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Energy and Water Efficiency in Vegetable Production[1]

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INTRODUCTION

Vegetable production in Southwest Florida is dynamic and responsive to new technology, market trends, consumer demands and social pressures. Area growers want to continue to produce in the area and they seek the latest technology and knowledge to help them produce our food efficiently. Environmental concerns demand low-input, efficient operations which ultimately save money and energy and protect the environment.

Micro-irrigation and fertigation systems can enhance the efficiency of vegetable production. Water and fertilizer conservation, reduction of foliar diseases, and the precise timing of water and fertilizer applications for optimal growth are some of the benefits. Overall, micro-irrigation and fertigation allow growers to closely monitor inputs, such as nitrogen fertilizer, through increased application efficiency.

There has been considerable research to develop vegetable growing practices which reduce inputs such as water, energy and fertilizer, yet maintain profitable yields. Increased water-use efficiency creates energy savings because less energy is used to pump water. At 33,000 British thermal units (Btu) of primary energy per pound of nitrogen fertilizer, the efficient use of fertilizer saves energy, too.

DEMONSTRATION

A demonstration was developed cooperatively between Bonita Packing Company, Lee County Extension Service, the Southwest Florida Research and Education Center and the University of Florida's Institute of Food and Agricultural Sciences (IFAS) through a grant provided by the Florida Energy Extension Service. The purpose was to demonstrate the energy that could be saved in vegetable production from the efficient application of fertilizer and water using micro-irrigation/fertigation.

The 20-acre demonstration site was located on the Corkscrew Growers Farm in Bonita Springs, Florida on a Pompano fine sand soil. The irrigation water had a pH value of 7.1 and a hardness of 275 ppm, acceptable values for drip irrigation.

Cultural practices followed, as much as possible, standard black plastic mulch procedures used by growers. The field was precision graded and lateral ditches were placed on 60-foot centers. Raised beds on 6-foot centers, 8 inches high and 30 inches wide, were formed. The tomato transplants, cultivar "Sunny," were planted on 18-inch centers and staked, pruned and tied when necessary.

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IRRIGATION

Subsurface irrigation is the most common irrigation method used in Southwest Florida. For this method, irrigation water is conveyed to the field via open ditches and applied through lateral ditches. The water flows horizontally beneath the soil surface to create an artificial water table, and water reaches the root zone by capillary action. In contrast, a micro-irrigation system slowly applies water directly to the root zone from a network of pipes. Research has shown a water savings of up to 80 percent with micro-irrigation when compared to seepage irrigation (Locascio et al., 1985).

The micro-irrigation system designed for the demonstration allowed for three fertigation treatments to be applied randomly across the site. A computerized irrigation controller was installed to control watering durations. Irrigation water was supplied from an existing well cased into the surficial water table and sand media filters were used to improve water quality.

Water was delivered to the field through buried PVC pipes. Lateral irrigation tubing or drip tape was placed approximately 10 inches from the plant row on top of the bed under the plastic mulch. Water flow from the tape was 24 gallons per hour per 100 feet at 8 pounds per square inch (psi). The length of each run was 330 feet.

The amount of water applied via open ditches to prepare the 20 acres of land was 5,489,000 gallons. Approximately 4,863,000 gallons of water were used to grow the crop. Thus, 243,150 gallons of water were used per acre by the micro-irrigation system from transplanting through harvest.

FERTILIZATION

Three fertilization treatments were applied to demonstrate different nitrogen (N) rates on winter tomato production. The nitrogen rates were 100 pounds N per acre; 160 pounds N per acre; and 220 pounds N per acre. The medium rate followed IFAS recommendations for nitrogen, phosphorus, potassium and micronutrient rates, representing a 50 percent reduction in nitrogen fertilizer as compared to practiced seepage irrigation fertilization rates.

A calibrated soil test determined that the existing phosphorus level was very high and the potassium level was very low. Therefore, no phosphorus was applied and sufficient quantities of potassium fertilizer were applied during bed formation to achieve 50 pounds of potassium per acre before the tomato seedlings were transplanted. In addition, 50 pounds of N per acre and the required micronutrients were added during bed formation.

Table 1. Fertigation Schedule for the Nitrogen Requirement.

Week	Low lbs. N/acre	Medium *lbs. N/acre	High lbs. N/acre
1	0	0	0
2	0	0	0
3	7	7	17.5
4	7	10.5	17.5
5	7	10.5	17.5
6	7	14.0	17.5
7	7	14.0	17.5
8	7	17.5	17.5
9	7	17.5	17.5
10	0	7	17.5
11	0	7	14.0
12	0	7	14.0
13	0	0	0
14	0	0	0

The remaining nitrogen fertilizer was injected into the drip irrigation system during the growing season through the micro-irrigation and fertigation system directly to the plant root zone according to a predetermined schedule (Table 1).

No fertigation was applied during the first two weeks because the amount of nitrogen fertilizer in the bed was sufficient to supply the plants' needs for this time period. As the tomato plants matured, nitrogen requirements increased and so did the fertilizer application rate. This schedule provided the tomatoes' nitrogen requirement without applying more fertilizer than could be utilized in one week by the plants. This reduced the potential for fertilizer leaching losses from the soil.

Table 2. IFAS Research Harvest and Grade (1st and 2nd harvest, green only).

N Fertilizer (lb/acre)	Size of Tomatoes			Total
	6 x 7	6 x 6	5 x 6	
	No. of 25-lb boxes/acre			
100	72	243	348	663
160	95	345	499	938
220	80	319	422	821

RESULTS

Since micro-irrigation places the water pumped through the system within the plant root zone, the quantity of water which needs to be pumped is greatly reduced in comparison with seepage irrigation. This study indicated that the substitution of micro-irrigation for seepage irrigation could save approximately 70,000 kWh of energy during the growing season per acre per year if the water table was 100 feet below the surface.

The demonstration sub-plots were harvested and graded on December 20, 1990 and again on December 31 by IFAS researchers. The results from the sampling were converted to a per acre basis for comparison (Table 2). The remaining tomato crop was harvested and graded on December 22, 1990 and January 2, 1991 by Bonito Packing Company using standard commercial practices (Table 3).

Both harvesting and grading techniques indicated that the highest total yield was produced by 160 pounds of N per acre. If 160 pounds of N per acre represented a 50% decrease in nitrogen fertilizer for the 20,600 acres of tomatoes planted in Southwest Florida in 1989-90, then approximately 95 billion Btu of energy could be saved. Ninety-five billion Btu of energy is equal to 761,000 gallons of gasoline.

Table 3. Commercial Harvest and Grade (1st and 2nd harvest, green only).

N Fertilizer (lb/acre)	Size of Tomatoes			Total
	6 X 7	6 X 6	5 X 6	
	No. of 25-lb boxes/acre			
100	302	351	213	866
160	339	511	327	1177
220	355	493	297	1145

SUMMARY

Micro-irrigation and fertigation may become an asset to vegetable producers in Southwest Florida. Reduced water, energy, money and fertilizer inputs seem to be extremely important in the environmentally-sensitive society of today. The initial capital cost of micro-irrigation is greater than that for seepage irrigation, but the operating water and energy budgets are smaller once micro-irrigation is installed. Increased management, equipment costs, and specially trained personnel are a few of the challenges for the vegetable grower that adopts micro-irrigation and fertigation. Overall, it is important to become accountable for all inputs and outputs.

REFERENCES

Locascio, S.J., S.M. Olson, F.M. Rhoads, C.D. Stanley and A.A. Csizinszky. 1985. *Water and fertilizer timing for trickle-irrigated tomatoes*. Proc. Fla. State Hort. Soc. 98:237-239.