Olive Mineral Nutrition

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Agriculture & Natural Resources
Olives are shallow rooted, naturally vigorous, and do well on weaker soils with good drainage.

- Don’t over-fertilize or they grow vegetatively and produce less fruit.
Adequate nutrition required for...

- New shoot growth
- Bud development
- Flowering
- Better fruit size
- Heavier production
- More regular bearing
Tissue & soil analysis

✓ Use leaf analysis:
  ▪ To assess nutrient status
  ▪ To focus your fertilization program

✓ Soil analysis used:
  ▪ As a baseline…checking pH
  ▪ To diagnose and correct problems (excesses or imbalances)
Soil analysis may also guide...

✓ Soil amendment applications
  - Lime application to adjust low soil pH
  - Gypsum application to adjust Ca:Mg ratio or to reclaim alkali soils
16 Essential plant nutrients

- 9 macro-nutrients needed in relatively large amounts: C, H, O, P, K, N, S, Ca, Mg
- 7 micro-nutrients are trace or minor elements that are needed in small quantities: Fe, Mn, B, Zn, Cu, Cl, Mo
Have only documented deficiencies of three nutrients in California olives…

✓ Nitrogen
Sometimes…
✓ Potassium
✓ Boron
Fertilization

- Base fertilizer applications on leaf analysis, growth, and tree performance
  - July sample, 100 leaves from non-fruiting shoots

Olive Leaf Analysis Critical Levels

<table>
<thead>
<tr>
<th></th>
<th>Deficient</th>
<th>Optimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>1.4%</td>
<td>1.5-2.0%</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>0.4%</td>
<td>0.8-1.0%</td>
</tr>
<tr>
<td>Boron (B)</td>
<td>14 ppm</td>
<td>19-150 ppm</td>
</tr>
</tbody>
</table>
Nutrient deficiencies not observed in olives in California…

- **Zinc** – deficiency not observed in California olives and could not be artificially induced
- **Calcium and Magnesium** – deficiencies not observed in California
- **Phosphorus** – neither has deficiency nor growth response to phosphorus fertilizer been observed in California olives…low levels associated with poor drainage
- **Copper, Iron, Manganese, and Molybdenum** - deficiencies are unknown in California olives
Where do we put fertilizer materials?

Olive has a shallow, spreading root system.

Nitrogen or Boron may be broadcast or spread in the tree row.

Potassium is banded along side the tree row.
Or, nutrients can be fertigated… injected through drip irrigation
Buy nitrogen-containing fertilizers based on price per pound of actual N

<table>
<thead>
<tr>
<th></th>
<th>% Nitrogen</th>
<th>~ 1 lb. actual N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>46-0-0</td>
<td>2.2 lbs.</td>
</tr>
<tr>
<td>Ammonium Nitrate</td>
<td>33-0-0</td>
<td>3 lbs.</td>
</tr>
<tr>
<td>Ammonium Sulfate</td>
<td>21-0-0</td>
<td>4.8 lbs.</td>
</tr>
<tr>
<td>Calcium Nitrate</td>
<td>15.5-0-0</td>
<td>6.5 lbs.</td>
</tr>
</tbody>
</table>

Amounts needed to supply an equal amount of actual Nitrogen
Nitrogen deficiency symptoms...

- Small, yellowish leaves
- Poor shoot growth
- Sporadic bloom
- Poor fruit set

Low N = Pale color, lack of new growth
Shoot growth, bloom, and fruit set demands adequate nitrogen.
Nitrogen fertilization

- Check leaf analysis to confirm actual need
- Using well water? NO$_3^-$ analysis
  - If NO$_3^-$ is present in water, include that contribution when calculating the total need
    
    \[(\text{NO}_3^- \text{ N ppm} \times 2.72 = \text{lbs. of N / acre-foot water})\]

- Excess N produces
  - Excessive vegetative growth
  - Poor fruit quality
  - Increased frost injury potential
  - Greater disease susceptibility
Nitrogen requirements

- Heavy cropping years:
  - Less N early in the season
    - High N may increase set and aggravate alternate bearing
  - No N deficit later in the season
    - Young trees -- promote growth
    - Mature trees -- maintain balance of shoots & crop

- Light cropping years:
  - Fertilize in early season but less total N / year
### Nitrogen rate vs. yield & size

**Mission olives, Palermo, February fertilization, heavy crop year**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield</th>
<th>% Canning Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 lbs. actual N / tree</td>
<td>226 lbs./tree</td>
<td>43</td>
</tr>
<tr>
<td>(144 lbs. N/acre)</td>
<td>(5.4 tons/ac)</td>
<td></td>
</tr>
<tr>
<td>1 lb. actual N / tree</td>
<td>196 lbs./tree</td>
<td>63</td>
</tr>
<tr>
<td>(48 lbs. N/acre)</td>
<td>(4.7 tons/ac)</td>
<td></td>
</tr>
<tr>
<td>1/2 lb. actual N / tree</td>
<td>172 lbs./tree</td>
<td>92</td>
</tr>
<tr>
<td>(24 lbs. N/acre)</td>
<td>(4.1 tons/ac)</td>
<td></td>
</tr>
<tr>
<td>Unfertilized</td>
<td>49 lbs./tree</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>(1.2 tons/ac)</td>
<td></td>
</tr>
</tbody>
</table>

Source: H.T. Hartmann, UC Davis
Maintaining nitrogen levels with inorganic nitrogen sources is easy…

- Broadcast ~ 50 lbs. N/acre/year (1 lb. per tree at 48 trees/acre)
- Soil applied in February
- Benefits flower bud development, fruit set, and spring growth
- If applied after on-crop-year bloom, may help moderate alternate bearing
When can olive trees use nitrogen most efficiently?

✓ For most efficient uptake, N should be available in the root zone just before and during the period of greatest demand

- In olive, that’s spring, during shoot growth, bloom, and fruit set
Legume cover crops…

✓ Fix N biologically

- Legumes provide nitrogen and release it slowly over time—weeks to months
- Require additional water
- Require mowing to control growth
- Gopher populations will increase
- May improve water penetration
- Other nutrients are not provided
Sub-clover cover crop
(15-30 lbs. seed/acre)
seeded with a no-till drill.

Legume cover crops....
annual sub-clovers compatible
If using sub-clover or other cover crops...

- Mow when 4 to 7 more inches of rainfall is expected
  - Helps move nitrogen from clippings into the soil
  - N is not leached too deeply
  - Less N lost to runoff
Mowing and throwing clippings into the tree row recycles nutrients where irrigation and most active roots are located.
So… What are potential benefits of legume cover crop organic matter?

- Can aid water infiltration
- Helps develop soil structure
- Provides larger reservoir for nitrogen and other micro-nutrients
- May provide 30 to 40 pounds of N / acre
Challenges with higher organic matter

- OM reservoir of nitrogen must be managed year round OR nitrates can be leached to groundwater or can run off
- A cover crop will use additional water
- Surface OM can reduce herbicide effectiveness
Potential nitrogen losses include…

- Volatilization of ammonia
- Denitrification
- Leaching
**Early 1970’s...Foliar Urea Study**
*Steve Sibbett, Tulare Co., 1972-73*

**Average value/ton of Manzanillo olives**

<table>
<thead>
<tr>
<th></th>
<th>1972</th>
<th>1973</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>$399.06</td>
<td>$332.65</td>
</tr>
<tr>
<td>Control</td>
<td>$403.21</td>
<td>$326.02</td>
</tr>
</tbody>
</table>

No difference between sprayed and unsprayed.

*August application made at 11.5 lbs/100 gallons
Foliar urea nitrogen application
Klein and Weinbaum, UC Davis, 1984

- Demonstrated uptake and transport of labeled N in olive following foliar urea applications
- October application increased leaf N but not the flower N the following spring
- March application increased leaf N that was later translocated to developing flowers and fruits
- Olive leaves are storage organs for N that release N to meet demands of developing fruits and shoots
Foliar urea applications
Ferguson, Connell, Krueger, Sibbett, UCCE, mid 1990’s

- Foliar urea examined in Manzanillo, Sevillano, and Mission olives
  - Tulare, Glenn, and Butte counties
- Replicated sets of trees sprayed
  - April, June, July, August, and November
- Individual tree yield, fruit size, and dollar value at harvest was measured
Early in the season

- Leaf N increases right after sprays then returns to pre-treatment levels
- N likely translocated out of the leaves to the bloom or developing fruit

Later in the season

- Leaf N increases right after foliar sprays, then remains higher in the leaves since less demand elsewhere
‘Mission’ olive leaf N % following foliar urea spray

1995 Season
Conclusions

- Total yield and fruit size not affected by any spray timing
- Gross value, $/acre, unaffected by the various dates of foliar sprays
- Demonstrated that foliar urea was taken up by olive leaves, therefore, some of the N requirement could be met this way
Conclusions

- If foliar N supplements or replaces soil applications, spring to early summer timing is preferred.
- Meets trees major needs by translocating to the strong sinks… the bloom and crop.
- Sufficient N remained to preserve shoot growth for the following year’s bloom.

Foliar urea applications
Ferguson, Connell, Krueger, Sibbett, UCCE, mid 1990’s
Potassium

Potassium deficiency symptoms…

- Dead leaf tips or margins
- Light green leaf color
- Short shoot internodes & twig dieback
**Tree response to potassium fertilizer**

<table>
<thead>
<tr>
<th>Yield</th>
<th>% Canning Fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 yr average</td>
<td>1&lt;sup&gt;ST&lt;/sup&gt; Yr</td>
</tr>
<tr>
<td>K&lt;sup&gt;+&lt;/sup&gt; Mass Dose</td>
<td>152 lbs./tree (3.7 tons/ac)</td>
</tr>
<tr>
<td>Unfertilized</td>
<td>36 lbs./tree (0.9 tons/ac)</td>
</tr>
</tbody>
</table>

Source: H.T. Hartmann, UC Davis

**Deficiency = less crop & smaller fruit size**
Correcting potassium deficiency

✓ Using potassium sulfate, apply 10-20 lbs. per tree (500-1000 lbs per acre)
  [mined by Great Salt Lake Minerals]
  ▪ Ringed or BANDED at drip line, NOT broadcast
  ▪ Soil applied in December – January
  ▪ Good for several years

✓ Or, if drip irrigating, fertigate with $\text{K}_2\text{SO}_4$
  ▪ 200-300 lbs./ac spread over the irrigation season
Foliar potassium
Klein, Israel, 1985

- Foliar sprays readily corrected potassium deficiency, effect not as persistent as soil application

- Uptake and persistence of applied K is proportional to the quantity deposited on the leaf surface (# sprays x concentration)

- 2 to 5 sprays:
  - Raised 0.4% K, to 1.3%
  - When 0.9 % K, sprays couldn’t raise it above 1.2 %

- Soil application is preferred, especially with drip irrigation (fertigation)
Soil and foliar potassium
Perica, Androulakis, Loupassaki, Crete, 1994

- Demonstrated that four KNO$_3$ applications during July-August increased leaf K content (and decreased Mg)
- K$_2$SO$_4$ soil application or KNO$_3$ foliar sprays resulted in nearly the same leaf potassium
- Foliar Urea + KNO$_3$ significantly enhanced the uptake of potassium in the leaves
Influence of foliar K with & without urea on fruit quality of Manzanillo olive
Steve Sibbett, Tulare Co., Exeter, 1997

Examined…

- Percent leaf nitrogen and potassium
- Fruit weight
- Fruit size
Effect of foliar sprays on olive...% leaf potassium

- Generally, K leaf levels increased following KNO₃ sprays and remained higher both with and without urea added.
- 3 sprays > 2 sprays > 1 spray which made the least difference.
## Foliar K & N effects on fruit weight*

### Manzanillo Olive, Exeter, 1997

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Timing</th>
<th>Avg. Wt. (g) 100 fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (no treatment)</td>
<td></td>
<td>373</td>
</tr>
<tr>
<td>KNO3 @ 32lbs/ac</td>
<td>June</td>
<td>369</td>
</tr>
<tr>
<td>KNO3 @ 32lbs/ac</td>
<td>June, July</td>
<td>386</td>
</tr>
<tr>
<td>KNO3 @ 32lbs/ac</td>
<td>Jun, July, Aug</td>
<td>378</td>
</tr>
<tr>
<td>KNO3 @ 32lbs/ac + 16lbs urea</td>
<td>June</td>
<td>357</td>
</tr>
<tr>
<td>KNO3 @ 32lbs/ac + 16 lbs urea</td>
<td>June, July</td>
<td>383</td>
</tr>
<tr>
<td>KNO3 @ 32lbs/ac + 16 lbs urea</td>
<td>Jun, July, Aug</td>
<td>366</td>
</tr>
</tbody>
</table>

* No difference detected in fruit weight
Foliar N & K effects on fruit size*
Manzanillo Olive, Exeter, 1997

* No recognizable shifts in fruit size
Boron deficiency symptoms…

- Leaves w/ dead tips, a yellow band, but still green at the base
- Twig dieback and excessive branching
- Defective fruit, “monkey face” symptom
- Premature fruit drop
Correcting boron deficiency

- Broadcast ½ to 1 lb. of a 14% to 20% borax material per tree on the soil surface (25-50 lbs. per acre)
- Apply in winter, good for several years
- Organic restrictions… deficiency and need must be documented by testing before application
Flowers and fruits of olive are powerful boron sinks

Boron was mobilized from young leaves during flowering to supply the requirements of flowers and young fruit

Foliar boron applications (0.5% Solubor) 3 days before flowering satisfied the need for boron during flowering and fruit set
In 1998 & 1999, Solubor (20.5% B) was applied in late April, 3 weeks before flowering, in a Manzanillo orchard with low leaf boron (17 ppm).

B conc. in flowers and pollen increased in proportion to the B concentration applied, but sprays had no effect on pollen germination.

B applied at 1 lb. Solubor / 100 gals. water, increased the percentage of perfect flowers and increased fruit set significantly in all treatments.

The “off” year application of 1 lb. Solubor / 100 gals. was most effective in increasing yield (30%) without negative effects on fruit size.
Questions?

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