on Thursday, June 15, 2006. This will allow for a greater participation of producers from the region. The second alternative date for the field day will be during November or Tuesday, December 5, in conjunction with our Field Tour planned for our Symposium on Stand Establishment (<http://sest2006symposium.tamu.edu/>)

Acknowledgments

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Task 1 – Photos



Trenching operation



Laying sub-mains



Connecting sub-mains



Sub-mains with drip lines



Sub-mains to water source



Complete valve set-up



Fertjet and controller



LPS system

Task 1- Photos



Artichoke transplants



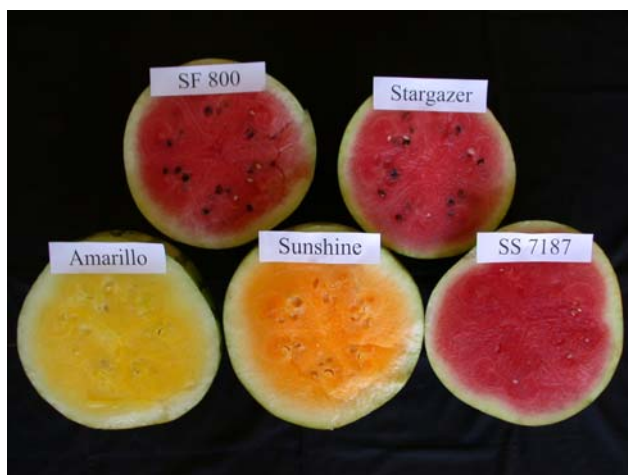
First head to harvest (under hat)



Early vegetative growth



Green Globe artichoke cultivar



Diploid and triploid watermelon under SDI



Spinach emergence with SDI

Task 2 - Photos



Installing drip tape



Growing Tifton 85 bermuda grass transplants



Connecting tape to headlines and back filling trench



Valves for 6 acres with water meter, filter and control