

SOIL SCIENCE

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Tomato Response to Nitrogen Fertilization in Indiana¹

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Although nitrogen is one of the major nutrient elements often limiting tomato growth in Indiana, proper application rates have been uncertain. When considering nitrogen availability, factors such as crop rotations, previous crop, soil type, weather, past fertilizer treatments, variety and intensity of production must be taken into account.

Rotations with legume hay crops are known to build up the available soil nitrogen. Reeve et al. (1) found that tomato yields were essentially doubled by two years of deep rooted legumes in a four year rotation as compared with rotations involving only tomatoes and onion sets or continuous tomatoes. Many of the present rotations used on farms in the tomato producing area utilize row crops so that the soil may or may not be depleted of soil nitrogen depending upon the fertilizer practices followed.

Without nitrogen fertilization of the row crop preceding the tomato crop, the soil could be depleted of its available nitrogen supply. However, a corn crop that has received 150 lbs. of nitrogen the preceding year will carry over a large portion of the nitrogen in stalks that are plowed down and this can be used by the succeeding tomato crop.

These experiments were run to measure the response of tomatoes to nitrogen fertilization on different soil types and over a range of N rates that extend into excessive levels of N.

Materials and Methods

Nitrogen was applied as ammonium nitrate in all the tests. In 1957, nitrogen rates from 0-160 lbs/A in 40 pound increments were applied, as side-dressing after the first fruit cluster was set, on two locations, a gravelly, sandy loam soil near Columbus, Indiana and a Miami silt loam near Converse, Indiana. At Columbus, urbana tomatoes were set on soil that had been fertilized with 600 lbs. 5-20-20 plowed down and the plants received starter solution. At Converse, the tomatoes were direct seeded in the field with a 300 lb. application of 8-32-0 banded two inches to the side and two inches below the seed. In 1958, the Epoch variety, a dwarf type, was tested at 3 populations and three nitrogen levels, 50, 100 and 150 lbs/A added two weeks after the plants were set.

In 1960 the experiment was run on Tecumseh tomatoes direct seeded on an Ockley silt loam soil which is an alluvial terrace and outwash plain soil with slow surface drainage and good to excessive internal drainage. Four nitrogen treatments 25, 75, 125 and 525 pounds/A were

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applied broadcast just before the tomatoes were seeded on May 5. The treatments were replicated six times in randomized block design. The soil analysis was pH 6.2, available phosphorus averaged 234 lbs/A and available potassium was 277 lbs/A by the Purdue soil test. Four foot rows were used and 15 pounds per acre of 10-52-17 was applied directly on the seed at planting time. Five hundred pounds/A of 5-20-20 was plowed down prior to any treatment application. Six weeks after planting, the plants were thinned to a population of 8,712 plants per acre. Each plot consisted of four rows, 27 feet long and 25 feet of the two center rows of each plot was harvested for yield.

The 1961 experiment was also conducted on an Ockley silt loam. The soil analyzed pH 6.3, P_2O_5 445 lbs/A and K20 346 lbs/A by the Purdue soil test. Nitrogen was applied at rates of 0, 50, 100, 200, 300 and 400 pounds per acre on corn stalks and plowed down in April. The six treatments were arranged in randomized blocks and replicated four times. Tecumseh tomatoes were direct seeded in four foot rows May 14, 1961 and fertilized with 5 lbs/A P as 10-52-17 applied directly on the seed. Due to the cold soil the seed did not come up until the first week in June. A stand of one plant every 12 inches was established in the plots. Flower cluster and fruit counts were made during the season and leaf samples collected for chemical analysis. The fruit was picked by hand in three pickings.

Results

In 1957, a significant response to the first increment of nitrogen was obtained at the Converse location, Table 1. There was little increase

TABLE 1. Effect of Nitrogen on Tomato Yields, Converse 1957

Nitrogen Applied	YIELD PER ACRE				Total
	Picking Date				
	8/21	8/30	9/9	9/19	
lbs/A			Tons		
0	3.21	5.10	2.80	3.71	14.8
40	3.44	5.39	3.68	5.12	17.6
80	2.70	4.06	4.44	6.03	17.2
120	3.28	5.04	4.24	5.60	18.2
160	3.08	4.56	4.80	6.98	19.4
LSD p = .05	N.S.	N.S.	1.04	1.98	2.6

to the higher rates of nitrogen applied. At the Columbus location there was no response to the nitrogen applications. In 1958, the effects of nitrogen fertilization rate and plant population on the dwarf tomato yields are presented in Table 2. As the rate of side-dressed nitrogen was increased from 50 to 150 pounds per acre the yields were decreased over 3 tons per acre at the lowest and highest population. This decrease was attributed largely to the delayed maturation of the fruit. The 150

TABLE 2. Marketable Yields of Epoch Tomatoes at Various Populations and Different Nitrogen Levels; O'Neill Farm, Lafayette, Indiana, 1958.

Plants per acre	Nitrogen rate (actual N added)	Yield per acre			
		Picking			Total
		8/26	9/4	9/19	
	Pounds				
12,444	50	2.69	8.11	5.12	15.92
	100	1.04	7.77	5.41	14.22
	150	0.98	5.79	5.36	12.13
24,888	50	2.01	5.25	6.10	13.36
	100	2.36	7.77	6.19	16.32
	150	1.27	6.63	6.58	14.48
37,332	50	3.11	9.19	5.10	17.40
	100	2.99	7.43	6.61	17.03
	150	1.69	6.30	6.01	14.00

pound nitrogen rate resulted in abnormal vine growth for the Epoch variety and was more pronounced at the low than at the high populations.

The effect of nitrogen applications on the yield of Tecumseh tomatoes in 1960 is shown in Table 3. At the first picking the yield from the 25

TABLE 3. Yield of Tecumseh Tomatoes, 1960

Treatment Rate of N Broadcast Preplant	Yield				Total
	1st Picking 8/26/60	2nd Picking 9/8/60	3rd Picking 9/22/60	4th Picking 10/6/60	
Lbs/A			T/A		
25	2.1	17.3	4.8	1.6	25.8
75	1.0	14.4	9.3	4.0	28.7
125	1.1	18.6	8.9	3.0	31.6
525	.8	13.5	11.1	5.6	31.0
LSD 5% Level	0.98	N.S.	3.1	1.5	4.6

pound N treatment was significantly higher than the yields obtained from the higher nitrogen treatments. However, at the second picking there was no significant difference between the four nitrogen treatments. The yield at the second picking for the 4 nitrogen treatments averaged 15.9 tons. At the third picking the yield from the 25 pound nitrogen treatment was significantly lower than the yield from the other three nitrogen levels. This was also true at the fourth picking. In a comparison of the effects of the nitrogen treatments on total yield, the

highest yield was obtained from the 125 pound nitrogen treatments and this yield was significantly higher than that obtained from the 25 pound. The 525 pound nitrogen treatment resulted in a tomato yield of 31 tons which is almost identical to that of the 125 pound nitrogen. However, the 525 pound N rate delayed maturity somewhat and spread the harvest period.

In 1961, vine growth and color response to the first two increments of N were apparent throughout the season. The results of the fruit

TABLE 4. Tomato Fruit Cluster Development, Fruit Set and Yield
Response to Rate of Nitrogen Fertilizer Application

Treatment	Flower clusters per plot		Fruit per plot	Yield
N rate per acre	7/24	7/31	8/8	Per/A
lbs				T
0	74	186	495	17.5
50	88	199	638	18.1
100	88	208	617	17.2
200	96	209	725	16.6
300	87	195	656	16.5
400	64	165	564	14.5
LSD $p=.05$	N.S.	36	118	2.3

count made August 8 are listed in Table 4. A significant increase in fruit was obtained from N fertilization comparing the 0 and 50 N rates. Maximum number of fruit were set at the 200 pound N treatment while fruit numbers decreased at the highest N rate. Fruit cluster counts made July 24 did not show differences due to N treatment while one week later the clusters at the 400 pound N treatment were fewer in number than for the lower N treatments.

The yield, Table 4, from the 400 pound N treatment was lower than for the lower N rates. The moisture during 1961 appeared to be deficient, especially during the last three weeks of August when the fruit were developing. Severe blossom end rot developed on fruit in the 400 pound N plots. This appeared to be directly associated with the decreased yield for this treatment. There was no significant difference between yields at the lower N rates.

Tissue samples, from the 1961 test were analyzed and the results are presented in Table 5. The sample collected at the first blossom cluster stage, July 21, showed that the nitrogen fertilization increased the N and Mg composition of the tissue. Leaf tissue collected when the plant was carrying a fruit load showed the nitrogen fertilization decreased P concentration and increased N, Mg and Ca concentration in the tissue. Potassium was not affected by N fertilization at either sample date.

At the first picking date, September 11, a hamper of tomatoes, from each plot of the 0, 50 and 400 pound N treatments was graded and

TABLE 5. Composition of Tomato Leaves at Various Rates of N Fertilizer Application.

Nutrient	Sample Date	Nitrogen fertilizer application, pounds per acre						LSD p = .05
		0	50	100	200	300	400	
		%						
N	7/21	2.90	2.99	3.18	2.96	3.48	3.68	.58
	8/15	2.29	2.60	2.38	2.86	2.92	2.83	.25
P	7/21	.18	.18	.17	.15	.18	.18	N.S.
	8/15	.20	.18	.15	.17	.16	.14	.03
K	7/21	3.38	3.17	3.04	3.04	3.56	3.22	N.S.
	8/15	3.08	2.98	2.68	2.75	2.96	2.76	N.S.
Ca	7/21	3.72	4.06	4.04	4.14	4.39	4.10	N.S.
	8/15	4.34	4.50	4.75	4.71	4.84	4.85	.40
Mg	7/21	.95	1.08	1.10	1.18	1.23	1.20	.18
	8/15	.99	1.12	1.18	1.22	1.30	1.29	.14

analyzed for pH, dry matter and color. The results are presented in Table 6. The grade was not affected very much by N fertilization. The best grade tomatoes were from the 50 pound N treatment. The tomatoes from the zero treatment graded a lower percent number ones but had less culls.

TABLE 6. Quality measurements of tomatoes fertilized with various N rates.

Measurement		N	rate	lbs/A
		0	50	400
Grade				
#1	Fruit Number	298	328	305
#2		144	101	105
cull		75	92	111
#1	Fruit per cent	56	61	59
#2		29	20	21
cull		15	19	20
pH		4.3	4.3	4.3
Refractive index (Solids)		1.3432	1.3439	1.3440
Color	L	24.4	24.4	25.2
	a	20.4	19.2	21.3
	b	10.6	10.2	11.0

The pH, dry matter (R.I.) and color were not affected by the N fertilizer treatments.

Tests made on the plant sap during the growing season indicated very low N in the plants of the zero N treatment from seedling stage through the entire season. The plants that received 50 pounds N did not show deficiency until after fruit was developing.

Discussion

Nitrogen was found to be deficient in soils typical of those used in tomato production for processing tomatoes for growth of determinate vine-type varieties. The dwarf variety did not respond to nitrogen applications above 50 lbs/A. Although time and method of application was not a factor in this series of experiments observations between years to response to side-dressing or broadcast preplant applications showed that about the same response to rate of nitrogen applied was obtained regardless of the method of application. Preference is given, therefore, to the preplant broadcast method of application because it more nearly assures a nitrogen sufficiency during the vegetative developmental period of the plant. Also the plant growth rate and development is not upset by a sharp change in nitrogen concentration in the soil medium as might be brought about if the plant were growing in a deficient condition when the side-dressing application of nitrogen is applied.

It was observed that as the nitrogen rate was increased the vegetative growth of the tomato plant increased. Under a heavy fruit load visible nitrogen deficiency symptoms developed in the 0 and 75 pound per acre nitrogen range. Maximum yields were obtained for the nitrogen rate at which visible deficiency symptoms did not occur until after the plant was carrying its fruit load. However, extension of the N rate to excessive levels did not detrimentally affect fruit set or yield, with the exception of 1961 at a location of severe drought during the period of fruit development.

In all years if response was obtained to nitrogen application, it was at the later harvest dates. This was related to the effect of nitrogen on stimulation of early vegetative growth which allowed increased branching and established a nutritive condition that supported an extended period of fruit set.

Summary

The response of tomatoes to nitrogen fertilization was tested in the field on soils typical of those used on commercial tomato production over a period of years from 1957 to 1961. In 1957, 40 pounds of nitrogen significantly increased the yield of tomatoes grown on a Miami silt loam following a grass sod. In 1958, the Epoch variety tomatoes, a dwarf variety, did not respond to nitrogen applications. In 1960 Tecumseh variety tomatoes responded to 125 pounds of N with no further effect at 525 pounds per acre of nitrogen. In 1961, an extremely dry season during the period of fruit development, no yield response was obtained to the nitrogen applications between 0 and 300 pounds per acre. Four hundred pounds per acre resulted in a decrease in yield due to a high incidence of blossom end rot. As the nitrogen rate was increased between

0 to 125 pounds, vine growth was increased and at the 125 pound rate visible deficiency symptoms under heavy fruit load failed to develop, whereas, visible deficiency symptoms would develop below 100 pounds N per acre under heavy fruit load.

Literature Cited

1. REEVE, E., R. M. MROCH, R. W. BACKES and R. D. PEEL. 1956. Influence of crop rotations and fertilizer treatment on tomato yields and soil properties. *Proc. Amer. Soc. Hort. Sci.* **67**: 350-354.