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Non-chemical pest control in agriculture

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Challenges in pest management research

Overview

1.) Introduction

Agriculture & Pest Management

2.) Challenges

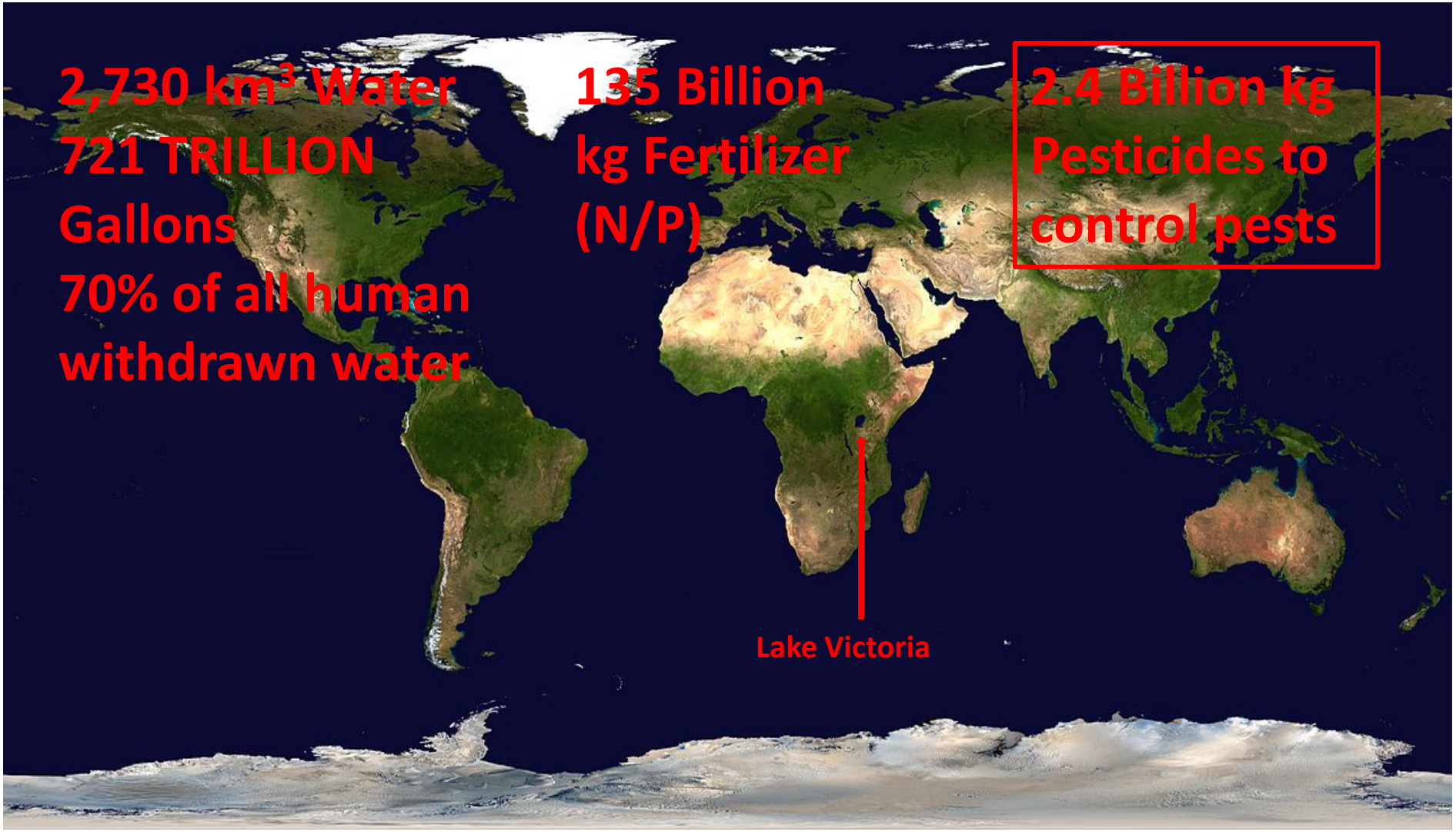
3.) Examples

4.) Conclusions and Take-Home Message

Introduction – Agriculture

NASA/FAO

Introduction – Resources



NASA/FAO

Numbers per annum

Introduction

Pesticides and Chemical Control

Climatevulture.com

Pesticide: Chemical which has the capability to destroy, repel, prevent or inactivate pest organisms when applied.

Chemical Pest Control

Prevention of pest induced harm to either humans, valuable objects, food or organisms **by using pesticides.**

Introduction

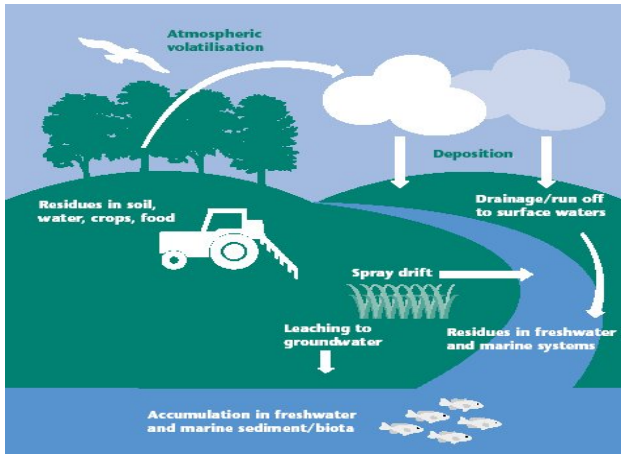
Chemical Pest Control – Advantages

Vox.com

- Increases Productivity
- Cost Efficient
- Reliable / Robust
- Available
- Supported and Serviced
- Guarantees Pest Control in most cases

Introduction

Chemical Pest Control – Disadvantages



Adlib.everysite.co.UK

- Resistance in pest organisms
- Residues in food, wildlife, humans
- Target of beneficial organisms
- Hazardous to humans
- Environmental footprint

Introduction

Chemical Pest Control – Restrictions

Clemson University

- Federal, state and community Regulations
- Buffer zones
- Organic farming

- Some pests cannot be controlled by pesticides

Introduction

Non-Chemical Pest Control - Definition

Pestcontrolmemes.com

Non-chemical Pest Control:

Prevention of pest induced harm to either humans, valuable objects, food or organisms **without the use of pesticides.**

Introduction

Integrated Pest Management - IPM

1. Monitoring
2. Prevention
3. Control

Chemical AND Non-Chemical!

Introduction

Integrated Pest Management - IPM

Non-chemical control can have a higher environmental footprint than chemical control!

- One application of Roundup® replaces 3 times mowing on roadsides
- Input of organic material instead of fertilizer increases N washout in rivers, lakes and groundwater

Challenges in Research and Practice

Challenges in Research and Practice

Non-Chemical Pest Control – Classification

Aim: Suppress; Kill/destroy; Repel; Inactivate

Nature of Method:

- Biological Control
- Physical Control
- Horticultural Practices
- Manure/Fertilization

Challenges in Research and Practice

Non-Chemical Pest Control – Problems

Power4consulting.com

The effects of non-chemical methods are poorly understood

The methods are poorly adapted to agricultural situation

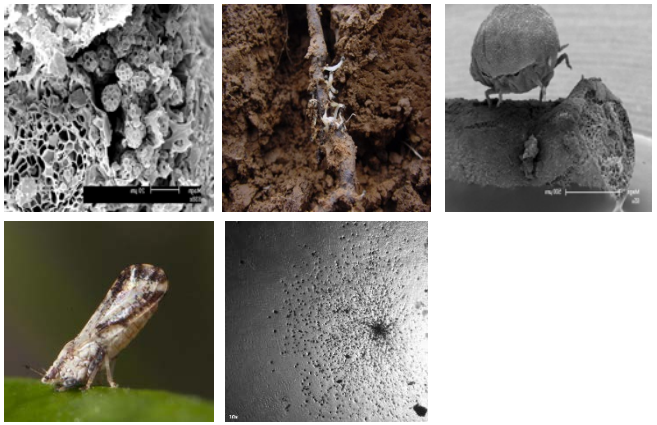
Challenges in Research and Practice

Non-Chemical Pest Control – Challenges #1

Kutschera & Lichtenegger, 2002

Biology and Ecology of Organisms

Identification/ Monitoring



Challenges in Research and Practice

Non-Chemical Pest Control – Challenges #2

Method Development

Integration

Examples

Examples

Hidden Belowground: Soil borne

- Biocontrol of Grape Phylloxera: Integration
- Soil Disinfestation in California: Method Development

Hidden Inside: Vector borne

- Citrus Greening in Florida: Biology

Examples

Example 1: Grape Phylloxera (*Daktulosphaira vitifoliae*)
Challenge: Integration

- Aphid, Host-specific to *Vitis.*
- Native North America
- Root and Foliar pest
- Severe damage and death of vineyards
- Cause of economic crisis in Europe late 19th century

Examples

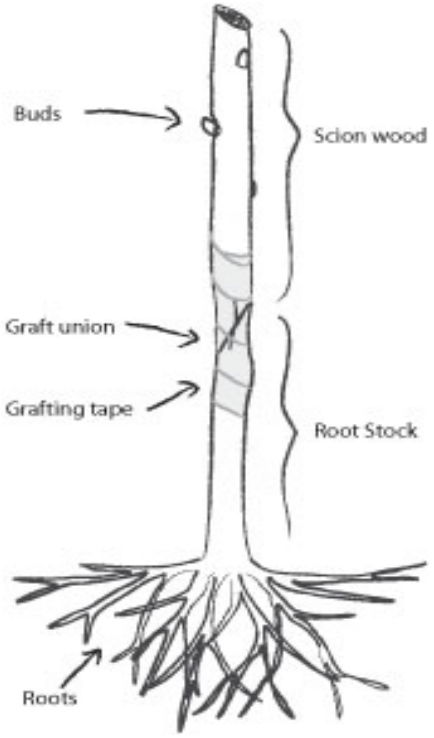
Example 1: Grape Phylloxera (*Daktulosphaira vitifoliae*)
Background

- European *Vitis vinifera* cultivars: Berry production
- *Vitis vinifera* cultivars are susceptible
- American *Vitis* species: tolerant/resistant

Examples

Example 1: Grape Phylloxera (*Daktulosphaira vitifoliae*)

Background



Woodbridgefruittrees.com

Management:

- Grafting: tolerant/resistant ('American') rootstocks to susceptible ('European') scions.
- Quarantine: avoid human assisted dispersal

Examples

Example 1: Grape Phylloxera (*Daktulosphaira vitifoliae*)

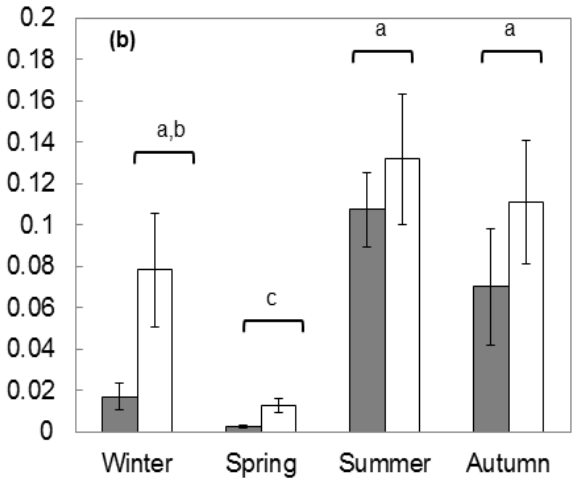
Damages

Examples

Example 1: Grape Phylloxera (*Daktulosphaira vitifoliae*)

Ecology

Why damages in grafted vineyards?



Belowground cycle still develops: overwintering

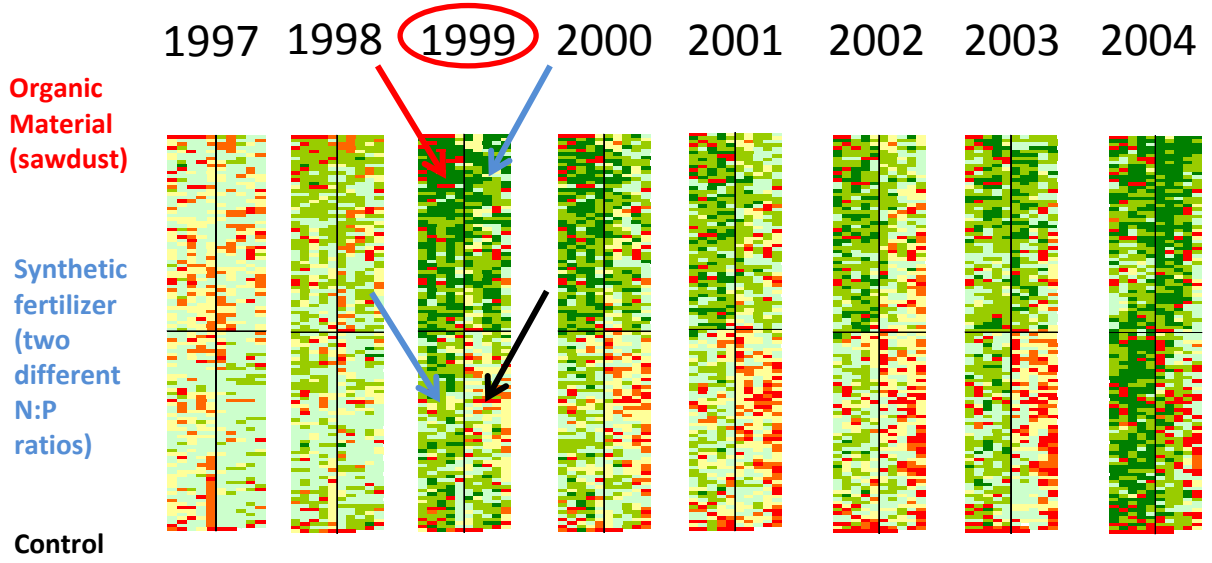
Hoffmann et al. 2016

Examples

Example 1: Grape Phylloxera (*Daktulosphaira vitifoliae*)

Damage

Non-organic;
Phylloxera present at roots;
Disease symptoms;



Constant grape phylloxera leves

very strong growth
strong growth
medium growth
weak growth
very weak growth
dead grapevine

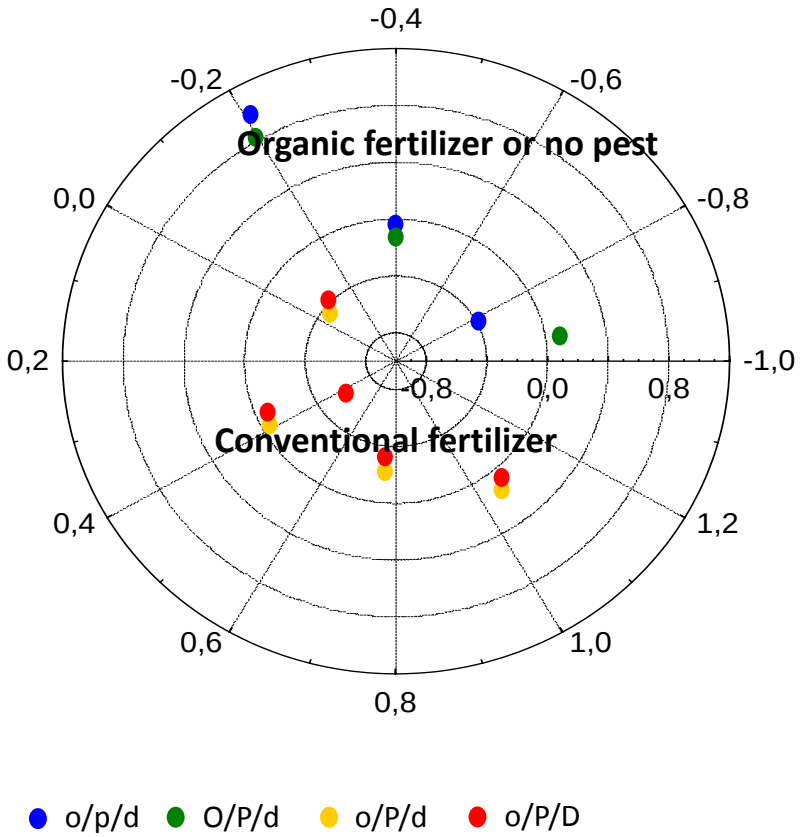
Huber, Hoffmann et al. 2009

Examples

Example 1: Grape Phylloxera (*Daktulosphaira vitifoliae*)

Effect of Soil Management?

Pathogenicity of fungal community



o/O = conventional / organic soil management

p/P = absence / presence of grape phylloxera

d/D = absence / presence of aboveground disease symptoms

Huber, Hoffmann et al. 2009

Examples

Example 1: Grape Phylloxera (*Daktulosphaira vitifoliae*)
Effect of Soil Management?

Without organic soil management:
higher abundance of secondary pathogens
→ Higher chance of Damage

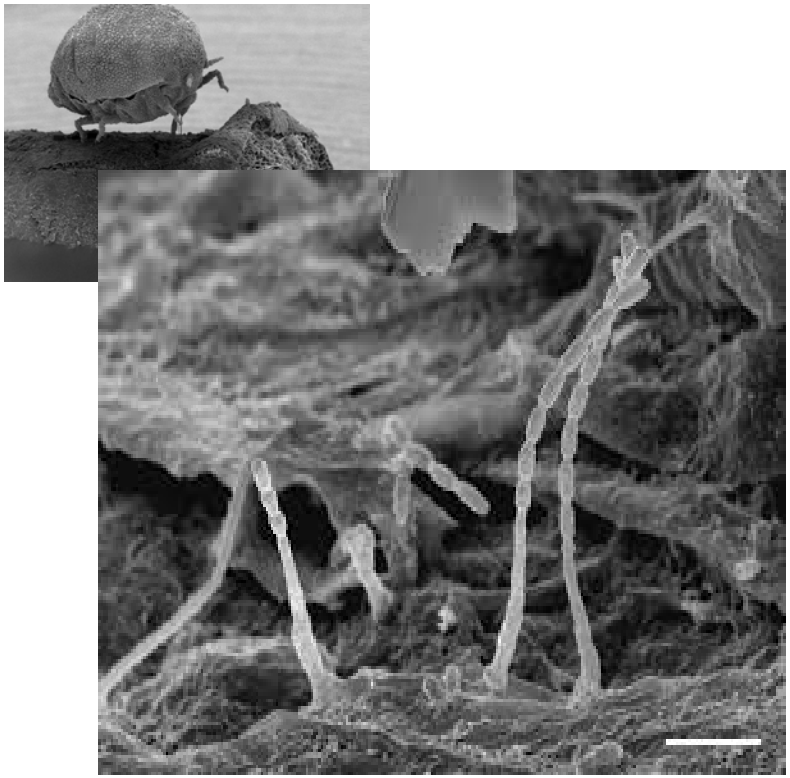
With organic soil management:
higher biodiversity and abundance of antagonists
→ Lower chance of Damage

Huber, Hoffmann et al. 2009

Examples

Example 1: Grape Phylloxera (*Daktulosphaira vitifoliae*)

Biocontrol



Biocontrol:

- Entomopathogenic Fungus: *Metarhizium anisopliae*
- Reduction of populations

Kirchmair et al. 2004
Kirchmair, Hoffmann et al. 2009

Examples

Example 1: Grape Phylloxera (*Daktulosphaira vitifoliae*)
Conclusions

- *Metarhizium anisopliae* can control soil borne grape phylloxera populations
- But damage is very likely to be also due to secondary pathogens
- Challenge: Integration!

Examples

Example 2: Soil Disinfestation in California Strawberry

Control of weeds
Control microbial pathogens
Control of nematodes and insects

Examples

Example 2: Soil Disinfestation Using weapons of mass destruction: Challenge: Method Development

Ars.usda.gov

- Methyl Bromide: used as fumigant for decades
- CH_3Br: Odorless Gas
- International Fade-Out due to ozone layer decline
- In CA largely replaced with Pic-Clor

Examples

Example 2: Soil Disinfestation

Restrictions in Conventional and Organic Strawberry

- Buffer Zones around schools and housing areas
- Township Caps
- No chemical fumigants allowed in organic farming
- Pic-Clor is expected to be strongly regulated

Examples

Example 2: Soil Disinfestation

Development of non-chemical Alternatives

- Anaerobic Soil Disinfestation (ASD): widely used
- Soil Solarization
- Cover Crops
- Mustard Seed Meal (MSM)
- Crop Rotation
- Steam

Examples

Example 2: Soil Disinfestation

Steam

- Heats soil to 65 – 70 °C for 30 min
- Controls pathogens and weeds
- Changes Nutrient Conditions
- Changes microbial community

Examples

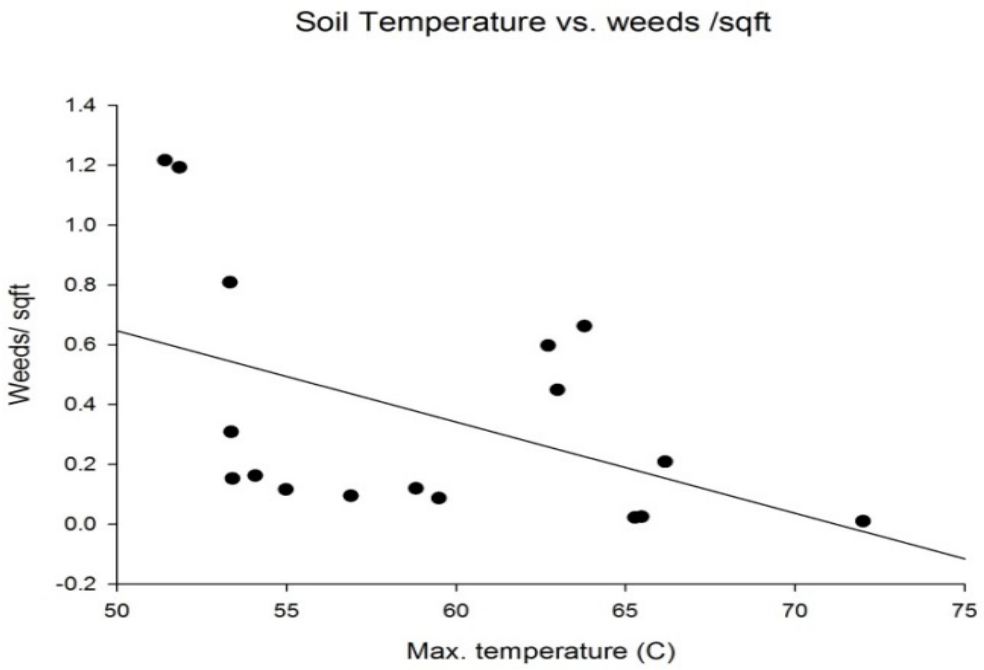
Example 2: Soil Disinfestation

Steam - Results

Examples

Example 2: Soil Disinfestation

Steam – Weed Control

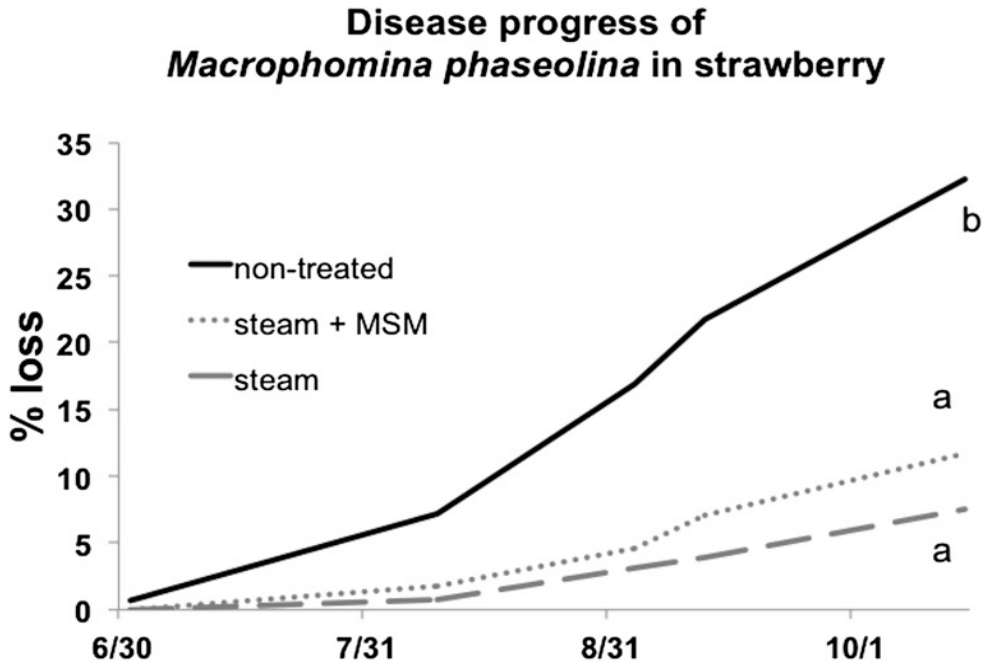


Hoffmann, Barbella et al*., in preparation*

Examples

Example 2: Soil Disinfestation

Steam – Pathogen Control

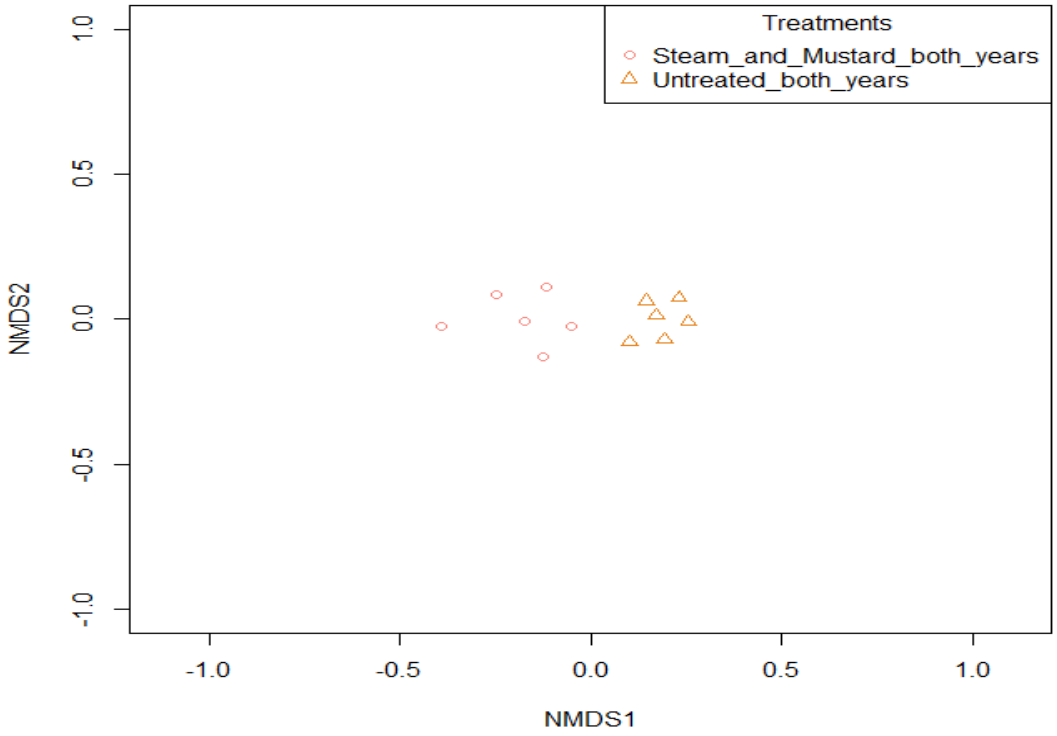


Fennimore et al. 2014

Examples

Example 2: Soil Disinfestation

Steam – Microbial Community



Hoffmann, Barbella et al., *in preparation*

Examples

Example 2: Soil Disinfestation

Steam – New Prototype 2016

Examples

Example 2: Soil Disinfestation

Conclusions

- Robustness
- Resources: Fuel, Water, Time
- Broadcast
- Role of Microorganisms?
- Challenge: Method Development

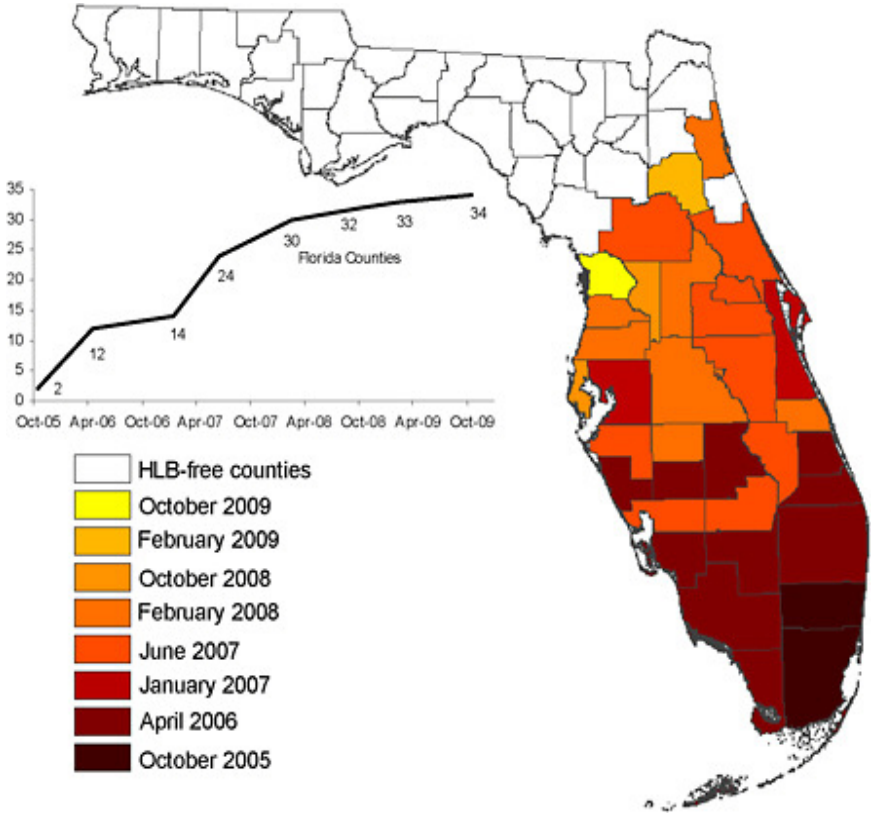
Examples

Example 3: Citrus Greening in Florida (*Candidatus* Liberibacter asiaticus)

Examples

Example 3: Citrus Greening

Background



Nap.edu

Estimated revenue impact for citrus growers in Florida:

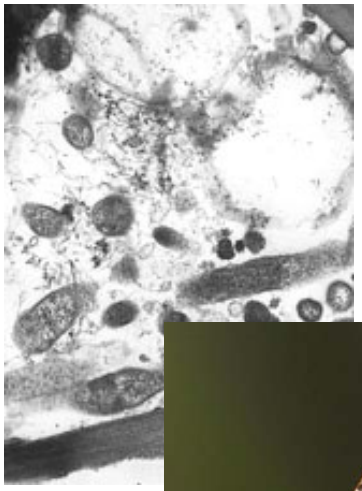
$331 Million/year = 19% of industry

Trees can die within the first 5 years after infection

Examples

Example 3: Citrus Greening

Background



Brlansky & Rogers, 2007

- *Candidatus* Liberibacter asiaticus (CLas) causal agent of citrus greening in Florida; not cultivable
- Transmitted via insect vector *Diaphorina citri* (Asian Citrus Psyllid)

Examples

Example 3: Citrus Greening

Management

Removal of infected trees

Insecticides to control vector

Not efficient enough to control the disease

Examples

Example 3: Citrus Greening

Management: Research

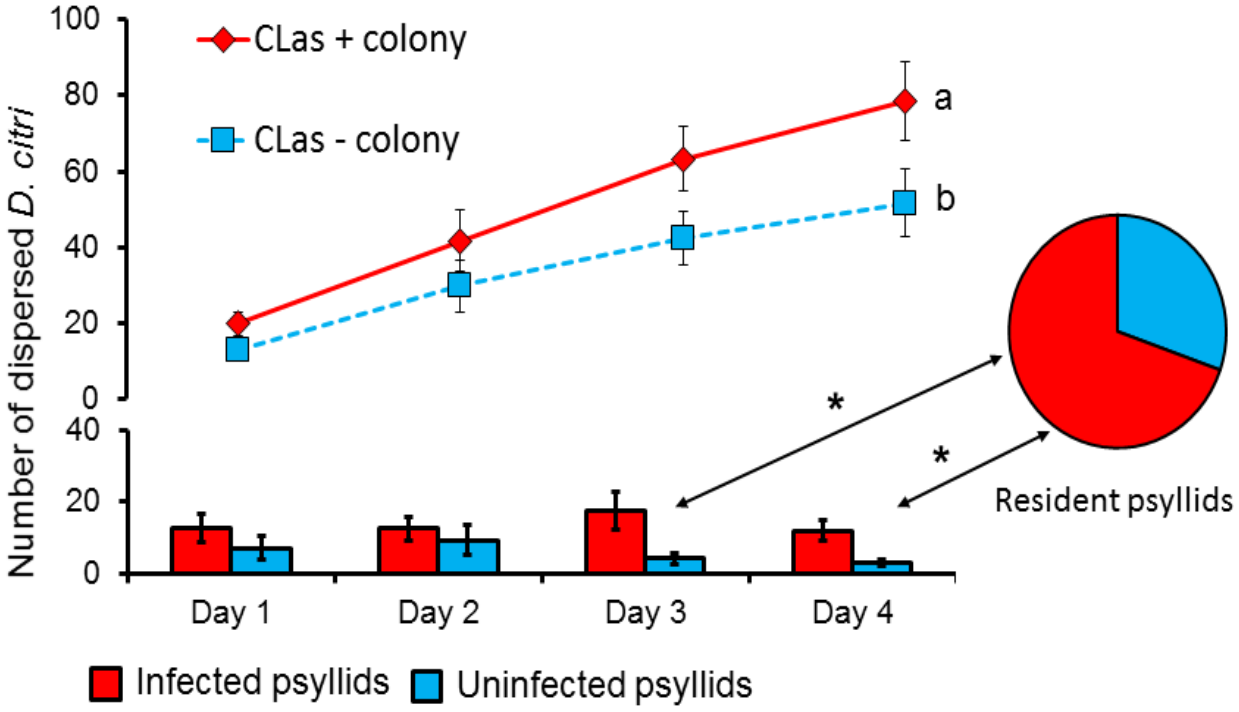
- *Reduce pathogen levels*
- *Enhance systemic resistance*
- *Reduce disease symptoms and increase productivity*

- *Early detection*
- *Improve scouting*
- *Vector Control*

Examples

Example 3: Citrus Greening

Management: Vector Dispersal

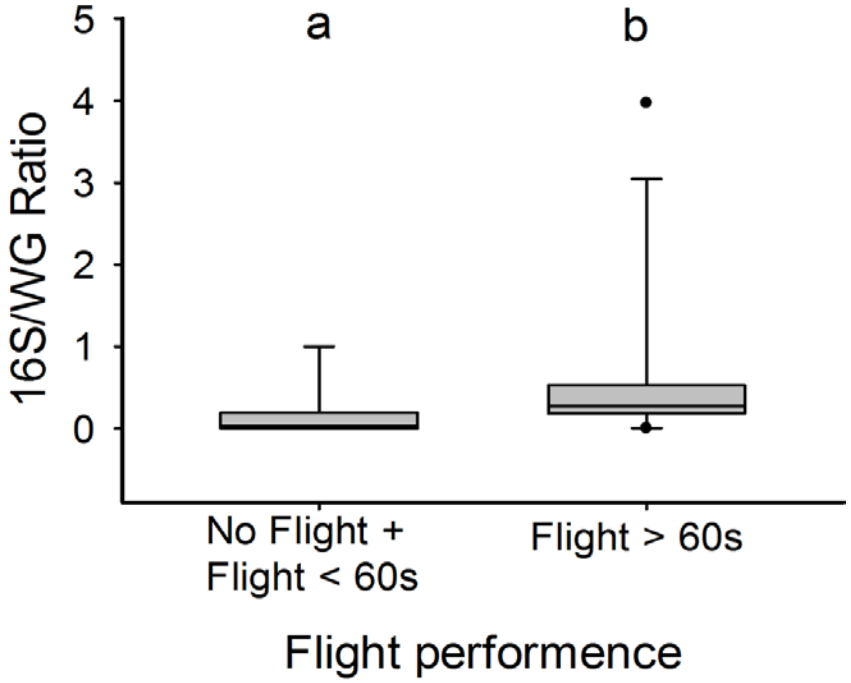


Martini, Hoffmann et al. 2015

Examples

Example 3: Citrus Greening

Management: Vector Dispersal

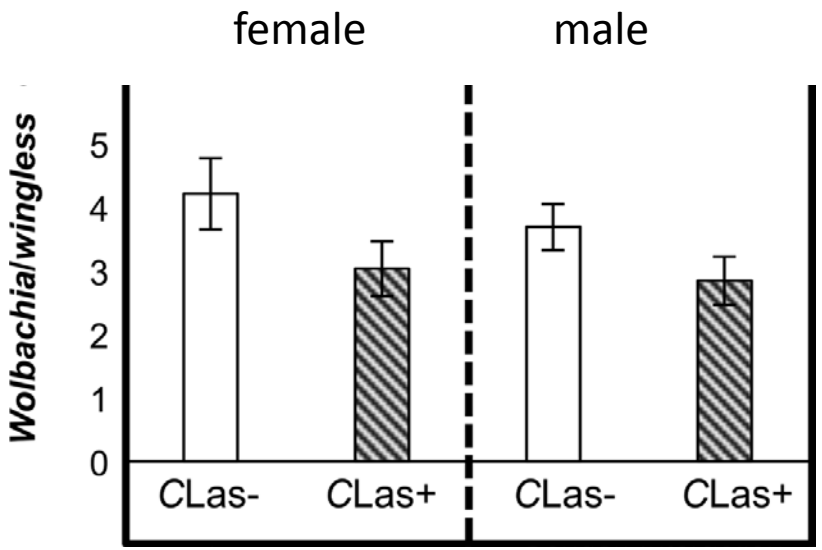


Martini, Hoffmann et al. 2015

Examples

Example 3: Citrus Greening

Management: Endosymbiotic vector control?



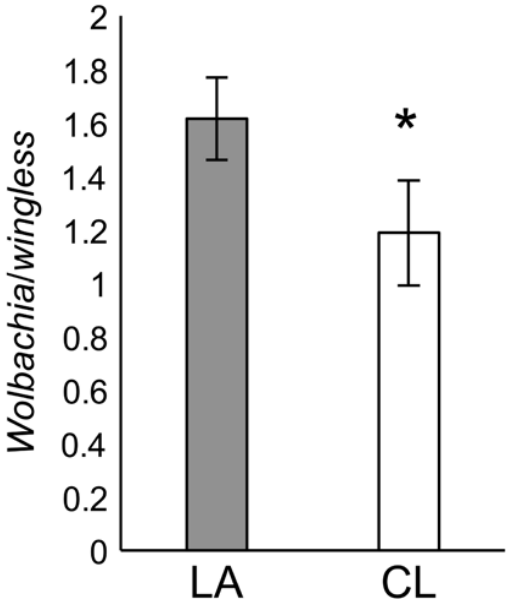
- *Wolbachia:* natural endosymbiont in *D. citri* with the potential to decrease pathogen levels!

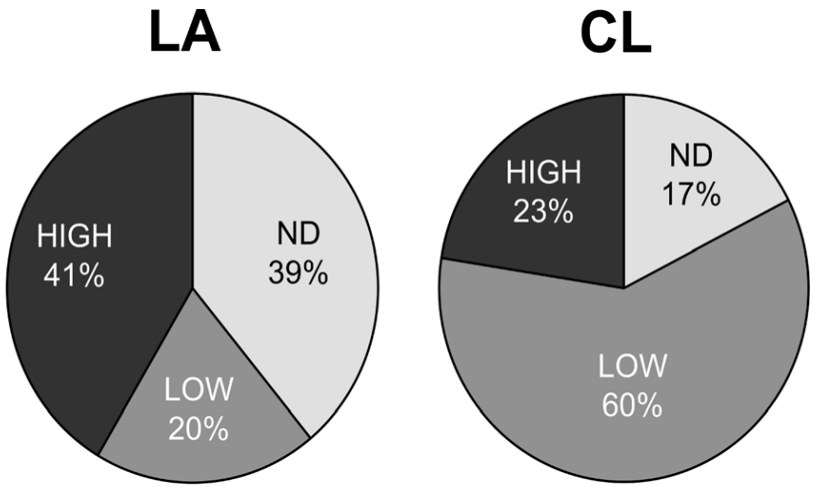
Chu, Hoffmann et al. 2016

Examples

Example 3: Citrus Greening

Management: Genotype vector control?





Chu, Hoffmann et al. 2016

Examples

Example 3: Citrus Greening

Conclusions

- *Wolbachia* vs. Psyllid Genotype? Or both?
- Challenge: Biology

Conclusions

Conclusions

Non-Chemical Pest Control – More Challenges

Youtube.com

Youtube.com

Thestir.cavemom.com

Research

Practicality

Acceptance

Conclusions

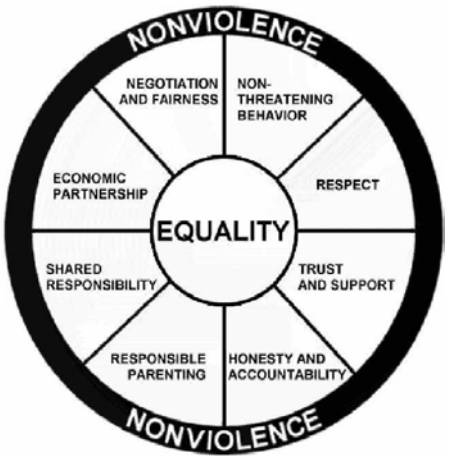
Non Chemical Pest Control – Integration

Dreamstime.com

- Integration of chemical and non-chemical pest control
- Integration of soil sciences, breeding, engineering, computer and data sciences
- Communication between industry, universities, communities and growers

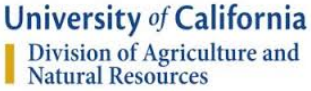
Conclusions

Out of the Box – New Approaches?



- Violent vs. non-violent approach?
- How do pathogens react under threat?
- ‘Communication’ with pathogens?
- Improve ‘relationship’ to pathogen?

Funding & Collaborations



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Thank you for your attention