Olive Mineral Nutrition

Joe Connell, Farm Advisor, Butte County

University of California
Cooperative Extension

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

Roland D. Meyer, Extension Soils Specialist
University of California Cooperative Extension
LAWR Dept., Davis, California

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

	Deficient	Optimum
Nitrogen (N)	1.4%	1.5-2.0%
Potassium (K)	0.4%	0.8-1.0%
Boron (B)	14 ppm	19-150 ppm

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.

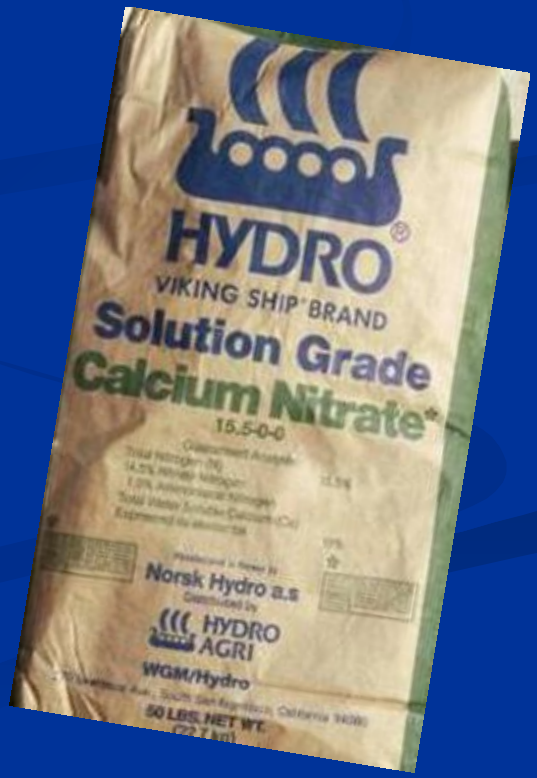
Potassium is banded along side the tree row.

Or, nutrients can be fertigated… injected through drip irrigation

Buy nitrogen-containing fertilizers based on price per pound of actual N

	% Nitrogen	~ 1 lb. actual N
Urea	46-0-0	2.2 lbs.
Ammonium Nitrate	33-0-0	3 lbs.
Ammonium Sulfate	21-0-0	4.8 lbs.
Calcium Nitrate	15.5-0-0	6.5 lbs.

Amounts needed to supply an equal amount of actual Nitrogen



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

    (NO_3^- N ppm x 2.72 = 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

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

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

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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

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Legume cover crops….
annual sub-clovers compatible

Sub-clover cover crop (15-30 lbs. seed/acre) seeded with a no-till drill.

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

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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

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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

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Potential nitrogen losses include…

- ✓ Volatilization of ammonia
- ✓ Denitrification
- ✓ Leaching

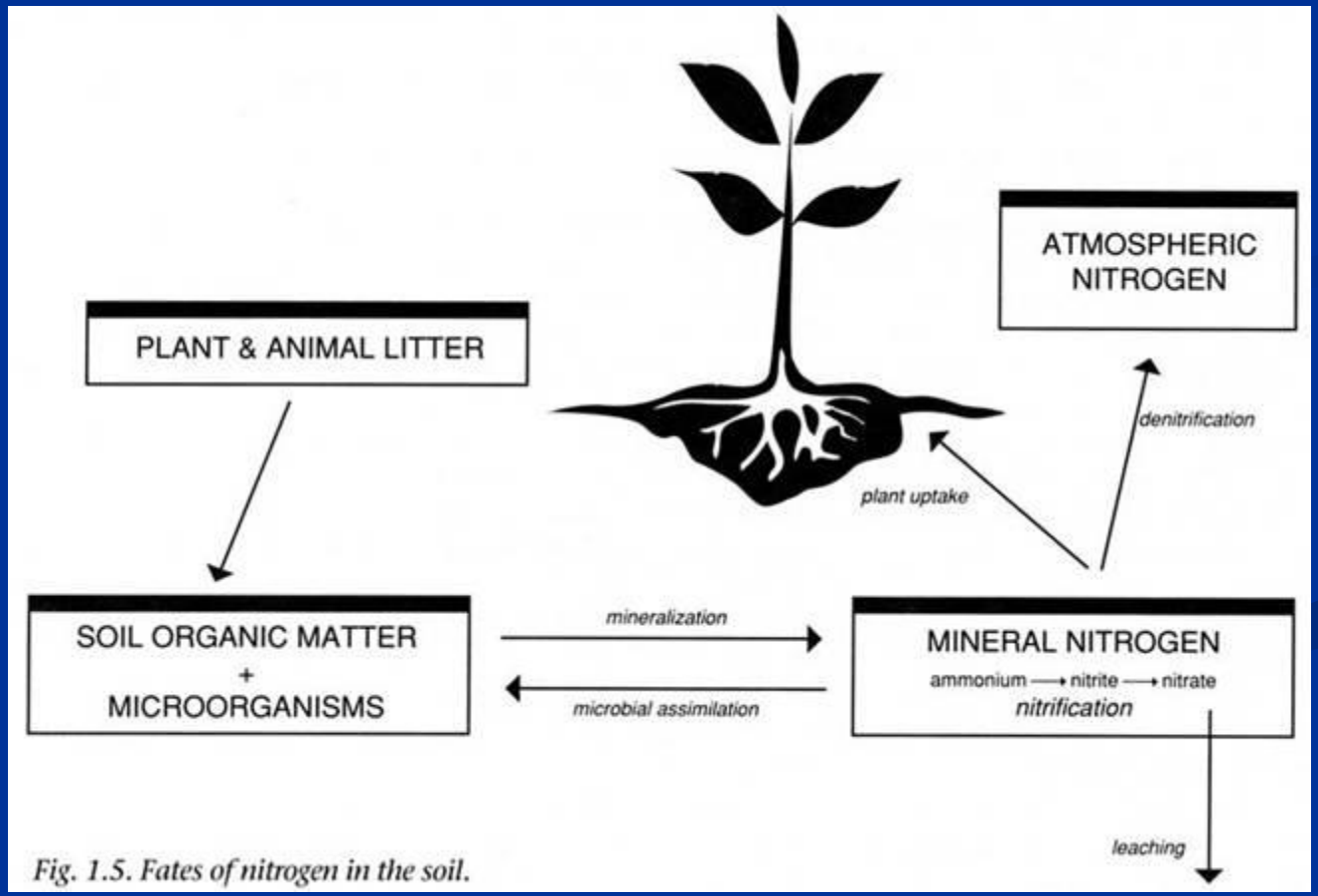

Fig. 1.5. Fates of nitrogen in the soil.

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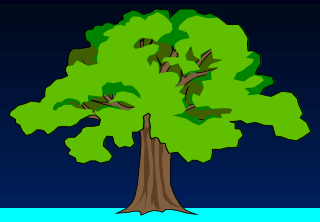
LAWR Dept., Davis, California

*Early 1970's…Foliar Urea Study**

Steve Sibbett, Tulare Co., 1972-73



Average value/ton of Manzanillo olives

1972

Urea	Control
$399.06	$403.21

1973

Urea	Control
$332.65	$326.02

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

Foliar urea applications

Ferguson, Connell, Krueger, Sibbett, UCCE, mid 1990's

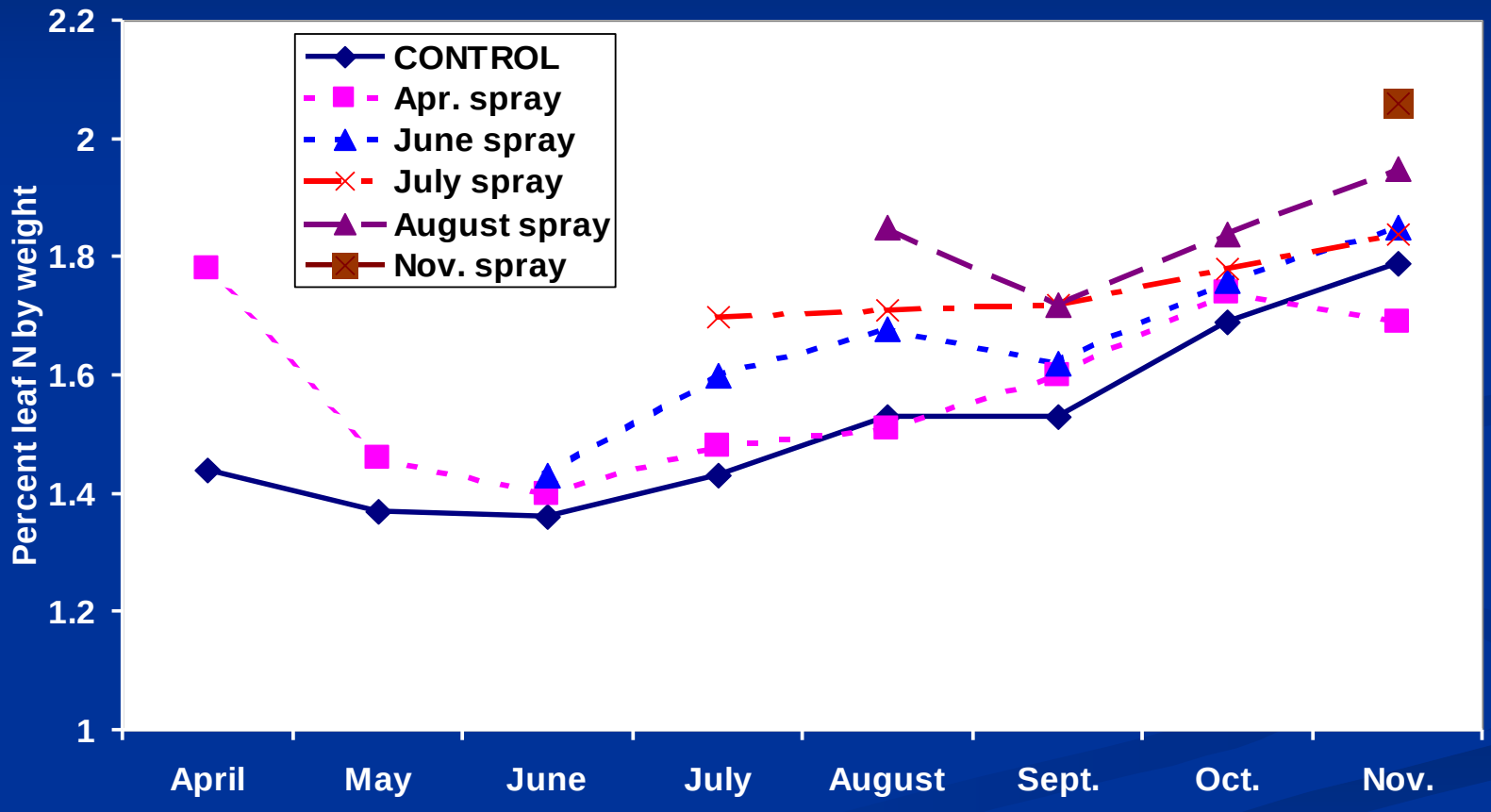
Early in the season

- 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

Foliar urea applications

Ferguson, Connell, Krueger, Sibbett, UCCE, mid 1990's

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

Foliar urea applications

Ferguson, Connell, Krueger, Sibbett, UCCE, mid 1990's

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

Potassium

Potassium deficiency symptoms…

- Dead leaf tips or margins
- Light green leaf color
- Short shoot internodes & twig dieback

Tree response to potassium fertilizer

	Yield	% Canning Fruit		
	4 yr average	1ST Yr	2ND Yr	3RD Yr
K^+ Mass Dose	152 lbs./tree (3.7 tons/ac)	70	62	33
Unfertilized	36 lbs./tree (0.9 tons/ac)	20	19	5

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 K_2SO_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_2SO_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 KNO_3 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**

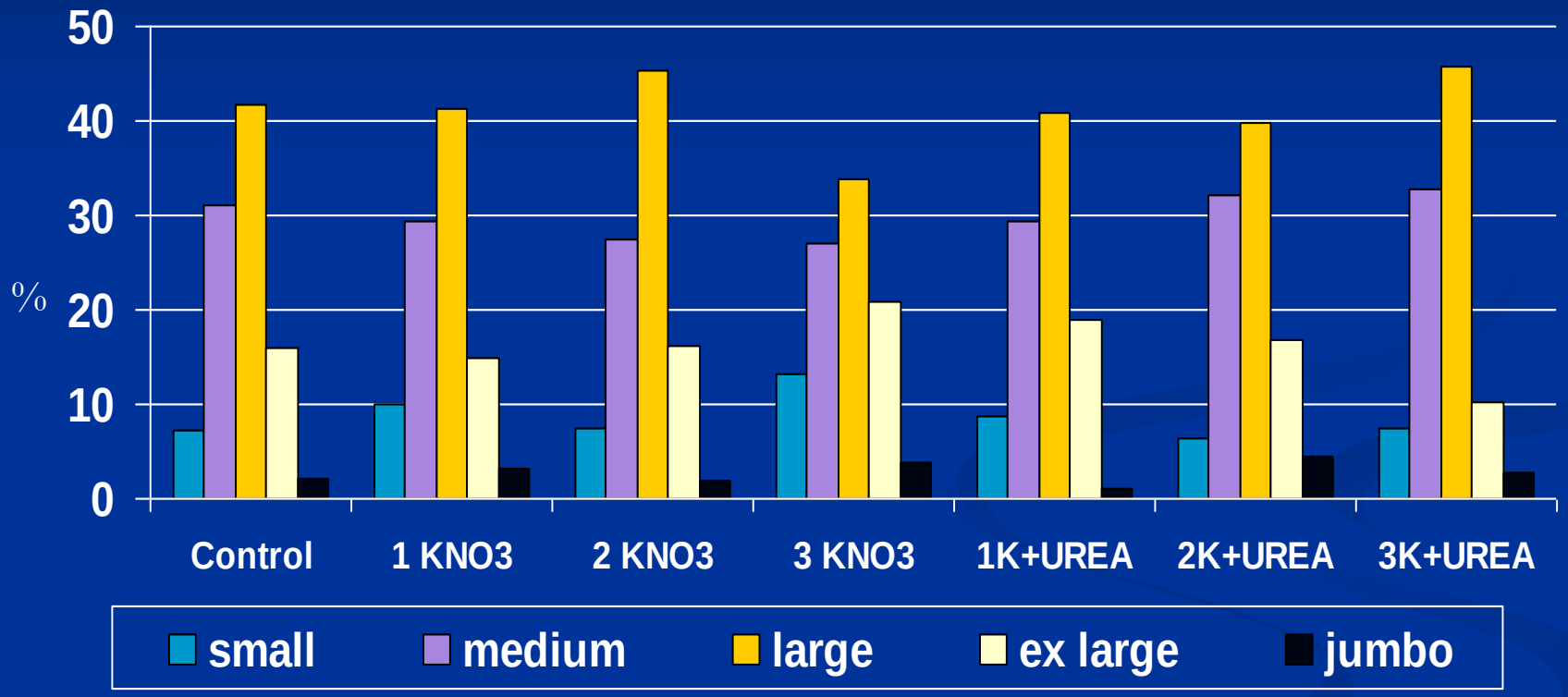
Manzanillo Olive, Exeter, 1997

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

* 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

Foliar boron

Delgado, Benlloch, Fernandez-Escobar, Spain, 1994

- 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

Foliar boron…flower fertility & fruit set

Perica, Brown, Connell, Nyomura, Dordas, Hu, Stangoulis, Butte Co., Oroville, 2001

- 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?

Joe Connell, Farm Advisor
Butte County

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