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INFLUENCE OF LATERAL TUBING LOCATION AND NUMBER ON GROWTH AND YIELD OF TOMATOES WITH MICRO IRRIGATION

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Abstract. **An experiment was conducted to determine the influence of location and number of micro-irrigation lateral tubes on the growth and yield of tomatoes (*Lycopersicon esculentum* Mill.). Comparisons of 1 and 2 lateral tubes per plant row and lateral spacings from the plant row of 24 cm and 12 cm on a sandy soil were assessed. Number of laterals and location influenced soil-water potential (SWP) in the plant row at the 15 cm depth but not at the 30 cm depth. The number of lateral tubes did not influence yield. However, laterals located 24 cm from the plant row resulted in greater yield than with those at the 12 cm distance.**

Florida is a major producer of fresh tomatoes for the domestic market. Much of the production occurs on the flatwood soils of southwest Florida. Soils of the region are sandy, nearly level and typically have an organic sublayer. These soils exhibit low water-holding capacity which presents special problems for the design and management of micro irrigation systems since small differences in soil moisture can have a large impact on plant growth and yield [5]. The effectiveness of micro irrigation for crop production on coarse-textured soils can be further limited by a shallow rooting depth [1].

Wetted soil volume is reduced by the limited lateral movement of water from the micro irrigation emitter in coarse textured soils. This reduction in wetted soil volume may contribute to the high evaporative demand water-stress that is often observed in tomatoes grown with micro irrigation. Increasing the number of laterals per crop row has been shown to be an effective means of increasing the wetted volume of soil for root development [7].

Since emitter and plant spacings are often different, the distance between the emitter and plant will vary. Uneven growth of young tomato transplants under micro irrigation may be caused by insufficient moisture reaching the root zone. Therefore, the distance the lateral tube is placed from the plant row may be important, especially when plants are young. Goldberg and Shmueli [3] observed a decrease in growth rate of sweet corn as the lateral line was moved from 10 cm to 50 cm from the crop row.

Given these observations, it was postulated that the location (distance from the plant row) of the lateral tubing or the number of lateral tubes per bed could influence the effectiveness of micro irrigation of sandy soils. Objectives of this study were to determine the influence of the location and the number of lateral lines on yield and growth of tomatoes in sandy soil.

Materials and Methods

An experiment was conducted in the fall of 1988 at the Southwest Florida Research and Education Center, University of Florida, Immokalee, FL. Soil at the experiment site was an Immokalee fine sand (silicious hyperthermic Arenic Haplaquods) containing more than 98 percent sand in the A horizon [4]. The experiment site was a uniform 0.4 ha field that was precision graded to 0.06% slope. A 1.2 m deep rim ditch was constructed around the field. The ditch was installed with a float-controlled lift pump that maintained the ditch water level below 1 m from the soil surface. This minimized the contribution of the water-table in meeting crop water demand.

The experiment was a 2^2 factorial with 6 replications. The two factors were distance and number, which resulted in the following treatments: 1) one lateral placed 24 cm from the plant row, 2) one lateral placed 12 cm from the plant row, 3) two lateral lines placed 24 cm—one on each side of the plant row, and 4) two lateral lines placed 12 cm—one on each side of the plant row.

Cultural practices, other than fertigation and irrigation, were standard commercial practices. Raised beds were formed on 1.8 m centers, 20 cm high and 75 cm wide. During the bedding procedure, fertilizer was incorporated into the bed at the following rates: 50 kg N/ha, 53 kg P/ha, and 87 kg K/ha. The lateral irrigation tubing was placed on top of the soil beds. The beds were then covered with polyethylene mulch (0.05 mm thick). The cultivar Sunny was transplanted on 12 Sept. 1988 on 38 cm spacings. The plants were staked and tied as necessary.

The irrigation tubing was a 0.25 mm biwall type with a flow rate of approximately 2 liter s^{-1} 100 m^{-1}. Emission points were located on 30 cm spacings. Irrigations were for a maximum duration of 1 hr. Up to 3 irrigations per day were applied. Daily irrigation amounts were based on pan evaporation from a standard U. S. Weather Service Class A evaporation pan multiplied by a crop age factor and then adjusted to maintain average soil-water potential (SWP) greater than −15 kPa. Tensiometers were located in the plant row at 2 depths (15 and 30 cm) and 2 locations within each treatment. They were monitored each work day at approximately 1500 hr EST. Each treatment re-

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ceived approximately the same total amount of water. The application rate differed since the treatments with 2 laterals per bed received nearly twice the flow rate but for one-half the time. To insure that each treatment was receiving the same amount of water, water supplied to treatments having 2 lateral tubes per bed was from 1 manifold, while to those treatments having 1 lateral per bed were supplied from a different manifold. The water applied to each manifold was metered. A record of daily rainfall and pan evaporation was maintained throughout the season. In addition, an observation well 1 m deep was placed in the center of the field and continuously monitored with a water level recorder.

Fertilizer was also applied through the irrigation system twice per week beginning the first week after transplanting. Each treatment received the following total fertilizer amounts: 240 kg N/ha, 53 kg P/ha, and 337 kg K/ha. The weekly fertigation schedule is provided in Table 1. In addition, the irrigation system was injected weekly with sodium hypochlorite to protect against bacterial growth within the irrigation tubing. Injection rate was set to achieve 1 ppm of free chlorine at the outlet most distant from the pump.

Each plot consisted of 80 m of plant row. Plant heights were measured bi-weekly from randomly selected plants in each plot. Plots were sampled for yield on 1 Dec. and 20 Dec. from randomly selected 4 m lengths of plant row in each plot. Tomatoes were culled and graded to estimate commercial packout. Analysis of variance was performed to separate the effects of distance and number of lateral tubes on total yield from each of the treatments.

Results and Discussion

The 1988 fall growing season was much drier than normal. In addition due to the polyethylene mulch, contribution of rainfall to meeting crop water demand was further limited. A water-table level recorder indicated the water-table was always greater than 1 m below the soil surface. This minimized upward flux contributions from the water table. Pan evaporation and rainfall for the growing season were 45.2 cm and 8.2 cm, respectively. Cumulative irrigation amount applied on a net area basis was 35.9 cm or approximately 80% of pan evaporation. Each of the measured components of the water budget is shown in Fig. 1.

Table 1. Fertigation schedule—drip irrigated tomatoes, fall 1988 (5-0-8 liquid fertilizer was injected two times per week).

Age—weeks after transplanting	Kg/ha/week N	Kg/ha/week K	Percent of total injected
1	3.8	5.0	2
2	5.7	7.5	3
3	7.6	10.0	4
4	9.5	12.5	5
5	9.5	12.5	5
6	9.5	12.5	5
7	15.2	20.0	8
8	15.2	20.0	8
9	15.2	20.0	8
10	22.8	30.0	12
11	22.8	30.0	12
12	22.8	30.0	12
13	15.2	20.0	8
14	15.2	20.0	8

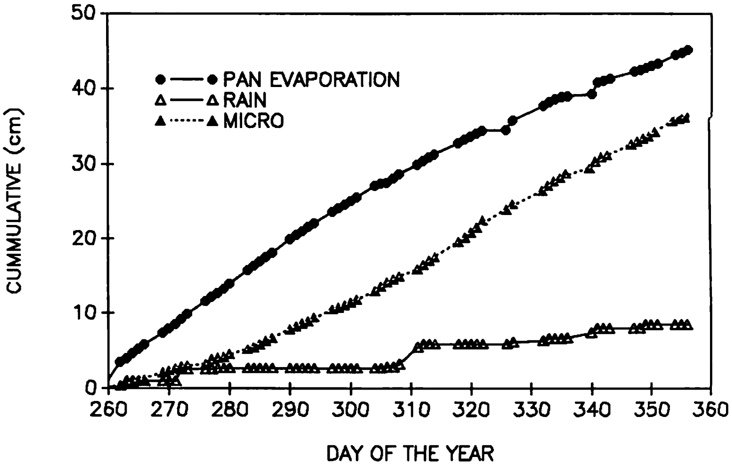

Fig. 1. Cumulative water budget (pan evaporation, rainfall and irrigation) for micro irrigated tomatoes, 1988.

Because tensiometers were located directly in the plant row, treatments with the lateral tubing located 12 cm from the plant row indicated soil water potential (SWP) higher (lower negative number) than treatments with the laterals located at 24 cm. Average SWP for the 24 cm and 12 cm treatments at the 15 cm and 30 cm depth, respectively, are

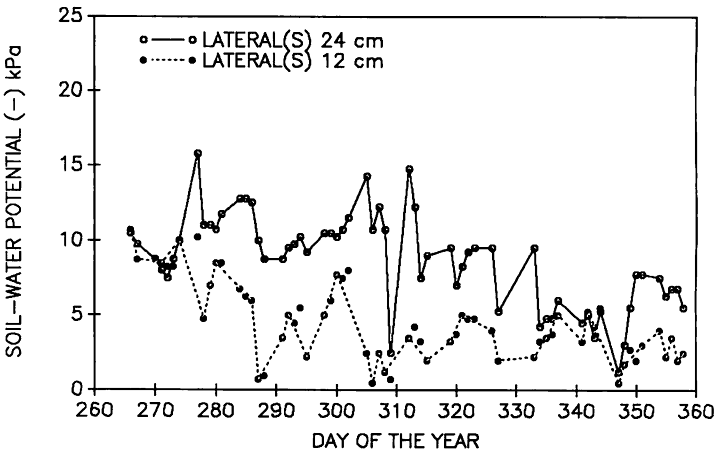

Fig. 2. Comparison of the average SWP at the 15 cm depth of treatments with the lateral tubing 12 and 24 cm from the plant row.

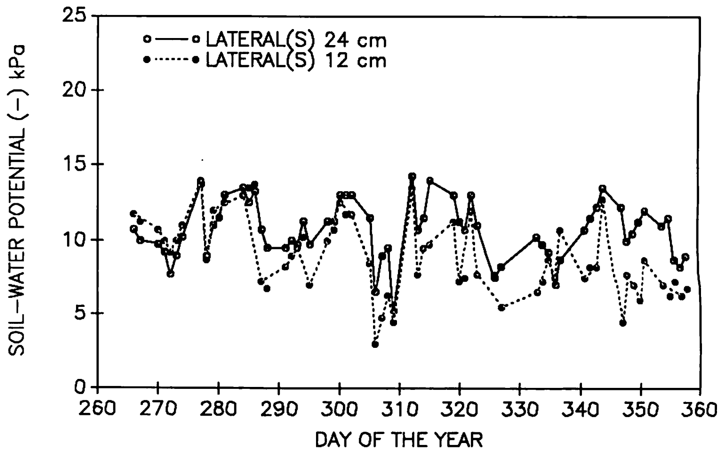

Fig. 3. Comparison of the average SWP at the 30 cm depth of treatments with the lateral tubing 12 and 24 cm from the plant row.

shown in Figs. 2 and 3. Similarly, Figs. 4 and 5 compare average SWP of plots having 1 lateral tube with plots having 2 lateral tubes. At each depth, SWP was maintained below (–15) kPa, which corresponds to approximately 50% deletion of available soil water [6]. Average SWP measured in the plant row was significantly lower (higher negative value) at the 15 cm depth with the lateral tubing spaced at 24 cm, but at the 30 cm depth the difference was not observed. Similarly, the plots with the single lateral had lower SWP at the shallow depth, but at 30 cm there was essentially no difference.

Initially plant height indicated slightly greater growth with double lateral tubing and with the lateral located closer to the plant row than with a single lateral tube at 24 cm. The greater plant height of Treatments 2, 3 and 4 over Treatment 1 was maintained over the entire observation period (Fig. 6). These differences were not statistically significant at each sampling; however, the trend was consistent over the sampling dates.

Treatment yield by grade is given in Table 2. Treatments with laterals placed 24 cm from the plant row produced the greatest total yield. The yield difference was particularly important since the greater yield was almost entirely due to a higher percentage of extra large fruit (size 5 x 6), which commands a better market price per unit weight. The statistical analysis indicated a highly significant ($P<0.005$) effect of distance on yield, with the greater distance (24 cm) having the greater yield (Table 3). The effect of the number of lateral tubes per bed was not significant.

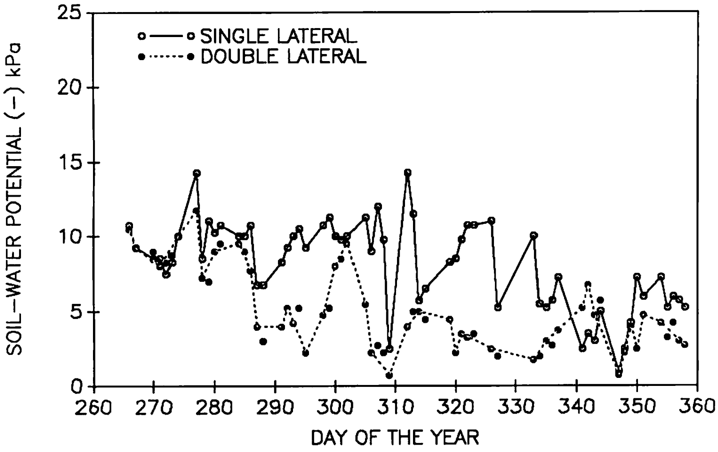

Fig. 4. Comparison of the average SWP at the 15 cm depth for treatments with single and double laterals per bed.

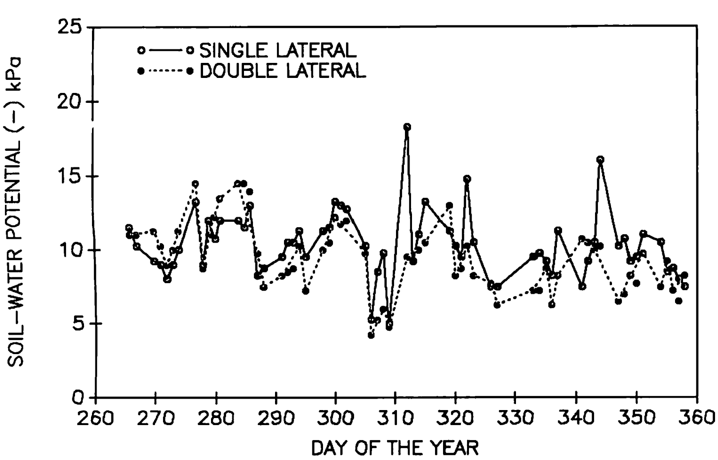

Fig. 5. Comparison of the average SWP at the 30 cm depth for treatments with single and double laterals per bed.

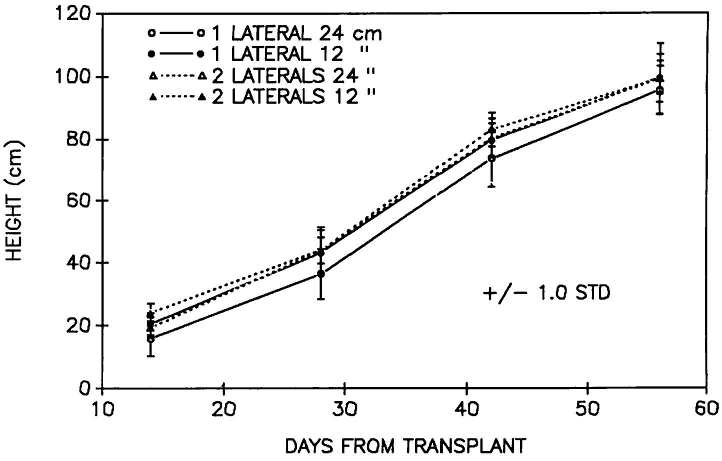

Fig. 6. Average plant height for each treatment.

The physical and biological processes producing these results are uncertain. It is possible, however, that the close spacing of the lateral tubing created a root-bound situation similar to that which can occur with a potted plant. Under those conditions the root tips and hairs (the most active part of the root system) typically have reduced function [2]. Conversely, wide spacing of the lateral tubing may have encouraged greater root distribution and thus better enabled the plant to extract nutrients and water. However, plant growth data does not support this hypothesis. Another hypothesis that can be supported by the tensiometer data was that by placing the lateral tubing closer to the plant row a very wet soil environment was created at the base of the plant. This wetter environment may not support optimum plant fruit development. Further investigation is needed to explain this anomaly.

Results of the experiment indicated that the use of 2 lateral tubes per bed to improve moisture distribution did not increase the yield of staked tomatoes grown with micro irrigation. However, using 2 lateral tubes per bed would significantly increase the cost of production. In addition, the placement of the lateral tubing approximately 24 cm from the plant row resulted in a significantly greater yield and larger fruit than placing the lateral at 12 cm from the

Table 2. Summary of tomato yield by size.

	(t/ha)^{zy}			
Treatment	(7 x 6)	(6 x 6)	(5 x 6)	Total
Lateral placement				
(24 cm)	6.7	14.6	31.9	53.2
(12 cm)	7.2	14.0	23.4	44.6
Significance	ns	ns	**	**
Lateral number				
1	6.4	14.0	28.5	48.9
2	7.5	14.6	26.8	48.9
Significance	ns	ns	ns	ns

[z] Based on 5480 m of plant row per ha.
[y] Culls and colors removed.

Table 3. Analysis of variance for tomato yield.

Source of Variation	F-ratio	Significance level
Lateral distance	10.284	0.0044
Number of tubes	0.001	0.9729

plant row. It must be emphasized that these are initial results. The experiment will be repeated with additional observations to substantiate these findings.

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DRIP IRRIGATED TOMATO AS AFFECTED BY WATER QUANTITY AND N AND K APPLICATION TIMING

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Abstract. **Polyethylene-mulched tomatoes (*Lycopersicon esculentum* Mill.) were grown with drip irrigation to evaluate the effects of water quantity, and time of N+K application on fruit production. Water quantities applied were 0, 0.17, 0.34, and 0.50 times pan evaporation. The N+K applications were 100% preplant or 40% preplant with 60% applied by drip irrigation in daily or weekly applications. Rainfall was low during the season and irrigation increased the fruit yield of extra large, large, and total marketable fruit by 76, 44, and 40%, respectively. Total marketable yields increased linearly from 2,300 cartons to 2,516 cartons/acre with an increase in water applied from 0.17 to 0.50 times pan. Extra large, large, and total marketable fruit yields were higher while yields of medium-size fruit were lower with N+K applied with drip than all applied preplant. Fruit yields were similar with daily or weekly N+K applications. Leaf tissue N and K concentrations at early harvest with all preplant applied N and K were lowest with 0.17 pan water quantity and similar with 0.34 and 0.50 pan. Water quantity had less effect on leaf N and K with drip applied N and K treatments.**

Grower use of drip irrigation for tomato production in Florida has frequently been unsatisfactory due to improper use of the system. With the application of water under the mulch and a lack of precise knowledge of tomato water requirements with drip irrigation, overwatering of the crop has often resulted in leaching of N+K and lower yields. With proper use of drip irrigation for tomato, the water used was reduced substantially over that with sprinkle irrigation with the production of similar yields (6) or higher yields (2). In recent studies on coarse textured soils, tomato yields were increased with a decrease in the amount of water applied from 1.0 times pan evaporation to 0.5 pan (5). In lysimeter studies, as much as 34% of the crop water needs was supplied from the water table (7).

Soluble nutrients move with the irrigation water (1, 5) and yields were higher with nutrients applied with drip irrigation than with all nutrients applied preplant (5). Information was not found regarding the frequency of drip applied nutrients for tomato. Since water quantity influences nutrient management, a reduction in water application below 0.5 pan may result in increased fruit production. The study reported here was conducted to evaluate the effects of water quantity and timing of N and K application on tomato production.

Materials and Methods

Tomatoes were grown during the spring of 1988 on an Arrendondo fine sand at the Horticultural Unit near Gainesville. Treatments were factorial combinations of 3 water quantities 0.17, 0.34, and 0.50 times pan evaporation applied by drip irrigation and 3 fertilizer application schedules, all preplant and part of the N and K applied with the drip irrigation in daily and weekly applications. In addition to these 9 treatments, a no irrigation control treatment was included in the study. The preplant soil pH was 6.2 and the soil tested 176 ppm for P and 56 ppm for K (Mehlich-I extraction). Beds spaced 6 feet apart were formed, plots were 30 feet long, and treatments were replicated 4 times. Fertilizer was applied at 200-50-240-40 lb./acre N-P-K-micronutrient mix. For the preplant treatments, all of the fertilizer was applied broadcast and mixed into the bed. For the split-fertilizer treatment, 40% of the N and K and all of the P and micronutrients were applied broadcast and mixed into the bed. The 60% drip-applied

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