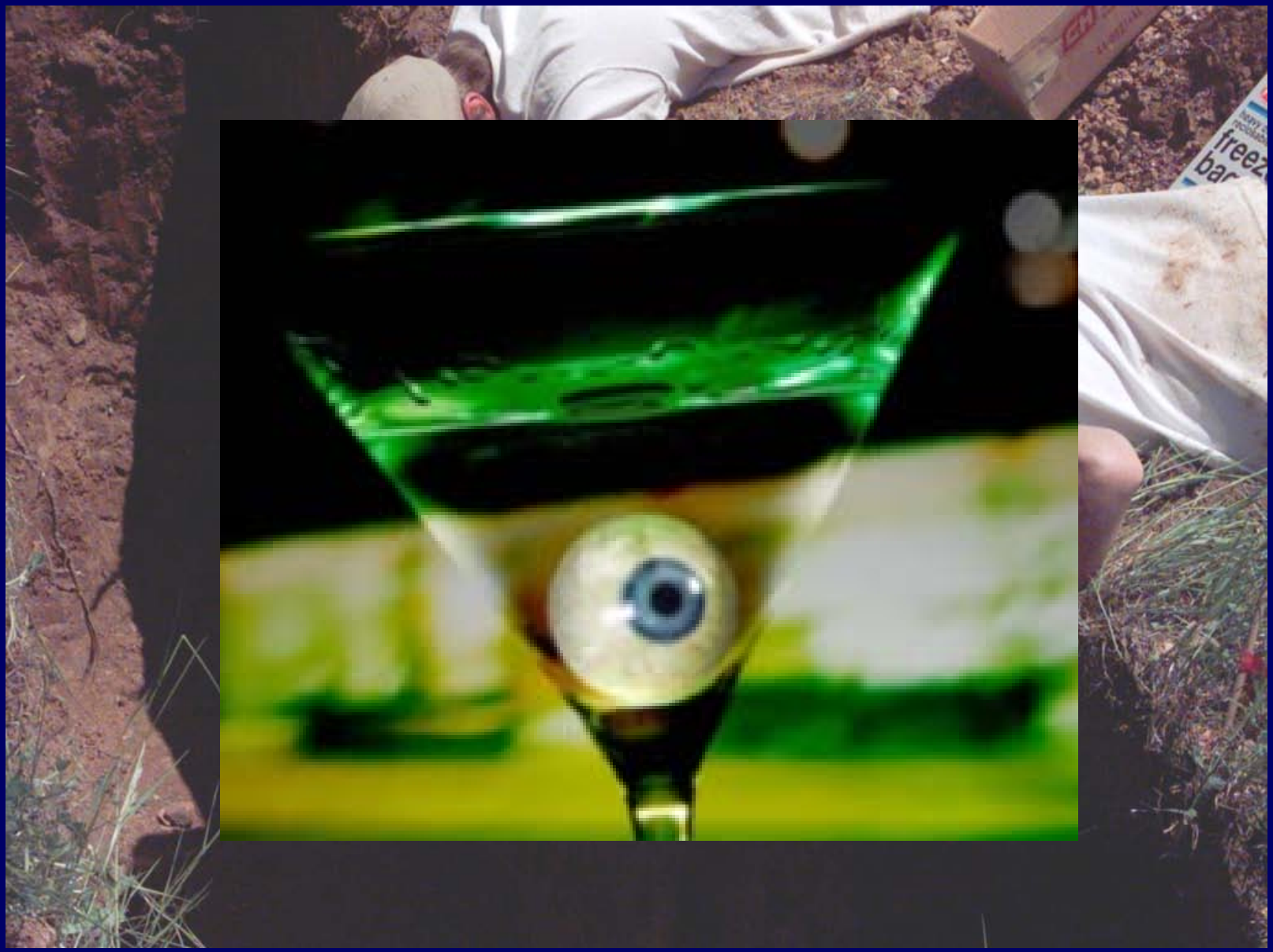
Mineral Nutrition in Perennials

How non-grape research at ARS
can benefit grape-growers

Perspective



Why are Viticulturists interested in mineral nutrition?

1. Vine Health & Productivity (what is required and when)
2. Sustainable Production (low environmental footprint, reduce production costs)
3. Fruit Quality

1. Nutrition & Vine Health -Things we know-

- Nutrients Required (N, P, K, Ca, Mg, S, Fe, Mn, B, Zn, Cu, Mo, others?)
- Tissue standards generally known for N, P, K, Ca, Mg, S that do not limit growth or yield (tweaking for different sites / scions / rootstocks / production goals)
- Tissue standards for B, Zn, Mn pretty well known
- Adequate but not excessive supply of macronutrients (particularly N!) – “never apply N to vigorous vines”

1. Nutrition & Vine Health -Things we don’t know-

- Cu, Fe, Mo tissue standards are not clear (just not enough data in most cases and few studies across regions and scions/rootstocks)
- Role of the Lesser known phytonutrients in Vine physiology (Ni, Mo, Co?, Cl? Na?) and disease resistance (Si?, Ni?).

Importance of Nickel (Ni) In Vitis Culture?

Bruce Wood, Supervisory Horticulturist,
Byron, GA

Ni is generally overlooked as a nutrient requiring consideration in crop management, even though it is an essential nutrient element.

►While almost all soils, and most plant tissues, possess sufficient Ni on a concentration basis, transitory deficiencies often arise due to either environmental factors or metal antagonisms that temporarily limit endogenous Ni bioavailabilty for key physiological processes regulating crop health, yield and quality.

Nickel deficiency in pecan (Woods & Nyczepir)

Rootknot nematodes (Meloidogyne partityla) reduce Ni uptake by roots and cause a Ni deficiency.

Higher Plant Enzymes Likely Affected by Low Nickel Bioavailability

- Urease (Dixon 1975, 1980a, 1980b; affecting urea oxidation),
- H^+-ATPase (Ros et al., 1990; affecting ion transport),
- IAA oxidase (Das et al., 1978; affecting auxin oxidation and homeostasis),
- Glutathione reductase (Schickler and Caspi, 1999; affecting reduction of glutathione),
- Ascorbate oxidase (Das et al., 1978; affecting oxidation of ascorbate),
- Superoxide dismutase (Schickler and Caspi, 1999; affecting $O_2^{\cdot -}$ deactivation),
- Catalase (Das et al., 1978; affecting degradation of H_2O_2),
- Perioxidase (Pandolfini et al., 1992; affecting polyphenolic oxidation);
- Acetyl CoA synthase (Webster et al., 2004; Bai et al., 2006; affecting carbon unit availability for multiple metabolic processes such as organic acids, fatty acids),
- Allantoate amidohydrolase and ureidoglycolate amidinohydrolase and / or ureidoglycolate amidohydrolase (Bai et al., 2006; ureide-N catabolism),
- Asparagines synthase and argininosuccinate synthase (Bai et al., 2007; urea-N and amino acid-N metabolism),
- RNase-A (Bai et al., unpublished, affecting N cycling from RNA) .

1. Nutrition & Vine Health
-Things we don't know-

- Cu Fe Mo tissue standards are not clear (just not enough data in most cases and few studies across regions and scions/rootstocks).
- Role of the Lesser known phytonutrients in Vine physiology (Ni, Mo, Co?, Cl?, Na?) and disease resistance (Si Ni).
- Timing of nutrient uptake (particularly to meet different goals).
- Variety or Scion / Rootstock requirements.

Nutrition in Nursery Crops

Carolyn Scagel
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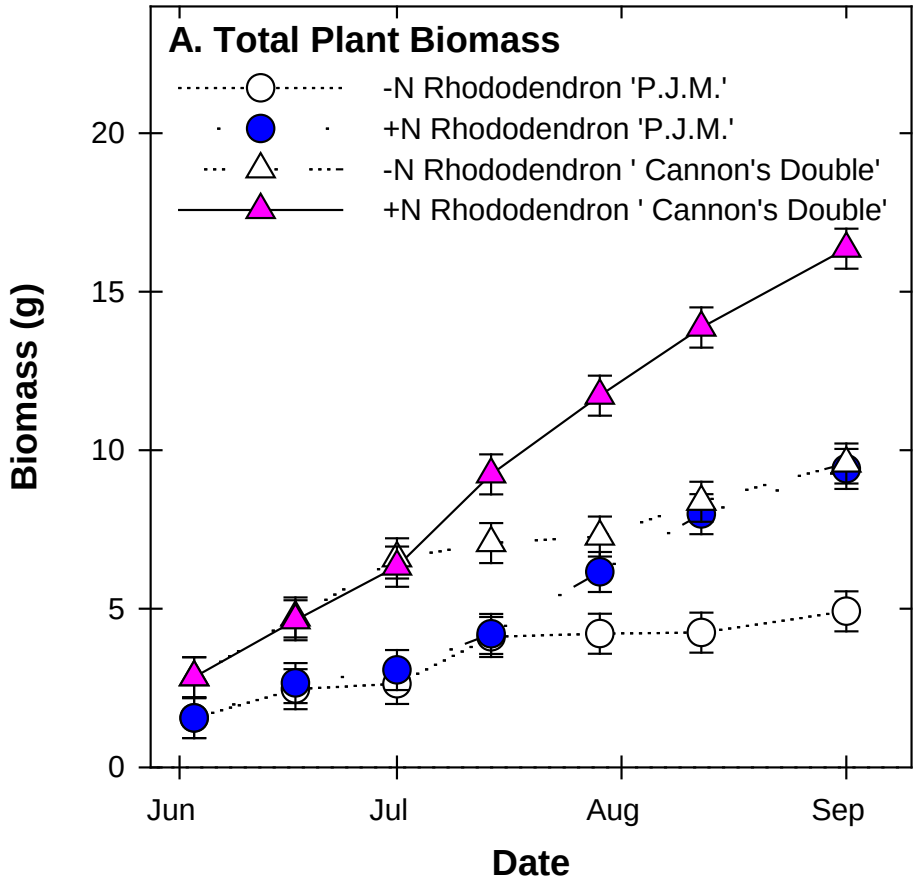
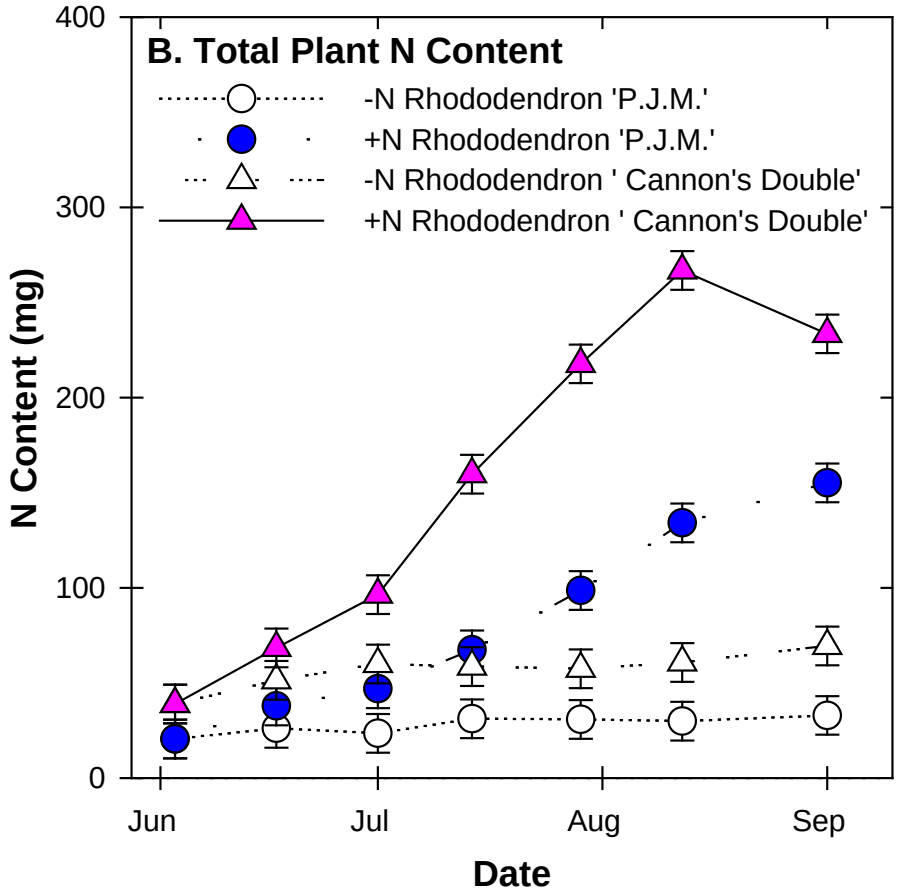
USDA ars

PLANT GROWTH & N CONTENT
-- June to September --





Residual N in plant stock was able to meet plant N demand until ~July.

Autumn Versus Spring N Supply
- Hydrangea -

No Urea in Autumn

Foliar Urea Autumn

No Spring N

Spring N

No Spring N

Spring N

Foliar urea in the autumn improved spring growth and flowering and decreased dependence on N in spring.

2. Nutrition & Sustainability -Things we know-

- Grapevines have a fairly low requirement for many nutrients (particularly N)
- Vines rely heavily on Reserves for N and P & this increases with vine age (other nutrients less clear)
- Rootstocks have different capacities for uptake of some elements, (genotype X environment interactions need to be better explored).

2. Nutrition & Sustainability -Things we don't know-

- Best forms of nutrients to use (fertilizers / cover crops / foliar)
- Interactions with irrigation (soil capacity to adsorb & release nutrients)
- Root traits important for nutrient uptake

Form of Fertilizers

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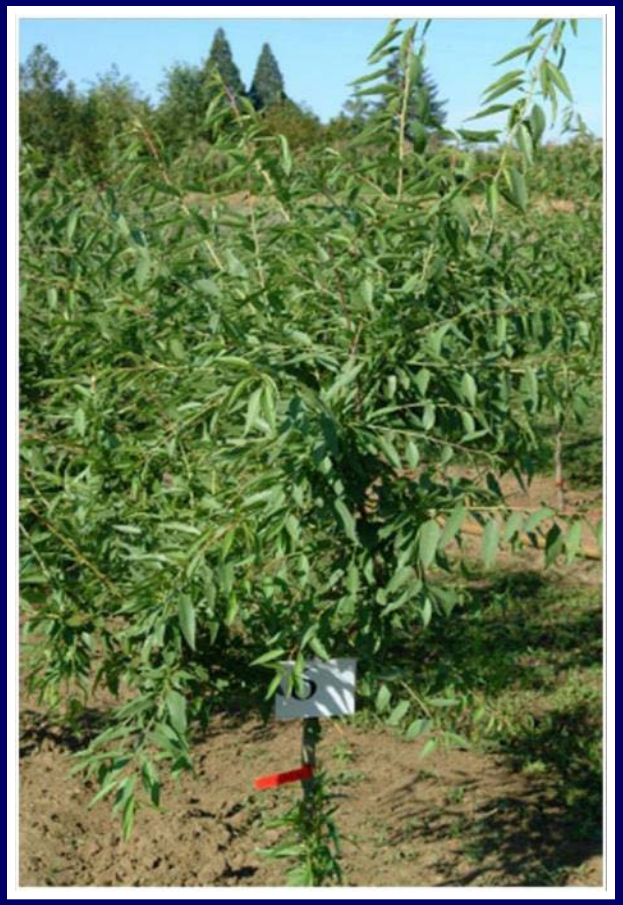
Using foliar fertilization to increase transplant performance of bareroot nursery stock (almond)

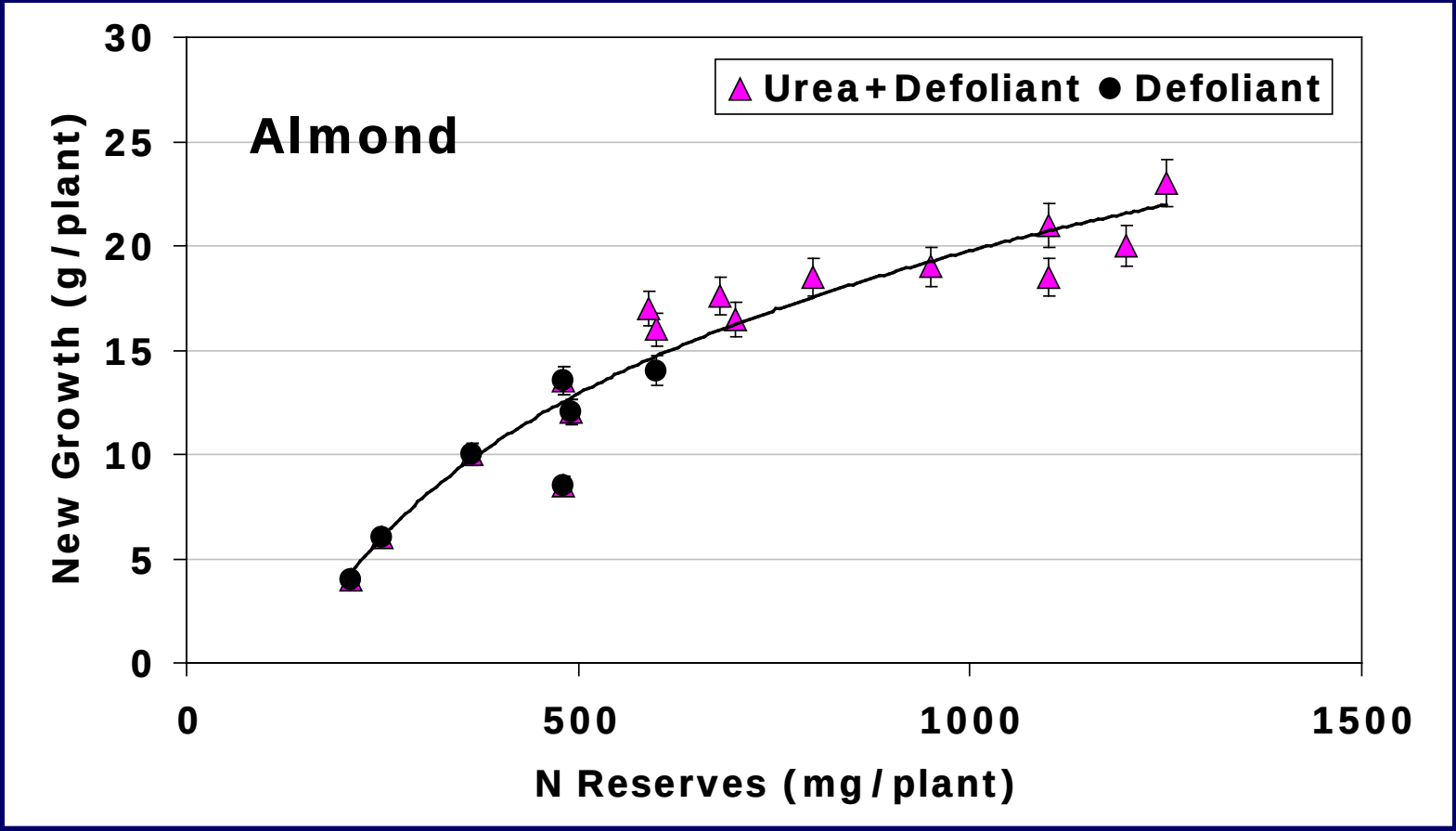
Defoliant in Autumn



3% Urea & Defoliant in Autumn

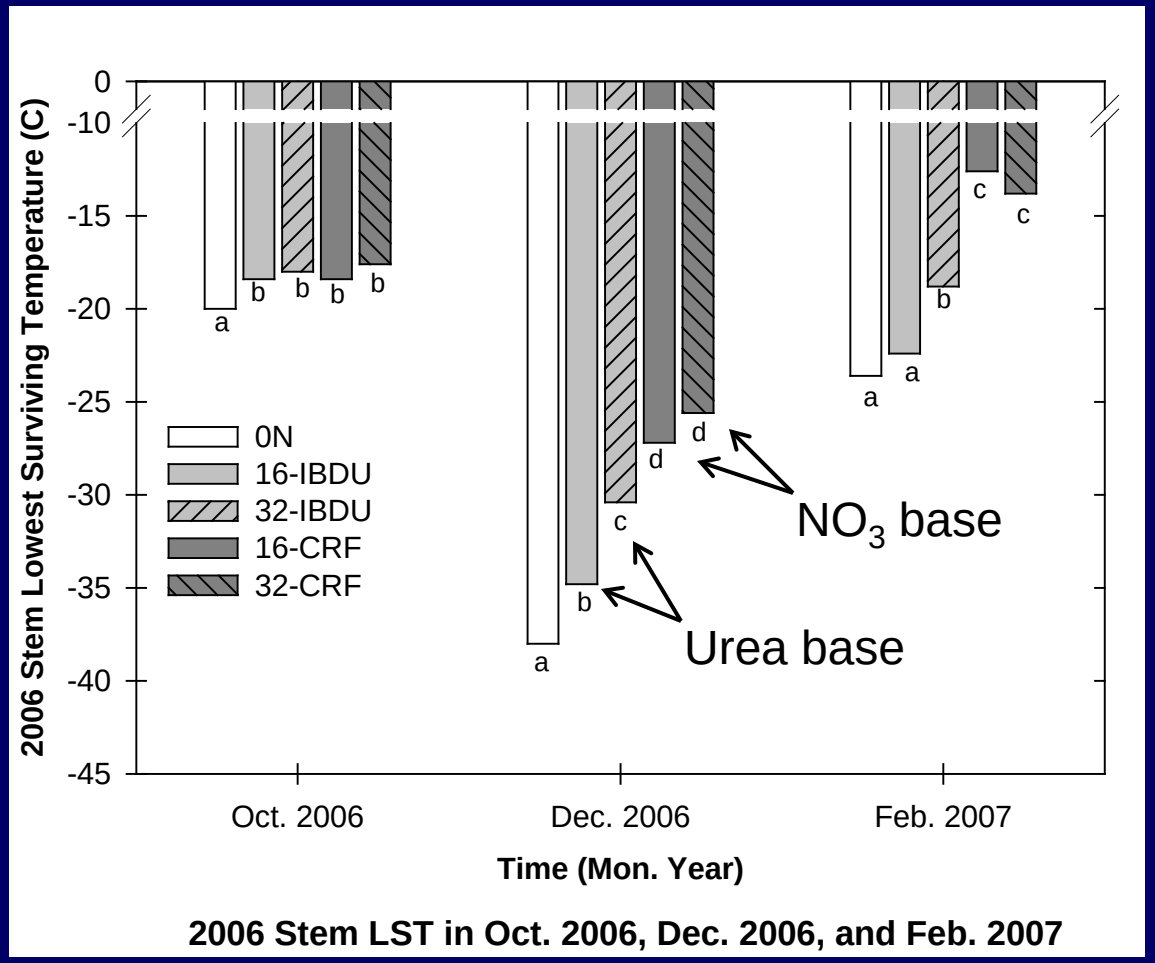
Using foliar urea with defoliant improves performance

INTEGRATED NUTRIENT MANAGMENT



Urea application in fall prior to defoliant use increases N reserves and new growth the following year.

Assessing effect of fertilizer type and application method on cold hardiness of nursery crops



2006 Stem LST in Oct. 2006, Dec. 2006, and Feb. 2007

High N rates during growing season decreased stem and bud cold hardiness. Plants given urea based fertilizers were less susceptible to cold damage.

Interaction with Irrigation

Dave Bryla
Horticulturist
Corvallis, OR

USDA ARS

Design and Management of Fertigation Systems for Blueberry

Objectives:

- Compare fertigation to conventional granular fertilizer application

- Identify best fertigation rates for maximum growth and production

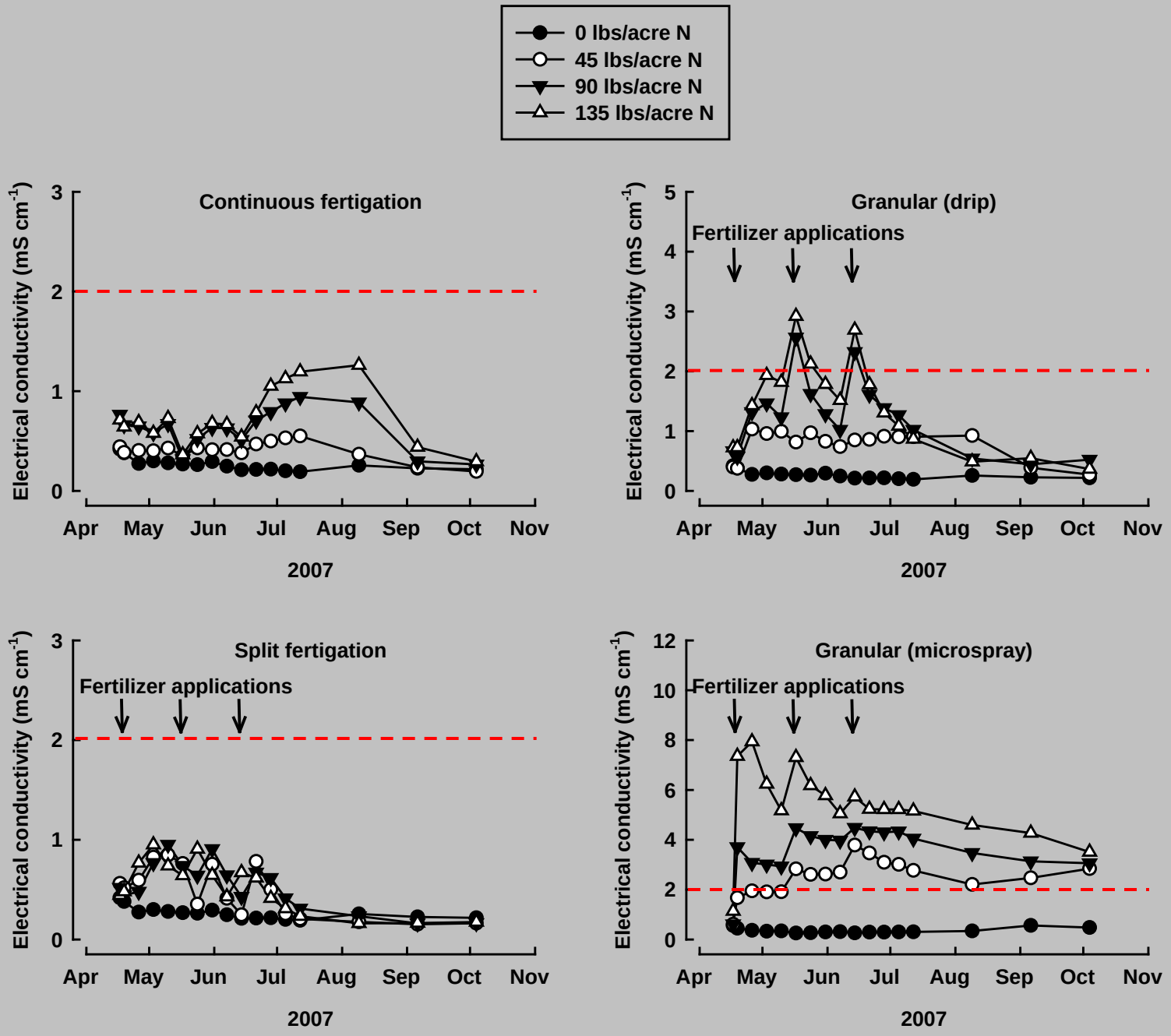

Granular fertilizer (drip or microspray) – 90-135 lbs/acre N
Discolored leaves


Necrotic & senesced leaves


Dead canes


Dead plants

Soil solution samplers

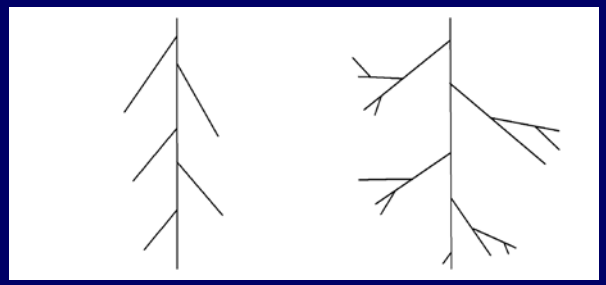

0 lbs/acre N
45 lbs/acre N
90 lbs/acre N
135 lbs/acre N
Continuous fertigation
Granular (drip)
Split fertigation
Granular (microspray)
Fertilizer applications
Electrical conductivity (mS cm-1)
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
2007

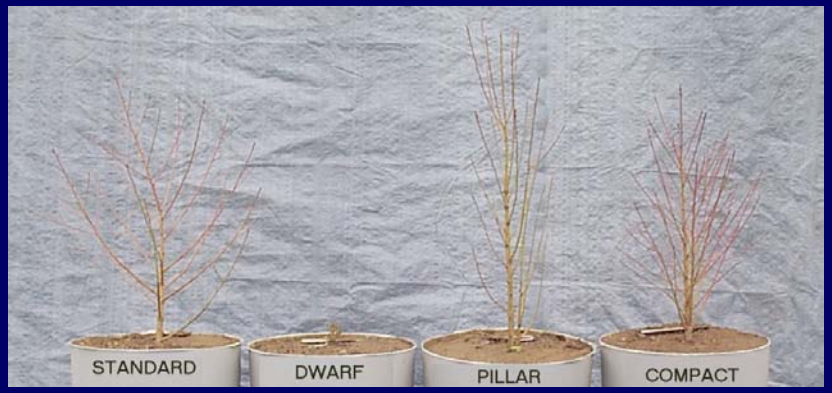
Peach Root Traits

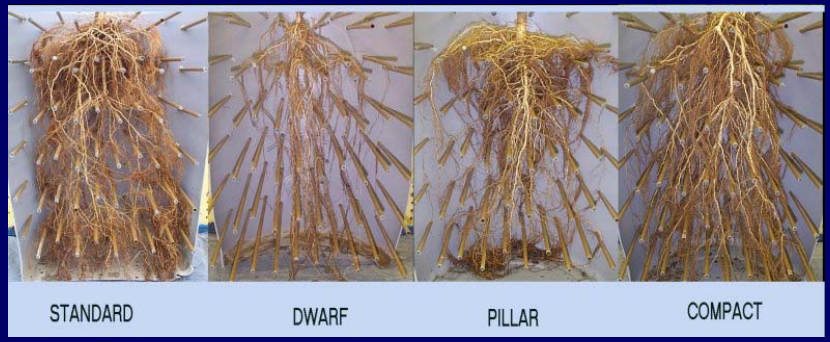
Tom Tworkoski
Plant Physiologist
Kearneysville, WV

- PREVIOUS WORK:
  - Hormone ratios in peach and apple were associated with different tree architectures.
  - Compact had 3-times more lateral roots than Pillar or Standard growth habits.
  - Compact trees absorb 2-times more phosphorous as nutrients become limiting.

- PRACTICAL VALUE:
  - Compact root systems increased access to nutrients like P which move via diffusion.
  - Growers may reduce fertilizer inputs with tree rootstocks that utilize nutrients more efficiently.







Root Foraging Capacity In Different Grape Rootstocks

Root Foraging Capacity In Different Grape Rootstocks

Paul Schreiner
Plant Physiologist
Corvallis, OR

USDA ARS

- Is capacity to Forage for a specific nutrient related to uptake & growth?

- Does capacity to Forage for N alter capacity to Forage for P or K?

- Is root topology in different rootstocks altered by different nutrients?

- Is root length in different rootstocks altered by different nutrients?

-Which root trait is more important for Foraging versus Uptake?

3. Nutrition & Fruit Quality -Things we know-

- Excessive N supply leads to poor fruit quality (shading / poor set / higher incidence of diseases)
- Low N also a problem - low yields, low YAN, too much solar exposure=sunburn
- K affects quality via pH - high supply leads to lower free acids and high must pH

3. Nutrition & Fruit Quality -Things we don't know-

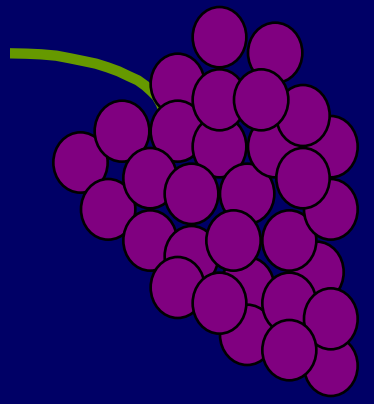
- Tissue standards not related to fruit quality
- How does P status affect quality?
- How do micronutrients affect quality?
- What is the correct balance of N supply that promotes good yields & YAN (low N issues), but allows for good exposure and flavor/color expression (high N issues).

Non-Grape ARS Research that relates to nutrition & fruit quality

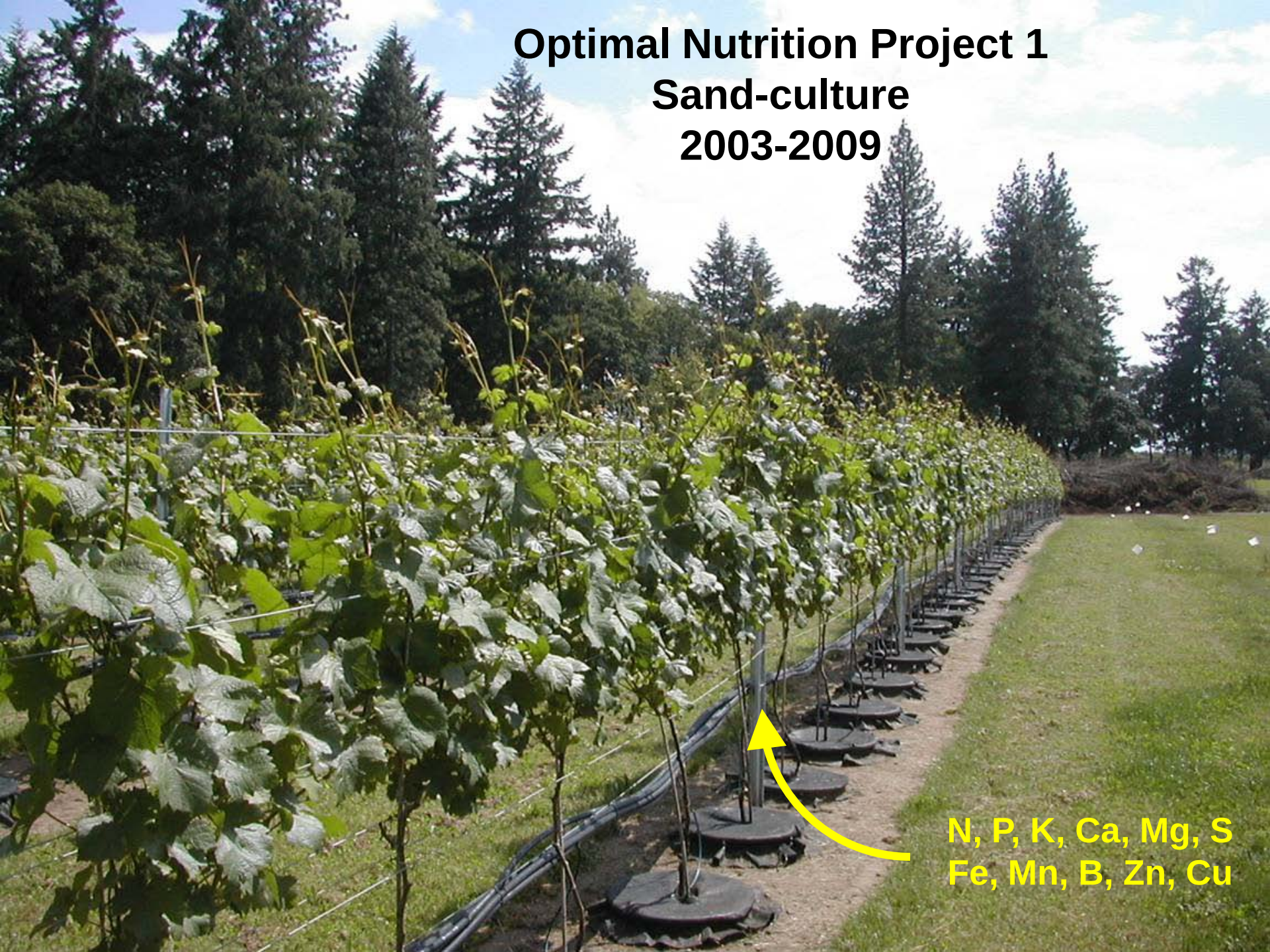
- Multiple ARS Groups - Breeding for fruit quality attributes
- Multiple ARS Groups - Impact of various farming practices on fruit quality
- Wenatchee Group (Mattheis, Ruddell, Curry, Zhu) - Apple fruit texture / aroma - metabolomics
- These programs not focused directly on nutrition & fruit quality
- Grapes (particularly wine) may be a bit unique - (small size matters, complex suite of quality indicators - fermentation expression)

Identifying optimal nutrient concentrations for premium wine grape production based on physiological needs and fruit quality

R. Paul Schreiner
USDA – ARS – HCRL
Corvallis, OR



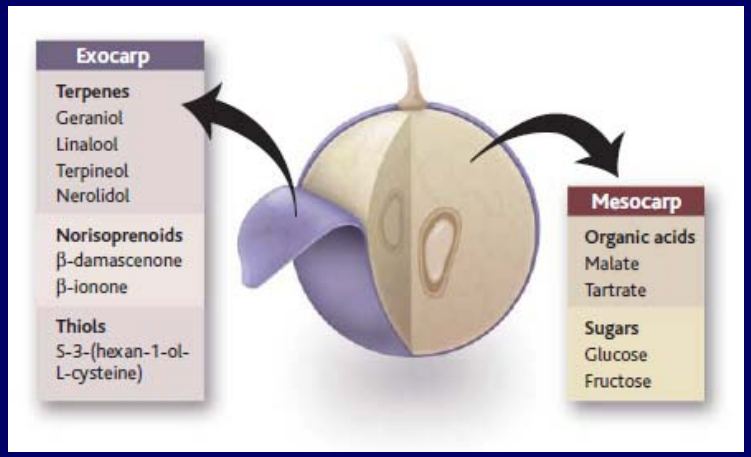
Jungmin Lee – USDA, Parma ID
Michael Qian – OSU, Corvallis OR
James Osborne – OSU, Corvallis OR
Patty Skinkis – OSU , Corvallis OR

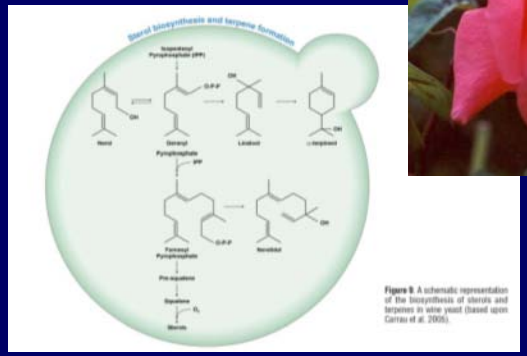

Optimal Nutrition Project 1
Sand-culture
2003-2009
N, P, K, Ca, Mg, S
Fe, Mn, B, Zn, Cu

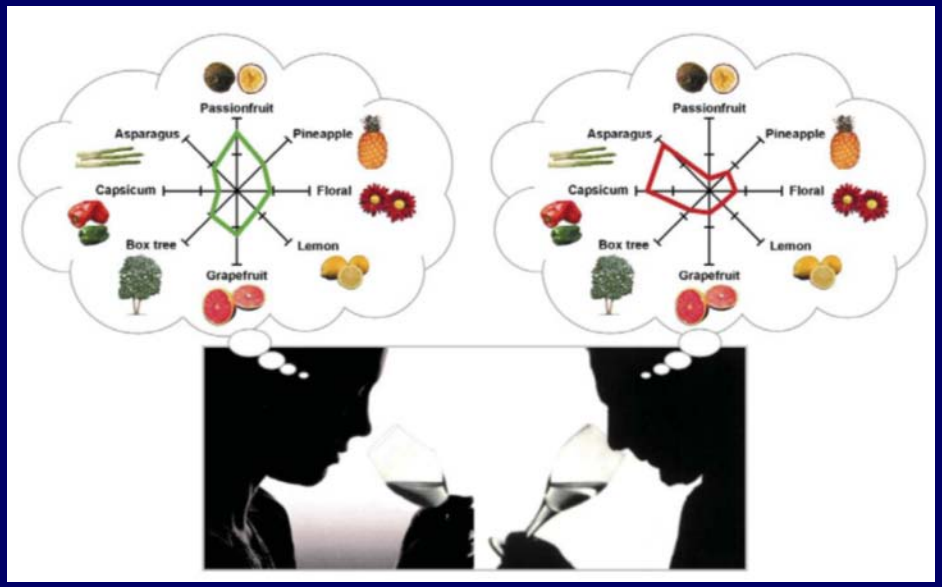
Effects on Vine Growth & Nutrients

Effects on Yield & Fruit Quality

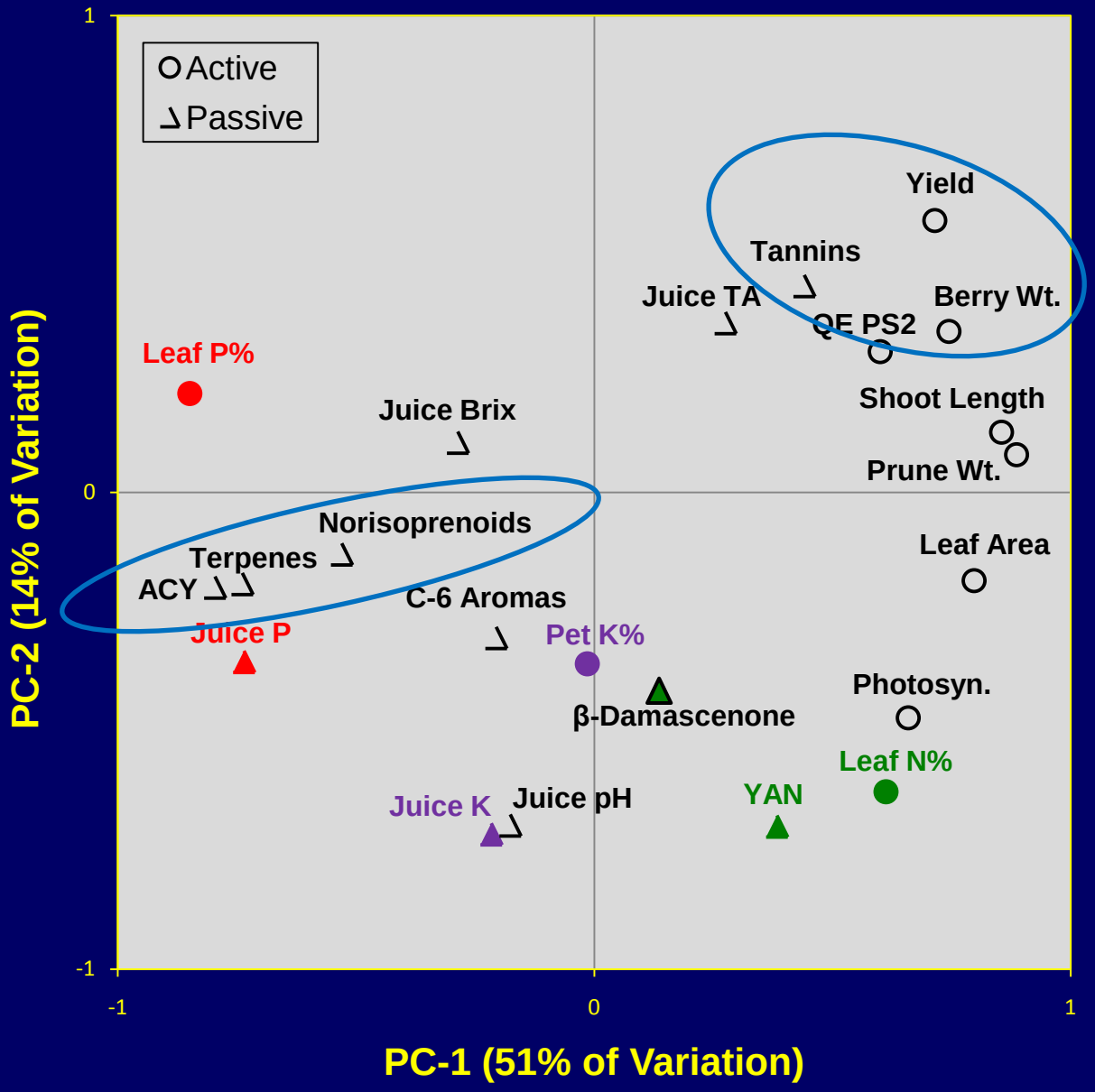
Effects on Berry Secondary Metabolites



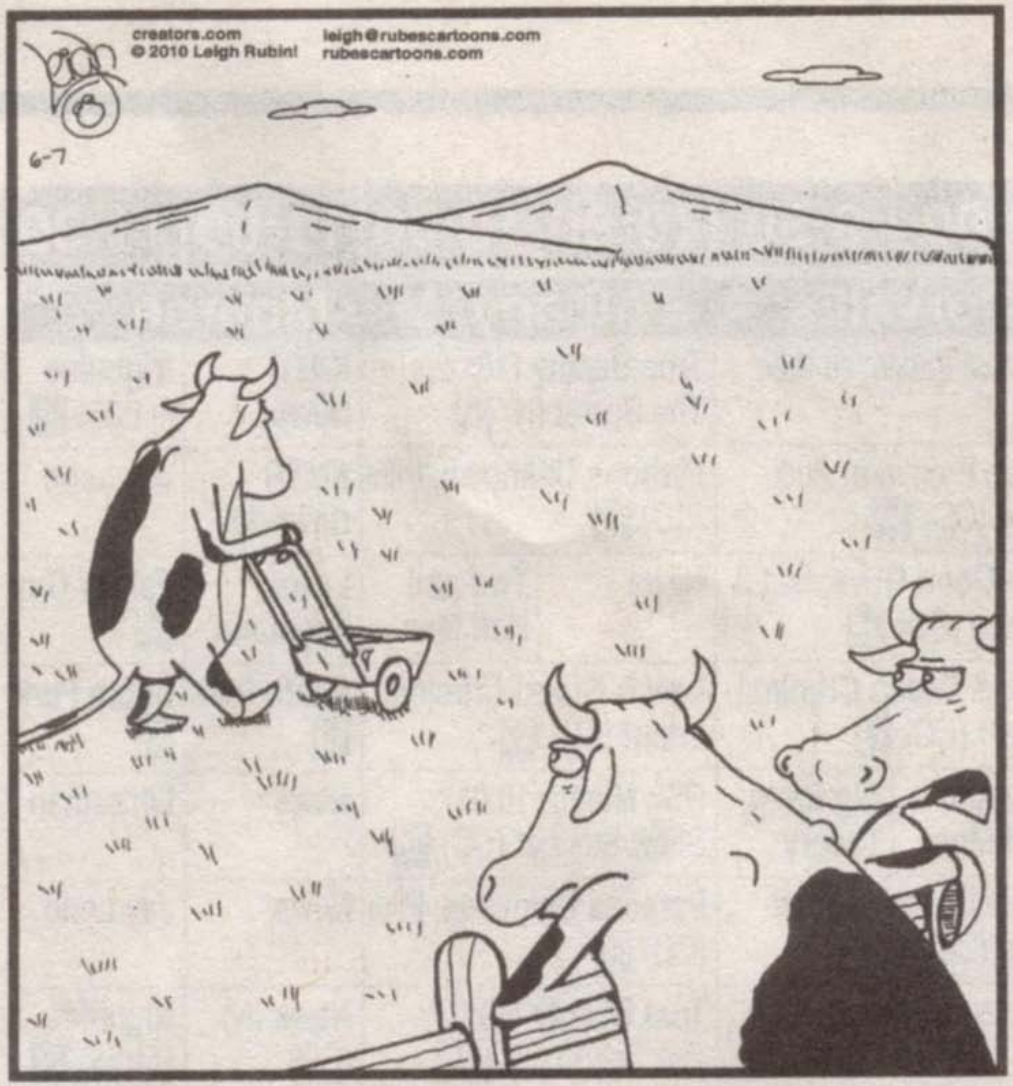




PCA Plot Based on Growth & N, P, K Status at Bloom



RUBES – By Leigh Rubin



"It's positively disgraceful. Just look at the way he's fertilizing. Has he no respect for tradition?!"

More, More, More
Other ARS Research Relating to Nutrient Management

- AMF ecology & on-farm inoculum production (Dave Douds, Wyndmoor, PA)
- Root trait selection for Al tolerance (Leon Kochian, Ithaca, NY)
- Rootstock scion interactions in tree fruits (Geneva & Kearneysville)
- Water & nutrient use in nursery crops (Joseph Albano, Fort Pierce, FL)
- Nutrient & water supply greenhouse crops (James Altland, Wooster, OH)
- Cover crops in Orchards (Multiple Groups across US)