STEAM-GENERATED SUPPLEMENTARY HEAT THERMOTHERAPY AS AN IMMEDIATE TREATMENT FOR PROLONGING PRODUCTIVITY OF HLB-INFECTED CITRUS TREES

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Introduction

PROJECTHEAT

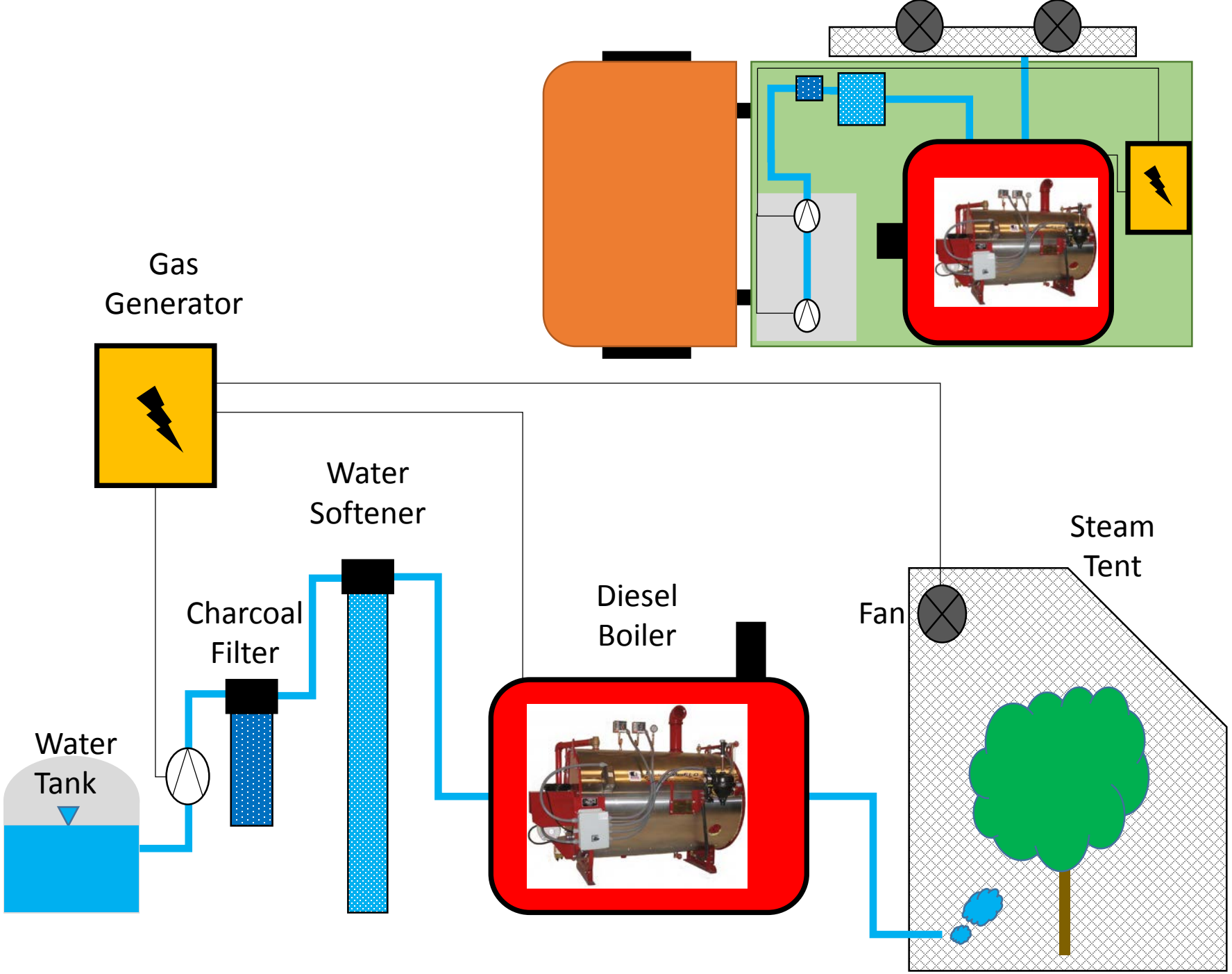
Huanglongbing Elimination by Applying Thermotherapy

Aims to:

- Provide scalable steam-based heat treatment as an immediate short-term solution for sustaining productivity of HLB-affected citrus trees
- Study and develop procedures for optimized heat treatment techniques that:
  - provide maximum reduction of HLB-causing bacteria
  - prolong the effectiveness of the treatment while reducing any possible adverse effects on yield and fruit quality

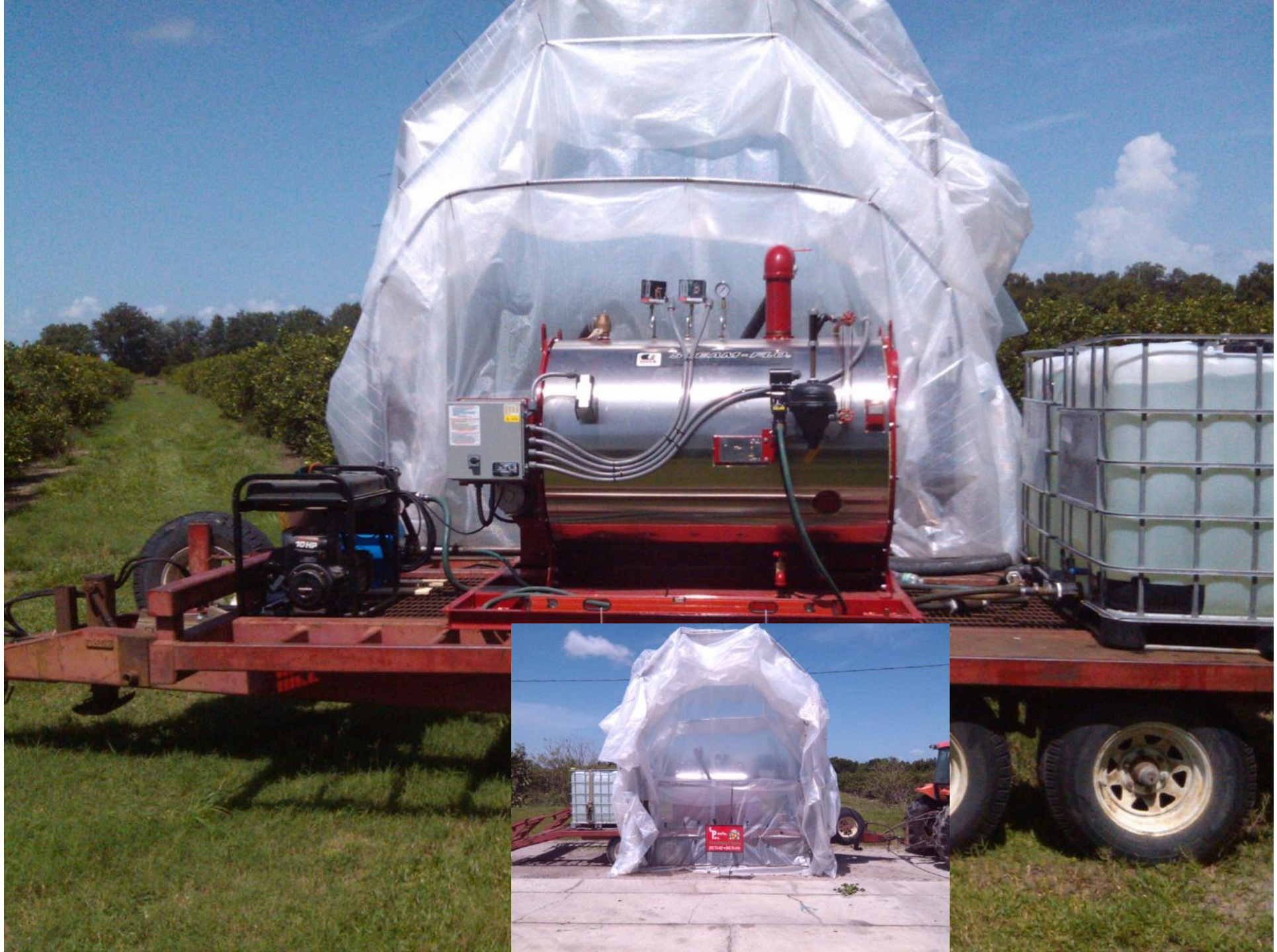
OBJECTIVES	PERSONNEL
Objective 1: Enhance the existing steam-generated supplementary heat thermotherapy system so that it will generate consistent heat and provide a uniform temperature to the canopy and roots.	Ehsani Xu
Objective 2: Determine the effect of steam treatment on *C*Las recolonization, overall tree health, and fruit yield, and quality.	Danyluk, Dewdney Etxeberria, Johnson
Objective 3: Determine the efficacy of steam-based thermotherapy related to *C*Las viability.	Gurley
Objective 4: Evaluate the effectiveness of steam-based thermotherapy considering the pretreatment condition of roots as affected by pests and diseases and characterize the effects of the treatment on pests and diseases.	Duncan Johnson
Objective 5: To determine time-temperature combinations for the inactivation of *C*Las that do not result in tree defoliation.	Danyluk, Dewdney Johnson, Reyes
Objective 6: As a canopy post-treatment, evaluate whether horticultural mineral oil (HMO) applications to tree surfaces will improve the thermotherapy process and develop new application technology.	Ehsani Khot
Objective 7: Conduct comprehensive economic analyses of the steam-generated supplementary heat thermotherapy system.	Roka

210


Gas
Generator
Water
Softener
Charcoal
Filter
Water
Tank
Diesel
Boiler
Fan
Steam
Tent

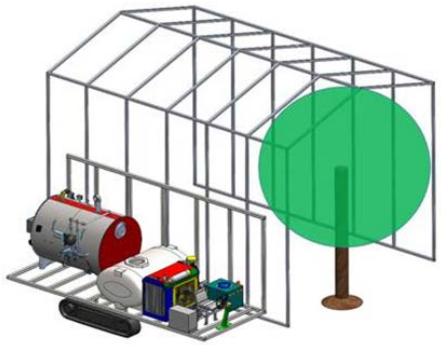
Premier Energy

ScoringAg, TreeSteamer



Ag Harvesters

24’ long, 24’ tall,
15’ wide,



- Enclosure is a rigid hexagonal prism made of insulated plastic panels.
- Steam injected at all heights from 4 sides
- Save the steam reduce heating time.
- It could get hot very fast.

Research Goals

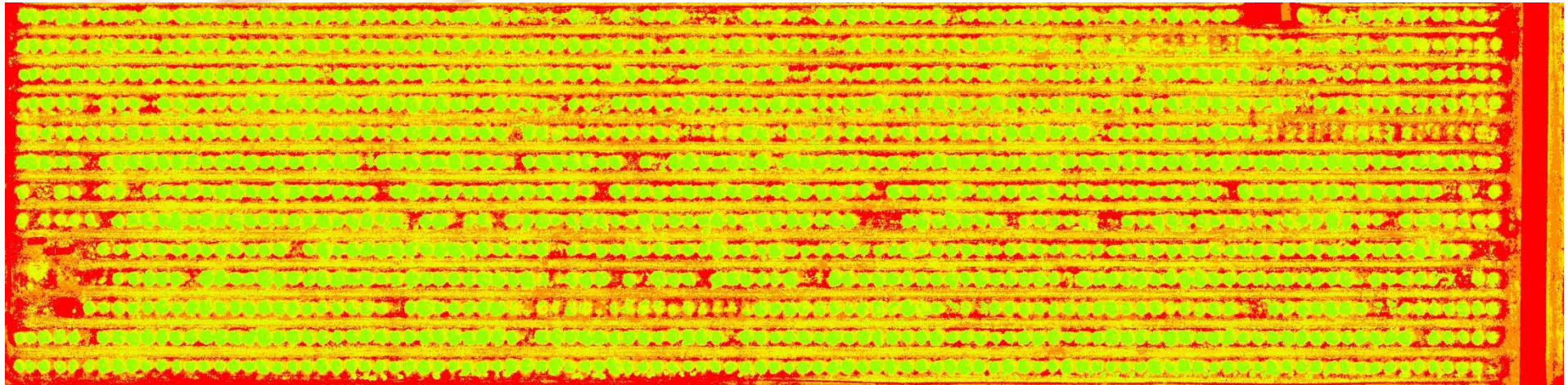
- **Collaborative effort between researchers in multiple fields:** Engineering, Plant Pathology, Plant Physiology, Cell Biology, Nematology, Ag Economy, and Food Science
- **Intends to address questions commonly asked by growers, such as:**
  - To what temperature and for how long does the tree need to be heated without causing excessive fruit or leaf drop?
  - Is it possible to heat treat tree roots, and if so, are there other benefits?
  - How does thermotherapy affect the yield and juice quality in subsequent years?
  - How long will the tree stay HLB-free after treatment?
  - When is the best time of the year for heat treatment?
  - How can the effectiveness of heat treatment be evaluated?

Field Trials

- Period: 4 years starting from the beginning of 2015

  6 treatments @ 3 replicates

  - Time-Temperatures used: 131°F for 0, 60, 90, and 120 seconds, 140°F for 30 seconds, and no treatment (control)



How to evaluate the effectiveness of heat treatment?

PCR Analysis

PMA-PCR Analysis

Fruit Quality Measurements

Fruit Yield

Fruit Drop

Juice Quality

Tree Health Measurements

Leaf Water Potential – evaluates how HLB affects the water transport system of the tree

Stomatal Conductance – directly related to transpiration which is an indication of overall tree health

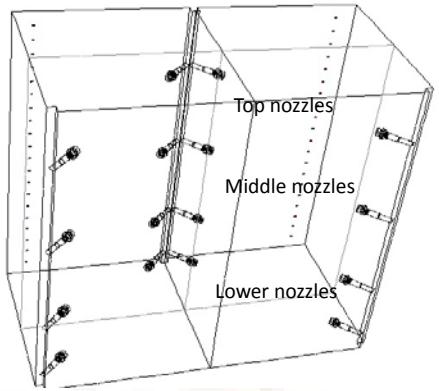
Leaf Anatomy – petiole cross-sections are evaluated for the damage done to HLB-affected phloem cells

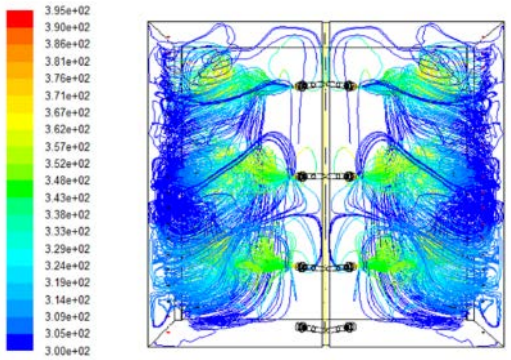
Chlorophyll Fluorescence- directly related to overall tree health

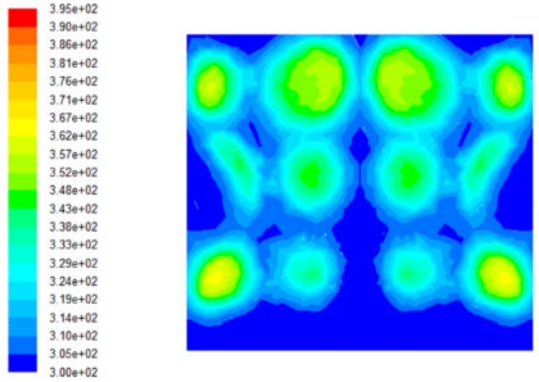
Green Index – vegetation index directly related to overall tree health

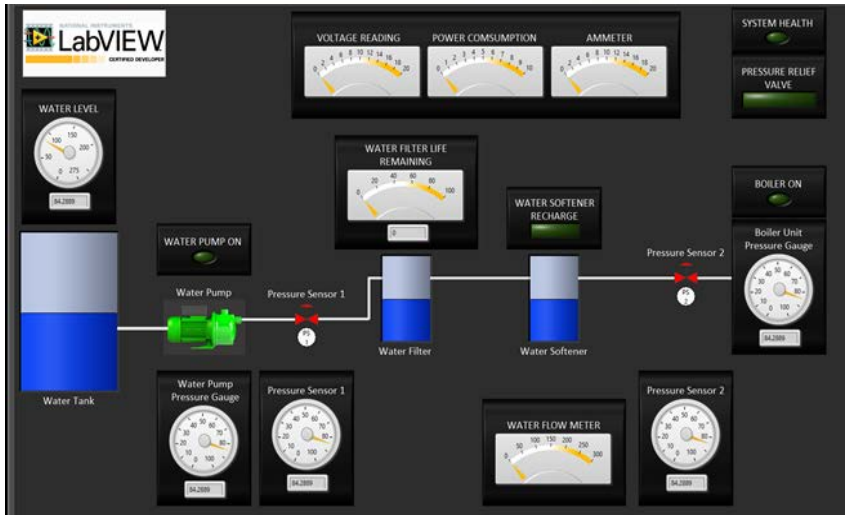
Progress on Engineering Objective

- GUI developed for the current thermotherapy system
- Model heat distribution

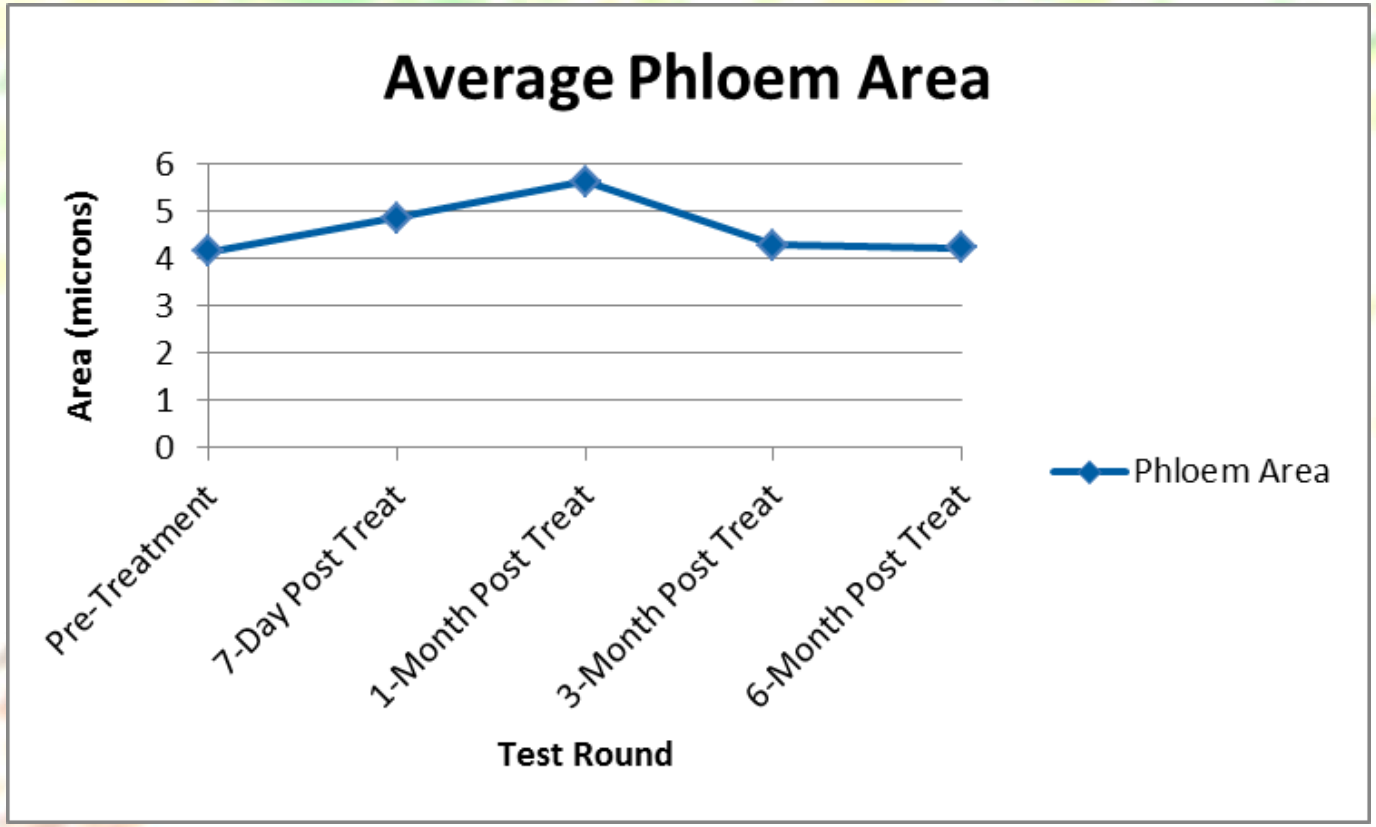






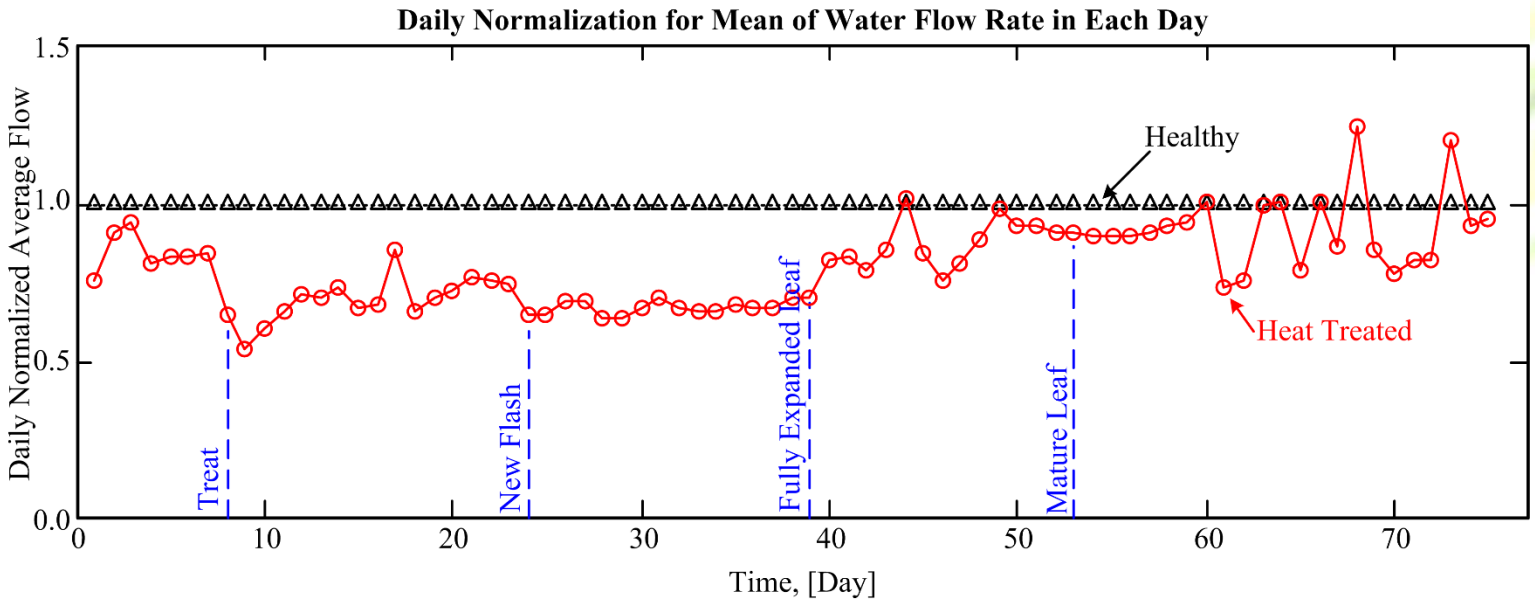


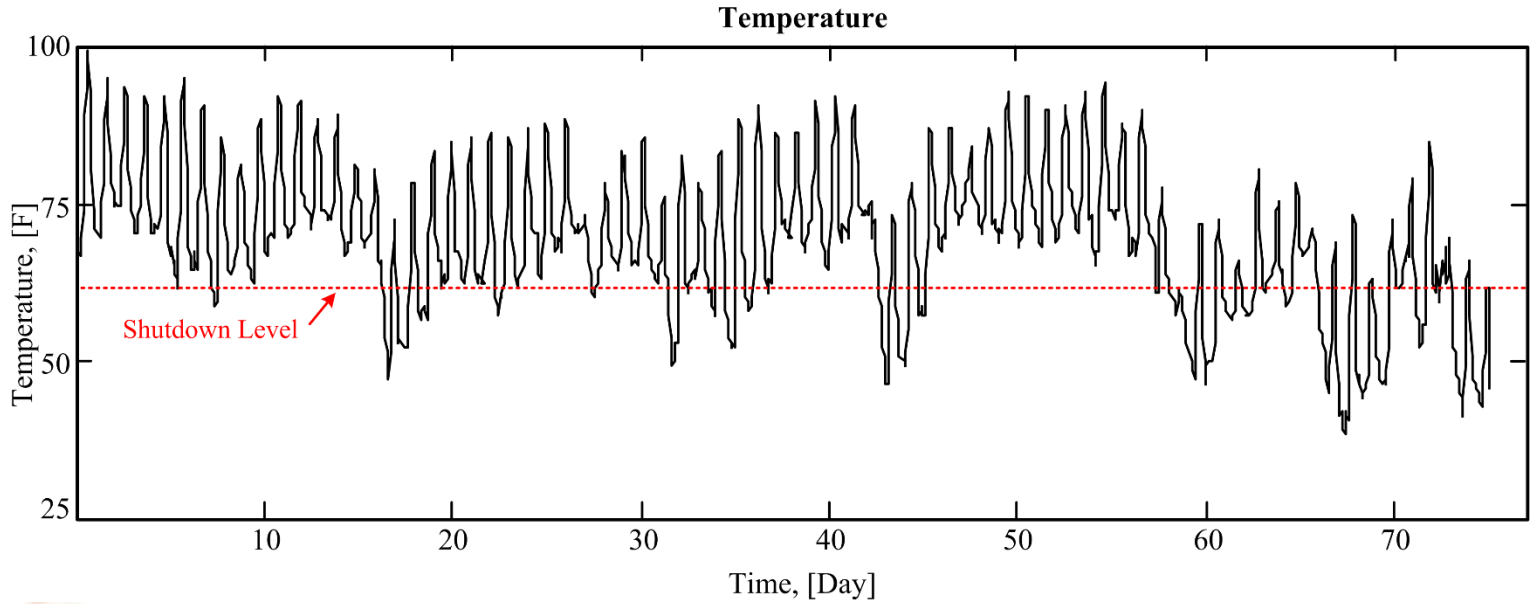
Phloem Area Variation



The phloem area average is *significantly higher* at *1-month* post treatment than the phloem area *before* treatment, *3-months* post treatment, and *6-months* post treatment.

Sap Flow Measurement





Cost Estimates

Operational costs for individual tree steam system

Quick-calculation for:

- 8 hours of operation (1 day)
- 150 trees treated/day

ITEM	UNIT COST	QUANTITY	HOURS	TOTAL
Labor	$15.00/hour	1 operator	8	$ 120.00
Water	$0.00/gal	62 gal/hour	8	$ 0.00
Fuel	$2.60/gal	5.5 gal/hour	8	$ 114.40
			TOTAL COST for 1 day	**$ 234.40**
			COST per tree	**$ 1.56**

Summary

- More than 60,000 trees were heat treated statewide in 2015.
- Trees treated to 131°F for 30 seconds take 2-3 minutes and cost $1.70 per tree.
- A better method of detecting live vs. dead bacteria is needed.
- Water uptake rate initially decreases after heat treatment but will recover about two months after heat treatment.
- An absence of *C*Las from the treated leaf material was not observed from the summer treatment. A migration of bacteria from roots to leaves was detected in the untreated control, so it was impossible to determine if this was due to a failure to reach a killing temperature or if it was rapid recolonization from the roots.

Acknowledgements

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National Institute of Food and Agriculture

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THANK YOU

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