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Nitrogen Status Evaluation of Tomato Plants[1]

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***Abstract*. Recently matured whole leaves of tomato *Lycopersicon esculentum* Mill cvs. Centennial and Knox) gave the most reliable indication of total N, while NO_3-N in older mature leaf petioles better reflected N availability and absorption. The NO_3-N content of petioles was more indicative of N status of the plant than total N analysis of whole leaves. The NO_3-N and total N contents of leaf parts generally decreased with increasing maturity. Soil solution NO_3-N concentration increased exponentially with increasing N application rates. The first 45 kg N/ha increments increased soil solution NO_3-N concentration only 10 ppm whereas the fourth 45 kg N/ha increment increased NO_3-N concentration 40 ppm. Ninety kg N/ha application produced a concentration of 48 ppm NO_3-N that resulted in a nearly maximum petiole concentration of 14,500 ppm NO_3-N, indicating that this NO_3-N concentration provided sufficient available N for the immediate reserve requirements for plant growth.**

Adequate N is required for tomato plant growth and leads to high yields, but supra-optimal N applications lead to excessive vegetative growth and delayed maturity (1, 12). Plant tissue analyses for NO_3-N and total N have been used to determine the N status of tomato plants.

Few studies have been conducted concerning N form in tissue, or the best plant part and growth stage to sample for N status evaluation of tomatoes. Past studies have shown that the total N in leaf blades increases from about 1% for basal leaves to over 5% for those located near the top of the plant, while total N in the petiole was relatively constant (11). Further, many researchers have reported that N content of leaves decreased with age (2, 4, 9, 10), although Maher (6) found little change with aging. Ward (10) determined that a N level of 5.25% in the 5th leaf from the top during fruit production was necessary for high yields of greenhouse tomatoes.

Gomez-Lepe and Ulrich (3) suggested a critical NO_3-N level of 500 ppm for the 2nd leaf from the plant tip while Sobulo et al. (8) suggested a critical value of 4,000 ppm for the 5th leaf and found severe deficiency with 1,000 ppm. Limited study suggested that 2,000 ppm NO_3- in mature leaf petioles at early bloom stage was deficient (5).

This study was conducted to determine the effect of growth stage, leaf part and age, and N application rate on the total N and NO_3-N content of tomato plant tissue. In addition, the influence of N application rate on soil NO_3-N level and soil NO_3-N level on the leaf petiole NO_3-N content was studied.

Materials and Methods

Experiment I. 'Centennial' tomato was seeded in an Ockley silt loam on the O'Neall Memorial Farm, Lafayette, Ind., on May 9, 1970, in single rows, 1.9 m apart with 3 to 4 seeds in clumps every 22.5 cm. Three weeks after emergence, the stand was thinned to a population of 22,222 plants/ha. Chemical and hand weed control and recommended spray schedules were used throughout the growing season to control insects and diseases. All plots were irrigated to maintain soil moisture between 30–100% field capacity from July 24 through August 25.

A basal fertilizer application of 560 kg/ha of 0–4.4—25.2 (N-P-K) was broadcast prior to plowing, and 200 mg P/30-cm row was applied as 11–15.9–0 in the row at seeding. Rates of 0, 168, and 336 kg N/ha as ammonium nitrate were broadcast prior to seeding. A randomized complete block design was used with 4 replications. The plots were 4 rows 6.1-m long with the 2 center rows used for data collection.

Whole leaves and petioles of recently matured leaves were sampled every 2 weeks from first fruit set on July 8 until August 24. In addition, old leaves and expanding leaves were sampled on July 8. Whole leaves and petioles were analyzed for NO_3-N by water extraction and measurement with an Orion NO_3-N electrode. Total N was determined by wet ashing and by Nesslerization. Fruit were harvested on September 9 from the 0 N plots and on September 21 from the N-treated plots.

Experiment II. 'Knox' tomato was seeded May 7, 1980, as in 1970, in rows 2 m apart with 3 to 4 seeds in clumps every 22.5 cm.

A basal fertilizer application of 560 kg/ha of 0–4.4–25.2 was broadcast prior to plowing and 200 mg P/30 cm row was applied as 2–3–0 in the row at seeding. Application rates of 0, 45, 90, 135, and 180 kg N/ha as ammonium nitrate were broadcast prior to seeding. A randomized compete block design was used with 4 replications. The plots were three rows 6.1-m long with data collection from the center row.

Leaf blades and petioles were sampled on June 15, July 15, July 29, and August 22. Petioles were analyzed for NO_3-N by water extraction and measurement with an Orion NO_3-N electrode. Total N was determined by rapid perchloric acid digestion (7) and microKjeldahl steam distillation. The soil was sampled on June 18 and a saturated paste extract was analyzed for NO_3-N using an Orion NO_3-N electrode. (2-Chlorethyl)phosphonic acid (ethephon) was applied on August 25 at 0.94 kg/ha and ripe fruit were harvested on September 9.

Results and Discussion

Experiment I. Plants were about 25 cm tall with the second fruit cluster visible on the July 8 sampling date. The total N content was highest in the younger leaves, while the NO_3-N content was highest in the older leaves (Fig. 1).

Petioles had a lower total N content than the total leaf on all sampling dates (Fig. 2). Through fruit accumulation and early fruit expansion, the 168 kg/ha N application resulted in a significant increase of the total N in whole leaves and petioles with little further increase from the 336 kg/ha application. However, on August 24, the 336 kg/ha N application resulted in increased N in petioles and whole leaves compared to the 168 kg/ha treatment. The total N content of leaves and petioles remained rel-

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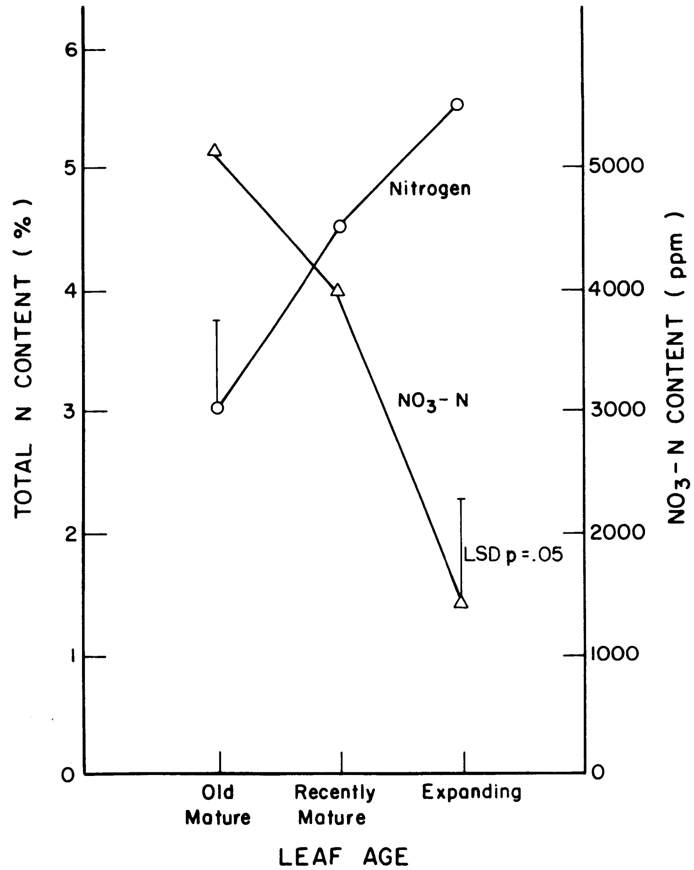

Fig. 1. The effect of leaf age on the total N and NO_3-N content of tomato leaves (1970).

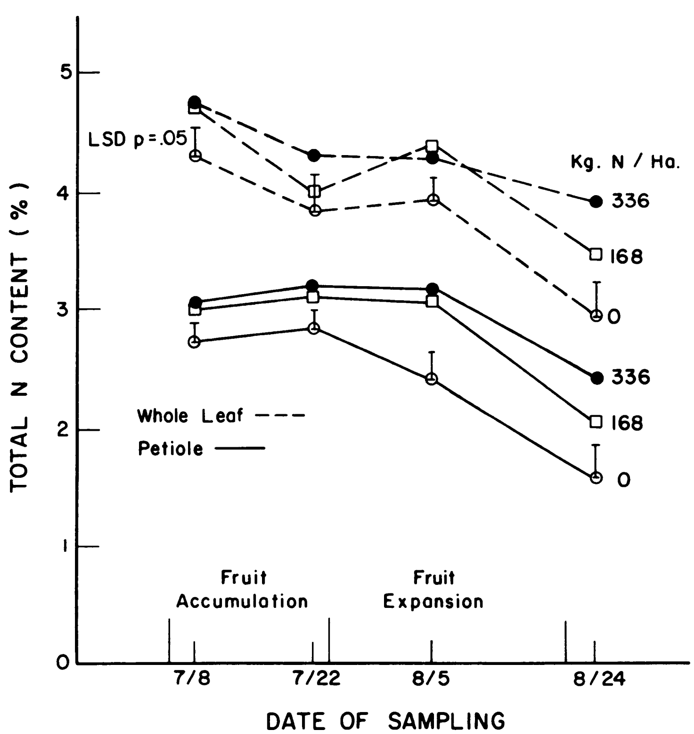

Fig. 2. The effect of sampling date and N application on the total N content of whole leaves and petioles of tomato (1970).

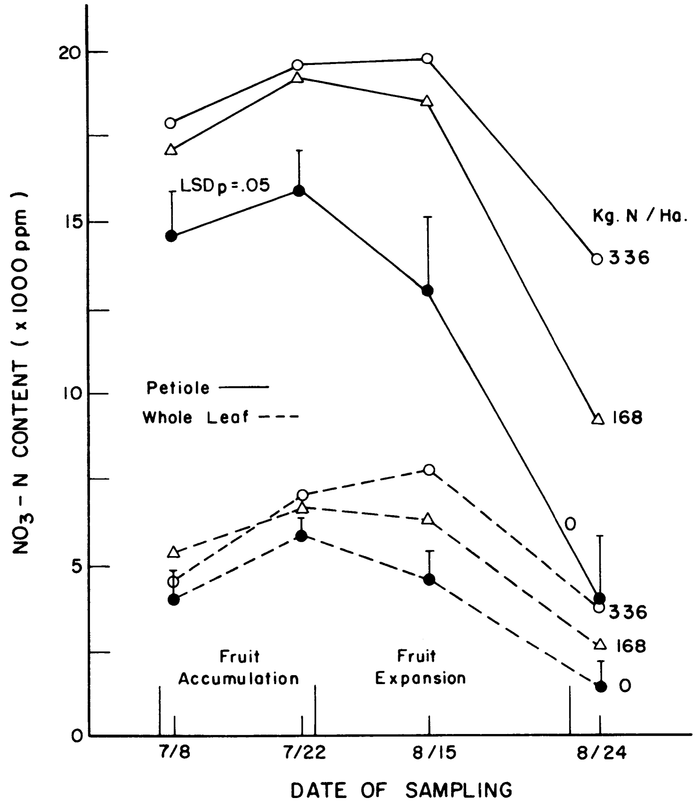

Fig. 3. The effect of sampling date and N application rate on the NO_3-N content of tomato leaves and petioles (1970).

atively constant in all the treatments until the August 5 sampling date, and then decreased rapidly during the late fruit expansion and ripening stages.

The NO_3-N content of the petioles was about 3 times that of the whole leaf for all sampling dates and N application rates (Fig. 3). The NO_3-N content of both petioles and leaves increased during the fruit accumulation stage and decreased during the late fruit expansion stage.

The harvest of the N treatments was delayed 2 weeks to allow the same portion of ripe fruit in the total fruit load as for the control. There was an increased ripe fruit and total fruit yield with increasing N application rate in this experiment (Table 1).

Experiment II. The NO_3-N content in tomato leaf petioles increased with increasing N application rates (Fig. 4). For the earliest sampling date, 45 kg N/ha significantly increased the leaf petiole NO_3-N content, while a 90 kg/ha application was

Table 1. Effect of nitrogen application rate on tomato fruit yield (1970).

	Fruit yield (MT/ha)			
Nitrogen rate (kg/ha)	Ripe	Green	Total	Ripe fruit (%)
0	49.5	38.5	88.0	56.2
168	55.1	44.8	99.9	55.2
336	62.7	50.4	113.1	55.2
LSD 5%	6.5	NS	11.1	NS

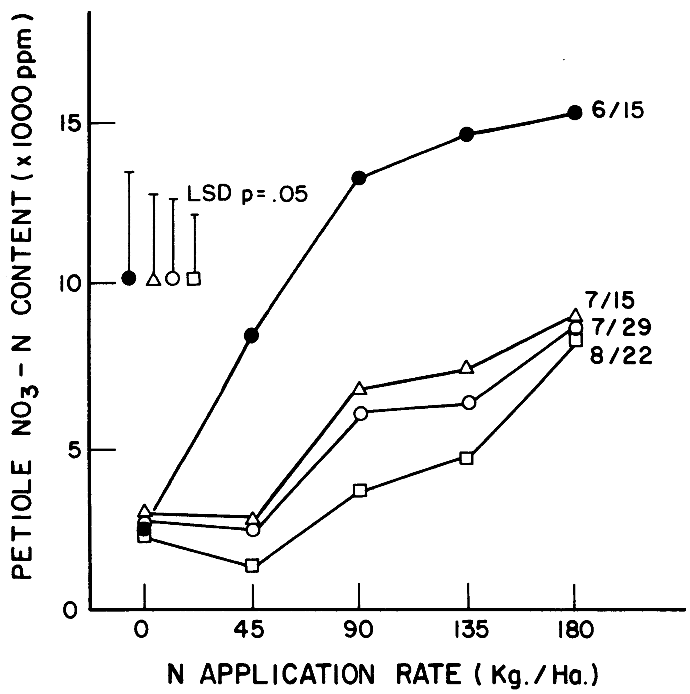

Fig. 4. The effect of N application rate and sampling date on tomato leaf petiole NO_3-N content (1980).

required for a significant increase on July 15 and July 29, and 135 kg/ha was required for an increase on August 22.

The total N content of the leaf blades increased as the season progressed (Fig. 5). The 135 and 180 kg/ha N treatments resulted in a significantly higher total N content in the leaf blade at the June 15 sampling, while no effects of rate of application were

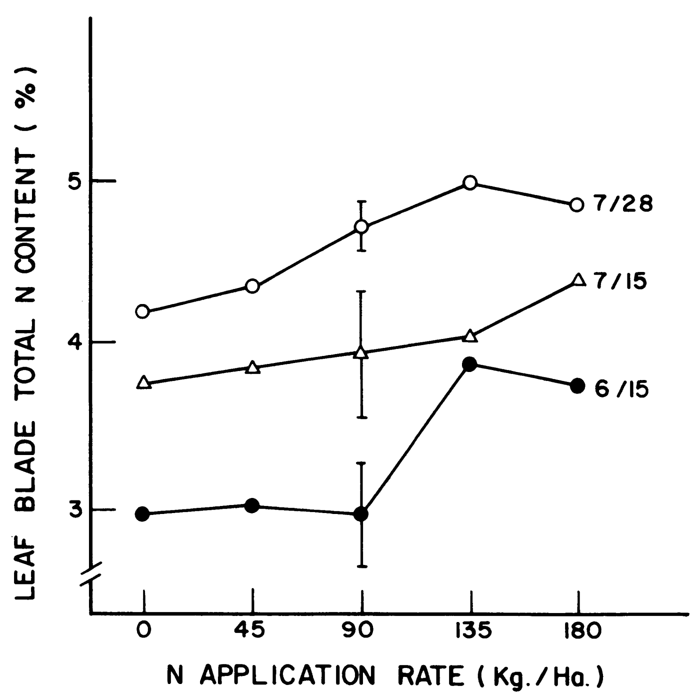

Fig. 5. The effect of sampling date and N application rate on total N content of tomato leaf blades (1980).

apparent on the July 15 sampling. The 90 kg/ha and higher rates resulted in an increased N level on the July 28 sampling.

The soil NO_3-N level at the June 18 sampling increased exponentially as the N application rate was increased (Fig. 6). A N application of 90 kg/ha significantly increased the soil NO_3-N content over the control, and each successive 45 kg/ha increase over the 90 kg/ha resulted in further significantly higher soil NO_3-N levels.

The petiole NO_3-N increased rapidly as the soil NO_3-N increased to near 48 ppm, but little further increase occurred at higher soil N levels (Fig. 7).

N rates had no effect on tomato fruit yield in 1980 (Table 2).

Results from these studies indicate that leaf age and leaf part are important considerations in sampling tissue for evaluating N status of tomato plants. Recently matured whole tomato leaves are most indicative for total N plant evaluation, while NO_3-N concentration in older mature leaf petioles should be used as an

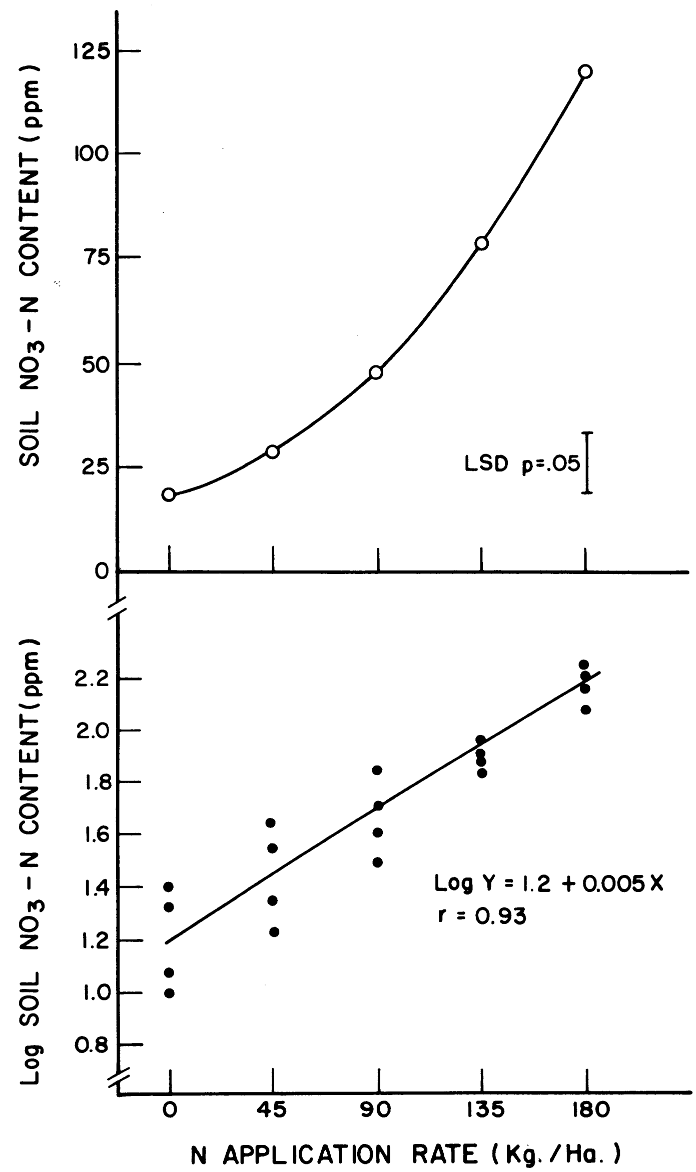

Fig. 6. Relationship between N application rate and soil NO_3-N content sampled on June 18, 1980.

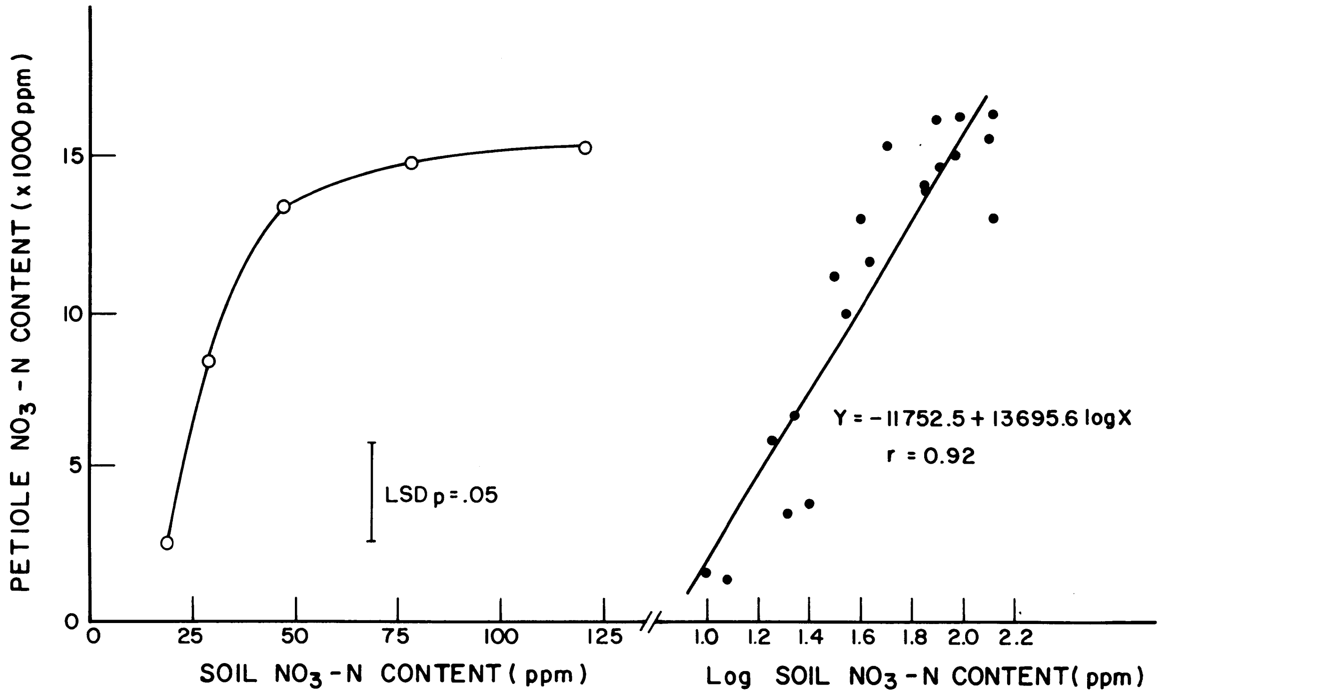

Fig. 7. Relationship between soil and tomato petiole NO_3-N content (1980).

Table 2. The effect of N application rate on tomato fruit yield (1980).

Nitrogen rate (kg/ha)	Fruit yield (MT/ha)
0	39.9
45	40.4
90	40.1
135	37.4
180	39.7
LSD 5%	NS

indicator of N status. A cardinal principal in N fertilization is that sufficient available N be present in the soil solution to meet the requirements of tomato growth and development. Higher rates of N than required for immediate plant needs are absorbed and stored as excess NO_3-N and translocated within the plant when needed later in the growth period. The 90 kg N/ha application increased the soil solution NO_3- concentration to a level that allowed an excess NO_3-N uptake by the tomato plant as indicated by the 14,500 ppm NO_3-N concentration in the petioles. The capacity of the plant to absorb and store N during its developmental stages is of great significance to the later fruiting stage when N is transported from the leaves and stems to meet the N needs of developing fruit. For machine harvest, the NO_3-N level in the petioles must decline in these later stages to avoid delayed fruit development and maturation and to promote optimum ripe fruit load at harvest.

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