External and Internal Blotchy Ripening and Fruit Elemental Content of Trickle-irrigated Tomatoes as Affected by N and K Application Time

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Abstract. Tomatoes (Lycopersicon esculentum Mill.) were grown on polyethylene-mulched beds of an Arrendondo fine sand during two seasons to evaluate the effects of trickle irrigation-applied N and/or K, percentages of trickle-applied nutrient(s) (50%, 75%, and 100%), and schedules of nutrient application (variable, 2% to 12.5% of total amount weekly, or constant, 8.3% of the total amount weekly) on the occurrence of fruit external and internal blotchy ripening and fruit mineral nutrient concentration. Trickle-applied fertilizer was injected into the irrigation water weekly during the first 12 weeks of each season. External and internal blotchy ripening were less severe with trickle-applied N supplied as N + K or N than with preplant-applied N. Trickle-applied N + K or N resulted in higher fruit concentrations of N, P, K, Ca, and Mg than with all preplant-applied N. Internal fruit quality improved slightly as the trickle-applied percentage of N and/or K increased from 50% to 100%, but significant differences in exterior quality were not obtained. Internal fruit quality was higher early in the season than late in the season during both years, but this response was not associated with fruit elemental concentration. The weekly schedule of nutrient injection had no significant effect on fruit quality or fruit elemental concentration. Highest yields of high-quality fruit were obtained with 50% trickle-applied N + K.

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Additional tissue preparation for nutrient analyses of leaf and shoot tissue was performed as described by Dangler and Locascio (1990).

The experimental design was a split-split-split plot arranged in a randomized complete-block design with four replications. Main-plot treatments were years and subplot treatments were factorial combinations of trickle-applied N and/or K, percentages of trickle-applied nutrient(s) (50%, 75%, and 100%), and schedules for nutrient application (variable, 2% to 12.5% weekly, and constant, 8.3% weekly). Harvest period was analyzed as a sub-subplot treatment.

Results and Discussion

The occurrence of blotchy ripening was low during the 2 years but was influenced significantly by year, trickle-applied nutrient, percentage of trickle-applied nutrient, and time of harvest, but not weekly schedule of nutrient application (Table 1). External blotchy ripening was slightly less severe in 1985 than in 1984, while the difference in internal blotchy ripening was more substantial, but in the reverse direction. Interior blotchy ripening was a more-severe blemish than exterior blotchy ripening in these and in other studies (Picha and Hall, 1981).

In both years, external and internal blotchy ripening were less severe with trickle-applied N + K than with either N or K trickle-applied individually. Also, blotchy ripening was less severe with trickle-applied N than with trickle-applied K (all N preplant-applied) (Table 1).

The trickle-applied percentage of nutrients had no effect on external blotchy ripening but had a small significant effect on interior blotchy ripening (Table 1). Internal blotchy ripening decreased linearly from a rating of 3.2 to 3.0 as the percentage of trickle-applied nutrients was increased from 50% to 100%.

Harvest period and year interacted in their effects on interior and exterior fruit quality (Table 2). In 1984, exterior blotchy ripening was less severe at midseason than at the early and late harvests; but in 1985 exterior blotchy ripening was less severe at the early and late harvests than at midseason. In both years, interior quality was consistently better earlier in the season than at the late harvest.

Higher fruit N, P, K, Ca, and Mg concentrations were obtained with trickle-applied N + K and N than with trickle-applied K (Table 1). Fruit K concentrations obtained with trickle-applied N + K and N were 4.40% and 4.11%, respectively, whereas the K concentration with trickle-applied K was 3.99%. Trickle-applied N was, therefore, more important than trickle-applied K for uniform fruit ripening and improved marketability of tomatoes, even though the ripening response appeared to be associated with an increase in fruit K concentration. Results of previous work showed a reduction in the severity of blotchy ripening with an increase in fruit (Picha and Hall, 1981) or leaf (Corey et al., 1986; Ozburn et al., 1967; Winsor et al., 1961) K concentration. The higher fruit K concentration obtained with trickle-applied N + K than with trickle-applied N or K in the studies reported here could not be explained by an increase in plant growth because shoot fresh and dry weights were not significantly affected by the trickle-applied nutrient treatment (data not shown). The fruit K concentrations (4.77% and 3.55%, mean values in 1984 and 1985, respectively) were higher than concentrations reported with similar amounts of preplant-applied fertilizer K (=2.5% to 3.5% K) (Picha and Hall, 1981; Picha, 1987).

Table 1. Main effects of year, trickle-applied nutrient(s), percentage of nutrient(s) trickle-applied, schedule of nutrient application, and harvest period on tomato fruit quality and composition.

| Treatments | Blotchy ripening rating* | Mineral concn (%) | Dry wt (%) |
|------------|--------------------------|-------------------|------------|
|            | External | Internal | N | P | K | Ca | Mg |           |
| Year (Yr)  |          |          |   |   |   |    |    |           |
| 1984       | 1.9      | 2.9      | 2.91 | 0.63 | 4.77 | 0.17 | 0.25 | 4.0 |
| 1985       | 1.7      | 3.4      | 2.99 | 0.44 | 3.55 | 0.14 | 0.21 | 4.5 |
| Significance | *       | **       | NS | *** | *** | ** | *** |     |
| Nutrients applied |          |          | N + K | 1.6 c | 2.8 c | 3.00 b | 0.54 a | 4.40 a | 0.16 b | 0.23 a | 4.3 a |
| |          |          | N | 1.8 b | 3.1 b | 3.06 a | 0.55 a | 4.11 b | 0.17 a | 0.23 a | 4.2 b |
| |          |          | K | 2.0 a | 3.5 a | 2.79 c | 0.51 b | 3.99 c | 0.14 c | 0.21 b | 4.3 a |
| Trickle-applied (%) |          |          | 50 | 1.8 | 3.2 | 2.86 | 0.53 | 4.14 | 0.14 | 0.22 | 4.3 |
| |          |          | 75 | 1.9 | 3.1 | 2.99 | 0.54 | 4.23 | 0.16 | 0.23 | 4.2 |
| |          |          | 100 | 1.7 | 3.0 | 3.00 | 0.53 | 4.13 | 0.17 | 0.22 | 4.1 |
| Significance | NS | L*** | Q* | NS | Q* | L* | Q* | L* |
| Schedule |          |          | Variable | 1.8 | 3.1 | 2.99 | 0.53 | 4.18 | 0.16 | 0.23 | 4.2 |
| |          |          | Constant | 1.8 | 3.2 | 2.92 | 0.53 | 4.15 | 0.16 | 0.22 | 4.2 |
| Significance | NS | NS | NS | NS | NS | NS | NS | NS |
| Harvest period (H) |          |          | Early | 1.7 b | 3.0 b | 2.95 | 0.54 a | 4.32 a | 0.17 a | 0.23 a | 4.1 c |
| |          |          | Mid | 1.7 b | 2.9 b | 2.94 | 0.55 a | 3.99 c | 0.16 a | 0.22 b | 4.2 b |
| |          |          | Late | 1.8 a | 3.5 a | 2.97 | 0.51 b | 4.19 b | 0.15 b | 0.22 b | 4.4 a |
| Yr × H significance | *** | *** | *** | *** | *** | *** | *** |

*Mean separation in columns by Duncan’s multiple range test at P = 0.05. Absence of letter indicates no significance.

*External and internal blotchy ripening ratings were 1) blotch-free; 2) 1% to 5% blotchy; 3) 6% to 25% blotchy; 4) 26% to 50% blotchy; and 5) >50% blotchy.

NS,*,**,***Main effects or interactions were nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively. Significant responses to percentage of nutrients trickle-applied were linear (L) or quadratic (Q).
Consistent patterns of fruit nutrient accumulation at the various harvest periods were not obtained. Unlike nutrient accumulation throughout the season, the elemental K concentrations at the harvest periods could not be associated with fruit quality. Although significant differences in fruit dry weight percentages were obtained among harvest periods, the relationship between this characteristic and fruit quality or fruit nutrient concentration was not evident. Results of previous work showed that the dry-matter content of blotchy-ripened whole fruit (Winsor and Massey, 1958) and yellow-shoulder tissue fruit (Picha and Hall, 1981) was lower than the dry-matter content of red-ripe fruit.

Fruit quality and nutrient concentration were not significantly affected by the weekly schedule of fertilizer application. It appeared that high-quality fruit was obtained as long as small portions of the total N and K were supplied to the plant late in the season, because there were no significant differences in quality between the constant and variable application schedules, and the effect of increasing the percentage of trickle-applied nutrients from 50% to 100% was small.

The mean total marketable yield at the early harvest decreased linearly from $\approx 25.4$ t·ha$^{-1}$ to $16.3$ t·ha$^{-1}$ as the percentage of trickle-applied N + K or N increased from 50% to 100% (Dangler and Locascio, 1990). Similar responses were obtained for yields of large fruit at the midseason and total harvest periods. Since highest yields were associated with 50% trickle-applied N + K and N, and the results of the fruit quality study reported here indicate high exterior and interior fruit quality was obtained with trickle-applied N + K (no interaction with trickle-applied percentage), the results of these studies taken together indicate the greatest yield of high-quality fruit was obtained with 50% trickle-applied N + K.

Although the average fruit evaluated in these studies was not severely blotched, marketable fruit should be blotch-free. Therefore, the small, significant differences in the severity of internal and external blotchy ripening (10% to 20%) obtained by manipulating the time of N and K fertilizer applied through the trickle system can significantly affect tomato marketability. Highest fruit quality was obtained with 50% to 100% trickle-applied N + K. The elemental concentration, especially K, was greater in higher quality fruit than in blotchy fruit. Higher internal fruit quality was obtained early rather than late in the season. Results of the ripening study reported here, and a tomato yield study reported elsewhere, indicate that highest yield of high-quality fruit was obtained with 50% trickle-applied N + K.

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