Teak Nutrient Disorder Symptoms In a Hydroponic System Correlated With Near-infrared Spectroscopy (NIR) models

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Nutrient Disorder Project Objectives

- Determine nutrient disorder symptoms and foliar nutrient levels in teak seedlings in order to better diagnose problems
- Develop photographic guide of symptoms
- Correlate foliar nutrient analysis results with NIR models in order to develop predictive models for N, P, and K
- Compare accuracy of handheld field NIR scanner to laboratory NIR scanning

4 Part Study

- A – Investigate nutrient solution concentrations, pH, buffer solutions, and germination media for ideal seedling growth
- B – Subject seedlings to nutrient disorders in order to describe and quantify responses and foliar nutrient levels
- C – Scan leaves with handheld microPHAZIR™ NIR scanner to develop predictive models of deficiencies
- D – Scan leaves with FOSS NIRSystems™ 6500 to develop predictive models of deficiencies

A - Nutrient Concentration

- Complete Hoagland solution at 100%, 50%, and 10% strength
- Study was completed winter of 2013

Macronutrients	Molarity	ml/100L
KNO_3	1M	500
$Ca(NO_3)_2 \cdot H_2O$	1M	500
KH_2PO_4	1M	100
$MgSO_4 \cdot 7H_2O$	1M	200
KCl	1M	nil
$CaCl_2 \cdot 2H_2O$	1M	nil
$NaNO_3$	1M	nil
$NaH_2PO_4 \cdot 2H_2O$	1M	nil
Na_2SO_4	1M	nil
$MgCl_2 \cdot 6H_2O$	1M	nil
FeDTPA	1M	100
Micronutrients		
$MnCl_2 \cdot 4H_2O$	20mM	90
$ZnCl_2 \cdot 7H_2O$	20mM	15
$CuCl \cdot 2H_2O$	20mM	15
H_3BO_3	100mM	45
$Na_2MoO_4 \cdot 2H_2O$	1mM	10
NaOH (pH adj.)	1M	~40

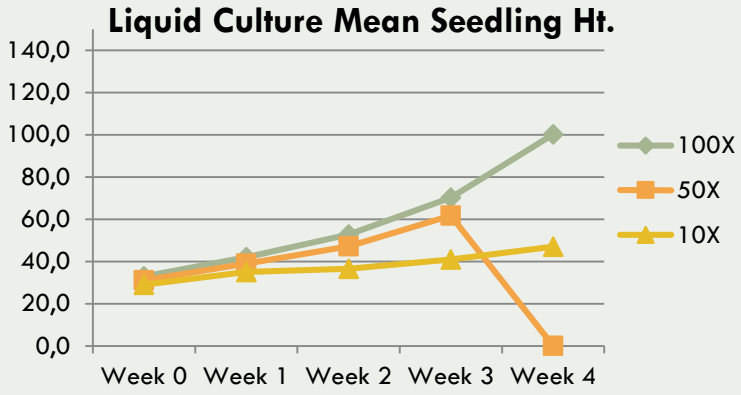
Hydroponic Systems

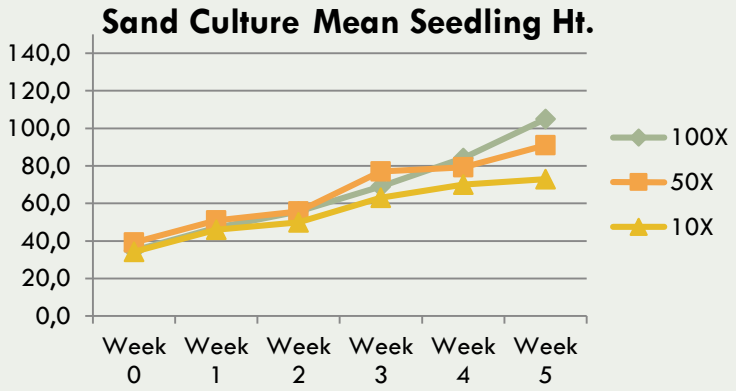
Liquid Culture Hydroponics

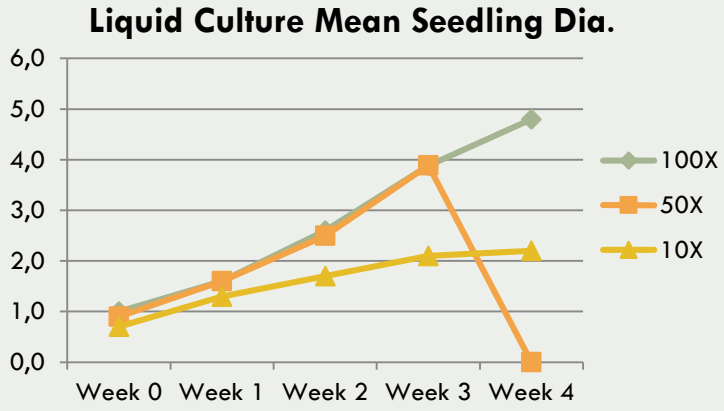
Sand Culture Hydroponics

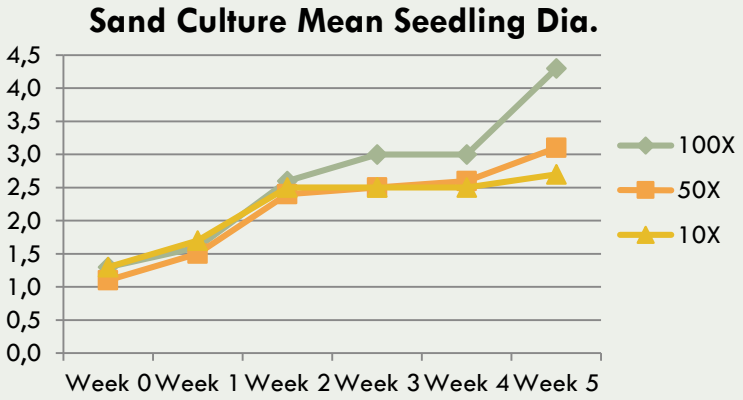
A - Solution Strength

100% strength solution resulted in superior growth



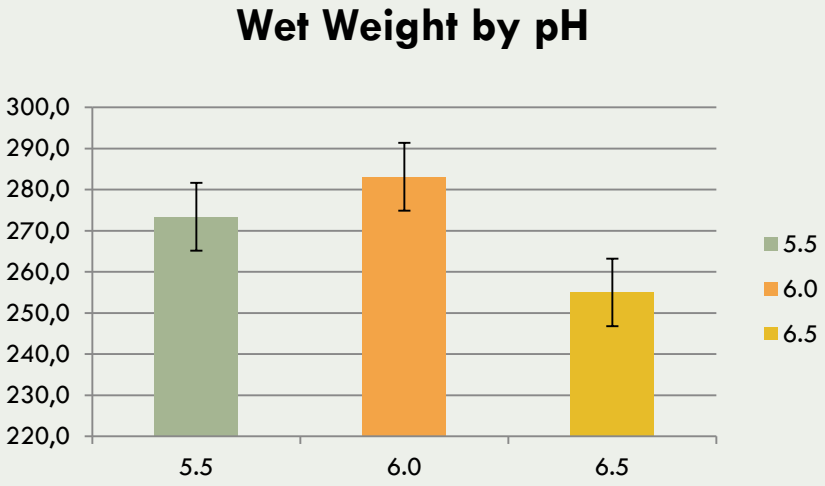


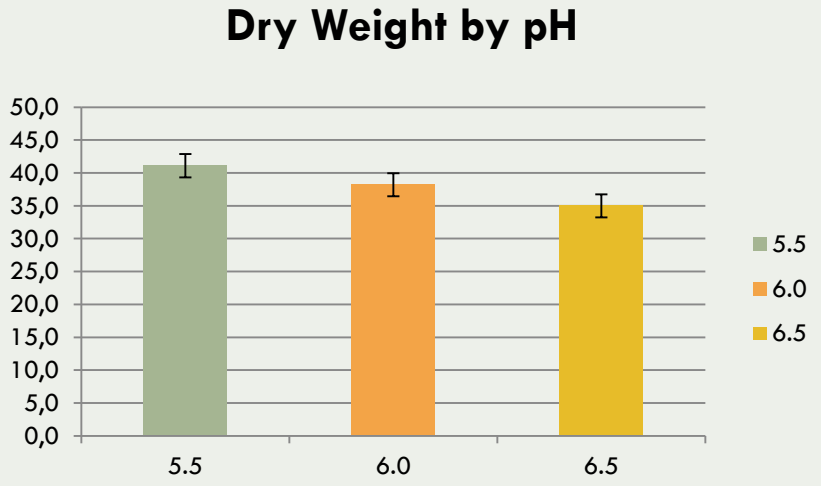




A - pH effect

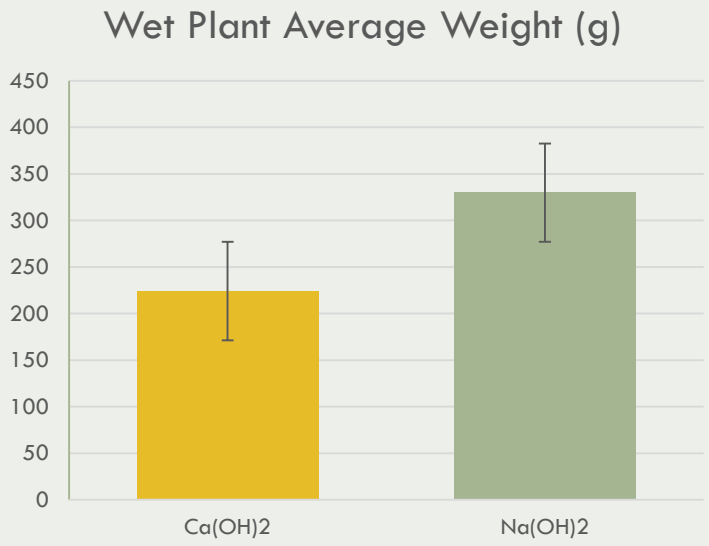
- 3 levels of pH: 5.5, 6.0, and 6.5
- pH of 6.0 had highest wet plant weight
- pH of 5.5 had the highest dry plant weight
- For my research I have a target pH of 5.8

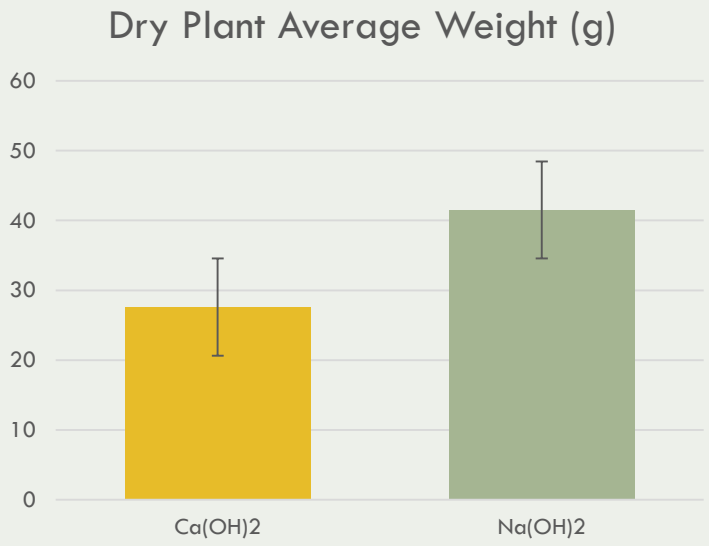




A - Solution Buffer

- 100% Solution, pH 6.0, buffers of $Ca(OH)_2$ and $Na(OH)_2$
- $Na(OH)_2$ buffer exhibited superior growth



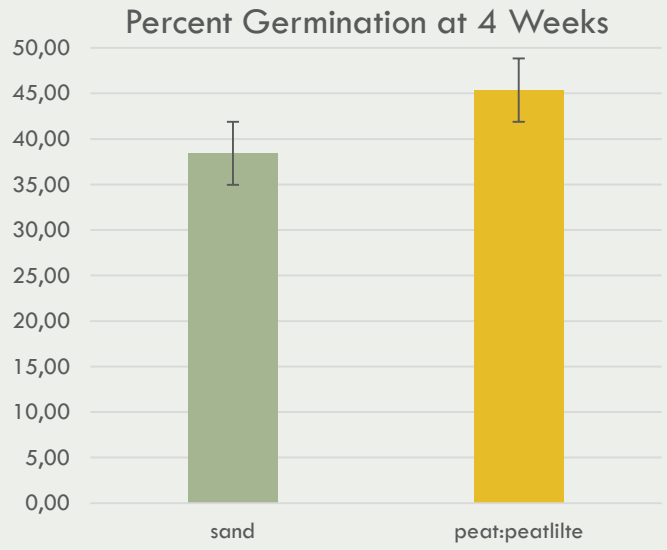


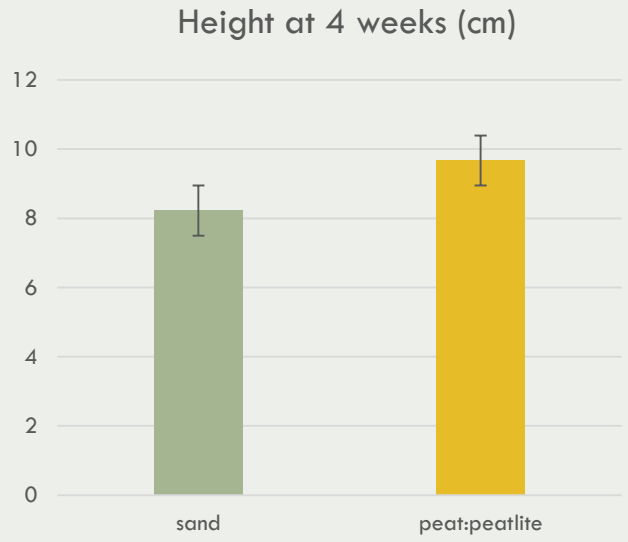
A - Germination Media

- Both washed concrete sand and an 80:20 peat:perlite (peatlite) media were used in germination
- Peatlite with added wetting agent and lime used in sand culture in order to have a well defined root plug
- Sand is preferred in hydroponics due to its ability to wash off roots before transferring to liquid solution

A - Germination Media

- Both washed sand and the peat:peatlite had suitable germination
- Growth in each media was not significantly different





A - Results

- 100% Strength Hoagland Solution
- Target pH of 5.8
- $Na(OH)_2$ buffer
- For sand culture the peat:peatlite media will be used in order to have a better plug to transplant
- In liquid culture hydroponics sand will be used for germination due to being easier to wash from roots
- Results from part A will be used in parts B, C, and D

Part B – Nutrient Disorder Symptoms

- Subject 2 provenances of teak seedlings to 12 different elemental disorders
- Seedlings will be grown in sand culture hydroponics
- Regular photographs taken to visually describe nutrient disorder symptoms
- Regular growth measurements will quantify response to deficiencies/toxicities
- Leaf material will be analyzed for elemental concentrations pre and post deficiency symptom

B – Sand Culture Nutrient Disorders

- Nutrients deficiencies tested in greenhouse at NCSU:
  N, P, K Ca, Mg, S, B, Cu, Fe, Mn, Mo, Zn
- Boron toxicity will also be examined
- Study completed fall of 2014

B - Disorder Study
Data Recorded

- Biweekly measurements of the following will be taken:
  - Height
  - Root Collar Diameter
  - Number of leaves
  - Date disorder symptom appeared
  - Munsell Color Code for symptomatic and control plants

B - Disorder Photographs

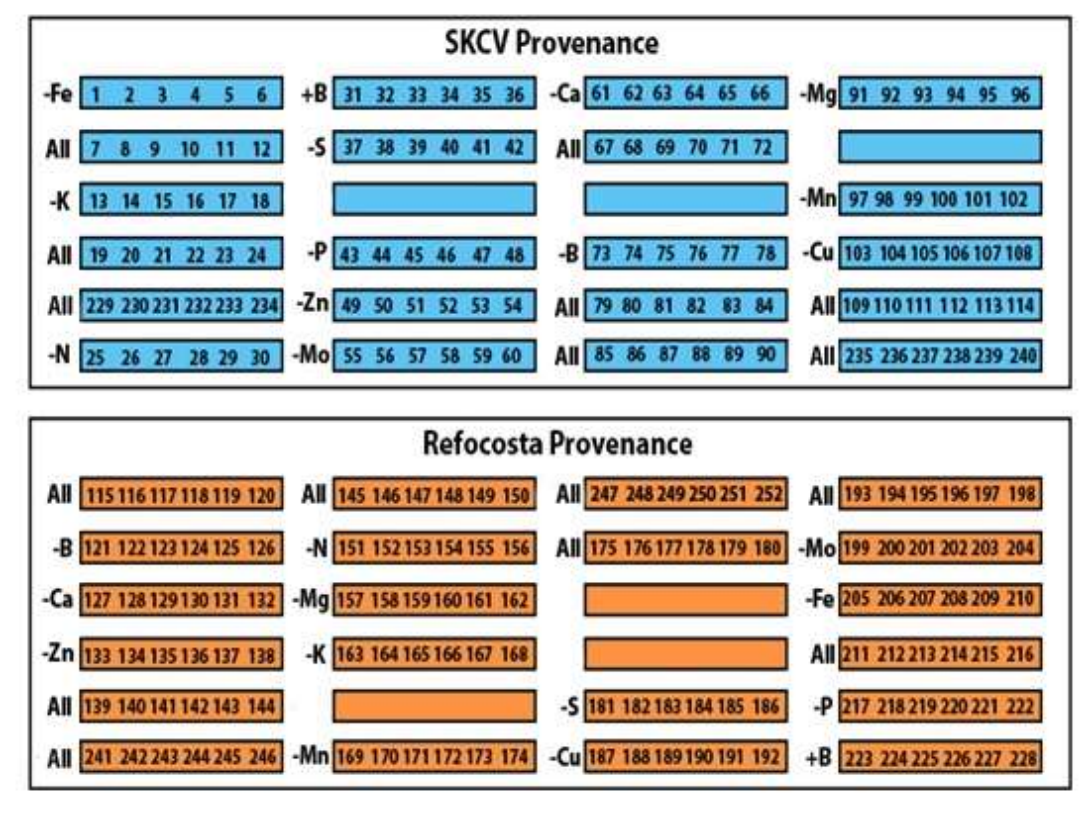
- High quality photographs will visually record plant response to nutrient disorders
- Descriptive guide of disorders will be developed and distributed to Camcore members

Calcium deficiency at 5 weeks

B - Floriculture Greenhouse Sand Hydroponics

B - Sand Culture Design

- 252 plants in the sand culture hydroponic setup
- 2 provenances each with 126 seedlings
- Each provenance has 6 seedlings split across 13 nutrient treatments and 8 controls



B - Foliage Analysis

- Foliage nutrient levels were analyzed by the North Carolina Department of Agriculture
- Analysis was done post deficiency appearance for each nutrient
- Most recent mature leaf used in analysis whenever possible

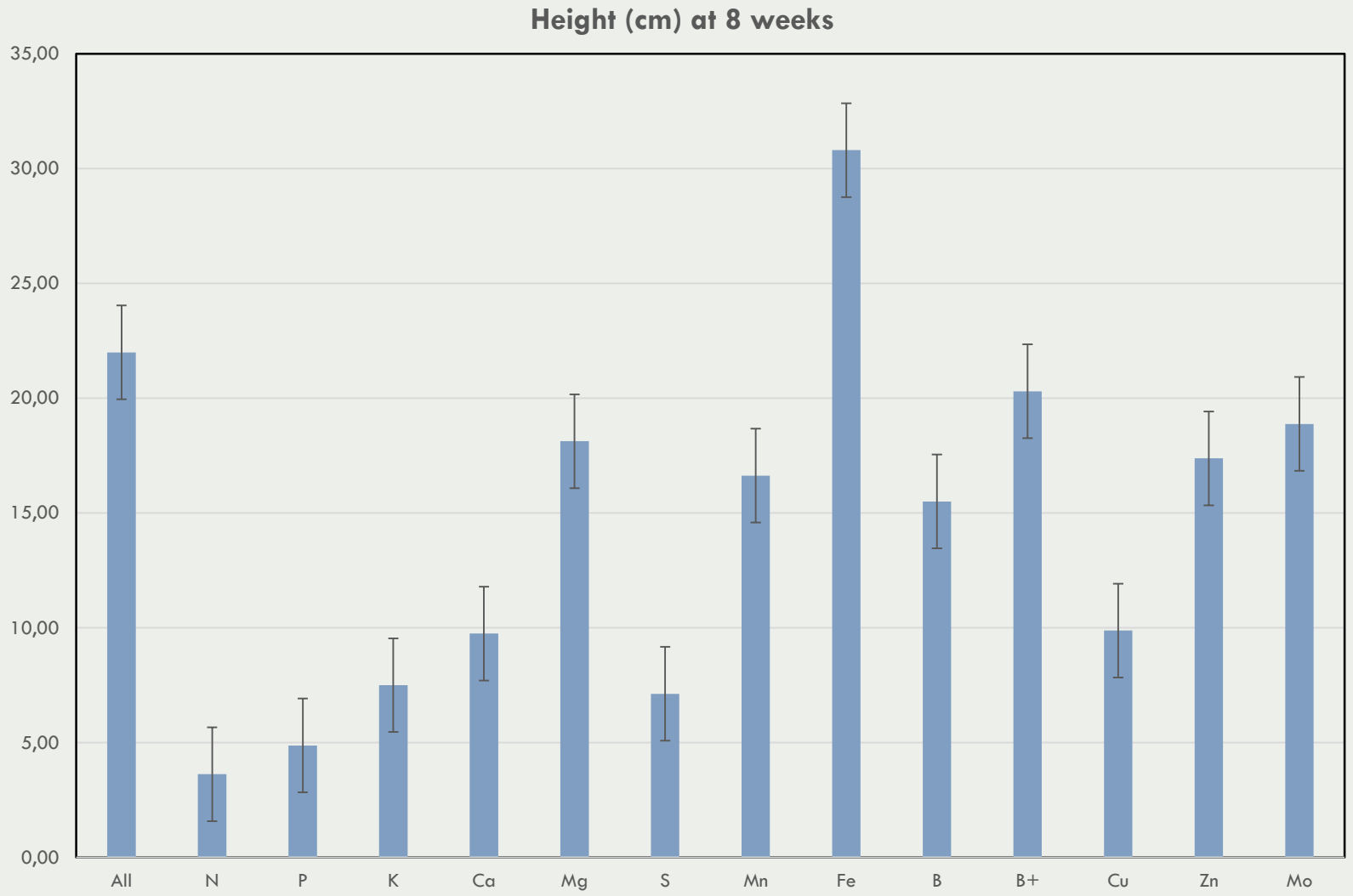
B - Major Nutrient Deficiencies

Nutrient	Symptom	Location	Date Observed	Deficient Plant Foliar Conc.	Complete Plant Foliar Conc.
-Nitrogen	Small, entire plant yellow	Whole Plant	14 Days	0.98%	4.25%
-Phosphorus	Small, yellow/brown tipped leaves	Lower	24 Days	0.10%	0.81%
-Potassium	Tip burnt leaves, Umbrella Form	Lower	17 Days	1.36%	3.99%
-Calcium	Dark/necrotic interveinal patches	Middle	24 Days	0.47%	2.00%
-Magnesium	Chlorosis prominent along midrib	Middle	53 days	0.09%	0.64%
-Sulfur	Brown spots mid. leaves, new leaves pale, cupped down	Top	30 Days	0.10%	0.23%

B - Minor Nutrient Deficiencies

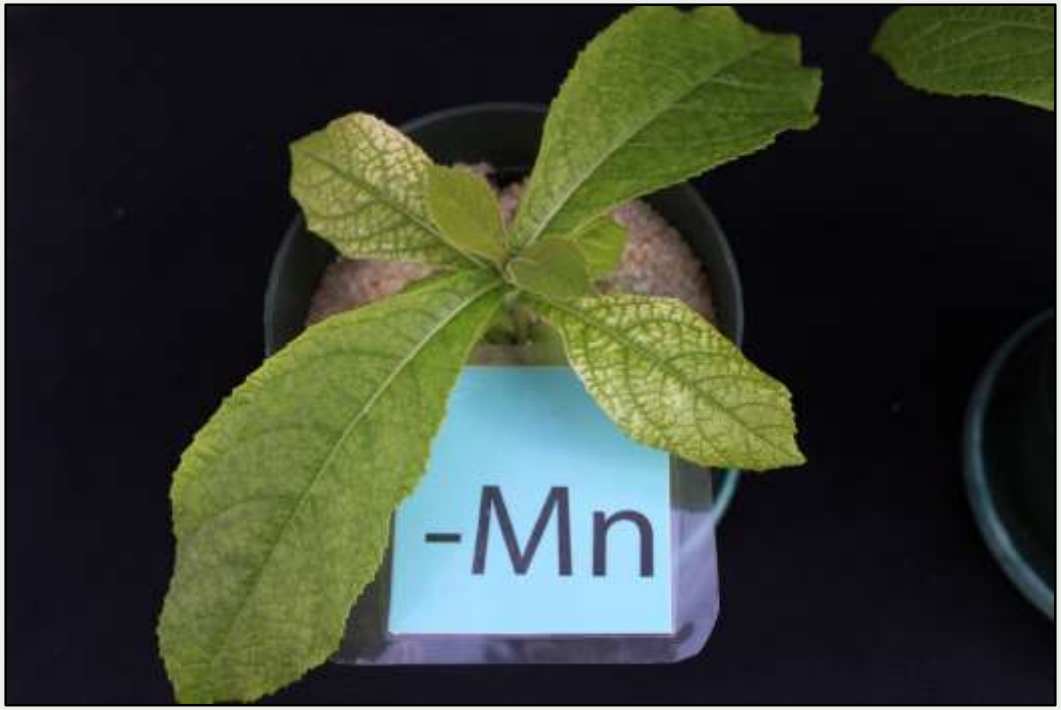
Nutrient	Symptom	Location	Date Observed	Deficient Plant Foliar Conc.	Complete Plant Foliar Conc.
-Manganese	Interveinal chlorosis, white patches	Middle	24 Days	13.9 ppm	129.5 ppm
-Iron	Interveinal chlorosis, dark green midrib	Middle	24 Days	34.2 ppm	42.0 ppm
-Boron	All Leaves drooping, new leaves necrotic patches	Whole Plant	33 Days	2.82 ppm	33.4 ppm
+Boron	Purple spots	Lower	17 Days	294.5 ppm	27.4 ppm
-Copper	New leaves narrow, curling down	Top	17 Days	2.7 ppm	3.5 ppm
-Zinc	Upper leaves long, narrow, cupped down. Leaves feel coarse	Top	33 Days	11.9 ppm	21.1 ppm
-Molybdenum	Middle Leaves chlorotic, straplike form	Middle	53 days	NA	0.69 ppm

B - Height Differences by Nutrient

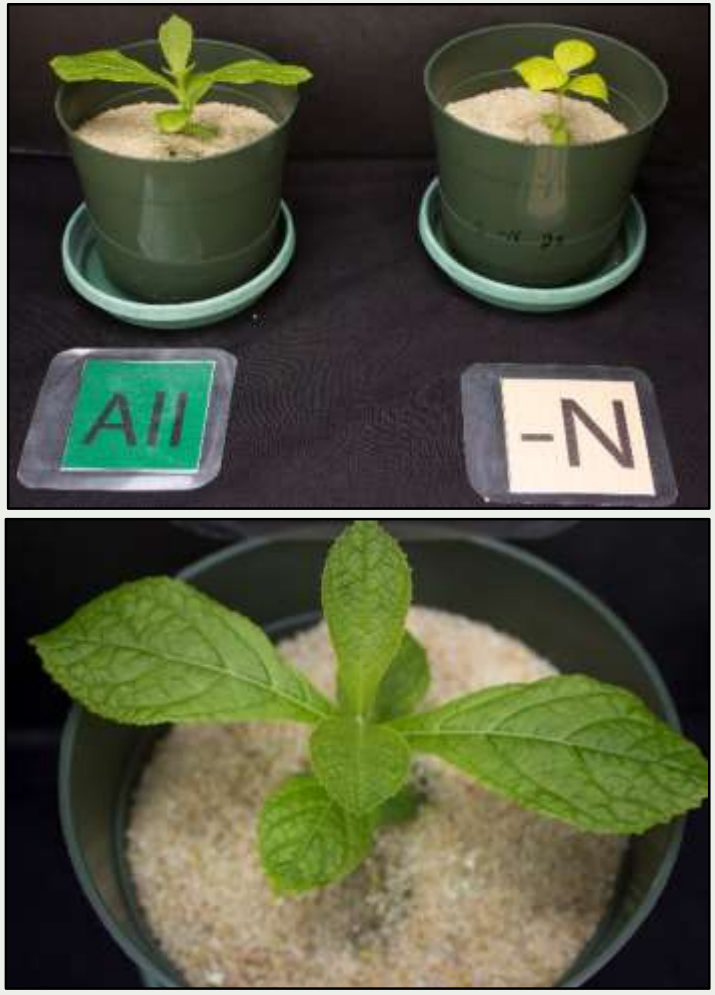


B - Diagnostic Guide

- Growth data from nutrient studies, foliar nutrient concentrations, NIR models, and descriptive photographs will be used to create guide
- Electronic and printed versions
- English and Spanish versions planned



B - Nitrogen Deficiency at 2 weeks



4.25% foliar N

0.98% foliar N

B - Copper Deficiency at 7 weeks

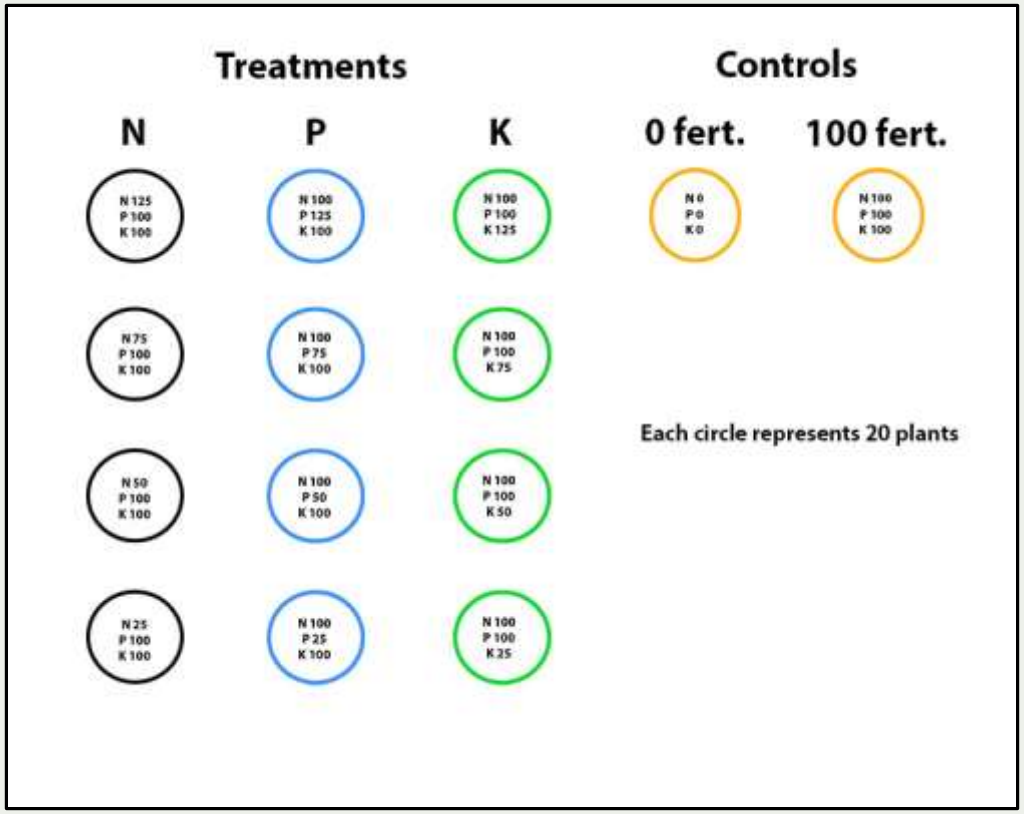
Cu Deficient: 2.66 ppm foliar Cu

Complete: 3.57 ppm foliar Cu

Parts C and D: NIR Models of N, P, and K Deficiency

C and D- NIR Models of NPK Design

- 14 treatments, 20 plants each
- 4 levels of N, P, and K and 2 controls
- Treatment levels: 25, 50, 75, and 125% of each N, P, and K
- Handheld and laboratory NIR analysis will be used to develop models of NPK in teak seedlings



C – Handheld NIR Models of NPK Deficiencies

- Camcore microPHAZIR™ NIRscanner was used to scan leaves every 3 weeks
- NIR models will be developed to predict NPK deficiencies in seedlings
- Study conducted summer and fall of 2014

D – Laboratory NIR Models of Nutrient Deficiencies

- Camcore FOSS NIRSystems™ 6500 used to scan dried ground teak leaves
- NIR models will be developed to predict NPK deficiencies in seedlings
- Material was scanned winter of 2015 with models slated for development summer 2015

Project Future

- Research is complete
- Currently analyzing data
- Develop predictive NIR models for N, P, K deficiencies
- Put together the diagnostic guide
- Write up findings
- Hopefully revisit Copper and possibly Molybdenum deficiency symptoms

Acknowledgments

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Questions