Effect of irrigation water acidification and soil pH on citrus nutrient availability

Dr. Kelly T. Morgan
University of Florida
Soil and Water Science Department
Southwest Florida Research and Education Center, Immokalee
239 658 3400
conserv@ufl.edu

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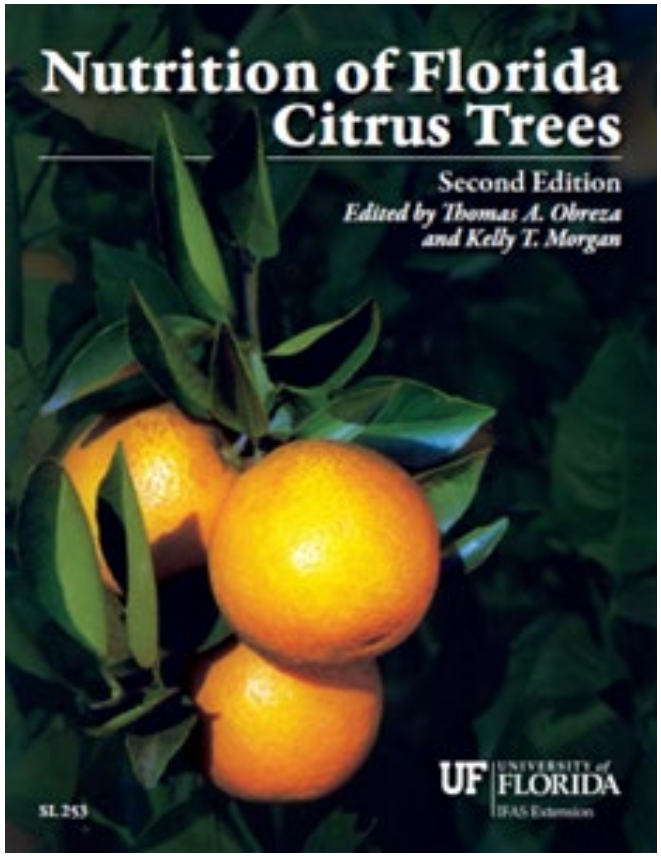
Nutrient recommendations for HLB affected trees

- Last Revision to the citrus nutrient recommendations – 2008
- Currently being reviewed to include information on nutrition of HLB affected trees



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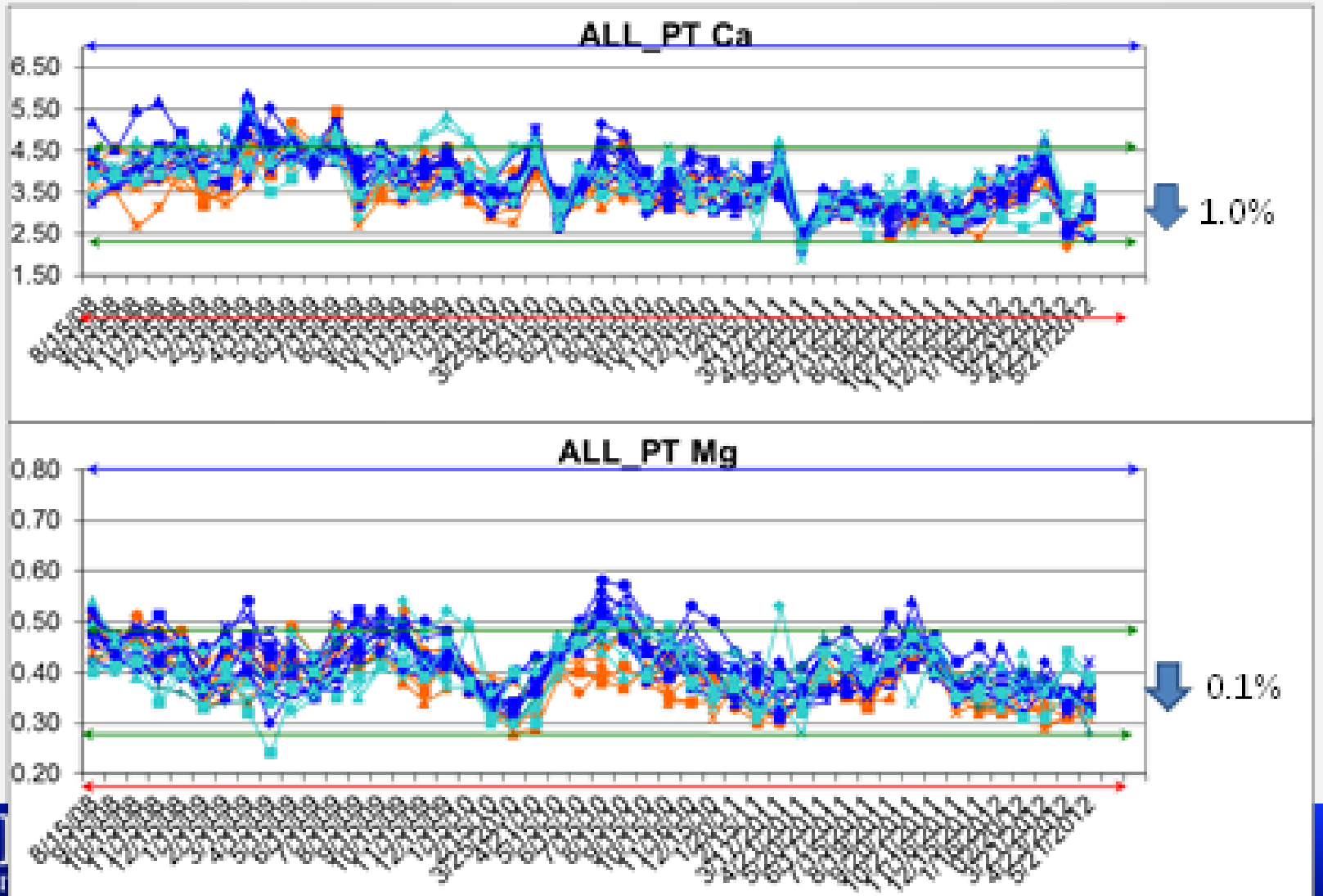
Impact of HLB root damage: decline in Ca and Mg leaf status over in ridge and flatwoods groves (Data from Bill Barber – Lykes Citrus)



Greening Foliar Nutrient Study

- Duration = 5 years 2010 – 2015
- Commercial Grove – Valencia on Swingle – 16’ X 30’
- No Spray control
- Mn, Zn, B at three rates (0.5X, 1.0X, 2.0X)- 1X = IFAS recommendation, applied 3 times per year
- Annual applications of 1.5x, 3.0x and 6x IFAS recommendations
- Mn and Zn as sulfates and phosphites
- Sulfates with and without Potassium nitrate
- Leaf samples taken prior to (pre) and after sprays (post)

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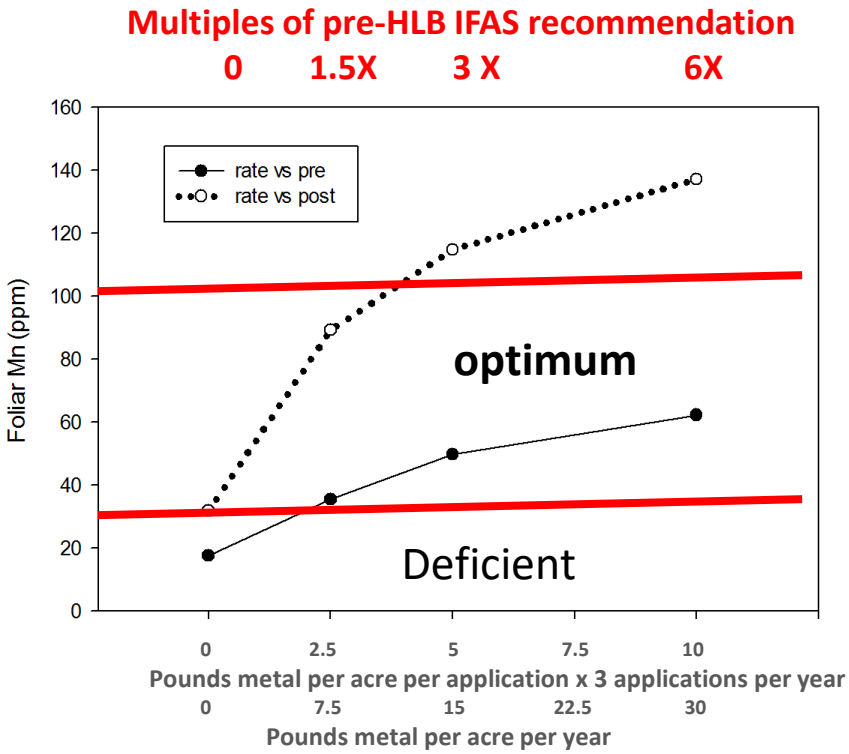
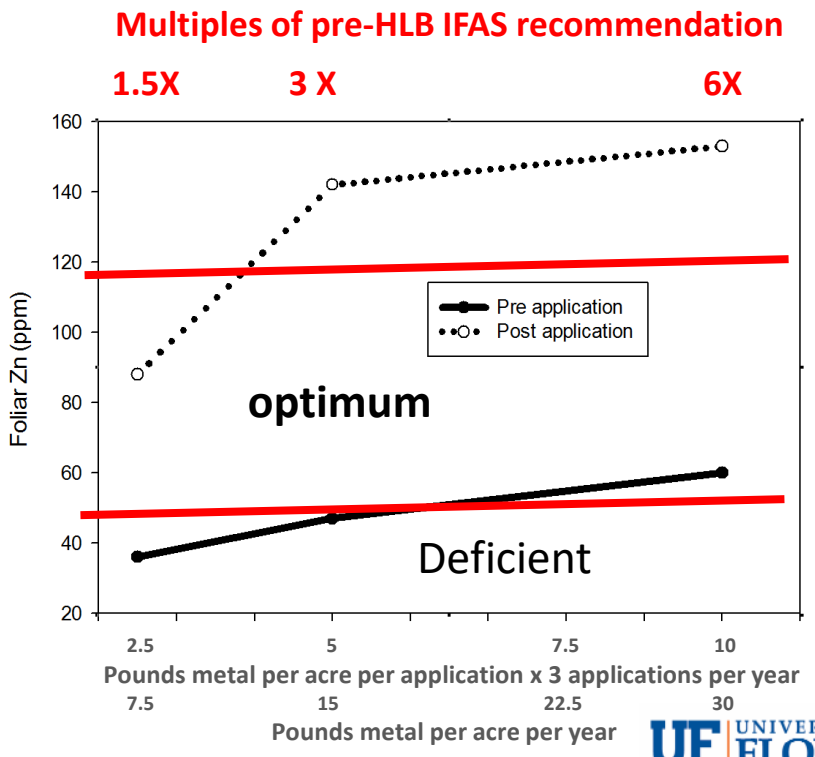
Effect of Sprays on New Growth

- Leaf Mn and Zn were lower in leaves of trees prior to foliar sprays but increased after spray applications
- 3.0 and 6.0 times recommendation were most effective





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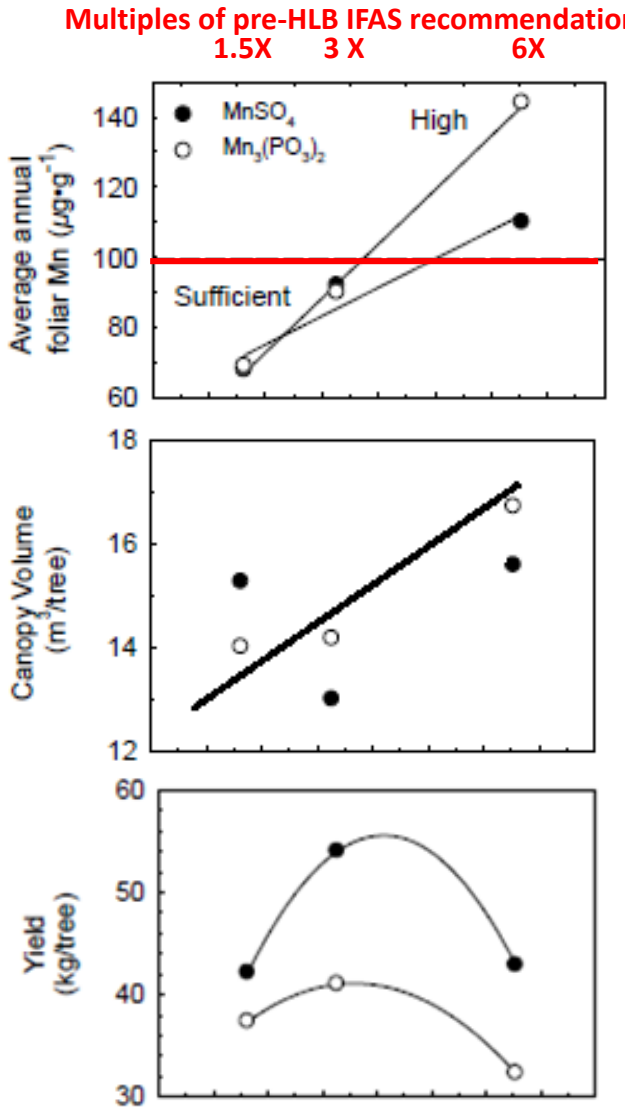
Effect of Leaf Nutrient Concentrations on Tree Growth and Yield



- Similar trends for both Mn and Zn
- Similar canopy volume at 3X rate
- Slight but significantly Greater canopy volume at 6X
- Increasing yield with increased rate to 3X but lower at 6X

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Soil Alkalinity

Primarily determined by presence of bicarbonates (HCO_3^-), Carbonates (CO_3^-), and hydroxides (OH^-) in water.

A measure of the capacity of water to neutralize acids.

Alkaline compounds in water remove H^+ ions and lower the acidity of water (increase pH).

Limits nutrient availability in soils

Bicarbonates in Water

Water above pH 7.5 is usually associated with high bicarbonates.

Recommend levels of 100 ppm or less

Forms bicarbonate salts with Ca, Mg, Na, and K.

High Ca concentrations will react to form Calcium carbonate or line.

Higher calcium carbonate in soils increases pH making many nutrients less available.

Particulates can drop out of water and plug emitters or microsprinklers.

Soils with excess Ca forms $CaCO_3$ (lime).

Treatments:

- calcium or gypsum (calcium sulfate) to increase calcium availability to plants and soil,
- elemental sulfur can be used to reduce soil pH,
- applications of acidified water or acidic fertilizer

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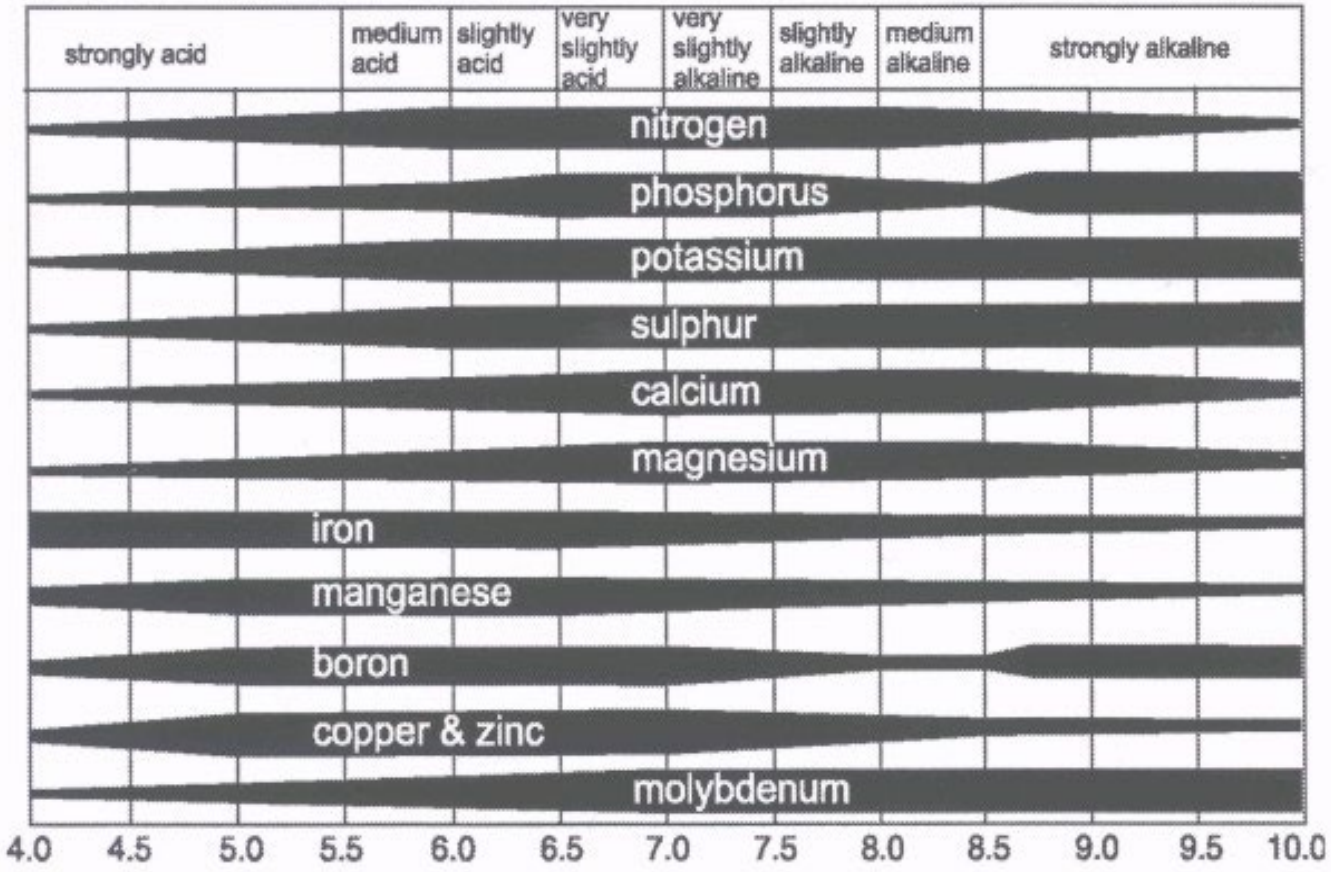
Effect of Soil pH on Nutrient Availability



Macronutrients (N, K, S, Ca and Mg) highly available between soil pH 6.5 and 8

Micronutrients (Mn, Zn B, and Fe) most available below soil pH 6.5

Best soil pH range for most crops is 6 to 6.5

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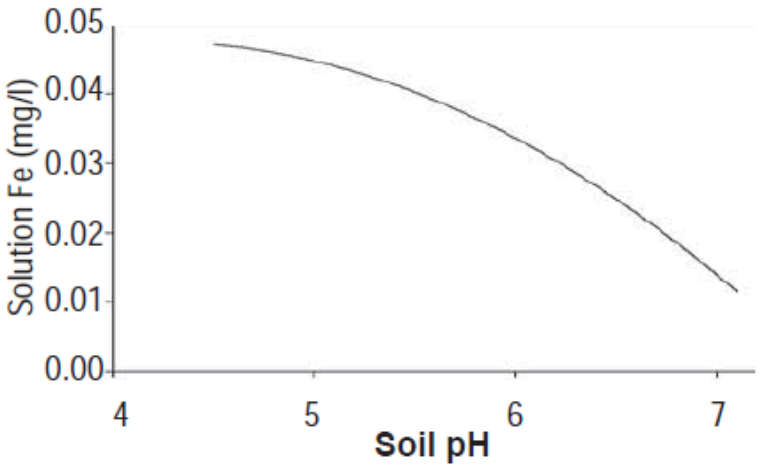
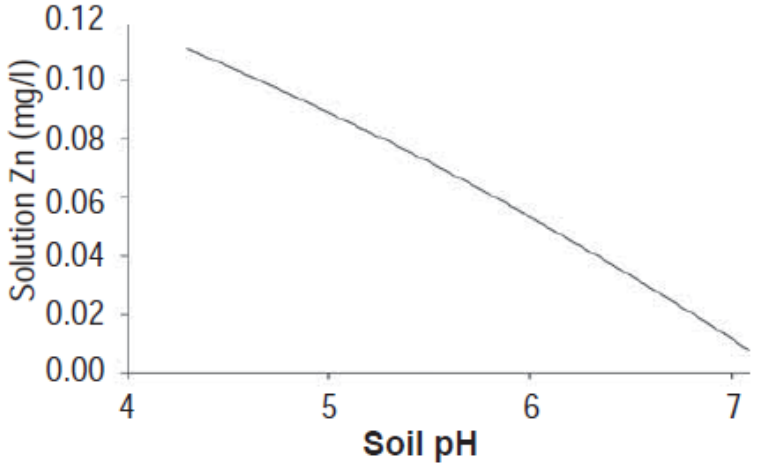
Plant Uptake

- ✓ **Bicarbonate induced chlorosis is caused by transport of bicarbonate into the plant leading to reduced nutrient uptake.**
- ✓ **Lime-induced chlorosis effects many annual crops and perennial plants growing on calcareous soils.**





Horneck, D. 2006. Acidifying Soil for Crop Production East of the Cascades. Oregon State

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Water Treatment

- ✓ Standard treatment is to lower the water's pH by adding an acid.
- ✓ Lowering the pH to 6.5 or lower neutralizes bicarbonate in the water.
- ✓ Bicarbonates in irrigation water leads to higher soil bicarbonates and pH.
- ✓ Injection of acidified water instead of a dry material to a wide area will reduce bicarbonate accumulation in the irrigated area.
- ✓ Most common acids to inject are sulfuric acid, phosphoric acid.

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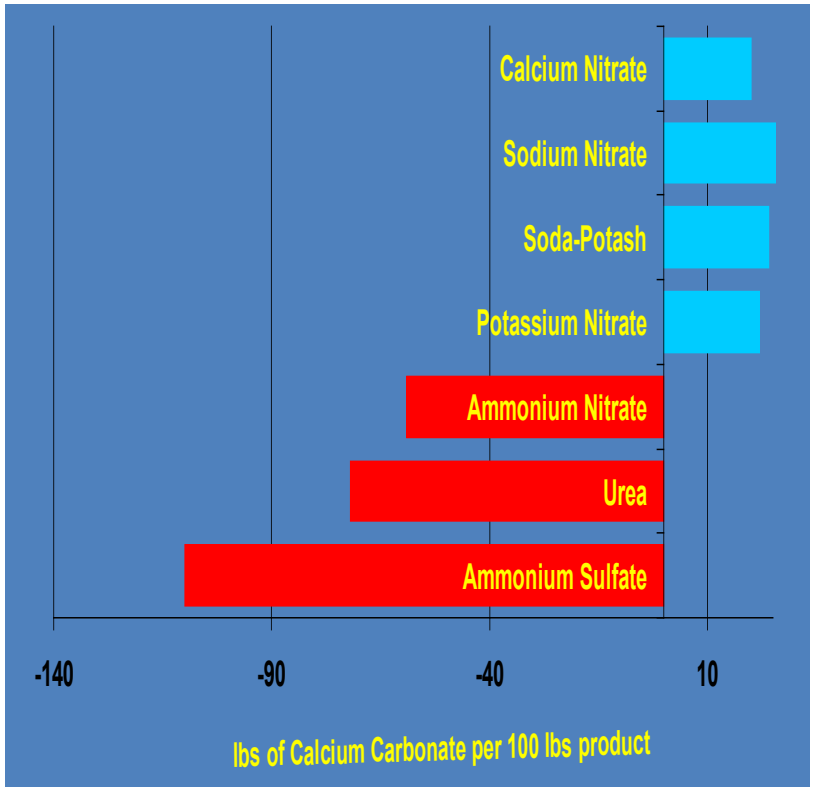
Acidifying Fertilizers

- ✓ **Alternative Acidifying methods**
  - ✓ **Formulations with acidifying materials**
    - ✓ **When ammonium is converted into nitrate in the soil $3H^+$ are released increasing soil pH**
    - ✓ **Ammonium thiosulfate is also acidifying because it supplies both ammonium and sulfur**
  - ✓ **Replace any filler with slow release forms of sulfur (e.g. Tiger 90)**



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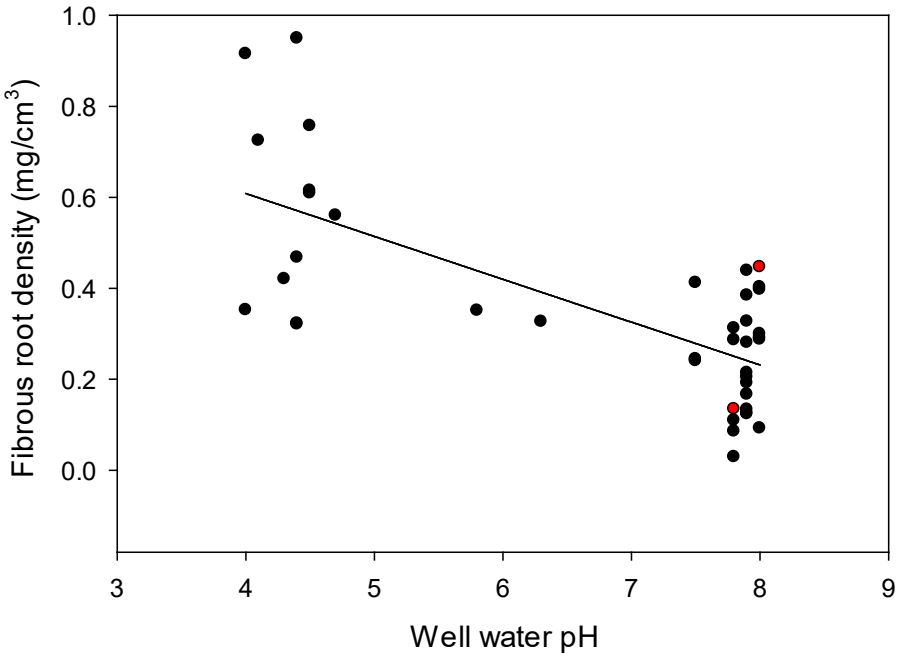
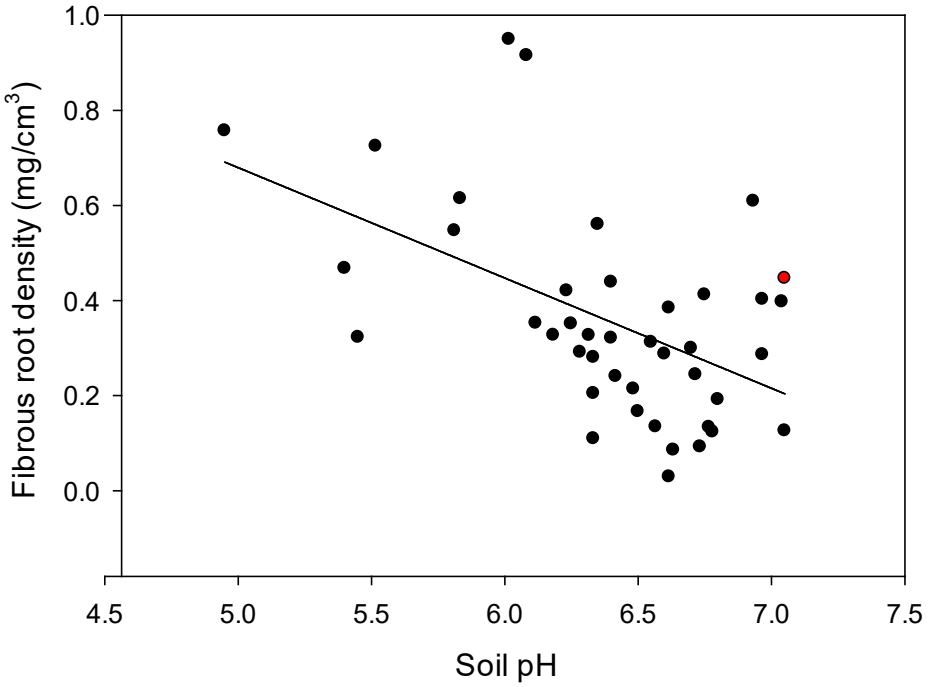
Lower Root Density is related to higher pH

Well water pH



Soil pH in the wetted zone



J.H. Graham, 2014 - 2016 survey of central Florida citrus groves for effect of bicarbonates

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Effect of soil pH on Nutrient status

- Mature Hamlin/Swingle – initial soil pH 7.3
- Irrigation water acidified for 3 years
- Soil pH range from 4 to 7.3
- Methods of pH moderation
  - Irrigation water acidification
  - Application of slow release sulfur product
- Soil and tissue samples, and yield estimation

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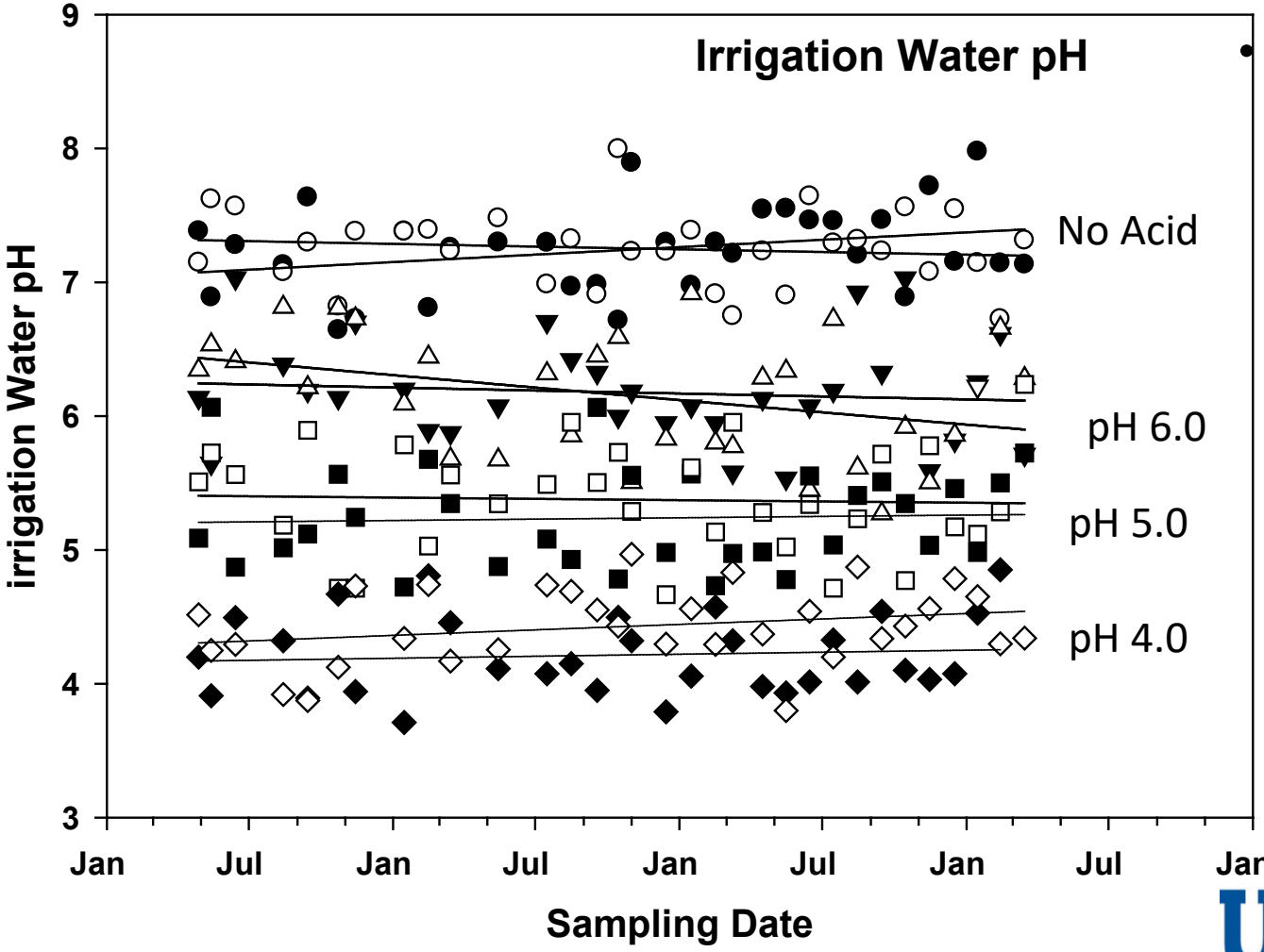
Effect of Acidificaiton on Water pH



Irrigation water within half a pH unit of target

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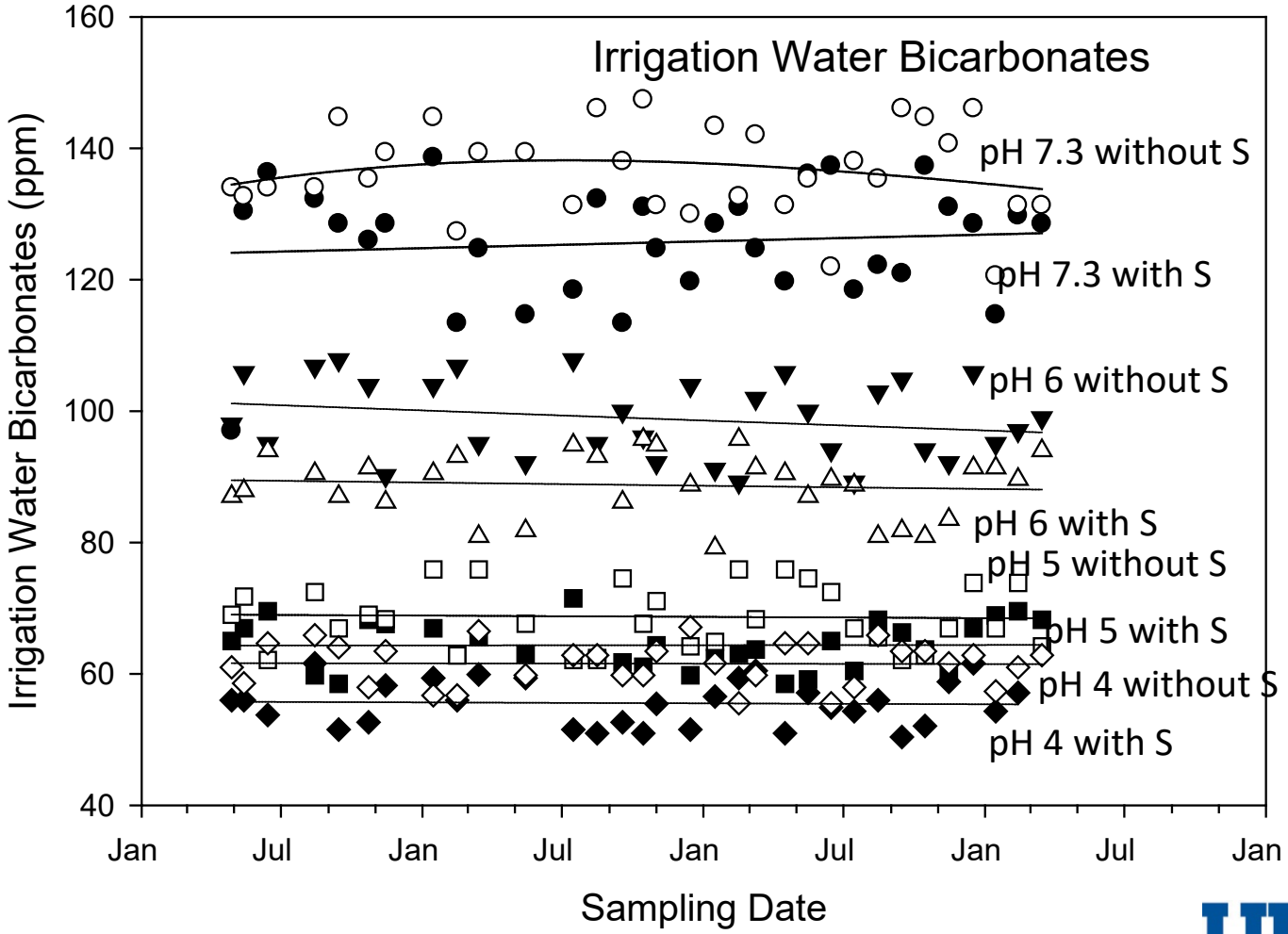
Effect of pH on water Bicarbonates



Suggested bicarbonate limit = 100 ppm

Little reduction in bicarbonates below pH 5

Soil applied S has no effect of irrigation water pH

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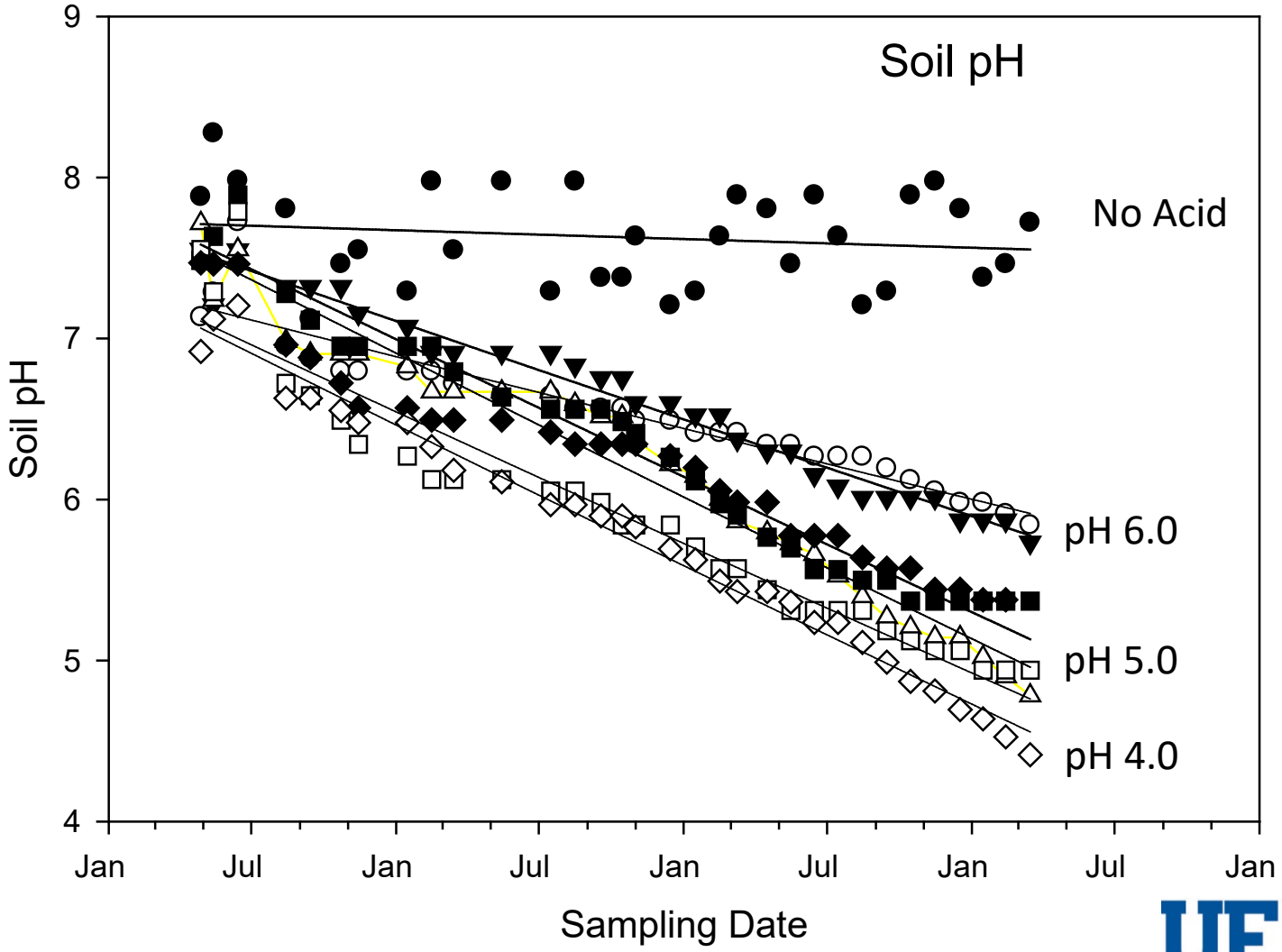
Effect of Irrigaiton Water pH on Soil pH



Three years to reach target pH

Applied soil S lowered pH by less than half pH unit

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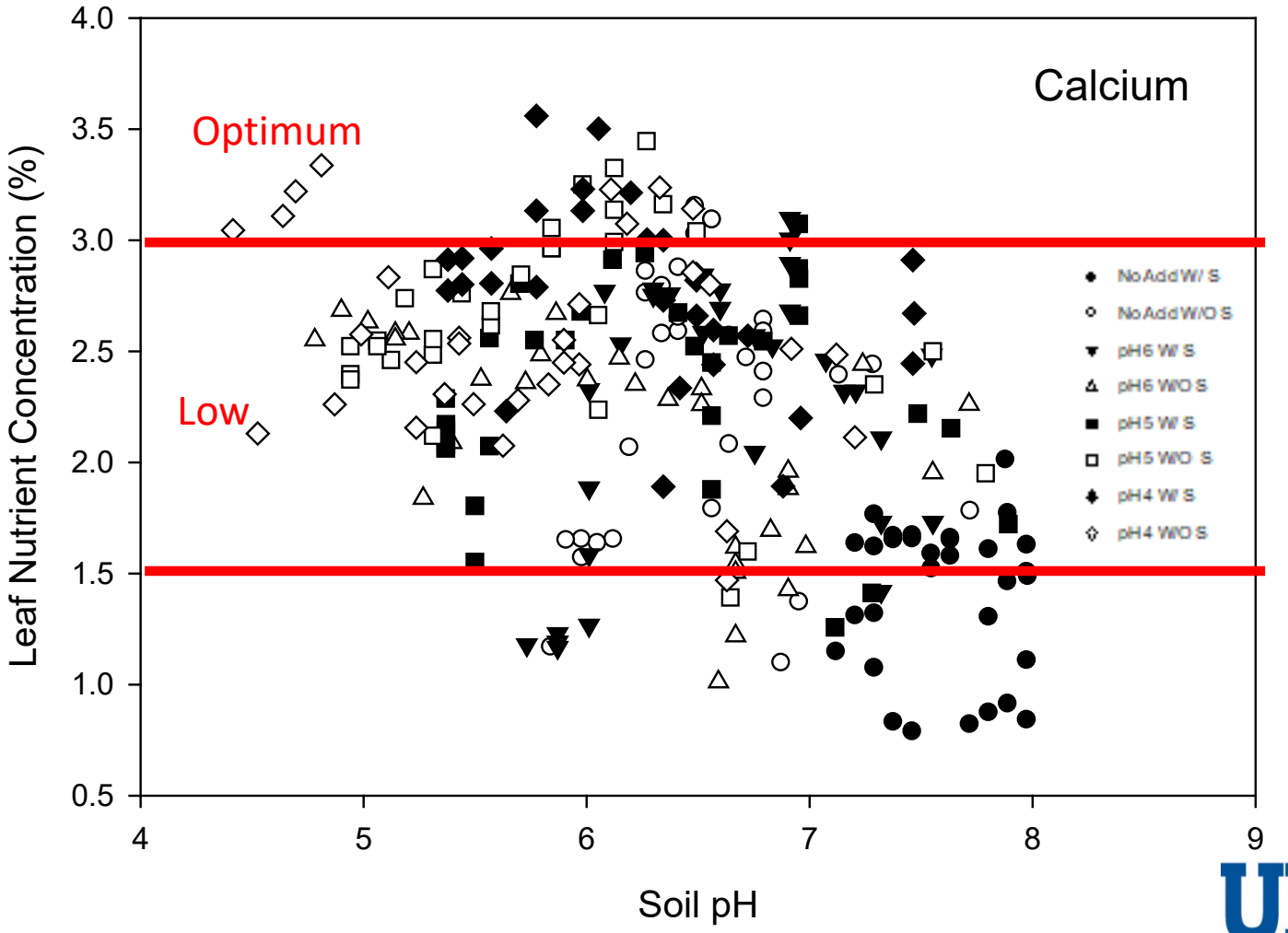
Effect of Soil pH on Leaf Calcium



Leaf calcium increased with lower soil pH

Calcium increased above optimum level below pH 6.5

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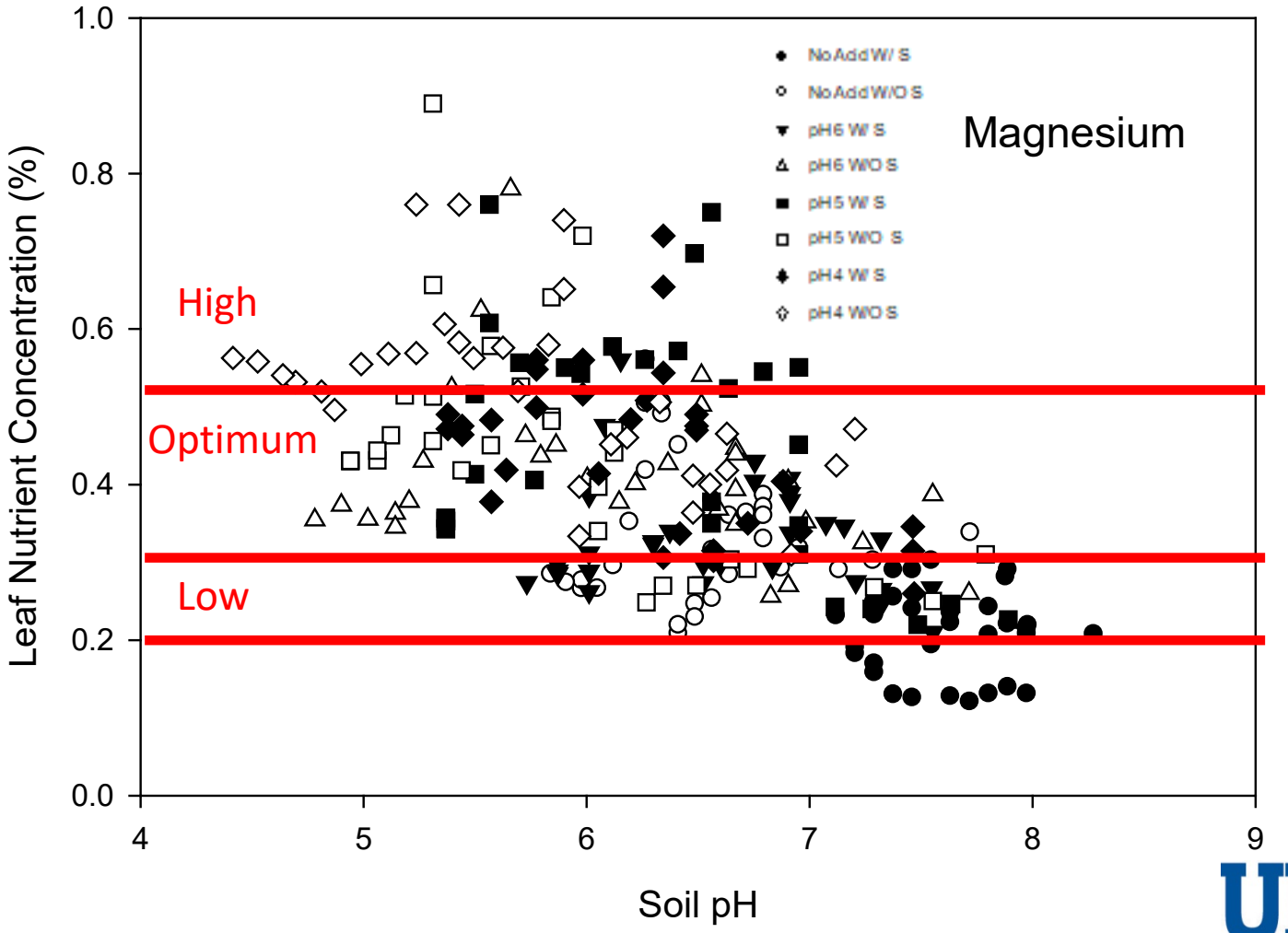
Effect of Soil pH on Leaf Magnesium



Increased leaf Mg with lower soil pH

Leaf Mg concentrations above optimum below pH = 6.5

Leaf Mg in high optimum or higher below soil pH = 6

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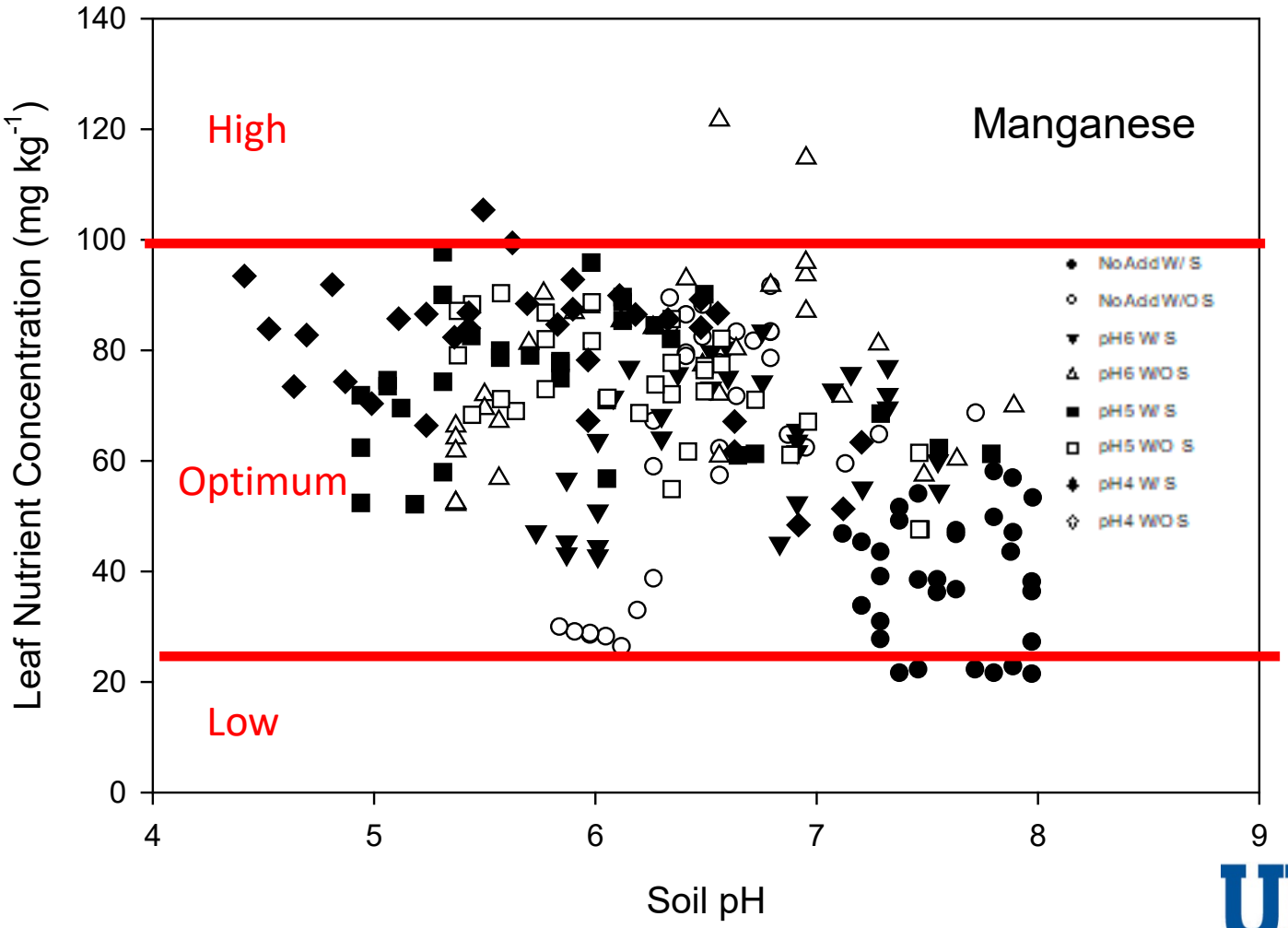
Effect of Soil pH on Leaf Manganese



Increased leaf Mn with lower soil pH

Leaf Mn concentrations above optimum below pH = 7

Leaf Mg in high optimum or higher below soil pH = 6

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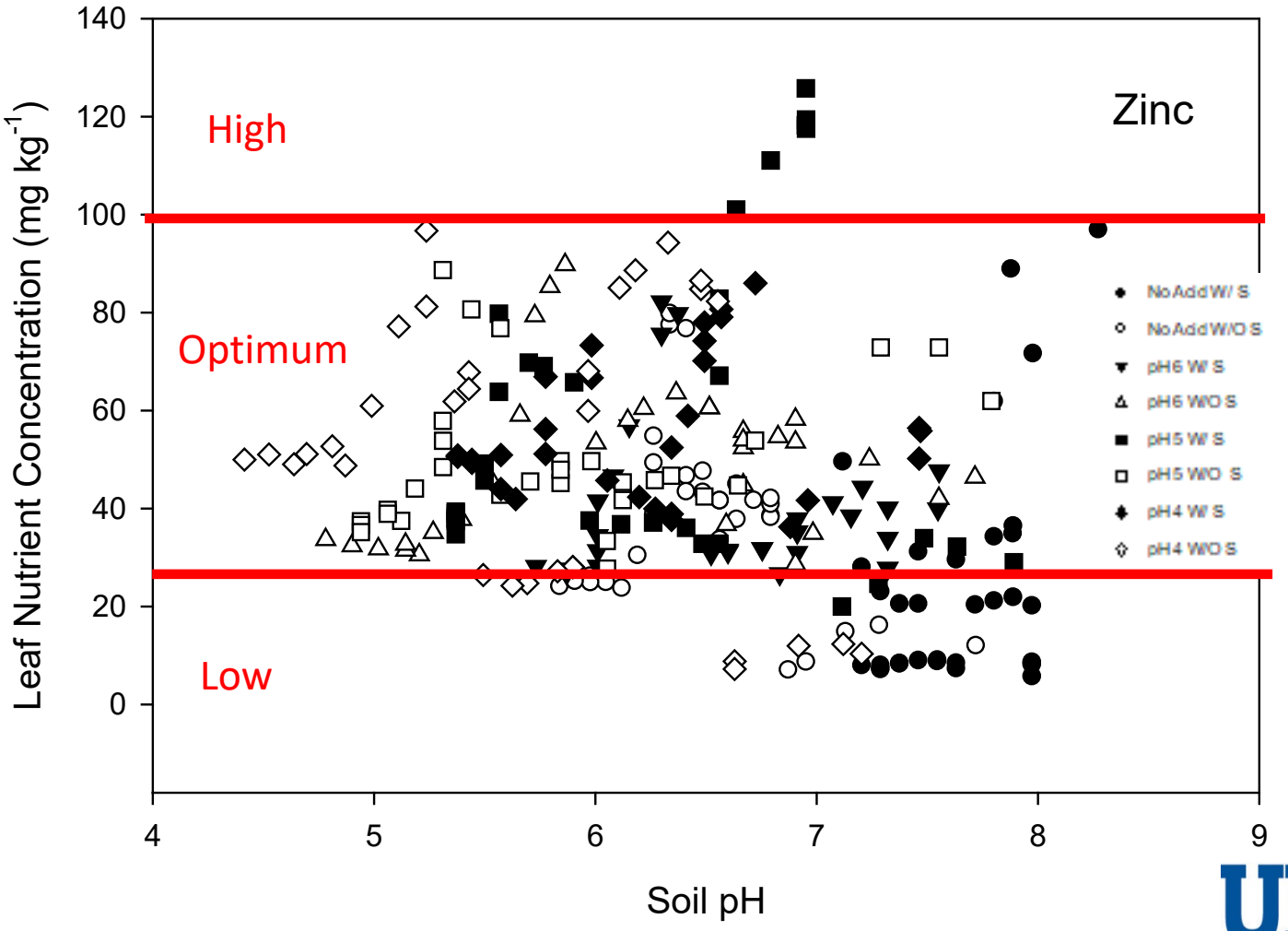
Effect of Soil pH on Leaf Zinc



Increased leaf Zn with lower soil pH

Leaf Zn concentrations above optimum below pH = 7

Leaf Mg in high optimum or higher below soil pH = 5.5

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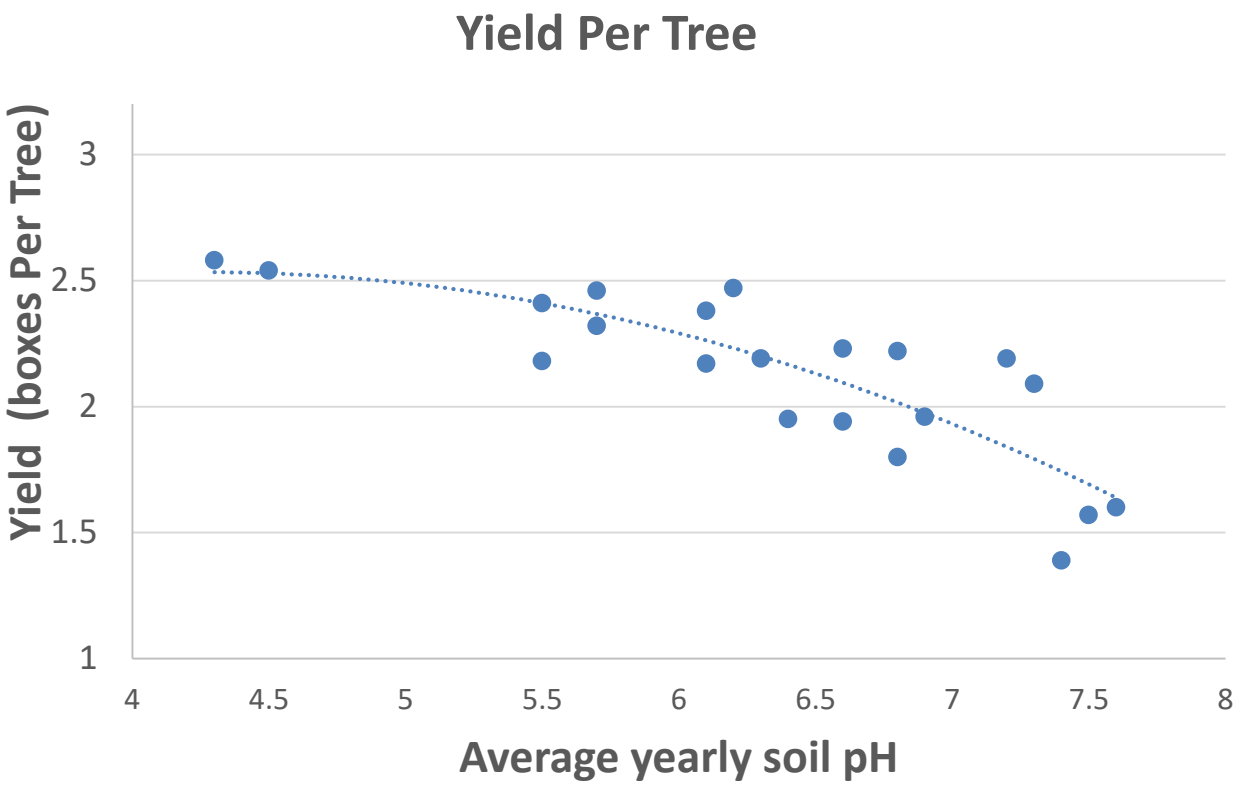
Effect of soil pH on Yield



- Yield per tree increases with average yearly soil pH.
- No significant increase in yield below soil pH of 6.0
- Recommendation – monitor soil pH and adjust to 6.0 – 6.5 as needed

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Conclusions

- ✓ Soil pH affects crop plants ability to extract nutrients, including N, P, K, Mg, Ca, Mn, Zn
- ✓ Higher soil pH reduce plant nutrient uptake by reducing soil water nutrient solubility,
- ✓ Water and soil bicarbonates should be addressed to allow for proper nutrient uptake,
- ✓ Irrigation water acidification or application of acidifying fertilizer materials should be used to reduce soil pH in the irrigated area,
- ✓ Yield improves to soil pH of 6.0, maintain soil pH between 6.0 and 6.5

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