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TELOGIA CREEK IRRIGATION ENERGY CONSERVATION DEMONSTRATION ON MULCHED STAKED TOMATOES

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Abstract. **Microirrigation of tomatoes (*Lycopersicon esculentum* Mill.) grown for the fresh market was monitored at six growers fields in southwest Gadsden County during two seasons. Tensiometers were placed at 6 inch and 12 inch depths to record soil water tensions in the drip line, in the bed center and on side opposite to the drip line. Pan evaporation and rainfall data were collected at grower sites. Plant sap testing was performed in the field and plant leaf samples for tissue analysis were taken at grower sites. Irrigation volumes were recorded daily for each grower. Growers reported fertilization programs and supplied harvested yield data. During the fall crop growth period, irrigation water use by growers ranged from 7 to 16 inches, while during the spring crop period, irrigation ranged from about 9 to 15 inches. Differences in irrigation usage between growers was partly due to differences in local rainfall amounts. Yield in the spring crop was lowest with the highest irrigation level indicating that over irrigation was a potential problem.**

Introduction

The Telogia Creek Basin encompasses approximately 40,200 acres of West-Central Gadsden County. Approximately 8,000 of these acres are cropland; 3,600 acres in irrigated farm land and 2,000 acres of fresh market tomatoes are grown on plastic mulch using drip (microirrigation or trickle) irrigation.

This area has been declared a "Critical Water Supply Problem Area" by the Northwest Florida Water Management District. This designation applies to an area experiencing, or is likely to experience within the next 20 years, water resource problems.

The West Florida Resource Conservation and Development Council through the Florida Department of Agriculture and Consumer Services received a grant of $39,032.32 from the Florida Governor's Energy Office to conduct an assessment of current irrigation systems and water use for tomato production in the Telogia Creek area. The R.C. & D. Council contracted with the Gadsden Soil and Water Conservation District to conduct the study. The Gadsden County Extension Service assisted with the grant proposal and agreed to coordinate the project.

Recent research indicated that energy and water savings may be realized through increasing the efficiency of water application on tomato crops in North Florida (Rhoads, 1990). Basin growers had already made a transition to drip irrigation prior to implementation of this energy conservation project.

The project focused on the assessment of irrigation systems for tomato production. Nutrient management was also considered an important aspect of this project.

Materials and Methods

The project was divided into two phases. Six tomato growers in the Telogia Creek basin assisted with the project during each phase. The first was during the Fall tomato crop season, July-November 1991 and the second was during the Spring season, March-July 1992.

Field data were collected during the two tomato crop seasons. Tomatoes were transplanted between 17 July and 1 Aug. 1991 for the first phase and between 7 Mar. and 15 Mar. 1992 for the second phase.

In the first phase of this project, water use was monitored daily and soil wetting data were recorded. The six growers agreed to make field (test) sites available, ranging in size from 3 to 8 acres. Because of standard crop rotational practices, first and second phase test sites were different. To monitor the crop evapotranspiration and other water uses, flow meters were installed within a few feet of the production test site. Flow meters were usually installed inline to four-inch lay flat hoses (collapsible irrigation hose). Flow meters were monitored at the pump site and at the field test site. Test site gallonage was recorded daily, while pump site flow rate data were collected periodically. Along with irrigation crop water use monitoring, daily rainfall was recorded at each test site.

Nine tensiometers were used at each of the six test sites during each phase to monitor soil moisture under the polyethylene mulch. Plant beds were moderately to slightly raised (3 inches-6 inches) and about 30 inches wide. Transplants were spaced from 20 to 28 inches apart in the center of the bed and the trickle tube was approximately 6 inches off center, allowing for trouble-free transplanting and staking. Throughout this survey all of the growers utilized a double wall drip hose (Chapin Tape, Twin-wall 10 mil., 0.5 gal/minute @ 10 psi/100 ft) with emitter spaced 9 inches apart.

First phase tensiometers were set to record soil moisture at the 6 inch depth throughout the entire bed. Tensiometers were placed in three replications at each test (grower) site.

Three tensiometers at a specific location within a test site were installed in the bed through the mulch. These were set to observe water movement throughout the plant bed soil profile by placing one on the off-drip-tube (dry) side, approximately nine inches away from the bed center. The second tensiometer was installed between tomato plants in the bed center and the third tensiometer was placed on the drip-tube side approximately nine inches from bed center.

The second phase (Spring) tensiometer methodology was changed to observe moisture levels at the 12 inch depth.

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The three tensiometers at a test location within a grower test site during the second phase were installed by placing one on the drip side at a 12 inch depth, one in the bed center at a 12 inch depth and the third tensiometer was placed at a 6 inch depth in the bed center. This resulted in three replications of 6 inch bed center, 12 inch bed center and 12 inch drip-side tensiometers at each of the six grower test sites.

The demonstration and assessment of pan evaporation technology was administered during the second phase of the project. Number 2 wash tubs were set up at the six grower locations with appropriate wire and fence to deter water removal by animals (Smajstrla, 1989). Daily pan evaporation was recorded.

During both phases of the project growers reported their total fertilization package. This included pre-plant bed fertilizer, (both bed mix and/or band) and their liquid fertigation program. All six growers utilized liquid fertilizer injection technology. Plant sap nitrate and potassium levels were monitored during the growing season (Hochmuth, 1991). In addition to sap nutritient level monitoring, standard leaf tissue samples were sent to a professional lab for analysis. Energy use, whether by electric motor or diesel engine was also recorded.

Results and Discussion

In Table 1, the irrigation application totals and accumulated rainfall that occurred during both seasons are shown. It should be noted that these totals do not fully represent the total water use. In both phases the data collection began at planting time. There was an additional moisture requirement for ground preparation. Irrigation volumes were calculated from the field meters and did not allow for efficiency losses encountered between the pump and the field. From Table 1 it can be seen that the average irrigation applied during Phase I was 12.0 inches. Phase I rainfall was 9.0 inches and the average irrigation plus rainfall for the six field test sites was 20.9 inches. There was a wide range of variability in irrigation use. Farm 4 used the most irrigation and received the least rainfall. Although the Telogia Creek basin is a localized area in the county, many of the thunder showers that often occur in this area of the state are even more localized. There was as much as 5 inches difference in rainfall between the six farms in the Fall of 1991. There was a 9.9 inch difference in rainfall between the lowest and highest amount in the Spring crop season (Phase II). Growers irrigated an average of 11.9 inches per acre at the six test sites during Phase II. Rainfall average was 19.5 inches, giving a rain plus irrigation water total of 31.4 inches per acre. The highest water total per acre (36.0 inches) received was 15% above the 31.4 inch average, while the lowest total occurrence (26.1 inches) during the Spring was 17% below average.

Table 1. Irrigation and rainfall totals.

	Water (inches/acre)					
	Fall 1991			Spring 1992		
Farm number	Irrig.	Rainfall	Irrig. & Rain	Irrig.	Rainfall	Irrig. & Rain
1	13.2	9.0	22.2	12.4	16.8	29.2
2	7.1	11.1	18.2	8.8	17.3	26.1
3	7.2	10.0	17.2	10.7	19.8	30.5
4	16.2	6.1	22.3	13.9	18.9	32.8
5	15.5	10.2	25.7	16.5	17.5	34.0
6	12.7	7.3	20.0	9.3	26.7	36.0
Average	12.0	9.0	20.9	11.9	19.5	31.4

During the Spring crop frequent, heavy rains came in late May and early June. April and May were well below the average monthly rainfall. Less than one inch of rain was recorded between late March and late May in the Telogia Creek basin. This was not a problem to growers who knew how to manage their irrigation. Only about 25% of rain water is effective in wetting the managed root zone in this polyethylene mulch culture situation for North Florida mineral soils (Rhoads, 1990).

Table 2 gives the monthly tensiometer averages throughout the Phase I growing season. An ideal average moisture level for mulched tomatoes is thought to be approximately 10 cb (Clark, 1991). It is suggested that growers need only monitor the bed center tensiometers. The difficulty in wetting the dry side was demonstrated, particularly, when plants were about 24 to 30 inches high 4-6 weeks after transplanting. As plants obtain this size a root barrier tended to prevent lateral moisture movement to the non-drip-tube (dry) side of the plant bed. Some of the growers tended to go from too wet to too dry as the plant became larger. At times they were over irrigating and at other times productivity was suffering from being too dry. Farm 4 and 5 in Table 2 (Phase I) were irrigating the most appropriately according to tensiometer data.

Table 3 tensiometer average monthly readings depict how growers managed irrigation during a drought period in the Spring phase (Phase II). All six growers maintained a 5.4 cb average tensiometer reading for the 6 and 12 inch

Table 2. Phase I, Fall crop, 1991 soil wetting data at 6 inch depth.

		Mean tensiometer values (cb)		
Month	Farm number	Drip side	Bed center	Dry side
July	1	3.2	2.1	1.4
Aug.	1	2.8	5.0	5.0
Sept.	1	1.7	5.1	16.1
Oct.	1	4.5	7.0	20.7
Nov.	1	5.3	5.6	6.7
July	2	1.3	1.2	2.0
Aug.	2	4.7	5.0	10.6
Sept.	2	18.6	38.9	55.8
Oct.	2	20.3	47.7	66.4
Nov.	2	5.3	5.6	6.7
July	3	1.5	1.3	1.8
Aug.	3	4.7	6.1	15.7
Sept.	3	8.4	11.9	51.9
Oct.	3	2.3	3.5	32.9
Nov.	3	4.3	5.5	15.7
July	4	2.5	2.7	2.3
Aug.	4	8.2	8.9	10.7
Sept.	4	11.6	16.6	31.4
Oct.	4	11.5	14.8	24.3
Nov.	4	5.7	6.4	14.2
July	5	2.3	3.1	2.4
Aug.	5	6.1	6.1	7.4
Sept.	5	7.9	11.3	23.9
Oct.	5	5.1	16.1	37.7
Nov.	5	3.5	7.3	22.4
Aug.	6	6.2	5.8	8.7
Sept.	6	12.2	35.4	52.4
Oct.	6	19.2	45.0	65.5
Nov.	6	5.0	14.1	63.9

Table 3. Phase II, Spring crop, 1992 soil wetting data at 6 and 12 inch depth.

Month	Farm number	Mean tensiometer values (cb)		
		Drip side	Bed center	
		12″	6″	12″
March	1	4.6	4.5	4.3
April	1	4.5	3.8	3.9
May	1	4.8	9.6	5.7
June	1	6.2	14.7	9.5
July	1	6.9	12.8	11.6
March	2	5.6	3.6	5.6
April	2	5.8	5.1	6.3
May	2	8.0	33.2	25.9
June	2	9.4	26.0	23.0
July	2	9.3	13.7	11.3
March	3	4.5	2.7	3.5
April	3	5.2	3.0	4.4
May	3	5.4	3.5	6.5
June	3	5.5	5.9	7.0
July	3	4.4	4.0	4.0
March	4	6.4	6.0	5.2
April	4	6.6	8.4	7.3
May	4	4.5	8.3	10.3
June	4	5.4	11.9	11.2
July	4	7.1	50.6	20.9
March	5	4.9	3.7	4.1
April	5	4.8	3.6	4.1
May	5	4.8	4.3	4.7
June	5	3.9	4.0	3.9
July	5	3.8	3.0	3.5
March	6	3.4	3.7	3.7
April	6	4.6	7.1	8.0
May	6	14.8	39.9	41.5
June	6	8.5	11.9	11.4
July	6	3.7	3.7	4.2

bed center tensiometers for the month of Apr. May '92 tensiometer readings averaged 16 cbs for the average bed center soil moisture level. Phase II revealed some improvement in the variability of soil moisture level management over Phase I. Farm #4 probably was doing the best job of irrigation management as indicated from data in Table 3. Slightly saturated soil moisture readings early on were required to start transplants and the 50.6 cb (Farm 4) high tensiometer reading was a reflection of cutting back irrigation at the end of the crop season. Farm 4 (Table 3) maintained an average 9.6 cb tensiometer reading in the 6 inch and 12 inch drill zone throughout April, May and June. There was little difference in soil moisture between the 6 inch and 12 inch depth in the bed center.

In Table 4 the total macronutrient fertilization program of Phase II is presented. These were grower reported total fertilizer programs for the spring crop season. The six farms had administered an almost identical fertilizer program during the previous fall crop season (Phase I), at their respective farm (test) sites.

Table 4. Phase II, Spring crop, 1992 grower fertilizer programs.

Farm number	Nutrient applied (lb acre)		
	N	P	K
1	266	48	323
2	266	48	323
3	239	63	327
4	256	54	330
5	308	53	442
6	250	58	365

In a spring tomato crop, much of the plant growth occurs in the month of May. In Table 5, the plant sap and dry tissue nutrient concentrations during this time are shown.

Plant sap nutrition sample data provided an immediate nutritional evaluation of the plant, whereas, conventional tissue analysis (dry tissue) takes longer to analyze. Fluctuations in Table 5 plant sap nutrition listed for N and K may have been due to the fertigation scheduling at the individual farms.

Over-irrigation, beyond soil saturation, leaches fertilizer nutrients, sometimes beyond the plants root system (Hochmuth, 1990). A look at tensiometer readings and plant nutrition levels in Tables 2, 3 and 4 reveal that this may be occurring in some situations. Tensiometer monthly averages below 5 centibars is a strong indication that these soils were often maintained at moisture levels above soil saturation, setting the stage for leaching to occur. All of the farms had high fertilizer application. Fertilizer rates were in excess of UF-IFAS soil test recommendations. Growers may have used higher rates to offset nutrient leaching without realizing this was occurring.

Figure 1 is the average evaporative water demand for the six test sites and the National Weather Service evaporation pan data collected at the Quincy NFREC during the spring crop season. Evaporation data, such as this, can be used to schedule irrigation amounts and timings (Smajstrla, 1989).

In Table 6, (daily pan evaporation) there was often a substantial difference in evaporation rates between individual farms even though they were all within a few miles of each other. The farms individual climate varied due to rainfall, cloud cover, wind speed and other factors. In most years evaporation rates gradually and continually climb as the season goes from the winter to the summer. In Table 6, it can be seen that the frequent and somewhat high rainfalls that occurred in late May and June caused a non-typical evaporation rate. Evaporation rates in late May and

Table 5. Phase II, Spring crop plant sap quick test results and dry tissue analysis.

Date	Farm #	Mineral Concentration			
		Plant sap (ppm)		Dry wt. (%)	
		N	K	N	K
May 4	1	670	2800	6.00	3.87
	2	840	3800	6.20	3.00
	3	670	2700	5.40	4.18
	4	560	2900	5.70	3.95
	5	560	4100	5.00	2.44
	6	670	2900	6.00	2.90
May 19	1	560	5300	4.90	3.38
	2	1010	4700	5.80	3.53
	3	650	5000	5.50	3.53
	4	670	5000	5.40	3.70
	5	300	4700	4.40	2.79
	6	650	4700	4.90	3.49
May 26	1	610	4900	4.90	4.00
	2	920	5000	5.80	3.50
	3	670	4800	5.00	4.08
	4	610	5000	4.90	4.15
	5	410	4600	4.70	3.64
	6	650	4700	5.20	4.03

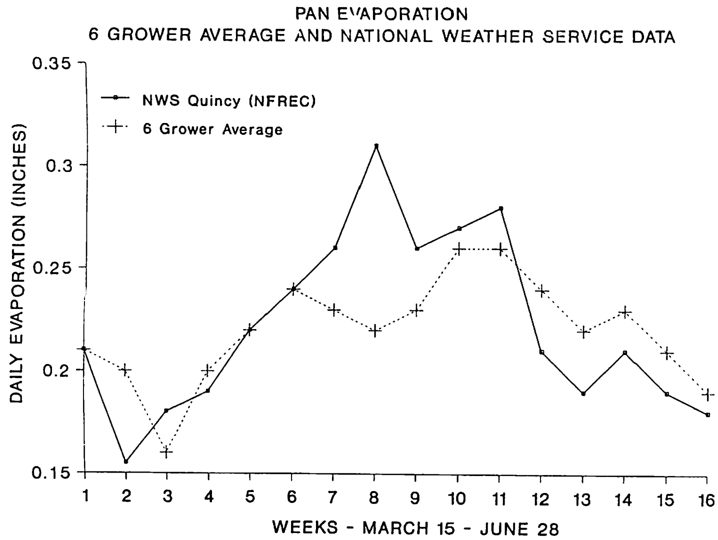

Figure 1. Pan evaporation. Six grower average and national weather service data.

Table 6. Daily pan evaporation Phase II - Spring crop 1992 weekly average (inches).

	Mean Pan Evaporation (inch/day)					
Week	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6
3/15	.17	.19	.19	.22	.20	.21
3/22	.23	.18	.20	.18	.23	.21
3/29	.16	.18	.18	.14	.15	.15
4/5	.19	.17	.18	.13	.23	.19
4/12	.25	.19	.22	.21	.23	.23
4/19	.25	.19	.20	.25	.25	.28
4/26	.21	.20	.25	.25	.25	.30
5/3	.25	.21	.18	.21	.21	.25
5/10	.23	.20	.23	.23	.25	.25
5/17	.20	.23	.25	.25	.31	.25
5/24	.24	.25	.25	.25	.25	.25
5/31	.19	.25	.21	.19	.18	.23
6/7	.19	N/A	N/A	N/A	.21	N/A
6/14	.20	.25	.19	.21	.28	.22
6/21	.21	N/A[z]	.15	.28	.25	.28
6/28	N/A	N/A	.19	.19	N/A	N/A

[z]N/A - Information unavailable due to heavy rains.

June were often around one-third inch per day. This was not the case in the Telogia Creek basin in Spring 1992.

During Phase I of this project, growers reported an average yield of 1731 boxes (25 lb.) per acre marketed from the six test sites. Fall yields averaged from 40% above the average to 30% below the average.

Growers pumped an average of 331,273 GPA during the spring. Average yield was 1645 boxes per acre during the Phase II Spring crop. The lowest test site yield was 16% below this average. During Phase II, Farm 5 reported the lowest yield and pumped 447,769 gal/acre of irrigation water. Farm 5 maintained the lowest tensiometer readings during Phase II and used 35% more water than the average.

Table 7. Energy use per water volume.

Phase	Farm #	Farm GPA	Energy/acre[z]	Yield[y]
I	1	357,950	44 Gal.	1214
I	2	193,043	328 KWH	1331
I	3	194,660	227 KWH	1532
I	4	438,800	508 KWH	2471
I	5	420,813	492 KWH	1917
I	6	346,067	410 KWH	1920
II	1	336,800	41 Gal.	1689
II	2	241,800	430 KWH	1732
II	3	290,865	391 KWH	1700
II	4	377,075	N/A	1914
II	5	447,769	290 KWH	1381
II	6	252,600	422 KWH	1454

[z]Gallons diesel or kilowatt hours.
[y]Grower reported yield in 25 lb. boxes per acre.

Farm 4 reported the highest spring tomato yield of 1,914 boxes per acre. Farm 4 (Phase II) was previously made reference to in this report because soil moisture levels were kept at the most optimal range compared to the other growers.

In Table 7 the volume of water pumped and the energy used during Phase I Phase II test sites are shown. As can be seen from this data, there was great variability in the energy used to irrigate. The average electrical energy consumption was 395 KWH used to apply an average 318,572 gal/acre. The variability in Table 7 may or may not reflect pump system inefficiencies. The investigation of pumping system inefficiencies was not a part of this demonstration project.

Data from this survey indicate that energy savings from cutting back seasonal irrigation volumes did not necessarily occur. At times growers were not irrigating enough and at other times they were irrigating too much. This would suggest that with approximately the same seasonal volume, yields could be increased with improved management.

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