Fertility management in drip-irrigated processing tomato production
Nutrient uptake dynamics in drip-irrigated fields:
- 6 fields in 2007-08 FREP project (N/P/K, Hartz et al.)
- 14 fields in 2013 CTRI-sponsored project (N only, Horwath et al.)

Field locations:
- 8 Sacramento Valley
- 4 mid Valley/Delta
- 8 San Joaquin Valley
Fruit yield and N fertilizer application in monitored fields

Mean 56 tons/acre total fruit yield

Mean 190 lb N/acre seasonal N application
How much N does a tomato crop take up, and how is it partitioned?

- Fruit N content ranged from 1.9 - 3.6 lb N/ton, averaging 2.8 lb/ton
- Fruit represented 60-70% of total N uptake in most fields

**Means**
- 253 lb N total
- 156 lb N fruit
- 97 lb N vine
Seasonal N uptake pattern:

- Peak N uptake about 4-5 lb/acre/day

N partitioning:
How much N do high-yield tomatoes *need* to take up?

Assumptions:
- Fruit contains 2.6 lb N/ton
- Fruit represents 62% of crop N uptake

Note: this overstates actual N requirement because some of the survey fields had substantial luxury N uptake; N uptake requirement > 300 lb N/acre unlikely
- Soil residual NO$_3$-N varied from 23-219 lb/acre, averaged 80 lb/acre
- Grower N application did not reflect this difference; ranged from 115-320 lb/acre, averaged 190 lb/acre

Data only from Horwath et al., 2013
Simplified N balance:

N application – crop N uptake

- Processing tomato typically recovers a significant amount of soil N
  - residual soil NO$_3$-N
  - in-season soil N mineralization
If efficiently fertilized, N loading to the environment can be minimized.
N management guidelines:
- Develop a fertigation template based on realistic yield potential, and soil type (in-season N mineralization potential)
- Determine residual soil NO₃-N early in the season, and modify the template to reflect the residual, primarily by delaying / reducing fertigation on the front end
- If irrigation water NO₃-N is high, adjust for N content

Bottom line:
The need for > 200 lb/acre seasonal N application is uncommon
How about Phosphorus and Potassium?

- Uptake pattern roughly similar to N, but of different magnitude

- P uptake varies from approximately 70-100 lb P$_2$O$_5$/acre
- K uptake varies more widely (250-500 lb K$_2$O/acre) depending on yield and soil K supply
How does drip irrigation change P and K management?

<table>
<thead>
<tr>
<th></th>
<th>Full bloom stage</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1996-97 furrow fields</td>
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<tr>
<td>Yield</td>
<td>38 tons</td>
</tr>
<tr>
<td>Leaf P</td>
<td>0.38%</td>
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<tr>
<td>Petiole P</td>
<td>2,700 PPM</td>
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<tr>
<td>Leaf K</td>
<td>2.8%</td>
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<tr>
<td>Petiole K</td>
<td>6.8%</td>
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<tr>
<td>Fruit K</td>
<td>5.2%</td>
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</tbody>
</table>

P and K fertilizer requirements will likely be higher than with furrow irrigation.
When:
- preplant, or at planting; with appropriate management, in-season application should not be necessary

How:
- get at least some P close to the transplant to support early growth

How much:
- soil test between > 15 PPM Olsen P
  - *fruit removal rate* (50-70 lb P$_2$O$_5$/acre) usually adequate
- soil test < 10 PPM Olsen P
  - *crop removal rate*, or more (> 80 lb P$_2$O$_5$/acre)
Potassium is the most commonly deficient element in California tomato fields:

2007-08 fields:

![Graph showing potassium uptake in different exchangeable soil K (PPM) levels.](image-url)
Predicting response to K fertilization

Soils tests give K availability both as PPM, and % of cation saturation

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Exchangeable cations (PPM)</th>
<th>Percent cation saturation</th>
<th>Cation exchange capacity (meq/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K</td>
<td>Ca</td>
<td>Mg</td>
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<tr>
<td>Smith Block 7</td>
<td>70</td>
<td>1147</td>
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<td>331</td>
<td>4325</td>
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<td>Miller Block 4</td>
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<td>878</td>
<td>187</td>
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<tr>
<td>Ruiz Block 1W</td>
<td>416</td>
<td>2826</td>
<td>436</td>
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</tbody>
</table>

K fertilizer recommendation is an inexact science:
- < 150 PPM exchangeable K - yield response likely
- 150-200 PPM K, ≤ 2.5% cation saturation - good chance of yield response
- > 200 PPM, > 2.5% - declining chance of yield increase
K fertilization

When:
- during fruit set

How much:
- first 100 lb $K_2O$/acre will be the most effective
- applying less than fruit K removal reduces long-term soil K supply
Can K fertigation reduce fruit color disorders?

Yes, but ‘curing’ color disorders may take an impractical amount of K
Can tissue analysis guide N fertigation management?

Leaf total N
- overall crop N status

Petiole NO$_3$-N
- NO$_3$-N taken up but not yet assimilated into organic compounds
High yield fields
(60+ tons total fruit yield)
Petiole $\text{NO}_3\text{-N}$ affected by environmental variability

![Graph showing the effect of nitrogen levels on petiole $\text{NO}_3\text{-N}$ over weeks after transplanting.](image)

- **Deficient N 2007**
- **Adequate N 2007**
- **Deficient N 2008**
- **Adequate N 2008**
- **Sufficiency level**

Y-axis: Petiole $\text{NO}_3\text{-N}$
X-axis: Weeks after transplanting
Bottom line on plant N testing:

- Leaf total N gives a good snapshot of current crop N status but, if it is in the ‘adequate’ range, does not ‘project forward’ more than 7-10 days to predict whether additional N application is required.

- Maintaining high petiole NO$_3$-N (based on current sufficiency standards) throughout the season will ensure crop N sufficiency; however, using petiole analysis to determine fertigation requirements will often lead to unnecessary fertilization.