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Effects of Plant Nutrients On Yield and Quality of Tomatoes In Southwestern Idaho

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Summary

Application of zinc, manganese, iron, copper and boron fertilizers did not significantly affect yield of tomatoes, maturity of tomatoes or tomatoes per plant. Soil tests indicated that the zinc level was low in 1970 but zinc levels in the tomato petioles were high, above 40 ppm. Since tomato production was not affected by addition of zinc fertilizer, the plant analysis would appear to be a better guide for determining the need for zinc fertilizer. The levels of other micronutrients shown in soil and petioles would appear to be sufficient to produce yields of ripe tomatoes up to about 35 tons per acre.

Soils with more than 20 ppm of nitrate nitrogen in the top 3 feet did not need additional nitrogen to produce yields shown. Where there were less than 20 ppm of nitrate nitrogen in the top 3 feet of soil, 80 pounds nitrogen per acre was sufficient to produce yields shown. Where the soil contained high amounts of nitrate nitrogen, nitrogen fertilizer delayed maturity, reduced yield of ripe tomatoes and increased yield of green tomatoes.

About 1,500 ppm of nitrate nitrogen in tomato petioles taken from the main stem of plants at early tomato set were sufficient to produce yields of ripe tomatoes shown. When nitrate nitrogen was below this level, nitrogen fertilizer increased concentration in plant and produced more tomatoes. Both the soil and plant analyses would appear to be satisfactory methods of determining nitrogen need in tomato production. Banding of ammonium sulfate fertilizer increased concentration of zinc and manganese in tomato petioles but yield of ripe tomatoes, maturity or tomatoes per plant were not affected by nitrogen sources used.

Phosphorus and potassium fertilizers did not affect total yield of ripe tomatoes, maturity or tomatoes per plant. Both the soil and petiole levels would appear to be high and sufficient to produce yield of tomatoes obtained.

None of the nutrients applied appeared to affect degree of curly top infection.

The Authors

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Tomatoes are probably the most common crop grown by home gardeners in Idaho. Small acreages of tomatoes for fresh market and canning are grown in the Magic Valley, Treasure Valley and the Lewiston area. While the acreage of tomatoes is small, the warm irrigated areas of southern Idaho produce good yields. Some large canneries are considering the possibility of commercial production in southwest Idaho.

Growers and processors have expressed concern about fruit quality for a fancy pack. Quality problems most frequently encountered by tomato growers are fruit rots, blossom end rot, cracking, proper maturity and uneven ripening of fruit.

Fertilizers may affect the quality and yield of tomatoes. Current fertilizer practices vary widely. Some growers fertilize tomatoes as they do beets or potatoes. Some home gardeners apply barnyard manure in the winter and inorganic fertilizer as the fields are fertilized in the spring. Other growers use no fertilizer on tomatoes. In the last reference for Idaho tomato growers on fertilizer use, fertilizers failed to show any effect on tomato production. *

Tomato varieties, farming practices and attitude toward use of fertilizers have all changed in the last 20 years. These experiments were conducted at the Parma Branch Agricultural Experiment Station from 1968 through 1970 in an attempt to answer some of the questions about tomato fertilization.

The tomato variety used in these trials was a numbered variety developed at the Parma Station. Identified as P 109, it is a Payette type, small with a compact vine. The small plant size allows for high plant populations per acre and this results in higher yields. The P 109 is about three days earlier in maturity than the Payette.

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* Kraus, James E. 1949. Tomato yield and grade as affected by variety, irrigation and fertilizer. Idaho Agricultural Experiment Station Bull. 277.

Procedure

All experimental plots were on a Greenleaf silt loam soil. Tomatoes followed barley each year in the crop rotation. Barley stubble and the volunteer barley were disked and plowed under in the fall each year. In 1968 and 1969, 120 pounds of nitrogen per acre as ammonium sulfate was plowed under with the barley stubble.

Fertilizer treatments

Nitrogen x phosphorus x potassium

In each of the three years, nitrogen, phosphorus and potassium were supplied as ammonium sulfate, treble super phosphate and muriate of potash. Nitrogen was applied at rates of 0, 80, 160 and 320 pounds per acre alone and in combination with 160 pounds of P_2O_5. The four nitrogen rates were also applied with 160 pounds of P_2O_5 and 160 pounds of K_2O. The treatments were banded about 6 inches deep and 6 inches to each side of the row in the spring before tomatoes were planted. Ten pounds of zinc per acre, as zinc sulfate, were applied to the test area in band with nitrogen fertilizer.

Micronutrients

Zinc, iron and manganese were tested on tomato plots each of the three years. Copper and boron were tested in 1969 and 1970 (Table 1). All fertilizer materials were mixed with 40 to 80 pounds of nitrogen per acre as part of the nitrogen application in the test area, and were banded with the other fertilizer before tomatoes were planted or seeded. About 200 pounds N, 160 pounds P_2O_5 and 160 pounds K_2O per acre were applied to the entire test area as ammonium sulfate, treble super phosphate and muriate of potash. Bands were about 6 inches deep and 6 inches to each side of the row.

Nitrogen source

Effects of source of nitrogen were tested in 1968 and 1970. Nitrogen was supplied as calcium nitrate, potassium nitrate and ammonium sulfate and compared with the no-nitrogen control. The fertilizer was applied at 160 pounds per acre with 160 pounds of P_2O_5 and 160 pounds of K_2O in a band about 6 inches to each side of the row and 8 inches deep before tomatoes were planted.

Sampling

Soil samples were collected at 0- to 8-inch depth and analyzed for nutrients and other soil conditions. Soil samples collected at 12-inch increments to 36-inch depth were analyzed for nitrate and ammonium nitrogen.

Plant samples were analyzed for nitrate nitrogen and phosphate phosphorus soluble in a 2 percent acetic acid solution, total percent potassium, and total parts per million of zinc, iron, manganese, copper

Table 1. Experimental application of micronutrients to tomatoes, 1968 and 1969-70.

Treatment No.	1968*			1969 - 1970**				
	Zinc	Iron	Manganese	Zinc	Iron	Manganese	Copper	Boron
	(Pounds per acre)							
1	0	0	0	0	0	0	0	0
2	10	0	0	10	0	0	0	0
3	10	5	0	0	5	0	0	0
4	10	5	10	0	0	10	0	0
5	10	0	0	10	5	0	0	0
6	10	10	0	10	5	10	0	0
7	10	10	10	10	5	10	5	0
8				10	5	10	5	3

*In 1968, treatments 2, 3 and 4 were applied as sulfates of zinc and manganese. Amounts are pounds of nutrient per acre. Iron in treatment 3 is pounds of chelated material (sequestrene 138) per acre. Treatments 5, 6 and 7 show pounds per acre of material applied as Rayplex (flavonoid) for all micronutrients.

**In 1969-1970, zinc, manganese and copper were applied as sulfates and iron as a chelate (sequestrene 138). Amounts are pounds of nutrient applied. Boron was applied as solubor. Amount is pounds of boron applied.

and boron. Petiole samples were collected on July 19 and August 15 in 1968. The other two years, samples were collected only once, on July 31, 1969, and July 16, 1970.

Petioles were collected from the last mature leaf on the main stem. All plants had set small tomatoes when samples were taken; some tomatoes were beginning to turn red when the August 15 samples were taken in 1968. Because of variations in planting dates, methods of planting, soil temperatures and moisture, growth and development of plants with time differed between years.

Planting

In 1968 and 1970, tomatoes were seeded in the greenhouse and transplanted when about 4 to 10 inches high. In 1968, the plants were transplanted on May 31 in rows 30 inches wide with 16-inch spacing within row. In 1970, the plants were transplanted on May 19 in rows 36 inches wide with 12-inch spacing within row.

In 1969, tomato seed was direct-seeded on May 5 in 30-inch rows. Plants were thinned to 12-inch within row spacing.

Irrigation

Each year, available moisture in seed or plant areas was maintained between 80 to 100 percent until plants became established. After plant establishment, moisture at 10-inch soil depth in center of the row was maintained above 65 percent availability. The last irrigation was applied about one week before first picking of the tomatoes.

Yield and Quality

Tomatoes were picked, counted and weighed to obtain data for treatment evaluation. Number of pickings depended on the year and degree of ripening. Both ripe and green tomatoes were harvested at the last picking before estimated frost.

Readings on curly top infection were made in 1970.

Table 2. Nutrient levels in soil and other soil measurements evaluating productivity of soil, 1968-1970.

	Soil depth 0-8 inches		
Soil variable *	1968	1969	1970
pH	7.23	7.00	7.50
Conductivity, mmhos	----	0.77	0.32
Organic matter, percent	1.49	1.65	1.23
Phosphorus, ppm	16.3	14.4	26.8
Potassium ppm	271	346	231
Zinc, ppm	2.35	1.0	0.10
Manganese, ppm	17.13	5.5	2.87
Iron, ppm	19.13	23.0	7.00
Copper, ppm	1.83	1.2	1.07
Boron,ppm	0.20	0.47	0.31

* Phosphorus and potassium values are from sodium bicarbonate extraction. Zinc, iron, manganese and copper are from the DTPA-TEA extraction, and boron is the hot water soluble extraction.

Table 3. Nitrate and ammonium nitrogen in soil.

	1968		1969		1970	
Soil depth	NO_3	NH_4	NO_3	NH_4	NO_3	NH_4
inches	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
0-12	12.4	4.2	7.4	3.3	3.8	3.6
12-24	4.1	1.3	9.7	3.1	2.1	1.9
24-36	2.1	2.1	3.3	2.3	1.9	2.7
Total	18.6	7.6	20.4	8.7	7.8	8.2

Results and Discussion

Soil Analysis

Most of the nutrients needed by plants are present in the soil at relatively high levels (Tables 2 and 3) at these study sites. Exceptions are the low nitrogen and zinc levels in 1970. Using soil analysis results to predict plant and crop response to fertilizers, both nitrogen and zinc fertilizers should produce some benefits in 1970.

The higher amounts of residual nitrogen in 1968 and 1969 compared with 1970 (Table 3) are a result of nitrogen fertilizer applied to barley stubble in the fall before the soil was sampled. No fertilizer had been applied to the barley stubble in 1970. Differences in zinc between locations result primarily from land leveling that removed surface soil from the 1970 location.

Although other nutrients varied between years and locations, the lower levels would appear to be sufficient to produce tomatoes without additions of commercial fertilizers.

Plant Analysis

Nutrient concentrations in tomato petioles are shown in Tables 4, 5 and 6.

Zinc was the only micronutrient that significantly affected nutrient uptake in tomato petioles (Table 4). This occurred in both 1969 and 1970 where soils were the lowest in zinc. Although zinc in plant petioles was increased by zinc fertilizer applied to soils, the lower 33.5 ppm of zinc in the control appears to be sufficient to produce tomatoes. Other micronutrients in plant petioles varied considerably between locations or years. The low levels of boron in 1970 could be expected to restrict tomato production. Levels of iron, manganese, and copper in the plant appear to be satisfactory for tomato production.

Nitrogen fertilizer increased nitrate nitrogen in plant petioles all three years, with levels ranging from 707 up to 7,617 ppm (Table 5). This indicates that plant analysis is a satisfactory method of determining nitrogen status in soils. In 1969 and 1970, zinc levels in the plant petioles were significantly increased by the 320-pound nitrogen rate. The manganese content of tomato petioles was also increased with increased nitrogen rates all three years.

Ammonium sulfate increased both the zinc and manganese content of tomato petioles compared with calcium nitrate and potassium nitrate (Table 6). These data indicate that banding ammonium sulfate fertilizer will increase concentrations of zinc and manganese in plants and may be an effective way of increasing the availability of these nutrients in soils to the plants. This appears to be more effective than applying the nutrients as commercial fertilizers.

Greenhouse studies in 1970 indicated that tomato plants growing in pots were larger and set tomatoes earlier when fertilized with calcium nitrate and potassium nitrate than with ammonium sulfate. In

Fig. 1. Effects of nitrogen fertilizer are apparent in the growth of tomatoes in the experimental plots. The plants in the center row received no nitrogen fertilizer. The filled-in rows at right had received supplemental nitrogen.

Table 6. Nutrient concentration in tomato petioles as affected by nitrogen source, 1968 and 1970.

Nitrogen source	Nutrients in petioles (ppm)							%
	NO_3-N	PO_4-P	Zn	Fe	Mn	Cu	B	K
				1968				
Calcium nitrate	2,187	3,375	48.8	121.9	54.6a •	12.2	25.0	5.71
Ammonium sulfate	2,312	2,875	52.5	120.3	90.6b	11.6	22.0	5.33
				1970				
Control	1,583a •	4,375	37.9a	131.3	44.2a	10.8	15.0	6.27
Calcium nitrate	3,350b	4,229	33.6a	109.4	44.0a	12.3	16.0	5.85
Potassium nitrate	4,000b	4,208	34.6a	70.9	42.5a	11.9	14.0	5.93
Ammonium sulfate	4,333b	3,917	41.7b	100.0	91.2b	10.4	16.0	6.05

• Means within groups with different letters are significantly different ($P \leq .05$). Unmarked means do not differ significantly.

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Total	18.6	7.6	20.4	8.7	7.8	8.2

In 1968, 80 pounds of nitrogen increased total yield of ripe tomatoes about 5.34 tons per acre over the control. No significant difference in yield was shown between 80 pounds N and higher rates. In 1969, nitrogen fertilizer reduced yield and number of ripe tomatoes at the first picking date but increased the yield at the second picking date. There was no significance between nitrogen rates on total yield of ripe tomatoes. Nitrogen fertilizer increased yield of green tomatoes and yield of all tomatoes. This yield effect appeared to be due to larger vines and more total tomatoes. In 1970, yield of ripe tomatoes at the second and third picking dates, total yield and yield of green tomatoes were increased by nitrogen fertilizer. More tomatoes per plant were produced with increased nitrogen rates.

These data demonstrate that the nitrogen fertility in the soil was higher in 1968 and 1969 than in 1970. Both soil and plant analyses show lower levels of nitrogen in 1970 as would be expected since 120 pounds of nitrogen per acre had been applied to the barley stubble in 1968 and 1969, but not in 1970.

Using the total nitrate nitrogen in the top three feet of soil as a guide to the nitrogen need in tomato production, about 20 ppm appears to be sufficient. In 1970 where soil nitrate nitrogen was about 8 ppm,

Table 8. Affects of nitrogen fertilizer rates on total yield of tomatoes, 1968-1970.

Rate of nitrogen	Ripe tomatoes per plant					Green tomatoes	Total per plant
	Picking*						
	1st	2nd	3rd	4th	Total		
(lb/acre)			(Tons per acre)				
			1968				
0	2.04	1.63	3.94	7.22	14.83a**	11.19	26.02
80	5.42	3.07	4.21	7.37	20.07b	7.63	27.70
160	3.02	2.55	5.34	8.64	19.55b	11.39	30.94
320	4.01	3.35	3.99	8.32	19.67b	9.46	29.13
			1969				
0	10.67b	24.93a	—	—	35.60	16.87a	52.47a
80	8.53a	28.53c	—	—	36.06	27.07b	64.13b
160	7.66a	27.40abc	—	—	35.06	32.93c	67.99b
320	7.33a	25.87ab	—	—	33.20	37.40d	70.60b
			1970				
0	8.23	10.04a	13.69a	—	31.96a	6.31a	38.27a
80	10.80	16.11c	19.01b	—	45.92b	8.13a	54.05b
160	9.67	15.49c	21.12b	—	46.28b	11.74b	58.82b
320	8.04	13.15b	20.80b	—	41.99b	12.00b	53.99b

* Picking dates in 1968 were August 15, 22, 29 and September 6; in 1969, September 5, 16 and 22; in 1970, August 19, 22 and September 3.

** Means having different letter within groups differ significantly ($P \leq .05$). Groups with no letter subscript do not differ significantly.

80 pounds of nitrogen per acre produced 45.92 tons of ripe tomatoes per acre, 13.96 tons more than the control. There is some evidence that higher rates of nitrogen delayed maturity of tomatoes (1969) and increased tons of green tomatoes (1969 and 1970).

Using plant analyses as a guide for nitrogen needs, levels below 1,500 ppm in plant petioles, taken at early tomato set, would appear to be deficient.

Yield increases from nitrogen fertilizer appear to be related to both size and number of tomatoes per plant. Although yield and number of tomatoes per plant were not affected by source of nitrogen, the banding of ammonium sulfate did increase concentration of zinc and manganese in tomato petioles when compared with calcium and potassium nitrate fertilizer. This increase was greater than that produced by zinc and manganese fertilizers. These data suggest that banding a fertilizer such as ammonium sulfate would be an effective way to provide zinc and manganese nutrition for tomatoes where soils indicate a need for these fertilizers.

Since phosphorus and potassium fertilizers did not significantly affect yield or number of tomatoes per plant, the levels shown in soil and plant apparently are sufficient to produce tomatoes at these locations. For phosphorus, this level is about 14 ppm in the soil and about 2,677 ppm of phosphate phosphorus in plant petioles. For potassium, this level is about 231 ppm in the soil and about 5.23 percent potassium in plant petioles.

Table 9. Affects of nitrogen fertilizer rates on numbers of tomatoes produced per plant, 1968-1970.

Rate of nitrogen	Ripe tomatoes per plant: Picking 1st	2nd	3rd	4th	Total	Green tomatoes	Total per plant
(lb/acre)							
				1968			
0	1.32	0.94	2.84	7.47	12.60	15.06	27.63
80	3.94	1.97	3.55	6.56	16.02	11.54	27.56
160	1.79	1.36	3.58	8.03	14.76	17.48	32.24
320	2.68	2.01	3.04	8.32	16.05	15.11	31.16
				1969			
0	7.2c*	17.7	—	—	24.9b	16.1a	41.0a
80	5.8b	19.2	—	—	25.0b	26.1b	51.1b
160	4.5a	18.1	—	—	22.6a	33.6c	56.2bc
320	4.6a	16.4	—	—	21.0a	38.4c	59.4c
				1970			
0	5.2	6.9	9.5a	—	21.6a	7.0a	28.6a
80	6.1	8.4	11.4b	—	25.9b	7.6a	33.5b
160	5.6	8.2	12.9c	—	26.7b	11.1b	37.8c
320	5.0	7.5	12.6c	—	25.1b	11.1b	36.2c

* Means having same letter within groups do not differ significantly ($P \leq .05$). Groups with no letter subscript do not differ significantly.

The largest variation in yield of tomatoes was shown between years. Yields of ripe tomatoes were about 18.5, 35.2 and 41.5 tons per acre for 1968, 1969 and 1970, respectively. The lower yield in 1968 was due primarily to a cool wet period in late July and early August which delayed growth and restricted yield. Over 4 inches of rain fell in a 2-week period.

Some curly top was present each year. There appeared to be no correlation between curly top infection and fertilizer treatment. In 1970 about 8 percent of the plants were infected with curly top.

Yield, number of tomatoes per plant and percent curly top were not affected by source of nitrogen at the 5 percent level of significance. While data are not tabulated here, the source-of-nitrogen plots produced about 45 tons of ripe tomatoes and 7 tons of green ones or a total of 52 tons per acre.