often did not reduce populations below levels found in unfumigated control plots.

MS/DD, MS/DD/C, and MS all achieved significant control of root diseases as indicated by browning indices, but MS was most similar to the methyl bromide-chloropicrin mixtures in obtaining maximum disease reductions. Results with metam-sodium were similar.

Some weed control was achieved in Test 1, with MB/C being most effective and MS/DD/C and metam-sodium similar in their activity. Generally, however, weed control was erratic in these tests and so it is difficult to generalize about weed control with the broad-spectrum fumigants studied. Metam-sodium, formulated as Busan or Vapam, actually enhanced yellow nutsedge populations in Test 3.

MS/DD, MS/DD/C, and MS are as effective as methyl bromide-chloropicrin mixtures on sandy soils in Florida (11), and their results on Rockdale soils are also encouraging. Some of the alternative fumigants performed nearly as well as methyl bromide-chloropicrin mixtures in most instances, and it is possible that future research and trials will further reveal their efficacy. Refinement of application technique and registration by the Environmental Protection Agency of several of the products tested could provide growers with alternative nematicides and fungicides to be integrated into crop management systems for commercial tomato production along with genetic and cultural methods for managing pest populations.

Literature Cited

1. Averre, C. W., III. 1966. Isolating *Pythium* and *Fusarium* from a limestone soil in subtropical Florida. Proc. Soil Crop Sci. Soc. Fla. 26:279-285.
2. Gallatin, M. H., J. K. Ballard, C. B. Evans, H. S. Galberry, J. J. Hinton, D. P. Powell, E. Truett, W. L. Watts, G. C. Wilson, Jr., and R. G. Leighty. 1958. Soil Survey (detailed-reconnaissance) of Dade County, Florida. U.S. Government Printing Office, Washington.
3. Helwig, J. G. and K. A. Council. 1979. SAS User's Guide, 1979 edition. SAS Institute Inc., Cary, NC.
4. Horsfall, J. G., and R. W. Barratt. 1945. An improved grading system for measuring plant diseases. Phytopathology 35:655-(abstr.).
5. Jaworski, C. A., S. C. Phatak, S. M. McCarter, A. W. Johnson, and N. C. Glaze. 1980. Evaluation of fall treatment with broad spectrum chemicals and nematicides for production of pepper, tomato, and cabbage transplants in southern Georgia. J. Amer. Soc. Hort. Sci. 105:756-759.
6. Jenkins, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Rptr. 48:692.
7. Kerr, A. 1962. The root rot *Fusarium* wilt complex of peas. Austral. J. Biol. Sci. 16:66-69.
8. McSorley, R. and J. L. Parrado. 1981. Effect of sieve size on nematode extraction efficiency. Nematropica 11:165-174.
9. Overman, A. J. and J. P. Jones, 1968. Effect of polyethylene mulch on yields of tomatoes infested with root-knot nematodes. Proc. Soil Crop Sci. Soc. Fla. 28:258-262.
10. Overman, A. J. and J. P. Jones. 1977. Efficacy of one stream versus three of a soil fumigant for production of tomato. Proc. Fla. State hort. Soc. 90:407-409.
11. Overman, A. J. and J. P. Jones. 1985. Soil fumigants for control of nematodes, fusarium wilt, and fusarium crown rot on tomato. Proc. Fla. State Hort. Soc. 97:194-197.
12. Overman, A. J., J. P. Jones, and C. M. Geraldson. 1965. Reaction of nematodes, diseases and fertility to tomato production on old land. Proc. Fla. State Hort. Soc. 78:136-142.
13. Overman, A. J., J. P. Jones, and C. M. Geraldson. 1970. Interaction of cultivars, nematodes, and fumigants on development of *Verticillium* wilt on tomatoes. Proc. Fla. State Hort. Soc. 83:203-208.
14. Overman, and F. G. Martin. 1978. A survey of soil and crop management practices in the Florida tomato industry. Proc. Fla. State Hort. Soc. 91:294-297.
15. Pohronezny, K. and R. McSorley. 1981. *Meloidogyne*-fungal complexes in tomato roots in calcareous soils. Nematol. Medit. 9:151-157.
16. Rebois, R. V., B. J. Eldridge, J. M. Good, and A. K. Stoner. 1973. Tomato resistance and susceptibility to the reniform nematode. Plant Dis. Rptr. 57:169-172.
17. Taylor, A. L. and J. N. Sasser. 1978. Biology, identification and control of root-knot nematodes (*Meloidogyne* species). North Carolina State University Graphics, Raleigh.

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WATER AND FERTILIZER TIMING FOR TRICKLE-IRRIGATED TOMATOES

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Abstract. **Tomatoes (*Lycopersicon esculentum* Mill.) were grown in Gainesville on an Arrendondo fine sand, in Quincy on an Orangeburg loamy fine sand, and in Bradenton on an Eau Gallie fine sand to evaluate the effects of water quantity and timing of water and fertilizer application with trickle irrigation on fruit production. 'Sunny' tomatoes were grown on mulched beds with water quantities of 0.25, 0.5, and 1.0 pan applied in 1 or 3 applications/day. Fertilizers, applied at 200-100-300, 206-50-300, and 238-48-382 lb./acre N-P-K on the 3 soil sites, respectively, were applied 100% preplant or 40% N and K and 100% P applied preplant with 60% N and K applied with the trickle irrigation water. On the sandy soils at Gainesville and Bradenton, tomato fruit yields were greater with 0.5 than 0.25 or 1.0 pan water quantity. The number of daily water applications had no effect on total yield. Yields were greater with preplant than split fertilizer application. On the loamy soil at Quincy, fruit production was greater with the 1.0 than 0.5 pan water application with little difference in yield due to water application and fertilizer application timing. Tomato leaf N and K concentrations were generally lower with the 1.0 than 0.5 pan water quantity.**

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Irrigation is necessary for successful tomato production in Florida. Overhead and seepage irrigation are the 2 most commonly used methods. Water shortages have increased grower interest in trickle irrigation. Tomato yields similar to those produced with overhead irrigation have been produced with trickle irrigation with one-half as much water (2,3). Since nutrient leach can occur with trickle irrigation (1), tomatoes generally respond to the application of nutrients with the irrigation water. In greenhouse studies with tomatoes, nutrient leaching increased with water quantity (4). With the rapid infiltration and low water holding capacity of sandy soils, it is possible that a number of smaller water applications may be better than a single large application.

These studies were conducted to evaluate the influences of water quantity, and time of water and fertilizer application on tomato production in 3 Florida locations.

Materials and Methods

Experiments were conducted during the spring and fall of 1984 at Quincy, Gainesville, and Bradenton, FL. Treatments were factorial combinations of a) water quantities, 0.5 and 1.0 times pan evaporation at Quincy and Gainesville and 0.25 and 0.5 pan at Bradenton; b) 2 water application frequencies, 1 and 3 times/day; and c) 2 fertilizer application times, fertilizer applied preplant and 40% of N and K and 100% of P and micronutrient applied preplant with 60% of N and K applied with trickle irrigation. Studies were conducted on an Orangeburg fine loamy sand at Quincy, an Arrendondo fine sand at Gainesville, and an Eau Gallie fine sand at Bradenton. Preplant soil pH values ranged from 6.2 to 6.7 and the soils tested medium to high for P and medium for K. Treatments were applied on 6-ft by 36-ft plots and were replicated 4 times. Fertilizer was applied at 206-50-300-40 lb./acre N-P-K-micronutrient mix at Quincy, 200-100-300-40 lb./acre at Gainesville and 230-48-382-20 lb./acre at Bradenton. For the all preplant fertilizer treatment, on the Eau Gallie soil, P, micronutrients, and 40% of the N and K were applied broadcast in the beds and 60% of the N and K was applied in a band 8 inches to one side of the bed center and 4 inches deep. On the other 2 soils, all of the fertilizer was applied broadcast in the bed. For the split-fertilizer treatment in all tests, 40% of the N and K and 100% of the P and micronutrients were applied broadcast in the bed. Nutrient sources were potassium nitrate, ammonium nitrate, concentrated superphosphate and FN 503 (Frit Industries, Ozark, Ala.) or Micromate 2424 (Stoller Chemical Co. Inc., Gericho, S.C.) micronutrient mix. Biwall (10 mil) trickle irrigation hose (James Hardie Irrigation, El Cajon, Calif.) was placed 2 inches to one side of the row center, beds were fumigated with 225 lb./acre 67% methylbromide 33% chloropicrin mix, and 0.0015-inch black polyethylene mulch was applied. 'Sunny' tomatoes were transplanted 5 to 50 days later on 26 Mar. at Quincy, 28 Mar. at Gainesville and 6 Sept. at Bradenton. Plants were spaced 1.5 to 2 ft apart and staked. Irrigation was applied daily through emitters spaced 12 inches apart that delivered 0.5 gal/hr. Irrigation water amounts were calculated based on the total plot size as 0.25, 0.50, or 1.0 times evaporation from a U.S. Weather Service Class A pan at each location and applied in the bed area. Trickle applied N and K were injected into the water weekly at 2, 4, 6, 8, 12.5, 12.5, 12.5, 12.5, 7.5, 7.5, 7.5, and 7.5% of the total in 12 consecutive weeks. The all preplant fertilizer treatments received only water.

Recently matured leaves were sampled for N and K analyses. Total N was determined by the micro-Kjeldahl method and K by flame emission spectroscopy. Mature green, pink, and ripe fruit were harvested weekly and graded into marketable and unmarketable fruit. At Quincy, harvests were made on 19 June, 27 June (early yield), and 7 July. At Gainesville, harvest dates were 14 June, 21 June (early), 28 June, and 5 July. Harvests were made at Bradenton on 5, 14, and 19 Dec. Soil samples were taken at Gainesville on 13 June from the bed center at 0 to 4 inches, 8 to 12 inches and 12 to 16 inches. Soils were dried at 100°C for moisture determination and NO_3-N was determined with a specific ion electrode.

Results and Discussions

Early fruit yields were not influenced by water quantity at Quincy and Gainesville (Table 1). Total yields, however, were significantly influenced by water quantity at the 3 locations. On the heavier soil at Quincy, water requirements were higher than on the sandy soil at Quincy, water requirements were higher than on the sandy soil and total yield increased 11% with an increase in water quantity from 0.5 to 1.0 pan. At Gainesville, total yield decreased 5% with an increase in water quantity from 0.5 to 1.0 pan and at Bradenton, yield was 11% greater with 0.5 than 0.25 pan. In greenhouse studies (4), maximum tomato fruit production was obtained with water quantities of 0.5 to 1.0 pan (calculated on a total plot area or 1.0 to 2.0 pan calculated in the row). Fruit yields were significantly lower with 0.25 pan than 0.5 pan when 2 trickle lines supplied the water. Apparently, a greater amount of water in a localized area results in better fruit production than putting the same amount of water in 2 bed locations.

The frequency of water application, either 1 or 3 applications/day, had no influence on total fruit yield at the 3

Table 1. Main effects of water quantities and timing of water and fertilizer application on tomato fruit production. 1984.

	Marketable yield (25-lb.-crates/acre)				
	Quincy		Gainesville		Bradenton
Treatment	Early	Total	Early	Total	Total
Water quantity (pan)					
0.25	–	–	–	–	1352
0.5	628	2228	377	2130	1506
1.0	693	2475	410	2023	–
F value[z]	NS	*	NS	X	X
Water frequency (no./day)					
1	669	2383	458	2119	1438
3	653	2320	328	2033	1420
F value	NS	NS	*	NS	NS
Fertilizer time applied					
Preplant	682	2300	432	2149	1569
Split	640	2403	354	2003	1289
F value	NS	NS	NS	*	*

[z]F values were significant at the 5% (*) or 12% (X) levels or not significant (NS).

Table 2. Main effects of water quantity, and timing of water and fertilizer application on tomato leaf N and K concentrations at Quincy and Gainesville. 1984.

	Leaf concentration (% dry wt)							
	Quincy				Gainesville			
	16 May		10 June		17 May		28 June	
Treatment	N	K	N	K	N	K	N	K
Water quantity (pan)								
0.5	5.76	3.76	3.47	2.79	4.63	1.95	4.14	1.18
1.0	5.62	4.08	3.14	2.74	4.17	1.73	3.39	1.70
F value[z]	NS	X	**	NS	***	X	***	X
Water frequency (No./day)								
1	5.65	3.79	3.24	2.72	4.38	1.90	3.86	1.88
3	5.73	4.04	3.38	2.80	4.42	1.78	3.66	1.71
F value	NS	NS	NS	NS	NS	NS	*	X
Fertilizer time applied								
Preplant	5.52	3.82	3.30	2.74	4.51	1.88	3.79	1.86
Split	5.86	4.01	3.31	2.79	4.29	1.81	3.74	1.73
F value	*	NS	NS	NS	*	NS	NS	NS

[z]F values were significant at the 0.1% (***), 1% (**), 5% (*), and 10% (X) levels or not significant (NS).

Table 3. Main effects of water quantity on soil moisture and soil nitrate-N concentrations at the end of harvest period. Gainesville. 1984.

Water	Soil moisture (%)			Nitrate-N (ppm)		
quantity	Soil depth (inches)					
(pan)	0-4	4-8	8-12	0-4	4-8	8-12
0.5	5.51	6.49	7.43	21	8	13
1.0	8.37	9.13	9.56	7	19	23
F value[z]	***	***	***	*	NS	NS

[z]F values were significant at the 0.1% (***) level, the 5% (*) level or not significant (NS).

locations (Table 1). Early marketable fruit yield, however, was 40% greater with 1 than 3 water applications/day at the Gainesville site. Apparently the water quantity applied had a greater influence on fruit production than the number of daily applications (1 or 3).

Fertilizer application timing had no influence on total yield at the Quincy site but effects were significant at the other 2 sites (Table 1). Total fruit yields were significantly greater at Gainesville and Bradenton with 100% of the N and K applied preplant. Yields were 7% lower at Gainesville and 22% lower at Bradenton with the application of the 60% of the N and K with trickle irrigation. This response is in contrast to previous studies where yields were greater with the split than all preplant N and K treatments with tomato (2,3) and strawberry (5). Differences in soil types and prefertilization fertility apparently determine the yield response to N and K application timing.

Tomato leaf samples were taken at early fruit development (16 and 17 May) and at the end of the fruit season (10 July and 28 June) at Quincy and Gainesville, respectively (Table 2). Leaf N and K concentrations were higher at Quincy than at Gainesville at both sample dates. Tissue N and K concentrations were influenced greater by water quantity than frequency of water application or time of N and K application. Concentrations of N and K were generally higher with 0.5 than 1.0 pan water quantity. Since soluble nutrients move with the wetting front (1), the larger amount of water probably moved some N and K out of the root zone and resulted in reduced nutrient uptake. Water application frequency had no effect on leaf N and K concentration at the earlier sampling at either location. At the later sampling, significant effects were obtained only at Gainesville where N and K concentrations were slightly higher with 1 than 3 water applications/day.

Application time of N and K significantly influenced the N concentrations of leaf samples taken only at early fruit development (Table 2). The leaf concentration values with all preplant and split fertilization with trickle irrigation were 5.52% and 5.86% at Quincy, and 4.51% and 4.29% at Gainesville, respectively. The K concentration at both samplings, and N at the end of harvest, were not influenced by fertilizer timing. All N and K concentrations were well above the critical concentration for tomatoes (6).

Soil moisture concentrations were significantly higher with 1.0 than 0.5 pan water at 0 to 4, 4 to 8 and 8 to 12 inch depths at the end of the fruiting season at Gainesville (Table 3). Nitrate N concentrations, however, were significantly greater at the 0 to 4 inch depth with 0.5 than 1.0 pan water. At the lower soil depths, NO_3-N concentrations were not influenced by water quality.

These studies indicated that the water requirement of tomatoes growing on a loamy sand and fine sandy soil is between 0.5 and 1.0 pan (between 1.0 and 2.0 pan in the irrigated bed area that is about 50% of the total area). The higher water quantity may result in lower tissue N and K leaf concentrations and reduce yield if these nutrients are below their critical levels. The frequency of water application during a day (1 or 3 times) had no effect on total marketable yield at the 3 locations. More studies are needed to establish the optimum time of fertilizer application. In this study, total fruit yields at 2 locations were significantly higher with all preplant fertilization than with split applied N and K. This finding is in contrast to previous studies and indicates that more information is needed on preplant soil fertility concentrations to determine the best method of fertilizer application with trickle irrigated tomatoes.

Literature Cited

1. Bar-Yosef, B. 1977. Trickle irrigation and fertilization of tomatoes in sand dunes. Water, N and P distribution in the soil and uptake by plants. Agron. J. 69:486-491.
2. Locascio, S. J. and J. M. Myers. 1974. Tomato response to plug mix, mulch and irrigation method. Proc. Fla. State Hort. Soc. 87:126-130.
3. Locascio, S. J., J. M. Myers, and J. G. A. Fiskell. 1982. Nitrogen application timing and source for drip irrigated tomatoes, p. 323-328. *In* A. Scaife, (ed.) Proc. Ninth Inter. Plant Nutrition Colloquium. Warwick University, England.
4. Locascio, S. J., J. M. Myers, and S. R. Kostewicz. 1981. Quantity and rate of water application for drip irrigated tomatoes. Proc. Fla. State Hort. Soc. 94:163-166.
5. Locascio, S. J., J. M. Myers, and F. G. Martin. 1977. Frequency and rate of fertilization with trickle irrigation for strawberries. J. Amer. Soc. Hort. Sci. 102:(4)456-458.
6. Tanaka, A., K. Fugita, and K. Kikuchi. 1974. Nutrio-physiological studies on the tomato plant. I. Out-line of growth and nutrient absorption. Soil Sci. Plant Nutr. 20:57-58.