

Tillage, Cover Cropping, and Nitrogen Fertilization Influence Tomato Yield and Nitrogen Uptake

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Abstract. Management practices can influence tomato (*Lycopersicon esculentum* Mill.) yield and N uptake. The effects of tillage (no-till, chisel plowing, and moldboard plowing), cover crop [hairy vetch (*Vicia villosa* Roth) vs. none], and N fertilization (0, 90, and 180 kg·ha⁻¹ N) on transplanted tomato yield and N uptake were studied in the field from May to August in 1996 and 1997 on a Norfolk sandy loam (fine-loamy, siliceous, thermic, Typic Kandiudults) in central Georgia. Plowing increased fresh and dry fruit yield and N uptake in 1996 and N fertilization increased yield and N uptake in 1996 and 1997. Plowing also increased stem and leaf dry weights and N uptake from 40 to 118 days after transplanting (DAT) in 1996. Fertilization increased stem weight and N uptake with or without hairy vetch from 54 to 68 DAT in 1996 and stem and leaf weights and N uptake at 68 DAT in 1997. Both hairy vetch and N fertilization increased leaf N concentration in 1997. Recovery of N by the plants was lower with hairy vetch than with N fertilization, but was similar to or greater with 90 than with 180 kg·ha⁻¹ N. We conclude that reduced tillage, such as chisel plowing, with 90 kg·ha⁻¹ N can sustain tomato yield and N uptake, with reduced potentials of sediments and/or NO₃ contamination in surface and groundwater.

Poor agronomic practices, accompanied by excessive N fertilization, increase soil erosion and NO₃ pollution potential in surface and groundwater (Hallberg, 1989; Linville and Smith, 1971). In Georgia, farming-associated NO₃ pollution of groundwater is often a problem (Berndt, 1993). Vegetable cropping systems require a greater degree of management and utilize a larger N input than most agronomic cropping systems (Power and Schepers, 1989). Also, vegetables recover less N than do agronomic crops (Lowrance and Smittle, 1988), thus the potential for NO₃ loss is greater with the former. Therefore, management practices that sustain vegetable production and improve soil and water quality are needed.

Tillage accelerates soil erosion and N mineralization, thereby increasing the potential for sediment and NO₃ pollution in surface and groundwater (Legg and Meisinger, 1982; Randall, 1990; Yadav, 1997). Similarly, NO₃ leaching increases with increasing N fertilization (Owens et al., 1994; Pang et al., 1998; Sexton et al., 1996). In contrast, cover crops planted in the fall, following a summer crop, recycle residual NO₃ and reduce its potential

for leaching (Meisinger et al., 1990, 1991; Sainju et al., 1998). Legume cover crops can also fix N from the atmosphere, thereby enriching soil N, increasing succeeding crop yield, and reducing the amount of N fertilization required for succeeding crops (Frye et al., 1988; Kuo et al., 1996; Sainju and Singh, 1997).

Tomato is an important vegetable crop in Georgia. In order to reduce groundwater pollution under vegetable crops, more sustainable cultural practices that maintain or improve groundwater quality without significantly decreasing crop yields need to be developed. Our objectives were to 1) determine the growth rate, yield, and N uptake by transplanted tomato as influenced by tillage, hairy vetch cover cropping, and N fertilization, and 2) compare N recovery by tomato from N supplied by hairy vetch residue vs. N fertilization.

Materials and Methods

The experiment was conducted for 2 years at the Agricultural Research Station farm, Fort Valley State Univ., Fort Valley, Ga., on a Norfolk sandy loam (fine-loamy, siliceous, thermic, Typic Kandiudults). Temperature and rainfall data were collected from a weather station, 20 m from the experimental site.

The treatments included three levels of tillage (no-till, chisel plowing, and moldboard plowing), two levels of cover crop (hairy vetch

vs. no hairy vetch), and three levels of N fertilization (0, 90, and 180 kg·ha⁻¹ N). Prior to chisel plowing (15- to 20-cm depth), plots were harrowed (15- to 20-cm depth). After plowing, they were leveled with an S-tine harrow (10- to 15-cm depth). Similarly, conventional tillage (moldboard plowing) consisted of harrowing (15- to 20-cm depth), followed by moldboard plowing (20- to 25-cm depth) and leveling (10- to 15-cm depth). No-till plots were left undisturbed except during planting of cover crop and tomatoes, when lines were drawn with a seed drill. The treatments were arranged in a split-split plot design where tillage was used as main plot, cover crop was used as split plot, and N fertilization as split-split plot. Each treatment had three replications, with a split-plot size of 7.2 × 7.2 m.

On 17 Sept. 1995 and 11 Oct. 1996, chisel and moldboard plots were harrowed, tilled, and leveled. No-till plots were left undisturbed except for drilling of cover crop seed. Hairy vetch seed was drilled at 28 kg·ha⁻¹, with a row spacing of 15 cm. No fertilizer, herbicide, or pesticide was applied to the cover crop. On 11 Apr. 1996 and 3 Apr. 1997, hairy vetch at the flowering stage was harvested from two 900-cm² areas within each plot for determination of dry matter yield and N concentration. Data for the two areas were pooled. In the no-vetch treatment, weeds [dominated by henbit (*Lamium amplexicaule* L.) and cut-leaf evening primrose (*Oenothera lacinata* L.)] were collected as above. Plant materials were oven-dried for 3 d at 60 °C, weighed, and ground to pass a 1-mm screen. After sampling, cover crop and weeds were mowed in all plots with a rotary mower. Residues in the no-till plots were killed by spraying with 3.36 kg·ha⁻¹ of glyphosate [N-(phosphonomethyl) glycine], and incorporated into the soil by harrowing in the other plots. They were allowed to decompose in the soil for 2 weeks before transplanting tomatoes.

On 25 Apr. 1996 and 17 Apr. 1997, P (from triple superphosphate) and K (from KCl) were broadcast each at the rate of 56 kg·ha⁻¹ based on the soil test in all plots, along with 67 kg·ha⁻¹ of 5% diazinon [diethyl 0-(2-isopropyl-6-methyl-4-pyrimidinyl)phosphorothioate] granule to control cutworms and 0.57 kg·ha⁻¹ of trifluralin [2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl) benzeneamine] to control weeds. In the tilled plots, fertilizers, pesticide, and herbicide were incorporated into the soil by plowing. Using a planter, lines were drawn 0.9 m apart in all plots, and holes (15 cm in diameter × 15 cm deep) were dug at every 0.9 m in the lines where 5-week-old tomato ('Sunbeam') seedlings were hand-transplanted. The spacing of 0.9 × 0.9 m in flat beds was used to produce large (marketable) fruit (Univ. of Georgia, 1995). Starter solution containing N-P-K was applied (0.4 kg·ha⁻¹ each) to each tomato plant after 1 week to encourage rapid establishment. Nitrogen fertilizer was applied in three equal quantities and each application was broadcast at 3-week intervals from the date of transplanting. A reel rain gun applied 25 mm of water immediately after fertilization and during tomato growth as needed to pre-

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vent moisture stress. Irrigation was applied at 2, 12, 21, 32, 42, and 63 d after transplanting (DAT) in 1996 and at 2, 11, 21, and 42 DAT in 1997.

To determine the rate of dry matter accumulation, two tomato plants (1.62-m² area) were harvested every 2 weeks from middle rows in each plot from 7 June to 30 Aug. 1996 and from 27 May to 21 Aug. 1997. Plants were separated into stems, leaves, and fruits; dried at 60 °C; weighed; and ground to pass a 1-mm screen for N analysis. In addition, fruits were harvested from five plants (4.05-m² area) from two center rows every 3 to 4 d in July and Aug. 1996 and 1997, as the color turned from green to pink. Fruits were weighed, cut into slices, oven-dried at 60 °C, and weighed again to determine fresh and dry yields. The dried fruits were ground, composited, and a subsample was used for N analysis.

The N concentration in the cover crop and tomato stem, leaf, and fruit samples was determined by the H₂SO₄-H₂O₂ method as described by Kuo et al. (1997b). The C concentration in the cover crop sample was determined by the wet digestion method as described by Kuo et al. (1997a). The N accumulation in the cover crop was calculated by multiplying dry matter biomass yield by N concentration. Similarly, N uptake in tomato stems, leaves, and fruits was calculated by multiplying the dry weight by N concentration. Nitrogen recovered by tomato was calculated as follows:

$$\text{Nitrogen recovery (\%)} = \frac{(N_{\text{ut}} - N_{\text{uc}}) \times 100}{(N_{\text{st}} - N_{\text{sc}})}$$

where N_{ut} = tomato N uptake with hairy vetch or 90 or 180 kg-ha⁻¹ N, N_{uc} = tomato N uptake with no hairy vetch or 0 kg-ha⁻¹ N, N_{st} = N supplied by hairy vetch or 90 or 180 kg-ha⁻¹ N, and N_{sc} = N supplied by no hairy vetch (weeds) or 0 kg-ha⁻¹ N.

Tomato stem, leaf, and fruit data were analyzed statistically using the MIXED procedure of SAS containing fixed and random effects (Littell et al., 1996). Sources of variation included tillage, cover crop, N fertilization, sampling date, and their interactions. The least square means test was used to determine significant differences between the means when treatments and their interactions were significant. Statistical significance was evaluated at $P \leq 0.05$.

Results and Discussion

Climate. In 1996, average daily temperature (ADT) increased steadily from 14.1 °C at 7 DAT to 27.6 °C at 37 DAT, dropped to 20.0 °C at 45 DAT, and then peaked at 29.8 °C at 77 DAT (Fig. 1A). In 1997, the increase in ADT during early tomato growth was more gradual than in 1996. It increased from 10.0 °C at 2 DAT to 24.1 °C at 39 DAT, dropped to 17.1 °C at 52 DAT, and then peaked at 29.8 °C at 78 DAT (Fig. 1B). As a result, ADT from 0 to 78 DAT was 3.0 °C greater in 1996 than in 1997. Total rainfall from 0 to 120 DAT was 406 mm in 1996 and 610 mm in 1997 (Fig. 1C and D). Most of the rain in 1997 fell from 40 to 120 DAT.

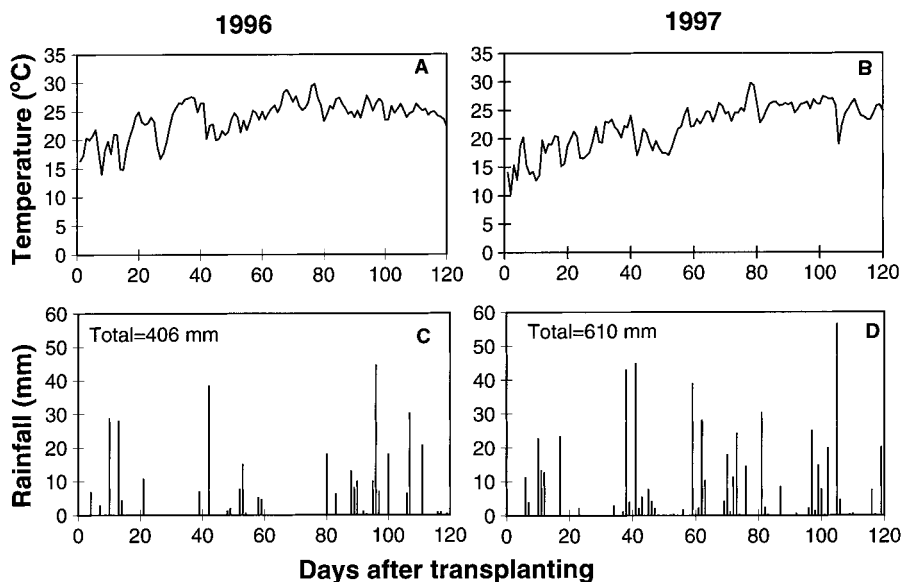


Fig. 1. Average daily temperature and total daily rainfall during tomato growth near the experimental site in 1996 and 1997.

Table 1. Biomass yield, N concentration, N accumulation, and C:N ratio of cover crops in 1996 and 1997.

Cover crop	Biomass yield (Mg-ha ⁻¹)		N concn (g-kg ⁻¹)		N accumulation (kg-ha ⁻¹)		C:N ratio	
	1996	1997	1996	1997	1996	1997	1996	1997
Hairy vetch	5.47 a ^z	4.16 a	37.5 a	18.5 a	206 a	77 a	11.7 a	23.6 a
No hairy vetch (weeds)	1.94 b	1.90 b	18.7 b	14.1 b	37 b	27 b	18.0 b	32.3 b

^zMean separation within columns by the least square means test, $P \leq 0.05$.

Cover crop yield, nitrogen concentration, and nitrogen accumulation. Dry matter yield, N concentration, and N accumulation in cover crops were not significantly influenced by tillage (data not shown). As expected, biomass yield was 2- to 3-fold greater and N concentration and accumulation were 1.5- to 6-fold greater in hairy vetch than in no hairy vetch (or weeds) (Table 1). As a result, C:N ratio of hairy vetch was also lower than that of weeds without hairy vetch. Nitrogen accumulated in cover crops was greater in 1996 than in 1997 due to higher N concentration.

Tomato fruit yield and nitrogen uptake. Fresh and dry fruit yield and N uptake were significantly influenced by tillage in 1996 and N fertilization in 1996 and 1997 (Table 2). Cover crop and its interaction with tillage or N fertilization did not influence fruit yield and N uptake (data not shown). Similarly, fruit number and N concentration were not influenced by tillage, cover crop, or N fertilization (Table 2).

Fresh and dry fruit yield and N uptake were significantly lower in no-till than in plowed plots in 1996 (Table 2), but were not significantly affected by the method of plowing. In contrast, N fertilization significantly increased fresh and dry fruit yield and N uptake in 1996 and 1997, with no significant difference between 90 and 180 kg-ha⁻¹ N.

Increased soil compaction and/or development of root restricting layers could have limited root growth, thereby reducing fruit yield and N uptake in no-till plots in 1996. Singh and Sainju (1998) observed that the number of tomato roots per cm² soil profile

from 19.5- to 58.5-cm depth in 1996 was 65% greater in moldboard-plowed than in no-till plots. Increased soil bulk density (a sign of increasing compaction) from transition of conventional tillage to no-till was observed by several researchers (Kaspar et al., 1991; McCarty et al., 1998; Wander et al., 1998). The compaction or development of root restricting layers in no-till results from incomplete amelioration of compacted soil over the winter (Bauder et al., 1981; Voorhees, 1983). In 1997, however, fresh and dry fruit yield and N uptake were not affected by tillage. Effects of tillage on crop yield were reported by several researchers (Dao, 1993; Kaspar et al., 1991; Merrill et al., 1996; Rao and Dao, 1996). Our data suggest that chisel plowing is as effective as moldboard plowing in tomato production; however, chisel plowing may be more effective in reducing soil erosion and N mineralization.

Increased N availability from N fertilization may have increased fruit yield and N uptake, as observed by several researchers (Melton and Dufault, 1991b; Weston and Zandstra, 1989; Widders, 1989). The similar fruit yield and N uptake with 90 vs. 180 kg-ha⁻¹ N indicates that the lower rate can produce sustainable tomato yield. The 180 kg-ha⁻¹ N rate is excessive for tomato in central Georgia and therefore should be discontinued. Reducing the rate of N fertilization will also reduce the potential for NO₃ leaching into groundwater.

Fruit number was lower but yield and N uptake were greater in 1996 than in 1997 (Table 2), perhaps because of differences in

Table 2. Effects of tillage and N fertilization on tomato fruit number, fresh and dry yield, and N concentration and uptake in 1996 and 1997.

Treatment	Fruit no./plant		Yield (Mg·ha ⁻¹)				N concn (g·kg ⁻¹)		N uptake (kg·ha ⁻¹)	
			Fresh		Dry					
	1996	1997	1996	1997	1996	1997	1996	1997	1996	1997
Tillage ²										
NT	18.7 a ³	40.3 a	35.0 a	32.1 a	1.32 a	1.68 a	38.5 a	40.9 a	50.6 a	69.1 a
CH	25.7 a	34.9 a	66.4 b	33.5 a	2.48 b	1.69 a	37.8 a	37.9 a	93.8 b	64.3 a
MB	25.9 a	39.8 a	62.9 b	30.5 a	2.44 b	1.66 a	35.8 a	38.8 a	86.9 b	63.1 a
N fertilization (kg·ha ⁻¹)										
0	22.8 a	36.7 a	49.5 a	26.6 a	1.83 a	1.32 a	38.0 a	39.1 a	69.1 a	51.8 a
90	22.6 a	40.2 a	58.1 b	36.0 b	2.20 b	1.86 b	37.1 a	39.9 a	82.4 b	73.1 b
180	25.0 a	38.1 a	56.6 b	33.6 b	2.22 b	1.87 b	37.0 a	38.7 a	80.0 b	71.7 b
Significance ⁴										
Tillage	NS	NS	**	NS	**	NS	NS	NS	**	NS
N fertilization	NS	NS	*	**	*	***	NS	NS	*	***

²NT denotes no-till; CH, chisel plowing; and MB, moldboard plowing.

³Mean separation within columns and factors by the least square means test, $P \leq 0.05$.

⁴Sources of variation that were nonsignificant are excluded.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, and 0.001, respectively.

temperature and rainfall patterns (Fig. 1). Increased ADT from 0 to 78 DAT may have resulted in setting of larger but fewer fruits in 1996 than in 1997, thereby increasing fruit yield and N uptake. Temperature can influence tomato yield (Melton and Dufault, 1991a; Teasdale and Abdul-Baki, 1995). Drier conditions from 0 to 80 DAT in 1996 (Fig. 1C) were compensated for by timely irrigation, but excessive rainfall from 40 to 120 DAT in 1997 (Fig. 1D) may have limited fruit growth, thereby resulting in a higher percentage of culls.

Tomato stem and leaf dry weights and nitrogen uptake. Tillage significantly influenced stem and leaf dry weights and N uptake in 1996, and N fertilization influenced these parameters in 1996 and 1997 (Table 3). Interactions were significant for tillage \times date of sampling (stem and leaf dry weights and N uptake in 1996), cover crop \times N fertilization \times date of sampling (stem dry weight and N uptake in 1996), and cover crop \times date of sampling (leaf N concentration in 1997).

In 1996, stem dry weight and N uptake were greater in plowed than in no-till plots from 40 to 118 DAT (Fig. 2 A and C). Similarly, leaf dry weight and N uptake were greater in plowed plots from 40 to 82 DAT (Fig. 3 A and B). Stem weight and N uptake were also greater following N fertilization, regardless of the presence or absence of hairy vetch from 54 to 68 DAT (Fig. 2 B and D). In 1997, stem and leaf dry weights and leaf N uptake were greater with 90 than with 0 kg·ha⁻¹ N but stem N uptake was greater with 180 than with 0 kg·ha⁻¹ N at 68 DAT (Table 4). Leaf N concentration was greater with than without hairy vetch at 82 and 104 DAT, and with than without N fertilization at 40, 55, and 92 DAT (Fig. 4 A and B).

Reduced root growth was also probably responsible for lower stem and leaf dry weights and N uptake in no-till plots in 1996. The nonsignificant difference between chisel and moldboard plowing suggests that sustained tomato growth can be achieved by using limited tillage. Chisel plowing can promote tomato root and shoot growth by subsoiling and breaking the hard pan below the plow layer (Univ. of Georgia, 1995).

The beneficial effects of N fertilization on stem dry weight and N uptake in 1996 and of

Table 3. Analysis of variance for dry weight, N concentration, and N uptake in tomato stems and leaves in 1996 and 1997.

Source ²	Dry wt		N concn		N uptake	
	Stems	Leaves	Stems	Leaves	Stems	Leaves
1996						
Tillage (Till)	**	**	NS	NS	***	*
N fertilization (Fert)	*	*	NS	NS	*	NS
Date of sampling (Date)	***	***	***	***	***	***
Till \times Date	**	***	NS	NS	**	***
Cover crop (Crop) \times Fert \times Date	*	NS	NS	NS	*	NS
1997						
N Fertilization (Fert)	**	*	NS	NS	***	*
Date of sampling (Date)	***	***	***	***	***	***
Cover crop \times Date	NS	NS	NS	*	NS	NS
Fert \times Date	NS	NS	NS	*	NS	NS

²Sources that were nonsignificant are excluded.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, and 0.001, respectively.

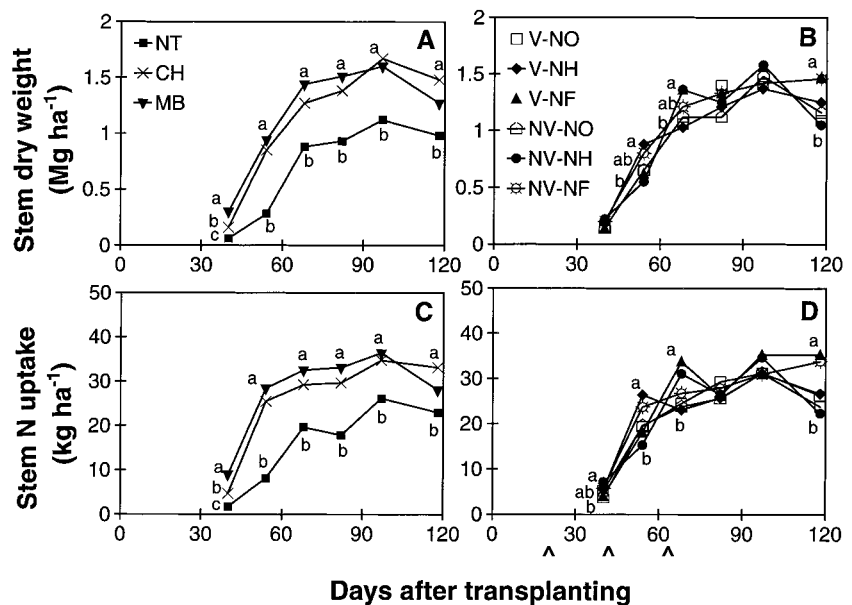


Fig. 2. Tomato stem dry weight and N uptake as influenced by tillage, cover cropping, and N fertilization in 1996. NT denotes no-till; CH, chisel plowing; MB, moldboard plowing; V, hairy vetch; NV, no hairy vetch; NO, 0 kg·ha⁻¹ N; NH, 90 kg·ha⁻¹ N; and NF, 180 kg·ha⁻¹ N. Means separation by the least square means test, $P \leq 0.05$. ^ denotes the time of N fertilization.

both N fertilization and hairy vetch on stem and leaf dry weights, N concentration, and N uptake in 1997 may reflect the promotive effects of N availability from N fertilizer or N mineralization from hairy vetch residue. Legume cover crops have increased tomato shoot

growth and fruit yield (Abdul-Baki and Teasdale, 1993; Shennan, 1992; Stivers and Shennan, 1991; Teasdale and Abdul-Baki, 1995). Fertilization with N also increased tomato shoot growth (Melton and Dufault, 1991b; Weston and Zandstra, 1989; Widders, 1989).

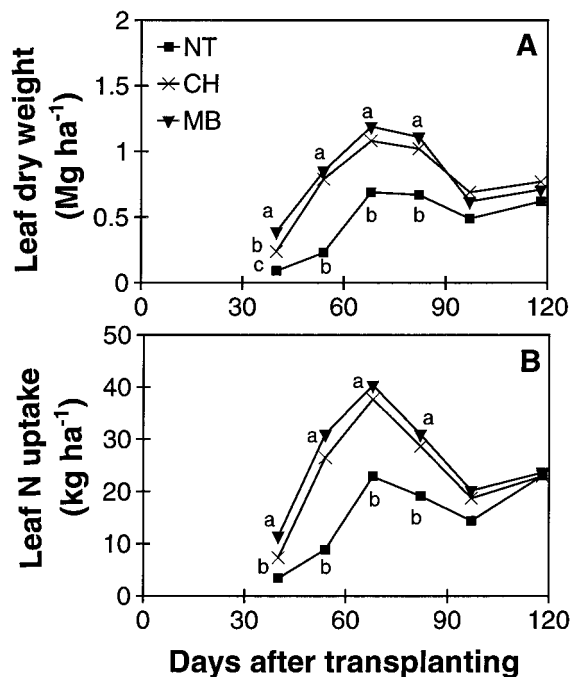


Fig. 3. Tomato leaf dry weight and N uptake as influenced by tillage in 1996. NT denotes no-till; CH, chisel plowing; and MB, moldboard plowing. Means separation by the least square means test, $P \leq 0.05$.

Table 4. Effects of N fertilization on tomato stem and leaf dry weights and N uptake at 68 d after transplanting in 1997.

N fertilization (kg·ha ⁻¹)	Dry wt (Mg·ha ⁻¹)		N uptake (kg·ha ⁻¹)	
	Stems	Leaves	Stems	Leaves
0	1.17 a ^z	1.13 a	32.6 a	34.0 a
90	1.35 b	1.30 b	37.7 ab	46.1 b
180	1.32 ab	1.25 ab	38.1 b	42.1 ab

^zMean separation within columns by the least square means test, $P \leq 0.05$.

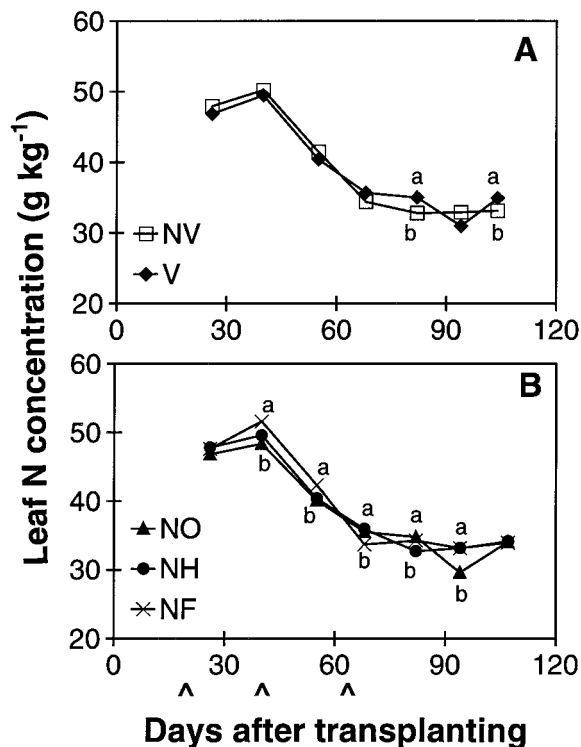


Fig. 4. Tomato leaf N concentration as influenced by cover cropping and N fertilization in 1997. V denotes hairy vetch; NV, no hairy vetch; NO, 0 kg·ha⁻¹ N; NH, 90 kg·ha⁻¹ N; and NF 180 kg·ha⁻¹ N. Means separation by the least square means test, $P \leq 0.05$. ^ denotes the time of N fertilization.

The pattern of stem and leaf dry weights and N uptake (Figs. 2 and 3) indicates that tomatoes grew rapidly from 40 to 68 DAT. As fruiting occurred or leaves fell, growth was minimal. The decline in leaf N concentration with increasing maturity (Fig. 4) indicates a dilution effect with growth (Barker, 1989). Tiessen and Carolus (1963) found that N concentration in tomato shoot tissue decreased for several days after transplanting because of remobilization of N from shoot to root. In our study, however, leaf N concentration was higher in plots receiving N fertilizer.

Unlike fruit yield and N uptake, total stem and leaf dry weights at maximum growth stage (68 DAT) were 14% greater and N uptake was 29% greater in 1997 than in 1996, stem N concentration was 24% greater, and leaf N concentration was 4% greater. Increased rainfall from 40 to 120 DAT (Fig. 1) may have increased soil N mineralization and availability in 1997, thereby increasing tomato shoot growth and N uptake at the cost of fruit yield and N uptake.

Nitrogen recovery. Nitrogen recovered by tomato stems and leaves at 54 and 82 DAT was similar, but fruits recovered most (Table 5). Recovery increased from 54 to 82 DAT as fruits set. Total recovery of N by stems, leaves, and fruits from N supplied by hairy vetch ranged from 1% to 3% at 54 DAT and from 4% to 24% at 82 DAT. Total N recovery was 2-fold greater with 90 than with 180 kg·ha⁻¹ N in 1996 but the difference was not significant in 1997. Total N recovered from N fertilization ranged from 1% to 6% at 54 DAT and from 13% to 30% at 82 DAT. Regardless of N supplied by hairy vetch or N fertilization, recovery at 82 DAT was greater in 1997 than in 1996. Sweeney et al. (1987) reported that N recovered by tomato in Florida ranged from 32% to 53%. This difference in N recovery could be due in part to variation in soil and climatic conditions and management practices.

Lower N recovery with hairy vetch residue than with N fertilization indicates that tomato was not able to utilize N supplied by the residue efficiently. Recovery with hairy vetch was, however, comparable with N fertilization at 82 DAT in 1997 (Table 5). Lower recovery with hairy vetch in 1996 than in 1997 probably resulted from decreased rainfall (Fig. 1), thereby influencing N mineralization from the residue. Even with N fertilization, the recovery was much less than the 32% to 53% found by Sweeney et al. (1987). Lower N recovery in tomato compared with the 50% value reported for most agronomic crops (Allison, 1955; Hallberg, 1989; Viets, 1965), suggests that N has greater potential to leach from the soil under tomato than under agronomic crops. Greater or similar N recovery with 90 than with 180 kg·ha⁻¹ N indicates that no more than 90 kg·ha⁻¹ N should be applied for tomato to sustain N recovery and to reduce N leaching.

Conclusions

Tomato yield and N uptake were affected by tillage, cover cropping, and N fertilization.

Table 5. Percentage of N supplied by hairy vetch residue or N fertilization recovered by tomato stems, leaves, and fruits at 54 and 82 d after transplanting (DAT) in 1996 and 1997.

Treatment	Stems		Leaves		Fruits		Total	
	1996	1997	1996	1997	1996	1997	1996	1997
54 DAT								
Hairy vetch	0.9	2.4	0.5	0.8	---	---	1.4	3.2
90 kg-ha ⁻¹ N	1.7	0.4	4.0	0.8	---	---	5.7	1.2
180 kg-ha ⁻¹ N	0.8	2.9	2.3	0.8	---	---	3.1	3.7
82 DAT								
Hairy vetch	0.2	16.2	1.4	5.8	2.4	2.0	4.0	24.0
90 kg-ha ⁻¹ N	5.2	3.8	4.9	11.7	14.9	11.0	25.0	26.5
180 kg-ha ⁻¹ N	3.2	2.7	3.6	3.1	6.1	23.7	12.9	29.5

While no-till decreased tomato fruit yield, stem and leaf dry weights, and N uptake compared with chisel or moldboard plowing in 1996, fruit yield, stem and leaf dry weights, and N uptake were not affected by the method of plowing in 1996 and 1997. Similarly, fertilization with N increased stem dry weight and N uptake at 54 to 68 DAT in 1996, whether or not hairy vetch was used, and increased fruit yield and N uptake in 1996 and 1997. However, 180 kg-ha⁻¹ N was no more effective than 90 kg-ha⁻¹ N. Nitrogen recovery was lower with hairy vetch than with N fertilization but was not affected by the rate of N fertilization. For a sustained tomato production with reduced potentials of sediment and/or NO₃ contamination in surface and groundwater, minimum tillage, such as chisel plowing, with 90 kg-ha⁻¹ N are recommended.

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