Rates of Nitrogen and Irrigation for Tomatoes[1]

B. D. Doss, C. E. Evans, and W. A. Johnson[2]
Agricultural Research Service, U. S. Department of Agriculture, and Auburn University, Auburn, AL

Abstract. Marketable tomato yields were influenced more by applied N than by irrigation. Irrigation increased total marketable tomato yields only at the intermediate level. Average yields for the 3-year period by soil water regimes were about 58,300, 70,000, and 68,900 kg/ha for no, intermediate, and high irrigation, respectively. Applied N increased yields, but the increase was limited mainly to the lowest application rate (65 kg/ha) in 1971 and 1972, and to the 2 lowest rates (65 and 130 kg/ha) in 1973. Average yields for the test period by N application rates were about 53,500, 67,100, 69,900, 70,600 and 67,600 kg/ha for 0, 65, 130, 195, and 260 kg/ha rates, respectively. These data indicate that the best combination of N rate and soil water regime was 65 to 130 kg/ha of applied N and supplemental irrigation as needed to maintain 30% or more available water in 0 to 60 cm soil depth.

Vegetable crops, such as tomatoes, are promising material for intensive production practices including supplemental irrigation and high rates of fertilization, but information on their response is limited. Common tomato production problems are stem-end or shoulder cracking and poor shelf life when an extended period of rain follows a drought. Irrigation and N fertilizer not only affect tomato yield, but may also influence their quality and general appearance, factors of prime importance in shelf life and consumer acceptance.

Many fertilizer experiments have been conducted with vegetables, but information on the actual effect of applied N on tomato yield is limited (8, 9). Vegetable crops are frequently fertilized at excessive rates to obtain maximum yields, however, the desired effect is not always realized. Blossom-end rot of tomatoes has been attributed both to climatic stress (3) and to Ca deficiency caused by excessive N and by high soluble salts in the soil (2). Sims et al. (6) found that tomatoes grown at high N applications had the shortest shelf life. Several experiments have been conducted with tomatoes involving fertility, spacing, and irrigation (4, 5, 6, 7, 8). Generally, high fertilization and close spacing increased yield, but reduced fruit size. Irrigation partially alleviated the reduced fruit size in closely-spaced plantings, and improved the color of the ripe fruit. Soluble solids were reduced by high irrigation levels, while both irrigation and high fertilization reduced firmness. Moore et al. (4) reported that maximum returns from supplemental irrigation were obtained by maintaining the available soil moisture above 50% in conjunction with close spacing. Bible et al. (1) reported that mist irrigation increased yields of marketable tomatoes by 31 to 50%.

In humid areas normal rainfall may not have the seasonal distribution needed for maximum yields. Even though the total rainfall is high and sometimes excessive, there frequently are drouth periods which result in water stress on plants, and supplemental irrigation to eliminate this water stress may be beneficial.

The purpose of this experiment was to determine the best combination of supplemental irrigation and applied N rates to obtain the most profitable yields of marketable tomatoes.

Materials and Methods

In 1971 and 1972 'Homestead 24' and in 1973 'Tropic' were grown at 3 soil water regimes with 5 N application rates on a Lucedale fine sandy loam soil (Rhodic Paleudult) in central AL. Variables were arranged in 3 replications of a split-plot design with soil water regime as main plots and N rates as subplots.

The 3 soil water regimes tested were (a) no irrigation, (b) irrigation when 70% (intermediate irrigation), and (c) irrigation when 40% (high irrigation) of the available soil water had been removed from the surface 60 cm of soil. Soil water suction was 2 bars for the intermediate treatment and 0.67 bar for the high treatment. Plants were furrow-irrigated in sufficient amounts to replenish the surface 60 cm of soil to field capacity. Available water-holding capacity of the soil was approximately 1 cm/dm of soil. A dike was constructed around each plot to confine all rainfall and irrigation water. Irrigations were based on readings from gypsum soil moisture blocks. In some cases rainfall occurred immediately after irrigation and resulted in excessive water in the soil profile for short periods of time.

The 5 N application rates were 0, 65, 130, 195, and 260 kg/ha. All tomatoes were adequately fertilized with P and K according to soil test, and plants were set in mid-April. Plants were staked and tied with twine when approximately 45 cm high and tied with additional twine as they grew higher. Fruits were harvested weekly from late June until late August and sprayed weekly throughout the season with insecticides (cygon and sevin) and fungicide (dithane M45).

The long-time average rainfall for mid-April to mid-August period for this location is 50 cm. Rainfall during the test period was about 95, 60, and 94% of normal for 1971, 1972, and 1973, respectively. Rainfall during July (normally 15 cm) was 149, 23, and 71% of normal for 1971, 1972, and 1973. The intermediate soil water regime received 2 irrigations per season for a total of 10 cm in 1971, 4 irrigations for a total of 19 cm in 1972, and 4 irrigations for a total of 20 cm of water in 1973. The high regime received 6, 10, and 8 irrigations, with totals of 19, 32, and 25 cm of water for 1971, 1972, and 1973, respectively.

Results and Discussion

Plant height. Rate of plant growth early in the season and plant height at the beginning of harvest were influenced more by N rate than by soil water regime (Fig. 1). The average height of plants at the beginning of harvest for the 3-year period shows that most of the increased height resulted from the first increment of N (65 kg/ha) with little or no additional effect at 130 and 195 kg/ha of N. At rates of N up to 195 kg/ha, soil water regime had little effect on plant heights, however, at 260 kg/ha of N, plant height was increased by increasing the irrigation level. At 260 kg/ha of N, plant height was 84 cm without irrigation, 90 cm with intermediate irrigation, and 100 cm with high irrigation.

Marketable yields. Marketable tomato yields, as affected by irrigation and N rate, are shown in Fig, 2, 3, and 4 for 1971, 1972, and 1973, respectively. Yields varied considerably from year to year. Yields were highest in 1972 and lowest in 1971. Maximum yearly yields of irrigated tomatoes were about 62,00, 106,00 and 78,000 kg/ha for 1971, 1972, and 1973, respectively. During the growing season irrigated tomato yields were inversely related to rainfall,

[1] Received for publication November 6, 1974. Contribution from Soil and Water Research, Southern Region, Agricultural Research Service, U. S. Department of Agriculture; and Departments of Agronomy and Soils and Horticulture, Auburn University Agricultural Experiment Station, Auburn, AL.

[2] Soil Scientist, USDA; Associate Professor, Department of Agronomy and Soils; and Assistant Professor, Department of Horticulture, Auburn University, Auburn, AL.

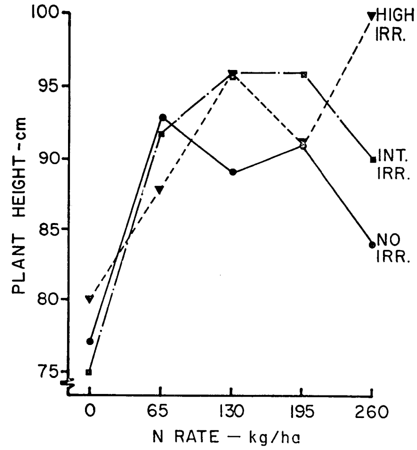

Fig. 1. Plant heights of tomatoes at beginning of harvest as affected by irrigation and applied N (Averages 1971–73).

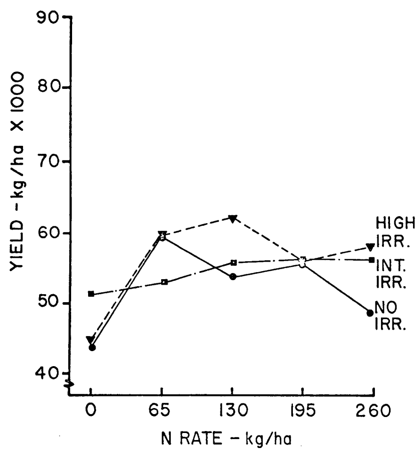

Fig. 2. Marketable tomato yields in 1971 as affected by irrigation and applied N.

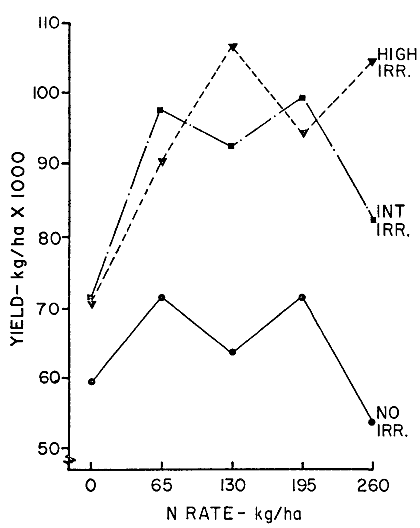

Fig. 3. Marketable tomato yields in 1972 as affected by irrigation and applied N.

especially during July, which probably resulted from the greater amount of sunlight, since irrigation supplied adequate water.

The N rate had an effect on total marketable yields in 1971 and 1972, but not in 1973 (Table 1). Irrigation affected total marketable yields in 1972 only (Table 2). Yields for the high soil water regime during 1973 were lower than for the other regimes, except at the highest N rate, where yields increased as irrigation increased. The lower yields in 1973 for the high soil water regime at the lower N rates (Fig. 4) were probably due to disease during the season (Fig. 5). The percentage of dead plants from disease at the 65, 130, and 195 kg/ha rate was higher on high-irrigation plots than on no-irrigation or intermediate-irrigation plots. The percentage of dead plants from disease decreased as N rate increased. The percentage of dead plants at the end of the 1973 growing season ranged from 2 to 53.

Table 3 is a summary of main effects of irrigation and N rate on marketable yields. An overall average for the 3-year period shows that intermediate irrigation increased yields by approximately 11,000 kg/ha over no irrigation, but showed little difference between yields at intermediate and high irrigation. The lowest rate of applied N (65 kg/ha) increased yields by about 14,000 kg/ha over no N. Additional increments of applied N resulted in little to no increase in yield. Total average marketable yields ranged from approximately 50,000 kg/ha with no N and no irrigation to approximately 80,000 kg/ha at the 260 kg/ha N rate and high irrigation.

Cull tomato yields were affected little by either applied N or irrigation. The overall average showed that cull tomatoes made up approximately 14% of the total yield. Most cull tomatoes were from catfacing, which is probably not greatly affected by soil fertility or irrigation treatments.

Fruit size. Both N rate and irrigation affected marketable yields by fruit sizes (Tables 1 and 2). An average for all treatments for all years shows that 70% of marketable tomatoes were large (5 × 6), 16% were medium (6 × 6), and 14% were small (6 × 7). In general, the percent of large tomatoes (5 × 6) increased as irrigation increased, and the percent of large tomatoes decreased as applied N increased.

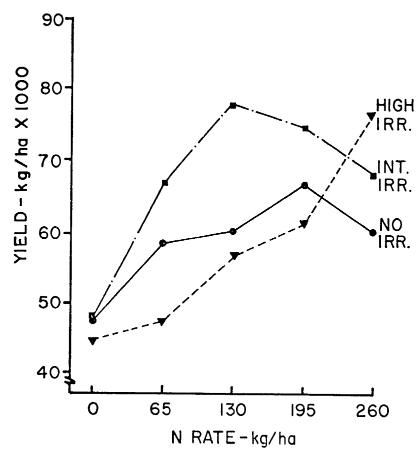

Fig. 4. Marketable tomato yields in 1973 as affected by irrigation and applied N.

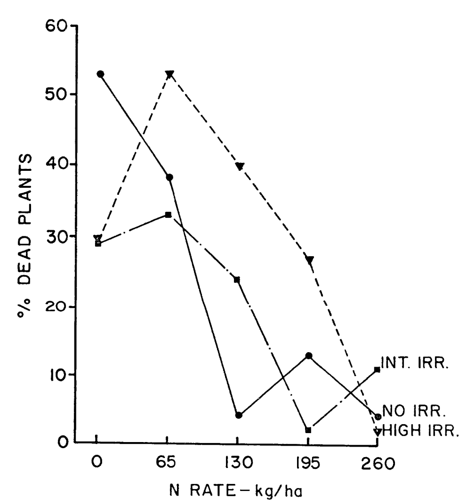

Fig. 5. Percent dead plants at end of 1973 harvest season as affected by irrigation and applied N.

Table 1. Marketable tomato yields by fruit size as affected by applied N.

N rate	Yield by fruit size[z]											
	1971				1972				1973			
	5 x 6	6 x 6	6 x 7	Total	5 x 6	6 x 6	6 x 7	Total	5 x 6	6 x 6	6 x 7	Total
						kg/ha						
0	37,180b[y]	6,280a	3,130b	46,590b	42,170a	12,750b	12,280b	67,200b	36,090a	5,200c	5,370c	46,660a
65	46,600a	6,900a	3,890ab	57,390a	53,780a	16,250ab	16,420ab	86,450a	44,530a	7,020bc	5,950bc	57,500a
130	45,550a	7,440a	4,310ab	57,300a	54,970a	16,230ab	16,260ab	87,460a	46,550a	8,940abc	9,460ab	64,950a
195	45,210a	7,110a	3,710ab	56,030a	54,240a	17,830a	16,230ab	88,300a	46,570a	10,810ab	10,110a	67,490a
260	42,180ab	7,570a	4,540a	54,290a	46,850a	16,410ab	16,850a	80,110a	46,480a	11,900a	9,940a	68,320a

[z]5 x 6-diameter 6.8 cm and larger
6 x 6-diameter 6.4–7.3 cm
6 x 7-diameter 5.1–6.7 cm
[y] Values within a column followed by the same letter are not significantly different at the 5% level.

Table 2. Marketable tomato yields by fruit size as affected by irrigation.

Soil water regime	Yield by fruit size[z]											
	1971				1972				1973			
	5 x 6	6 x 6	6 x 7	Total	5 x 6	6 x 6	6 x 7	Total	5 x 6	6 x 6	6 x 7	Total
						kg/hg						
No irrigation	40,180a[y]	7,750a	4,420a	52,350a	34,770b	14,560a	14,640a	63,970b	39,320a	8,720a	10,650a	58,690a
Intermediate irrigation	43,730a	7,080a	3,670a	54,480a	56,420a	16,050a	16,010a	88,480a	48,620a	9.740a	7,560ab	66,902a
High irrigation	46,120a	6,350b	3,650a	56,120a	60,000a	17,080a	16,170a	93,250a	43,190a	7,860a	6,290b	57,340a

[z]5 x 6-diameter 6.8 cm and larger
6 x 6-diameter 6.4–7.3 cm
6 x 7-diameter 5.1–6.7 cm
[y] Values within a column followed by the same letter are not significantly different at the 5% level.

Table 3. Summary of main effects of irrigation and N rate on marketable tomato yields (av. 1971–73).

N rate	No irrigation	Intermediate irrigation	High irrigation	Av.
		kg/ha		
0	50,120	56,790	53,520	53,480
65	63,400	72,240	65,660	67,100
130	59,240	75,290	75,140	69,890
195	64,730	76,700	70,360	70,600
260	54,160	68,740	79,780	67,560
Av.	58,330	69,950	68,890	65,720

Conclusion

Tomatoes were grown for 3 years including 1 year with above-normal rainfall during the growing season and 2 years with below-normal rainfall. Irrigation increased total marketable tomato yields in 1972 only, but tended to increase total yields in other years by increasing yields of at least one fruit size. The yield increase from irrigation was limited to the intermediate irrigation level with little difference between yields of intermediate and high irrigation levels. Applied N increased marketable yields all years, but the increase was limited to the lowest application rate (65 kg/ha) in 1971 and 1972, and to the 2 lowest application rates (65 and 130 kg/ha) in 1973. Data from this experiment indicated that the best combination of N rate and soil water regime is 65 to 130 kg/ha of applied N and supplemental irrigation as needed to maintain 30% or more available water in the 0- to 60-cm soil depth.

Literature Cited

1. Bible, B. B., R. L. Cuthbert, and R. L. Carolus. 1968. Response of some vegetable crops to atmospheric modifications under field conditions. *Proc. Amer. Soc. Hort. Sci.* 92:590–594.
2. Geraldson, C. M. 1957. Cause and control of blossom-end rot of tomatoes. *FL Agr. Exp. Sta. Cir.* S-101.
3. Gerard, C. J., and B. W. Hipp. 1968. Blossom-end rot of 'Chico' and 'Chico Grande' tomatoes. *Proc. Amer. Soc. Hort. Sci.* 93:521–531.
4. Moore, J. N., A. A. Kattan, and J. W. Fleming. 1958. Effect of supplemental irrigation, spacing, and fertility on yield and quality of processing tomatoes. *Proc. Amer. Soc. Hort. Sci.* 71:356–368.
5. Ogle, W. L., K. B. Mack, and W. P. Cook. 1964. Tomato fertilization in Coastal South Carolina. *SC Agr. Exp. Sta. Bul.* 512.
6. Sims, E. T., Jr., W. L. Ogle, D. O. Ezell, and K. B. Mack. 1963. The influence of nitrogen, potassium and calcium on quality and postharvest physiology of tomatoes. *Assoc Southern Agr. Workers Proc.* 60:233–234.
7. Vittum, M. T., and W. T. Tapley. 1957. Spacing and fertility level studies with a paste-type tomato. *Proc. Amer. Soc. Hort. Sci.* 69:323–326.
8. Ware, L. M. and W. A. Johnson. 1949. Fertilizer studies with vegetable crops on representative soils. *AL Agr. Exp. Sta. Bul.* 269.
9. Wight, J. R., J. C. Lingle, W. J. Flocker, and S. J. Leonard. 1962. The effects of irrigation and nitrogen fertilization treatments on the yield, maturation, and quality of canning tomatoes. *Proc. Amer. Soc. Hort. Sci.* 81:451–457.