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FIELD EVALUATIONS OF NITROGEN FERTILIZATION PROGRAMS FOR SUBSURFACE-IRRIGATED TOMATOES[1]

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Abstract. **Three studies were conducted to evaluate tomato (*Lycopersicon esculentum* Mill.) response to N rates at 2 locations in southern Florida. Tomato fruit yields were statistically similar with N rate from 160 to 402 lb. N/acre. Results showed that current IFAS recommendations for N of 160 lb./acre are correct. Commercial growers could reduce N rates considerably without sacrificing yields or fruit size. Adequate N concentrations in most-recently-matured tomato leaves of optimally growing plants were about 4.0 to 4.5% at first flower, 3.5 to 4.0% at first fruit set, and about 3.0% just before first harvest.**

The fresh-market tomato crop is the most important vegetable crop in Florida. In 1987-1988, 57,000 acres were grown with a value of $535 million at the farm gate level (1); however, this value rose to $600 million for the 1988-89 crop (8). Tomatoes are produced in large quantities in several counties in southern Florida including Palm Beach, Dade, Collier, Manatee, and Hillsborough. In these regions, (except for Dade county) most tomato crops are produced using subsurface irrigation. Traditionally, large amounts of fertilizers are used in commercial tomato culture (6). Commercial applications of fertilizers are often 2 to 3 times greater than those recommended by IFAS.

Research on N rates for tomato has been conducted for at least 40 years. Results of this research have been variable depending on production practices used. In general, tomato yields did not increase when N rates were raised above 200 lb./acre (2,3,12). In some studies, yield did not increase above about 150 lb./acre (4,6,12). In one experiment, yields decreased as N rate was increased above 225 lb./acre (5).

Based on previous research with N on tomatoes, the Crop Nutrient Requirement value for N for tomatoes was set at 160 lb./acre (10). The objectives of these studies were to field-test in different locations and different seasons the current IFAS standardized N recommendations for tomato, and to demonstrate the results of reducing N rates on tomato fruit production on commercial tomato farms in southern Florida.

Materials and Methods

Three experiments were conducted in Palm Beach and Manatee counties during the 1988-89 production season to evaluate tomato response to rates of N and K. All crops were grown on commercial tomato farms using polyethylene mulch and stake culture with subsurface irrigation. The cultivar Sunny was used at each location.

Details for each experiment are presented in Table 1. The commercial grower-cooperator prepared the beds, applied the in-bed starter fertilizer (Table 1), fumigated the soil, and applied mulch. Results of pre-plant Mehlich-I soil tests are presented in Table 2. Experimental fertilizer treatments were established by varying the rates of N and K in the shoulder-placed bands (Table 3). Fertilizer sources were ammonium nitrate, potassium nitrate, calcium nitrate, and potassium sulfate. Mulch was removed, fertilizer treatments applied, and then the mulch was replaced and the plots planted with tomato transplants.

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TABLE 1. Production information for three tomato fertilizer studies in southern Florida.

	Experiment (county)		
	(1) Manatee	(2) Palm Beach	(3) Manatee
Season	Fall 1988	Winter 1988-89	Spring 1989
City	Myakka City	Boynton Beach	Myakka City
Soil type	Myakka fine sand	Olsmar sand	Myakka fine sand
Soil order[z]	Spodosol	Spodosol	Spodosol
Expt design	RCBD[y]	RCBD	RCBD
Replicates	4	3	4
Plot size (ft)	13×24	5.5×23.8	13×24
LBF/acre[x]	3350	7920	3350
No. plants/plot	12	12	12
Plant spacing (inches)	24	22	24
Planting date	15 Aug.	15 Nov.	28 Feb.
Leaf sample dates (1)	21 Sept.	12 Dec.	4 Apr.
(2)	6 Oct.	4 Jan.	4 May
(3)	20 Oct.	26 Jan.	29 June
Harvest dates (1)	26 Oct.	10 Feb.	12 May
(2)	15 Nov.	17 Feb.	1 June
(3)	5 Dec.	1 Mar.	
(4)	—	14 Mar.	
Starter fertilizer analysis N-P-K (lb./acre)[w]	20-78-34	30-47-50	40-156-68

[z]Myakka fine sand is a sandy, siliceous, hyperthermic, Arenic haplaquods and Oldsmar sand is a sandy, siliceous, hyperthermic, alfic, Arenic haplaquods.
[y]Randomized complete-block design.
[x]No. of linear bed ft (LBF) of crop in 43,560 sq. ft.
[w]Based on 6-ft crop row with 7260 LBF/acre (43,560) sq. ft) except Palm Beach which was based on 5.5 ft crop row.

Tomato-leaf samples were collected during the season (Table 1) for mineral analyses. Samples consisted of most-recently-matured whole leaves (about fifth leaf from tip). Leaves were analyzed for N by micro-Kjeldahl procedures and for K by atomic absorption spectrometry following dry ashing. Sampling dates listed in Table 1 corresponded to first flowering (1), first fruit set (2), and first harvest (3), respectively.

Water table height was measured by a water stage recorder placed in the center of the experimental area. Distance from the top of the bed to the water table was monitored continually throughout the season. Tomato fruits were harvested at mature-green stage 3, 4, and 2 times in fall, winter, and spring crops, respectively (Table 1). Fruits were graded according to grade standards of 5×6, 6×6, 6×7, and cull (10). Minimum and maximum diameters in inches for these grades are: 5×6 (minimum of 2 24/32), 6×6 (minimum of 2 16/32 and maximum of 2 26/32), and 6×7 (minimum of 2 8/32 and maximum of 2 18/32.

Data were subjected to analysis of variance and regression analysis.

TABLE 3. Fertilizer treatments used in tomato studies in southern Florida.

	Manatee (fall)[z]		Palm Beach (winter)[y]		Manatee (spring)[z]	
Treatment	N	K	N	K	N	K
	lb./acre					
1	160	66.5	160	66.5	180	100
2	160	133	160	133	180	166
3	160	199	160	199	180	232
4	220	66.5	220	66.5	240	100
5	220	133	220	133	240	166
6	220	199	220	199	240	232
7	280	66.5	280	66.5	300	100
8	280	133	280	133	300	166
9	280	199	280	199	300	232
10 (grower)	366	440	336	560	402	518

[z]Fertilizer rates expressed on 6 ft crop row with 7260 LBF/acre (43,560 sq. ft) and includes starter fertilizer.
[y]Fertilizer rates expressed on 5.5 ft crop row with 7920 LBF/acre (43,560 sq. ft) and includes starter fertilizer.

Results and Discussion

No N×K rate interactions were present; therefore, only the N main effects are presented in this paper. Effects of K were presented elsewhere (11).

Yield. Tomato early or total season yields were not affected by N rates at any location (Tables 4,5,6). Yields averaged 739 ctn./acre based on 3350 LBF of crop/acre. Yields were better than the state average of 1330 ctn./acre which are based on an acre of 7260 LBF of crop.

The fall crop yields were lower than those for the winter and spring, probably due to reduced fruit set and size resulting from high temperature. Yields from the plots with the grower rate of fertilizer were not significantly different from those with the lowest N rate (Table 4). Large fruits (5×6) averaged only 16% of the total marketable yield in this fall crop.

Nitrogen rate did not have a significant effect on yield of tomatoes in the winter crop in Palm Beach County (Table 5). Higher yields were obtained in this test compared to the fall crop in Manatee County. Yields from plots at this location that received the grower N rate were not significantly different from the lowest N rate. Large fruits (5×6) made up 20% of the total marketable fruits while the combined 5×6 and 6×6 grades made up 66% of the total.

In the Manatee County spring test, high yields were obtained with only 2 harvests (Table 6). Large fruit (5×6) made up 61% of the total marketable yield, while the combination of 5×6 and 6×6 fruit made up 90% of the total. Yields with the grower fertilizer rate were not significantly different from those with lowest N rate.

TABLE 2. Pre-fertilization Mehlich-I soil-test indices for tomato fertilizer studies in southern Florida, 1988-89.

			Index (Mehlich-I) (ppm)						
Location	Season	Soil pH (1:2 S:W)	P	K	Ca	Mg	Zn	Cu	Mn
Manatee	Fall, 1988	7.6	150 VH[z]	14VL	1382	220	17	14	14
Palm Beach	Winter, 88-89	7.7	300 VH	16VL	1242	74	12	14	15
Manatee	Spring, 1989	7.1	62 VH	26VL	1044	140	9	5	5

[z]Mehlich-I interpretations are very low (VL), low (L), and very high (VH), respectively.

TABLE 4. Effects of nitrogen rates on yields of tomatoes, Manatee County, fall, 1988.

N rate[y] lb./acre	Yield (25-lb. ctn./acre)[y] Fruit grade 5x6	6x6	6x7	Culls 7x7	Culls Other	Tot. mkt.
	Early (first harvest)					
160	55	23	7	1	9	85
220	44	24	6	1	8	74
280	48	24	7	1	8	79
F-test (P = .05)	NS[z]	NS	NS	NS	NS	NS
Grower (366)	30	22	6	0	3	58
	Total season					
160	137	266	349	38	102	752
220	117	259	322	40	90	698
280	111	281	374	39	94	766
F-test (P = .05)	NS	NS	NS	NS	NS	NS
Grower (366)	84	244	310	30	68	637

[z]Effects of N rate were nonsignificant (NS).
[y]Rates of N calculated on 6 ft crop row basis of 7260 LBF of crop per 43560 sq. ft. Yields expressed on basis of 3350 LBF of crop per 43560 sq. ft.

Based on yield responses to N rate, it appears that current IFAS recommendations for N are correct. Higher N rates, up to 402 lb./acre (grower rate) did not result in better fruit size or higher total yields. Yields across all tests were similar with 160 to 402 lb. N/acre.

Leaf-N concentrations. Tomato leaf-N concentrations were rarely affected by N rate (Table 7). Although significant responses were found in the fall for the last 2 sample dates, all N concentrations were well within the adequate N concentration range for most-recently-matured leaves (7). In Palm Beach County, leaf-N concentration was slightly lower than that for Manatee County, fall, 1988, but within the adequate range all season. In Manatee County, spring, 1989, leaf-N fell from about 4.0% early in the season to slightly less than 3.0% near harvest, then below 3.0% at the end of the harvest season.

TABLE 5. Effects of nitrogen rates on yields of tomatoes, Palm Beach County, winter, 1988-89.

N rate[y] lb./acre	Yield (15-lb. ctn./acre)[y] Fruit grade 5x6	6x6	6x7	Cull	Tot. mkt.
	Early (first harvest)				
160	211	436	40	36	687
220	182	404	38	33	624
280	196	406	38	36	640
F-test (P = .05)	NS[z]	NS	NS	NS	NS
Grower (336)	171	365	30	35	566
	Total season				
160	385	1252	285	167	1922
220	354	1128	248	181	1730
280	376	1113	178	175	1668
F-test (P = .05)	NS	NS	NS	NS	NS
Grower (336)	393	1562	358	186	2313

[z]Effects of N rate were nonsignificant (NS).
[y]Rates of N calculated on basis of 7920 LBF of crop per 43560 sq. ft. Yields expressed on basis of 7920 LBF of crop per 43560 sq. ft.

TABLE 6. Effects of nitrogen rates on yields of tomatoes, Manatee County, spring, 1989.

N rate[y] lb./acre	Yield (25-lb. ctn./acre)[y] Fruit grade 5x6	6x6	6x7	Culls 7x7	Culls Other	Tot. mkt.
	Early (first harvest)					
180	442	258	107	17	49	807
240	459	275	103	17	50	837
300	457	274	113	22	53	843
F-test (P = .05)	NS[z]	NS	NS	NS	NS	NS
Grower (402)	414	288	118	22	66	821
	Total season					
180	795	378	135	21	74	1308
240	824	367	133	21	72	1325
300	771	373	138	27	76	1282
F-test (P = .05)	NS	NS	NS	NS	NS	NS
Grower (402)	785	401	145	26	98	1332

[z]Effects of N rate were nonsignificant (NS).
[y]Rates of N calculated on 6 ft crop row basis of 7260 LBF of crop per 43560 sq. ft. Yields expressed on basis of 3350 LBF of crop per 43560 sq. ft.

Results of leaf-N analyses indicate that adequate leaf-N concentrations are about 4.0 to 4.5% at first flower, 3.5 to 4.0% at first fruit, and 3.0% just before first harvest. High yields, absence of visual N deficiency, symptoms, and large fruit size in the Manatee, spring, 1989 test provide the most convincing support for this conclusion.

Water table levels. The water table height at the Manatee, fall 1988 location ranged from 11 inches to 27 inches below the bed surface. In general, the water table level was maintained between 14 and 18 inches below the bed surface, except for a lowering of the water table toward the end of the season. Although the water table was allowed to rise to

TABLE 7. Effects of nitrogen rates on leaf-N concentrations.

N rate (lb./acre)	Leaf-N conc. (%) Sample date 1	2	3
	Manatee, fall, 1988		
160	5.7	4.2	4.1
220	5.8	4.3	4.8
280	5.5	4.7	5.0
F-test (P = .05)[z]	NS	L*	L**
Grower	5.7	4.6	4.8
	Palm Beach, winter, 1988-89		
160	4.5	4.0	3.8
220	4.5	4.1	3.7
280	4.6	4.3	3.7
F-test (P = .05)[z]	NS	NS	NS
Grower	4.6	4.5	4.1
	Manatee, spring, 1989		
180	3.8	2.9	2.9
240	3.9	3.2	2.7
300	3.9	3.0	3.1
F-test (P = .05)[z]	NS	NS	NS
Grower	3.3	3.8	3.0

[z]Nitrogen rate effects were nonsignificant (NS) or linear (L) at the 5% (*) or 1% (**) level of probability.

only 11 inches below the bed surface on several occasions, little negative nutritional effects resulted because leaf-N concentration remained high.

In the Palm Beach study, the water table was maintained between 18 and 20 inches most of the season. The water table dropped to about 28 inches on 3 occasions and never rose above 14 inches below the bed surface.

At the Manatee, spring, 1989 location (same farm as fall, 1988), the water table was allowed to fluctuate greatly early in the season. Early in the season, during a drought period, the water table fluctuated between 14 and 36 inches and dropped below 30 inches on 4 occasions. Later in the season, the water table was maintained more uniformly between 15 and 18 inches below the bed surface.

Results of these studies show that current IFAS recommendations for N of 160 lb./acre are adequate for high yields of high quality fruits. These crop nutrient requirements were the same for crops in various seasons and locations. Results show that tomato growers could reduce N rates without sacrificing yield or fruit size. Similar results were obtained recently with pepper (9). Large-scale field demonstrations should be used to demonstrate results of small successive (10 to 20%) reductions in N rates to commercial tomato growers.

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RECOLONIZATION OF FUMIGATED TOMATO PRODUCTION SOIL IN DADE COUNTY BY *PYTHIUM* SPP.[1]

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Abstract. **Rockdale fine sandy loam soil in a field planted to tomato (*Lycopersicon esculentum* Mill.) in Dade County, FL was monitored at 20-day intervals over a 120-day season for the presence of *Pythium* spp. Points along transects across the bed were assayed with tomato-seedling baits and a medium selective for *Pythium* spp. *Pythium aphanidermatum* (Edson) Fitzp. and *P. ultimum* Trow accounted for up to 95% of all *Pythium* spp. recovered from fumigated or nonfumigated soil on a given sampling date. *Pythium oligandrum* Drechsler, *P. catenulatum* Matthews, and nonidentified species of *Pythium* were recovered less frequently. *Pythium aphanidermatum* was first recovered from fumigated soil on the interior edge of the bed 60 days after planting, and it was detected throughout the bed 80 days after planting. In contrast, *P. ultimum* was detected throughout the bed after 40 days, although it was never recovered as often as *P. aphanidermatum*. *Pythium aphanidermatum* and *P. ultimum* significantly reduced ($P < 0.05$) seedling emergence and caused post-emergence damping-off of 'Duke' tomato during pathogenicity tests in artificially infested potting mix. Treatment of soil in the field with metalaxyl prior to fumigation reduced recolonization of fumigated soil at some bed locations by both species of *Pythium*. Fruit yields were not increased by treatment with this fungicide.**

Tomato in Florida can be affected by soilborne factors which include nematodes, weeds, and pathogens. Within the last 25 years, fumigants such as methyl-bromide and chloropicrin have been used in conjunction with polyethylene mulches to reduce losses due to soilborne problems, such as "old-land" disease, fusarial wilt, and root-knot nematode in tomato-production areas throughout Florida (11).

That broad-spectrum fumigants reduce soilborne problems is widely recognized (10). The effectiveness of such

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