WALNUT NUTRITION
How to Develop a Balanced Program

Bob Beede, UC Farm Advisor
Kings County
http://cekings.ucdavis.edu/
Nutrition Management Involves

Knowledge of:

• Site/Soil characteristics and chemistry
• Plant requirements
• Cropping history
• Fertilizer inputs
• Cultural practices (Irrigation, vegetation management, pruning)
• Tissue analysis
• Observation and judgement
**MOST PLANTS REQUIRE 14 ESSENTIAL ELEMENTS FOR NORMAL GROWTH AND REPRODUCTION**

**THESE ELEMENTS ARE GROUP INTO TWO CATEGORIES, BASED ON THE QUANTITY REQUIRED (MACRO=LARGE, MICRO=SMALL)**

<table>
<thead>
<tr>
<th>Macronutrients</th>
<th>Micronutrients</th>
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</thead>
<tbody>
<tr>
<td>NITROGEN (N)</td>
<td>IRON (Fe)</td>
</tr>
<tr>
<td>PHOSPHORUS (P)</td>
<td>MANGANESE (Mg)</td>
</tr>
<tr>
<td>POTASSIUM (K)</td>
<td>BORON (B)</td>
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<tr>
<td>CALCIUM (Ca)</td>
<td>COPPER (Cu)</td>
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<tr>
<td>MAGNESIUM (Mg)</td>
<td>ZINC (Zn)</td>
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<tr>
<td>SULFUR (S)</td>
<td>MOLYBDENUM (Mo)</td>
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<tr>
<td></td>
<td>CHLORINE (Cl)</td>
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<tr>
<td></td>
<td>NICKEL (Ni)</td>
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</table>
How are nutrients obtained?

Soil Science and Plant Nutrient Uptake

- Nutrients are taken up in water only by active roots.
  - Active root growth is required.
  - Water, oxygen, suitable temperatures are required for uptake
  - Leaves are required for nutrient uptake by roots
- N, S, Mg, Ca, B are mobile in most soils
  - Water movement delivers these nutrients to roots
- Mn, Zn, Cu, Ni, Fe have restricted solubility and movement in soils, hence:
  - Active root growth and soil exploration are critical
  - Nutrients and roots must be in the same place
  - Soils that limit root growth can cause Zn, Fe, Cu deficiencies
- K is mobile in some soils but not others
  - Soil tests to determine K-fixation are essential to K management.
Annual Leaf Tissue Sampling:

• A plant-based measurement which integrates all the factors associated with nutrient extraction from the soil that it inhabits.

• Provides cause for further evaluation of soil and water quality, and fertilization practices.

• Best performed in July. Sample good and bad trees separately. Sample trees suspected of deficiency any time. Compare to good trees.
Nutrient Curves through Season

- **N, P, Zn**
- **Cu**
- **Mn**
- **K, Mg, Cl, B**
- **Ca**

Month:
- A
- M
- J
- J
- A
- S
- O
- N

MONTH
What approaches do we have to manage and optimize nutrition?

**Leaf Samples and Critical Values for Walnut**

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<th></th>
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<th>Adequate</th>
<th>Toxic</th>
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<tr>
<td>Nitrogen</td>
<td>&lt;2.1</td>
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<tr>
<td>Potassium</td>
<td>0.9</td>
<td>&gt;1.2</td>
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<tr>
<td>Zinc</td>
<td>18</td>
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<tr>
<td>Boron</td>
<td>20</td>
<td>36-300</td>
<td>&gt;300</td>
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Concerns:
- Validated for mid-summer samples only.
- Limited guidance provided on how to sample effectively or respond appropriately.
Soil type and texture, pH and irrigation water all affect nutrient availability

Effect of Soil pH:

\[
\begin{align*}
\text{pH} & > 7.5 \quad \text{< Zn, Cu, Mn, Fe} \\
\text{pH} & < 6.0 \quad \text{< P, Ca, B}
\end{align*}
\]

• Old river beds, sandy soils, cuts or fills, old corrals, alkali patches, etc.)

• Soil series: Mg, K availability (dolomite, gypsum, lime)

• Irrigation waters differ in nutrient content
Value of Soil Testing (How and Why)

How:

• Collect soil samples that reflect where roots will be growing
• Collect samples from all parts of the orchard and build a ‘map’ of the whole property. Do it and do it right, most soil characteristics don’t change with time.

What:

• Soil tests that provide background information on general soil physical and chemical characteristics are essential for all orchards.
  • pH, Lime/Bicarbonate - as an index of potential solubility of natural and applied nutrients
  • CEC, OM as a measure of buffering capacity
  • Salinity, Toxic Elements, nutrient imbalances.
• Determine K fixation characteristics.
• For most nutrients (with the exception of K, B), soil analyses of nutrient availability are of limited value.
Central Valley Coalitions

- Sacramento Valley Water Quality Coalition
  • Bruce Houdesheldt

- California Rice Commission
  • Tim Johnson

- Goose Lake Water Quality Coalition

- San Joaquin County & Delta Water Quality Coalition
  • Michael Wackman

- Westside San Joaquin River Watershed Coalition
  • Joseph C. McGahan
  • David Cory

- East San Joaquin Water Quality Coalition
  • Parry Klassen
  • Wayne Zipser

- Southern San Joaquin Valley Water Quality Coalition
  • David Orth

- Westlands Coalition
  • Sue Ramos
What Will Be Required

**Grower Responsibilities**

- Complete Farm Evaluation *(everyone)*

- Complete Nitrogen Management Plan  
  *(In high vulnerability groundwater area)*  
  - Certified by 3rd party or grower trained  
  - Low vulnerability keep on site; no certification required

- Sediment and Erosion Control Plan  
  *(In areas identified as high vulnerability for erosion and sediment discharge)*

- More time provided for farming operations < 60 acres total
Farm Management Plans

- Template to be developed by coalitions, reviewed by Water Board

- Report practices “protective of surface and groundwater quality”

- Periodic Updates
  More frequently in high vulnerability areas

- Deadline for reports
  - High vulnerability: 2014
  - Low Vulnerability: 2017 (keep on farm)
Nitrogen Management Plans

Key mechanism to minimize nitrogen discharge to surface and groundwater

- **High Vulnerability Areas**
  - CCA certifies nitrogen budgets for members
    - CDFA certification program in development
  - Member self-certification with training
  - Plans kept on site, summary info reported to Coalition

- **Low Vulnerability Areas**
  - Required but keep on farm
Nitrogen Management Plan Components

- Apply N at crop removal rates
  - Dairies regulated to 140% of crop use (N applications)
- Test well water for nitrogen levels (then adjust N applications accordingly)
- Leaf / tissue testing
- Soil testing

- Deadline for reports
  - High vulnerability: 2015 for crop year 2014
  - Low Vulnerability: 2017 (keep on farm)
# Annual Nitrogen Budget

## CROP NITROGEN DEMAND

<table>
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<tr>
<th>Crop</th>
<th>Nitrogen Crop Needs to meet Expected yield (lbs of Production/acre)</th>
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<tr>
<td>WALNUT</td>
<td>6000</td>
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## NITROGEN SUPPLY

### Credits and Applications

<table>
<thead>
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<th>Nutrients: Total N applied to field</th>
<th>Spring</th>
<th>Summer</th>
<th>Fall</th>
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<tr>
<td>Nitrogen fertilizers (conventional and organic)</td>
<td>75</td>
<td>125</td>
<td>0</td>
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<tr>
<td>Foliar fertilizers</td>
<td>0</td>
<td></td>
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<tr>
<td>Other fertilizers</td>
<td>0</td>
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</table>

| Manure | 0 |
| Compost | 0 |
| Bacterial extracts/Compost teas | 0 |
| Other nutritional product | 0 |

**TOTAL N Applied**: 200

<table>
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<tr>
<th>Soil Nitrogen Credits</th>
<th>Soil N ppm³</th>
<th>Lbs N/acre</th>
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<td>Nitrogen from previous legume crop</td>
<td>0</td>
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<tr>
<td>Residual from long-term manure applications</td>
<td>10</td>
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<tr>
<td>Soil organic matter mineralization</td>
<td>5</td>
<td></td>
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<tr>
<td>Current soil test levels⁴</td>
<td>10</td>
<td></td>
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<tr>
<td>Irrigation water nitrogen credits (annualized)</td>
<td>55</td>
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**TOTAL N CREDITS**: 80

**Totals N Credit and Applications**: 280

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<th>Crop N needs</th>
<th>Balance</th>
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<td>200</td>
<td>90</td>
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**Ratio**: 1.40
Nutrient Fluxes (N, K, S, P) in Walnut

- Stored Nutrients
- Current Year Uptake

The scale of nutrient demand is determined largely by Yield.

Environmental Constraints: Cold Spring or Drought
Excess Demand

Spring Growth
Flowering
Leaf Expansion
Bud development
Nutrient Storage, leaf senescence
Nut Development
Nut maturity
Figure 18.5 This graph shows development-related changes in the proportions of fats (oils), proteins, and alcohol-soluble sugars in the walnut kernel.
Weinbaum N Experiment
1984-1990

Studied N utilization, efficiency of N recovery using isotopic labeled NH$_4$SO$_4$

Yield reduction in Serr and Hartley corresponded to midsummer leaf N concentrations below 2.3% dry weight.

Yield recovery requires a minimum of 2 years after N re-application, even though tissue N levels recover in one year.
Approximately 110 lbs/acre of N was removed annually from the orchard in the form of fruit, prunings, and leaves. 80% of the consumed N was in the fruit.

65% of leaf N was transported back into the fruitwood before leaf fall!

Depending upon fertilizer application method, time of application, and irrigation uniformity, about 150-200 lbs actual N should be applied annually as a maintenance program.
Weinbaum N Experiment
1984-1990

The rate of uptake is function of demand and availability.

Approximately 50% of the N within the walnut tree is replaced annually by soil N.
PHOSPHORUS DEFICIENCY: LEAF BROWNING AND DROP, BEGINNING AT THE BASE OF THE SHOOT
POTASSIUM DEFICIENCY IN WALNUT
Role of Potassium

1. Taken up in ionic form (K$^+$)

2. Unlike nitrogen, K$^+$ is not synthesized into compounds, but remains largely in ionic form within cells and tissues.


4. Regulates stomata through the guard cells.

5. Promotes root growth.

6. Reduces potential for disease infection.

7. Increases fruit size and quality.

8. Increases winter hardiness.
### Properties of Potassium (K) Salts

<table>
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<tr>
<th></th>
<th>Potassium Chloride</th>
<th>Potassium Sulfate</th>
<th>Potassium Nitrate</th>
<th>Potassium Thiosulfate</th>
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<tr>
<td>% K₂O</td>
<td>62</td>
<td>50</td>
<td>46</td>
<td>25</td>
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<tr>
<td>Solubility 20°C H₂O</td>
<td>34gr/100</td>
<td>11gr/100</td>
<td>31.6gr/100</td>
<td>155gr/100</td>
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<tr>
<td>Cost per Ton</td>
<td>$695.00</td>
<td>$770.00</td>
<td>$0.85/lb</td>
<td>$700.00</td>
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<tr>
<td>Cost per Ton K₂O</td>
<td>$1,121.00</td>
<td>$1,540.00</td>
<td>$2,353.00</td>
<td>$2,800.00</td>
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<tr>
<td>250 lb of K₂O</td>
<td>$140.00</td>
<td>$192.50</td>
<td>$294.00</td>
<td>$350.00</td>
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**Note:** K₂O *X* .83 = K

Annual walnut K requirement estimated at 61 lbs K₂O per year for 2 ton crop
Bill Olson K Experiment
(UC Farm Advisor, Emeritus, Butte County)
1984-1990

A. Two trials in K deficient walnut orchards

B. Treatments (all KCL):
   1. 1000 lbs/ac drilled one time
   2. 400 lbs/ac banded both sides 6ft from trunk annually in Nov.
   3. 400 lbs/ac fertigated in sprinklers 4X annually
      (100 lbs each)
   4. 1500 lbs/ac banded in 1986
   5. 1500 lbs/ac banded in 1986-88, and 400 lbs banded in 1989
   6. Untreated check
Orchard 1 results (clay loam)

1. Five years required before annual 400lbs. KCL treatment corrected deficiency

2. Banded applications better than sprinkler

3. Single 1000 lbs. treatment only slightly effective

4. Single and multiple 1500 lbs. treatments both showed immediate and continued tissue K improvement
Orchard 2 (1987): Sandy loam

Treatments (all KCL applied with Ranchero spreader):

1. 400 lbs/ac banded annually in Nov. on both sides 6 ft from trunk

2. 400 lbs/ac banded annually in Nov. in center of row

3. 1600 lbs/ac banded once in 1987

4. Untreated Check
Results

Orchard 2 (Sandy loam):

All Treatments provided correction
MICRONUTRIENT DEFICIENCIES IN NUT CROPS:

HOW COMMON ARE THEY?

<table>
<thead>
<tr>
<th></th>
<th>Zn</th>
<th>B</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Ni</th>
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<td>2</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
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<tr>
<td>WALNUTS</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
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<td>PISTACHIOS</td>
<td>3</td>
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<td>2</td>
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<tr>
<td>PECANS</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
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</tbody>
</table>

VISUAL SCALE: 0 = never seen, 1 = rarely, 2 = occasional, 3 = often
The Role of Zinc in Plants

1. Required for Auxin (NAA) formulation
2. Auxin involved in cell elongation
3. Associated with chloroplast formulation
4. Essential for pollen development, flower bud differentiation and fruit set
Diagnosing Zinc Deficiency

1. Visual symptoms
2. Consider soil chemistry
3. Rootstock: Nemaguard > Lovell > Marianna
4. Variety: Plum > Peach, Nectarine
   – Friar, Blackamber
Diagnosing Zinc Deficiency (continued)

5. Tree vigor
6. Nitrogen source:
   - High Phosphorous (manure) ties up Zinc
7. Weather/Spring irrigation source
8. Tissue analysis
Factors Affecting Soil-Zinc Availability

1. pH
   - Solubility decreases 100 fold for each unit increase in pH
     - pH 5 = $10^{-4}$ M (6.5 ppm)
     - pH 8 $10^{-6}$ M (0.007 ppm)

2. Cut areas likely to be more deficient
Factors Affecting Soil-Zinc Availability

3. High Magnesium or Phosphorous reduces Zinc availability
4. Methyl Bromide fumigation causes temporary loss of mycorrhizal fungi
5. Calcareous materials (lime) reduce Zinc availability
Tissue Sampling for Zinc Deficiency

1. Compare leaves of similar age from trees with and without symptoms
2. Sample leaves with symptoms
3. Do not sample leaves sprayed with zinc
Correcting Zinc Deficiency

Soil:
1. Expensive
2. Less effective due to fixation
Mobilization of soil metal ions by chelates (after Lindsay [1974])
Correcting Zinc Deficiency

Foliar

1. Effective
2. Safe with correct material for desired time
3. Concentrate (100 GPA) safer than dilute (300-400 GPA)
SPRING FOLIAR TREATMENT RECOMMENDATIONS FOR NUT CROPS:

ALMONDS:
A. CHLEATED ZINCS OR ZIRAM AT PETAL FALL WHEN ADEQUATE FOLIAGE EXISTS

B. WHEN RAIN UNLIKELY, 10 LBS/AC BASIC ZINC SULFATE IN 100 GALS. APPLIED ONCE OR TWICE, 3 WEEKS APART.

C. ADD ZN COMPATIBLE WITH COVER SPRAYS DURING SEASON

WALNUTS:
A. 3-4 LBS/AC 36% ZN IN 100GPA APPLIED POST-BLOOM AT 6-10" OF SHOOT GROWTH. REPEAT IF ZINC SYMPTOMS SEEN

B. FOR SEVERE DEFICIENCY, APPLY ONE LB. ZN EDTA 14% PER TREE, 4-5’ FROM TRUNK, IN A SMALL TRENCH. COVER.

C. SURVEY TREES> 40’ FOR ZINC IN UPPER CANOPY. TREAT BY AIR WITH 36% OR CHELATE
Shoot Zn Distribution Through A Dormant Peach Tree (ppm)

- 16.3 - shaded water sprout
- 19.1 - sun exposed
- 28.5 - sun exposed
- 47.9 - shaded
- 39.7 - sun exposed
- 70.3 - shaded
Boron

Boron is a Building Block for the cell wall and hence all Growth, especially flowers and fruits.

• Nutrient Uptake and Assimilation
  – Uncharged element, not fixed in CA Walnut soils. Deficiency can occur in all soils supplied with low B irrigation water.
  – Stored in organic residue.

• Function
  – Cell Wall Construction
  – Pollen formation and fertilization

• Mobility
  – Highly immobile in Walnut
  – Lack of mobility and high demand for reproduction can result in critical short term deficiencies that are hard to detect or predict but are potentially very important.
The occurrence of B deficiency and the response to B sprays has been inconsistent but occasionally very significant.

Boron demand and B response is hard to predict.
Methyl Bromide Alternatives
Trial-Kings County

Bob Beede, UC Kings Co. Farm Advisor
Mike McKenry, Extension Specialist Riverside
Dan Kluepfel, USDA-ARS Davis
Tony Garcia, Kings Co. Ag. Assist.
USDA-ARS and UC GIVE GREAT THANKS

To Tri-Cal, Inc. for their superior support!

Local Reps:
Bob Montgomery
Ramon Sanchez
Treatments

1 - White: Untreated Control
2 - Pink: Methyl Bromide broadcast at 400 lb/ac.
3 - Yellow: Telone II at 33.7 g/ac strip-treated (10’ swath) and shanked at 20”.
4 - Blue: Telone II at 33.7 g/ac broadcast and shanked at 20”.
5 - Orange: Telone II at 33.7 g/ac broadcast and shanked at 20” plus Chloropicrin at 175 lb/ac shanked at 28”.
6 - Green: Telone II at 33.7 g/ac broadcast and shanked at 20” plus Methyl Bromide at 125 lb/ac shanked at 28”.
Kings County Fumigation Trial
Cooperator: Doug Verboon
Spacing: 25' Between Rows: 40' between Trees
Plots: 12 trees (6 Paradox Seedlings, 6 VX211) Tulare Cultivar
TOTAL ACREAGE: 13.14

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Dirt Road Between Young Walnuts and New Planting Site
FUMIGATED
Two-year-old Tulare Scion
NO FUMIGATION CONTROL
SAME TREE AGE
Walnut Replant Trial
Effect of pre-plant fumigation on first-year production of “Tulare” walnuts in a replant situation. Averages based on six .35 acre plots in a Latin Square Design. October 10, 2012

<table>
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<th>Product</th>
<th>Average In-Shell (lbs.)</th>
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<td>Control</td>
<td>64</td>
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<tr>
<td>Methyl Bromide</td>
<td>109</td>
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<tr>
<td>Telone II strip</td>
<td>109</td>
</tr>
<tr>
<td>Telone II broadcast</td>
<td>115</td>
</tr>
<tr>
<td>Telone II + Chloropicrin</td>
<td>98</td>
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<tr>
<td>Telone II + Methyl Bromide</td>
<td>113</td>
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</tbody>
</table>
EFFECT OF RETAIN TIMING AND CONCENTRATION ON REDUCING SERR WALNUT PISTILLATE FLOWER ABORTION

Efird Farms, 2012
2011 ReTain Timing Trial: Efird Farms

Data represents average dry wt yield of seven single trees

Rate per application: 1 bag/ac, 200 gpa (50 tree/ac)

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>AVE. DRY IN SHELL WT. (lb/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>104 b</td>
</tr>
<tr>
<td>15-20% Bloom</td>
<td>115 b</td>
</tr>
<tr>
<td>30-40% Bloom</td>
<td>124 ab</td>
</tr>
<tr>
<td>50-60% Bloom</td>
<td>127 ab</td>
</tr>
<tr>
<td>15-20% 30-40%</td>
<td>130 ab</td>
</tr>
<tr>
<td>30-40% 50-60%</td>
<td>135 ab</td>
</tr>
<tr>
<td>4 sprays (15 - 85% Bloom)</td>
<td>164 a</td>
</tr>
</tbody>
</table>
2012 Retain Trial Effird Farms Yield Data

Average Dry In Shell Weight

Treatment

UTC | 30% 1/2 Bag | 30% 1 Bag | 50% 1/2 Bag | 50% 1 Bag | 30% & 50% 1/2 Bag | 30% & 50% 1 Bag

98 | 133 | 134 | 145 | 153 | 150 | 175
THANK YOU!

HAPPY FARMING!

THANKS TO ALL OUR SPONSORS!
Zinc

**Nutrient Uptake and Assimilation**
- Walnut (and Pecan) are very sensitive to low Zn.
- $\text{Zn}^{2+}$ is a charged ion easily immobilized ‘fixed’ in the soil
- Deficient in alkaline (pH>7), bi-carbonate rich soils (co-precipitation of Fe-Oxides), leached acid soils and organic rich soils.
- Soil fertilizers must overcome this fixation (Chelates, high local concentrations and bands) or foliars.

**Function**
- Key roles in gene regulation and protein synthesis (bud break and shoot extension)
- Alters stress tolerance (high light, drought, disease?)

**Mobility**
- Phloem immobile or slightly mobile in walnut in the fall and spring.
- Limited foliar uptake into mature leaves.
Nitrogen, Potassium, Sulfur, Phosphorus, Magnesium, Calcium

*Essential for all stages of plant growth.*

- N, K and P exported in the crop should be replaced to avoid soil depletion (yield drives fertilization)
- K, S, P, Mg are mobile in plants and can be effectively stored for later use (1 fertilization - prolonged effect)
- K response is highly soil specific
  - Conduct soil tests and follow soils consultant advice
- N is mobile in plant and soil and can be lost to the environment
  - apply only when the tree is growing actively.
- S, Mg, Ca and P are rarely deficient in CA soils
  - S is supplied in K, Ca and Mg sulfate fertilizers, if none of these are used S monitoring is recommended.
- Ca is important for growth and is immobile,
  - some responses to in-season foliar Ca at flowering have been reported.
When are nutrients required?

Nutrient Demand Is Not Uniform Through the Year.

- Uptake only occurs in actively growing plants
  - No uptake in fall, winter or before leaf out.
- For N and K yield determines demand
  - The size of the crop determines the demand for N and K
- Short Term Nutrient Deficiencies can be important (transient)
  - During times of High Nutrient Demand
    - Heavy crop, marginal supply.
  - When Environmental Conditions prevent uptake
    - Cold weather at flowering
    - Drought
  - For immobile elements with critical short term demand
    - Zinc during spring growth
    - Boron during flowering
New Program Requirements

Grower Responsibilities

- Farm Management Practices performance standards (*everyone*)
  - Minimize waste discharge offsite in surface water,
  - Minimize percolation of waste to groundwater,
  - Minimize excess nutrient application relative to crop need,
  - Implement effective sediment discharge and erosion prevention practices to minimize or eliminate the discharge of sediment above natural background levels
  - Prevent pollution and nuisance,
  - Achieve and maintain water quality objectives and beneficial uses
  - Protect wellheads from surface water intrusion.
Waste Discharge Requirements
Irrigated Lands Regulatory Program

Groundwater Assessment Report

• Rank land vulnerability based on Assessment Report
  
  • High Vulnerability
    
    Areas ID’d using DPR pesticide groundwater protection areas, State Water Board vulnerable areas
  
  • Low Vulnerability
    
    • Keep farm assessment / nitrogen budgets on farm