Prescription-Based Nitrogen Fertilization of Vine-Ripened Tomatoes

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STATEMENT OF RESEARCH PROBLEM

Production of vine-ripened tomatoes (*Lycopersicon esculentum*) is a significant source of income for many limited resource farmers in southern Arkansas. Due to the perishable nature of the commodity, gross revenue is highly sensitive to fruit yields, fruit quality, and markets immediately following harvest. Nitrogen fertilization management can have a significant impact on fruit yield, quality, and harvest cycles. Nitrogen management may include combinations of preplant N, scheduled drip-line N injections, and drip-line injections based on petiole sap NO_3-N monitoring. The primary objective of this research was to identify efficient N management strategies for optimal fruit yields and quality.

BACKGROUND INFORMATION

Nitrogen fertilization in black-plastic mulched, drip-irrigation production systems of vine-ripened tomato can involve N applied all preplant, all injected, or combinations of preplant and injected N. It is important to identify efficient N management programs that optimize yield and fruit quality and reduce or eliminate excessive N losses to the environment.

Total fruit yield, quality, size, weekly yields, and certain disease incidences have all been related to N fertility management in tomatoes (Motis et. al., 1998; Francis and Cooper, 1998; Lacasio et al., 1997; Cook and Sanders, 1991; Barker and Ready, 1989; and Maynard, 1979). Nitrogen management practices that maximize fertilizer recovery efficiency and optimize fruit yield and quality, all of which are related to N rates and timing, will maximize gross returns. This is especially critical given that commercial production of vine-ripened tomatoes is a significant source of income for many limited resource farmers in southern Arkansas.

The availability of inexpensive, hand-held NO_3-N meters has great potential for N management in tomatoes. Several researchers have noted the correlation of quick, in-field petiole NO_3-N sap tests with plant N status for crops such as potato (*Solanum tuberosum,* Zhang et. al., 1996), cauliflower (*Brassica oleracea* var. *Botrytis*, Kubota et al., 1996), broccoli (*Brassica oleracea* var. *Italica*, Kubota et. al., 1997) and tomato (Anderson et. al., 1999; Taber, 2001). This report is a summary of three years of N-management studies in tomatoes. The overall objective was to identify efficient N-management programs and evaluate the feasibility of in-field petiole sap NO_3-N monitoring.

PROCEDURES

Field studies were conducted on the Roger Pace farm near Monticello, AR, in the 2000, 2001, and 2002 growing seasons. Tomatoes (var. 'Mt. Spring') were grown on raised, black-plastic mulched, micro-irrigated beds 5 ft apart with plants spaced 21 inches apart. Each year, preplant applications of 45 lb P_2O_5/acre as 0-46-0 and 90 lb K_2O/acre as 0-0-60 were incorporated prior to mulching. In the 2000 growing season, a severe outbreak of Tomato Spotted Wilt Virus (TSWV) reduced stands by over 60%, resulting in a lost study. TSWV losses in the 2001 and 2002 season were less than 16%. Plots were composed of six plants, with fruit from the inside two plants harvested three times a week and graded to U.S. No. 1 XL, U.S. No. 1 L, U.S. No. 2, or unclassified. The experimental design during each year was a randomized complete block with four replications.

In 2001, N treatments were limited to drip-line injections of season totals of 0, 60, 120 , 180, and 240 lb

N/acre (mulched acre) applied once a week incrementally from either ammonium nitrate or urea. In addition, a ‘prescription’ treatment was also added, which involved weekly monitoring of undiluted petiole sap NO_3-N of the most recently matured leaf using a hand-held CardyÒ nitrate meter and injecting 20 lb N/acre as ammonium nitrate when measured sap NO_3-N was within ± 50 ppm of the lower threshold of published NO_3-N sufficiency ranges (Hochmuth et.al., 1991). Readings were taken at mid-morning and petiole sap was extracted using a garlic press. Drip-line injections were accomplished using a manifold system to apply 60 oz of solution to each plot, followed by 2 to 5 hrs of mainline irrigation.

In 2002, combinations of preplant and injected N treatments from ammonium nitrate were studied. Preplant plus injected treatments were 0, 60, and 120 lb N/acre pre-plant with either 0, 10, and 20 lb N injected on an ‘as needed’ basis from weekly petiole sap NO_3-N monitoring as described for the 2001 study. Injected treatments were limited to season totals of 120 or 180 lb N/acre from ten weekly incremental applications. In 2002, the cooperator had established a very good stand of Austrian winter pea (*Pisum sativum* subsp. *arvense*) legume cover crop that was incorporated into the soil 10 days prior to bedding.

RESULTS AND DISCUSSION

In 2001, season total-N rate applied with the prescription-N treatment equaled that of the scheduled-N treatment of 120 lb N/acre (Table 1). Single degree-of-freedom contrast tests in a general linear model did not detect any yield or petiole sap NO_3-N differences between N sources (analysis not shown). There were no significant differences in yields of U.S. No. 1 XL grade tomatoes for N treatments of 120 lb N/acre or higher. A single degree of contrast test in a general linear model did detect a significant difference (Prob >F 0.03) between the 0- and 60-lb N/acre treatments versus the 120 lb N/acre or higher treatments (analysis not shown). Therefore, the optimal level of N fertilization rate in 2001 was 120 lb N/acre applied in ten weekly, equivalent injections, or from injections of 20 lb N/acre when needed based on petiole sap NO_3-N monitoring. At the beginning of harvest, a clear relationship between applied N and petiole NO_3-N existed (Table 2). Petiole NO_3-N levels below 268 ppm at this stage were related to lower fruit yields.

There were no treatment effects on cumulative yield of U.S. No. 1 XL grade tomatoes at the end of the 2002 harvest (Table 3). The excellent winter legume cover crop no doubt increased soil levels of mineralized N as evidenced by petiole NO_3-N levels on 14 May of 530 ppm for the unfertilized control (0 lb N/acre treatment, Table 4). Petiole NO_3-N was related to total N applied (preplant + injected) through 4 June. However, on the 18 June sampling, petiole NO_3-N was related more to the cumulative amount of injected N (Table 5), indicating plant uptake and translocation of injected N into the sap flow. Recent studies have shown that tomato yields are more related to petiole sap NO_3-N concentrations from early- to mid-fruit than from late fruit set to harvest (Taber, 2001; Krusekopf et. al., 2002). The 14 May 2002 petiole NO_3-N measurements were taken during mid-fruit set growth, and all treatments were above or just below the minimum recommended threshold of 600 ppm (Tables 4 and 5). These results support using petiole sap NO_3-N monitoring during initial fruit set as an N-management tool.

PRACTICAL APPLICATIONS

Mid-morning readings from a quick in-field sap NO_3-N meter at early fruit set (about early to mid-May for southern Arkansas) of plasticulture micro-irrigated tomatoes can be used to determine if supplemental drip-line injections of N are needed. Nitrogen management can be accomplished using combinations of preplant and/or injected N applications by using the petiole sap NO_3-N test as a monitoring tool. Nitrogen application rates >120 lb total N/acre did not increase fruit yields of the Mt. Spring variety. Using petiole NO_3-N monitoring and drip-line N amendments gives the producer a mechanism for making adjustments of N fertilization that helps account for variations in native soil N, weather, disease pressure, and fruit loads.

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Table 1. Cumulative yields of U.S. No. 1 XL grade tomatoes during 2001 season.

Injected N rate	Nitrogen source[z]	Cumulative yield, by harvest time (day/month) 22 June	29 June	6 July	11 July
(lb/acre)		(lb/plant)			
0	---	1.13	2.13	2.24	2.56
60	AN	1.25	2.59	3.09	3.94
60	UR	1.44	3.03	3.86	4.61
120	AN	2.18	2.90	3.63	4.49
120	UR	1.35	2.48	4.01	5.31
120[y]	AN	2.00	2.93	4.26	5.66
180	AN	1.11	2.54	3.31	4.24
180	UR	1.72	2.69	4.69	5.85
240	AN	1.46	2.98	4.69	5.46
240	UR	1.91	3.06	4.27	5.19
$LSD_{.05}$		NS	NS	2.05	2.46

[z] AN = ammonium nitrate (34-0-0), UR = urea (46-0-0).
[y] Prescription-based treatment.

Table 2. Petiole sap NO_3-N at early harvest, 21 June 2001.

N applied to date	NO_3-N
(lb/acre)	(ppm)
144	322
108	465
80[z]	307
72	268
36	142
0	101
$LSD_{0.05}$	48

[z] Prescription-based treatment.

Table 3. Cumulative yields of U.S. No. 1 XL grade tomato during 2002 season.

Preplant N rate	Injected N rate	Total N rate	Cumulative yield, by harvest time (day/month) 14 June	21 June	30 June	6 July
(lb/acre)			(lb/plant)			
0	0	0	0.86	2.12	4.33	6.74
0	60	60	0.78	1.68	4.51	6.95
0	80	80	0.78	1.54	3.49	6.56
0	120	120	0.84	1.54	5.18	7.62
0	180	180	1.31	1.96	4.07	7.13
60	0	60	1.51	2.50	4.08	6.67
60	30	90	0.87	1.72	3.69	7.04
60	60	120	0.96	1.54	3.32	6.41
120	0	120	0.26	1.33	3.36	5.19
120	40	160	1.99	3.10	4.28	7.56
120	60	180	1.11	1.69	3.86	7.38
$LSD_{.05}$			0.94	1.15	NS	NS

Table 4. Petiole sap NO_3-N concentration in relation to total N applied (preplant + injected) at three specified sampling dates during 2002.

	14 May Total N	14 May NO_3-N	4 June Total N	4 June NO_3-N	18 June Total N	18 June NO_3-N
	(lb N/acre)	(ppm)	(lb N/acre)	(ppm)	(lb N/acre)	(ppm)
	0	530	0	97	0	109
	6	695	18	353	30	237
	12	455	36	475	60	227
	18	768	54	435	80	373
	20	523	60	451	90	285
	60	960	70	214	100	208
	70	1008	80	205	120	104
	80	743	120	206	150	258
	130	680	130	270	160	233
	130	1033	140	383		
	140	865				
Sufficiency range		600-800		400-600		200-400
P-value		0.0034		<0.0001		0.2328
R^2		0.29		0.40		0.10

Table 5. Petiole sap NO_3-N concentration in relation to cumulative amounts of injected N during 2002.

	14 May Injected N rate	14 May NO_3-N	4 June Injected N rate	4 June NO_3-N	18 June Injected N rate	18 June NO_3-N
	(lb N/acre)	(ppm)	(lb N/acre)	(ppm)	(lb N/acre)	(ppm)
	0	530	0	97	0	109
	0	723	0	191	0	108
	6	695	10	242	30	234
	10	1020	18	353	40	220
	12	455	20	294	60	343
	18	768	36	495	80	373
	20	770	54	435	90	363
			60	473		
Sufficiency range		600-800		400-600		200-400
P-value		0.7077		0.0015		0.0002
R^2		0.03		0.32		0.38