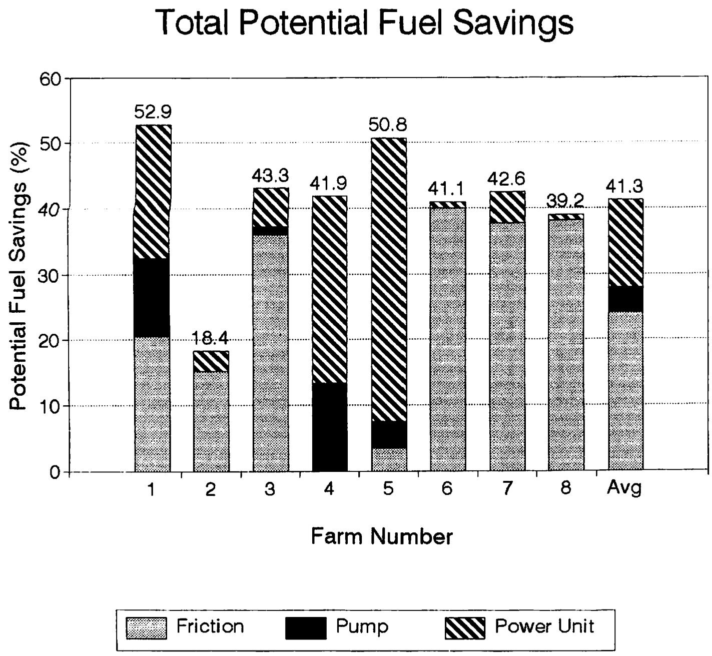

Figure 2. Total potential fuel savings as a percentage of current fuel use rates.

rate. From Fig. 2, the average potential fuel savings from all causes studied was 41.3%, however two systems had potential savings over 50%, and even the most efficient system (Farm No. 2) had a potential savings of 18.4%. These potential fuel and energy savings are believed to be representative of the annual 5,000 acre drip-irrigated tomato crop in north Florida. From the average fuel use data in Table 3, the annual energy usage is the equivalent of about 141,000 gal of diesel fuel at a cost of about $155,000 per year. Thus, the potential savings is demonstrated to be about 58,000 gal of diesel fuel with a value of about $64,000 per year.

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PAN EVAPORATION SCHEDULING FOR DRIP-IRRIGATION TOMATO

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Abstract. **Tomatoes (*Lycopersicon esculentum* Mill.) were grown with polyethylene mulch and drip irrigation on a fine sandy soil to evaluate the effects of water quantity scheduled by pan evaporation. Water was applied at 0, 0.25, 0.50, 0.75 and 1.0 times pan evaporation in one irrigation per day during the 1990 season. In this extremely dry season, fruit yields were doubled by irrigation. Total fruit yield were highest with irrigation quantities of 0.75 and 1.0 pan and significantly lower with 0.25 and 0.50 pan. Fruit yields were similar with 0.75 pan, 1.0 pan, and with the soil maintained at 10 cb. As compared with tensiometer (10 cb) controlled treatment, water applications were higher early in the season with the 0.75 pan treatment but were similar later in the season. Total water use was higher with the 0.75 pan schedule than with the 10 cb treatment. Tomato leaf N concentrations were reduced with an increase in water quantity.**

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Introduction

Tomato is the highest valued vegetable grown in Florida. During the 1991-92 season, the crop was grown on 20,760 ha with an on-farm value of $728.6 million (Freie and Young, 1993). Most of the crop is grown from transplants with polyethylene mulch and must be irrigated to prevent water stress. The most common forms of irrigation are subsurface with the application of about 115 to 150 $cm \cdot ha^{-1}$ and sprinkler with 38 to 50 $cm \cdot ha^{-1}$ (Locascio et al., 1989). In 1974, Locascio and Myers reported that tomato yields similar to those produced with sprinkler irrigation could be produced with less than one-half as much water applied by drip irrigation provided that N-K were injected with the irrigation water.

Drip irrigation has been slow to be used by commercial growers where water was abundant because of the increase in cost and the intensity of management required to use drip irrigation (Prevatt et al., 1984). In recent years, the need to conserve water has increased along with the use of drip irrigation. Currently 4700 ha of tomatoes are grown with drip in Florida (Hochmuth et al., 1993).

Water application scheduling is important since overwatering or underwatering may result in a reduction in yield. A convenient method to schedule drip irrigation water quantity is to apply water as a factor of evaporation from a U.S. Weather Service Class A evaporation pan (pan). On a sandy soil, tomato water requirements were reported to be more than 0.50 pan (Locascio and Smajstrla, 1992) and below 1.0 pan (Locascio et al., 1989). The study reported here was conducted to evaluate the effects of water quantity as a factor of pan on tomato production.

Materials and Methods

Tomatoes were grown on an Arredondo fine sand (Grossarenic Pleudult) at the Horticultural Unit near Gainesville during the spring of 1990. The soil had been previously cropped and after the application of 1.7 Mt·ha^{-1} $CaCO_3$, the soil pH was 7.1 and Mehlich I extractable nutrients were as follows: 783 ppm Ca, 120 ppm Mg, 35 ppm K and 121 ppm P. Treatments were five water quantities applied at 0, 0.25, 0.50, 0.75 and 1.0 times pan. In one additional treatment, irrigation was scheduled to maintain soil water tension above 10 cb with a tensiometer. Treatments were arranged in a randomized block design and were replicated 4 times in single row plots 1.83 m wide and 8.5 m long.

The soil was disked and beds 1.83 m apart with 0.6 m bed tops were formed. Fertilizer was applied broadcast on the bed tops at 90-45-108-45 kg·ha^{-1} N-P-K-micronutrient and mixed into the bed for all treatments. Double wall drip tubing (Chapin Twinwall, Watertown, N.Y.) with emitters spaced 30.5 cm apart and a delivery rate of 62 ml·m^{-1}·min^{-1} was placed 7.5 to 10 cm from the bed center. Beds were fumigated with 390 kg·ha^{-1} 67% methylbromide 33% chloropicrin mix, and 0.0038 cm thick black polyethylene mulch was applied over the bed.

On 15 Mar. 1990, 'Sunny' tomatoes were transplanted 0.5 m apart on the beds. Irrigation water quantities for the pan treatments were calculated based on the total plot area using the previous 7 days pan and were applied daily. For the 10 cb treatment, water was applied at 0.50 pan at each time the soil water tension reached 10 cb. The system was designed so that water could be applied as frequent as 2 times daily. One time weekly, 13.4-0-15.7 kg·ha^{-1} N-P-K fertilizer was injected with the irrigation water (no additional fertilizer was applied for the 0-water treatment). Nutrient sources were ammonium nitrate, concentrated superphosphate, potassium chloride, and micronutrient mix (FN503, Frit Industries, Ozark, AL). Tomatoes were pruned and staked and insecticides and fungicides were applied as needed.

Recently matured whole leaves were sampled for N analysis on 1 May, 1 June, and 22 June. Soil water tension was measured with recording tensiometers placed in the bed center at 15 and 30 cm depths. Mature green fruit and riper fruit were harvested on 13 June and 21 June. Fruit were graded by size into extra-large, large, and medium marketable fruit by U.S. Grade standards. Soil samples were taken from the bed center to a depth of 15 cm and analyzed for NH_4-N and NO_3-N. Data were analyzed by an analysis of variance and mean separation was by orthogonal comparison.

Results and Discussion

The spring of 1990 was extremely dry (Table 1). Except for one week during the 16 Apr. to 30 Apr. period when 8.4 cm rain was recorded, rainfall averaged only about 1.5 cm/week from 16 Mar. through 15 May. Pan evaporation during the entire season exceeded rainfall in all 15-day periods except the 16 Apr. to 30 Apr. period. The amount of water applied with the 1.0 pan treatment totaled 42.5 cm during the season. With the 10 cb treatment, water use was only 15.0 cm or about 0.35 times Epan.

Table 1. Rainfall and irrigation during bi-monthly periods during the 1990 tomato season with 1.0 pan and 10 cb application quantities.

1990 Time period	Rainfall (cm)	Irrigation quantity (cm) 1.0 pan	Irrigation quantity (cm) 10-cb
16/3-31/3	4.6	2.54	1.77
01/4-15/4	4.1	4.99	0.75
16/4-30/4	8.4	4.17	0.52
01/5-15/5	2.0	13.01	2.12
16/5-31/5	6.6	9.58	5.01
01/6-15/6	7.4	5.12	3.18
Total	33.1	39.42	13.35

The effects of applied water quantity on the yield of extra-large, large, medium, and total marketable yields are shown in Table 2. With the application of no water, plant growth was poor and yield of marketable fruit was low (30.7 Mt·ha^{-1}). Also, over one-half of this fruit was in the medium category. With the application of 0.25 pan, the yield of extra-large fruit increased about 3 times and yield of large fruit was double that obtained with no irrigation.

With an increase in water quantity from 0.25 pan to 0.75 pan the yield of extra-large fruit increased to 36.5 Mt·ha^{-1}. With a further increase in water quantity to 1.0 pan, extra-large fruit yield dropped to 35.1 Mt·ha^{-1}. However, the marketable yield of large, medium, and total fruit increased linearly with increases in water quantity from 0.25 to 1.0 pan. Total fruit yield increased from 48.6 Mt·ha^{-1} with 0.25 pan to 87.0 Mt·ha^{-1} with 1.0 pan. With the 10 cb treatment, total fruit yield was 84.0 Mt·ha^{-1}. Water use of tomatoes with the latter treatment was only 35% of that used with the 1.0 pan treatment. In earlier similar work, pan water requirements were found to be greater than 0.5 pan (Locascio and Smajstrla, 1989) and between 0.5 pan and 1.0 pan (Locascio, et al., 1989). Similar savings in water with tensiometer scheduled irrigations were also shown earlier with tomato (Smajstrla and Locascio, 1990).

Leaf tissue N concentrations were over 70 g·kg^{-1} (Fig. 1) with all treatments at the 1 May sampling and were not consistently influenced by water quantity applied. At the 1 June sampling, leaf N concentrations were lower with 0

Table 2. Tomato marketable yield by size as influenced by irrigation quantity 1990.

Irrigation quantity	Marketable yield (Mt·ha^{-1}) Ex-large	Large	Medium	Total
E pan				
0	5.9	8.5	16.3	30.7
0.25	15.8	15.0	17.8	48.6
0.50	28.0	20.3	19.4	67.7
0.75	36.5	21.7	21.1	79.3
1.00	35.1	27.4	24.5	87.0
0 vs irr.[z]	**	**	*	**
Irr. quantity	Q**	L**	L*	L**
Tensiometer				
10 cb	31.3	28.3	24.4	84.0
0.75 pan vs 10 cb	NS	**	*	NS

[z]Mean separation of no irrigation vs mean of E pan irrigation quantities were significant at the 5% (*) or 1% (**) levels. Significant irrigation quantity effects were quadratic (Q) or linear (L).

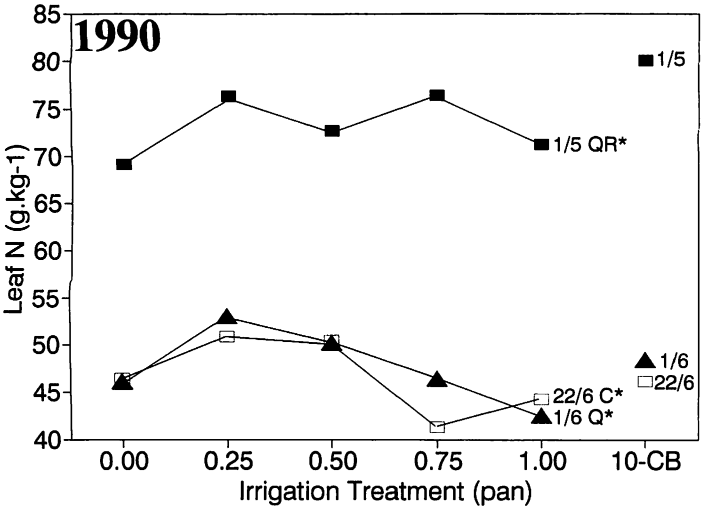

Fig. 1. The influence of irrigation treatment as a fraction of pan and water applied at 10 cb on leaf tissue N concentration at three samplings. Effects of pan water quantity were significant at the 5% level (*) and were quadratic (Q), cubic (C), or quartic (Qr).

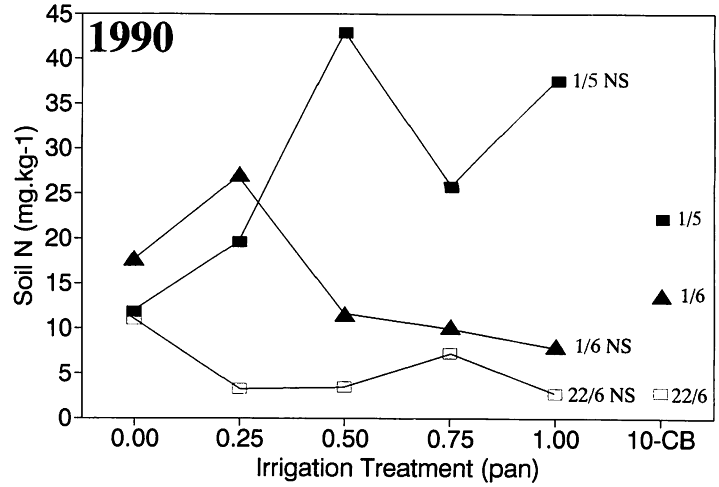

Fig. 2. The influence of irrigation treatment as a fraction of pan and water applied at 10 cb on soil N (total of NO_3-N and NH_4-N) at three samplings. Effects of treatments were not significant (NS).

water than 0.25 water quantities. These N concentrations reflect that only preplant N and no fertigated N was applied with the 0 water treatment. With an increase in water quantity from 0.75 pan to 1.0 pan, leaf N was reduced from 53 $g \cdot kg^{-1}$ to 43 $g \cdot kg^{-1}$. With the 10 cb treatment, leaf N concentration was 48 $g \cdot kg^{-1}$ and between the value of 50 and 46 $g \cdot kg^{-1}$ with 0.5 pan and 0.75 pan, respectively. Leaf N concentrations were similar at the end of the season (1 July) as at 1 June.

Total soil available N (NO_3-N + NH_4-N) values are shown in Fig. 2. At the 1 May sampling, soil N values were variable and not influenced by water quantities from 0.25 to 1.0 pan and averaged 31 $mg \cdot kg^{-1}$. With no irrigation, available soil N was significantly lower than with the former treatment and averaged 12 $mg \cdot kg^{-1}$. With the 10 cb treatment, soil available N averaged 22 $mg \cdot kg^{-1}$. At the later samplings in 1 June and 1 July, available soil N values were lower but not influenced by water quantity applied.

The quantity of water to apply by pan evaporation to obtain maximum tomato production varies by soil type (Locascio et al., 1989), season (Olson and Rhoads, 1992) and with rainfall. In these studies, maximum yields were consistently produced with water quantities of between 0.5 and 1.0 pan. However, in this study as in past studies on a fine sandy soil (Smajstrla and Locascio, 1990), maximum production was obtained with water equivalent to about 0.35 pan with the use of tensiometer scheduling of water. On heavier soils, tensiometer scheduling did not result in yields equivalent to that produced with 0.5 pan (Olson and Rhoads, 1992). In addition to an apparent reduction in water use, tensiometer scheduling can be more automated than the use of pan. Also, over-watering during rainfalls is less likely to occur with tensiometer scheduling than with pan scheduling. Further work is needed to perfect tensiometer scheduling of water for tomato grown on various soil types.

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