ABOVE AND BEYOND IS WHERE WE BEGIN

BIOWORKSINC.COM

BIOPESTICIDES FOR PLANT DISEASE MANAGEMENT: THE GOOD ~~THE BAD AND THE UGLY~~

MICHAEL BROWNBRIDGE

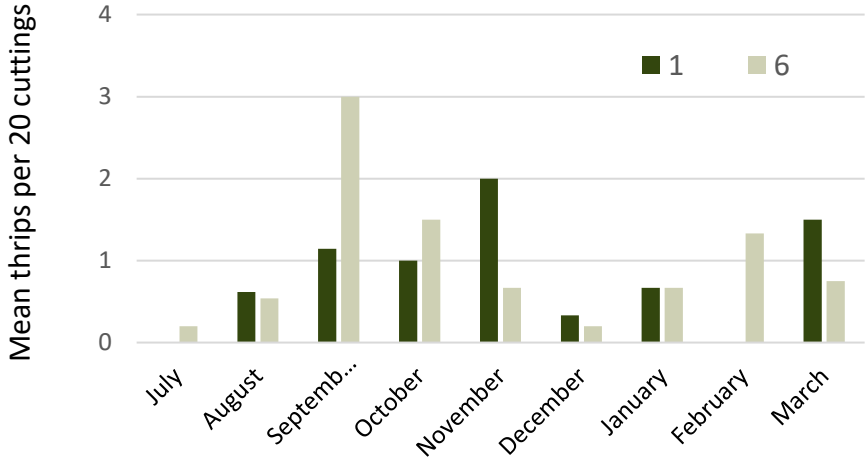
BioWorks®

PROPAGATIVE MATERIALS TAKE MANY FORMS

PESTS ON UNROOTED CHRYSANTHEMUM CUTTINGS

Thrips (WFT)

- 84% of samples infested
- Little variation among cultivars and months
- 1-2 thrips / 20 cuttings
- Mostly eggs and larvae



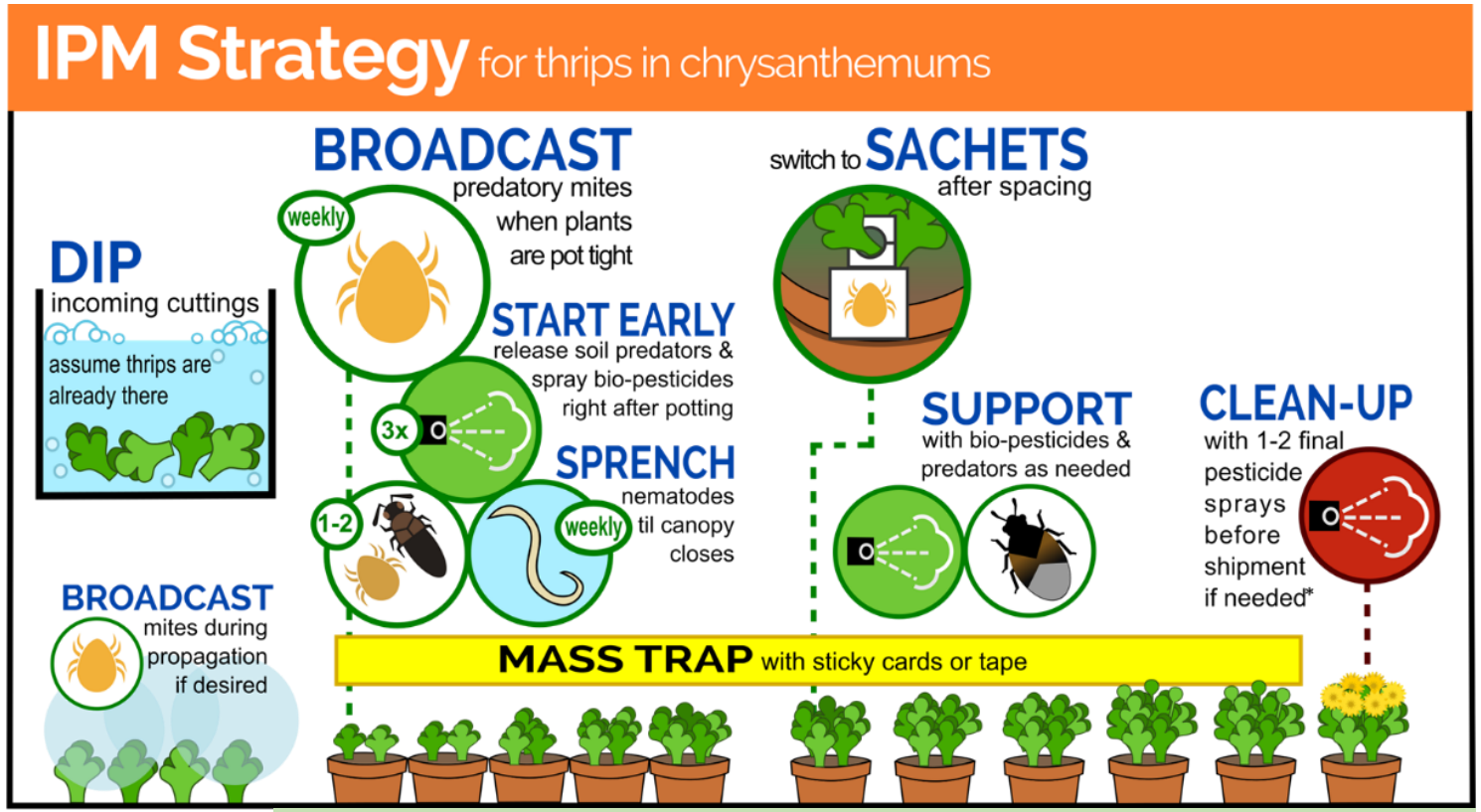
Data: courtesy of Vineland Research and Innovation Centre ca. 2018

Spider mites (TSSM)

- 48% of samples infested
- Few to 118 mites / 20 cuttings
- All developmental stages
- Infestations variable and inconsistent

Picture by J. Obermeyer, Purdue Extension

INTEGRATED STRATEGY FOR THRIPS



Infographic created by Ashley Summerfield, Vineland Research

RootShield PLUS pre-incorporated (G) or applied by drench (WP)

Dips and sprays

- Whiteflies:
  - *Beauveria bassiana*
- Thrips or spider mites:
  - SuffOil-X

Root diseases (media treatment)

Foliar diseases (sprays)

- Biofungicides

BIOFUNGICIDES ARE KEY TOOLS IN IPM

The value they bring to a program

- Proven efficacy against diseases
- Safety, compatibility
  - Workers
  - The environment
  - Natural enemies, chemistry
- Different MOA than conventional pesticides
  - Critical in resistance management
- Short REIs do not interfere with other crop management activities

TWO BROAD CATEGORIES

Biochemical fungicides

Potassium bicarbonate – physical MOA

Citric acid, Zinc salts – physical MOA

Plant/microbe derived extracts – induce plant defenses/physical MOA

Microbial fungicides

Based on bacteria, fungi or yeasts

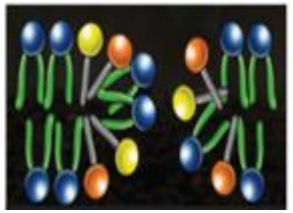
- *Bacillus*, *Streptomyces* spp.
- *Trichoderma* spp., *Ulocladium*, *Clonostachys*
- *Aureobasidium*

Multiple MOAs

BIOFUNGICIDES FOR FOLIAR DISEASES

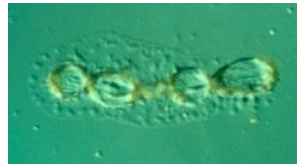
Antagonism

- *Bacillus spp., Streptomyces* spp.
- Metabolites (lipopeptides) produced during fermentation
- Physically disrupt cell membranes, inhibit fungal growth.



Pathogen membrane damaged

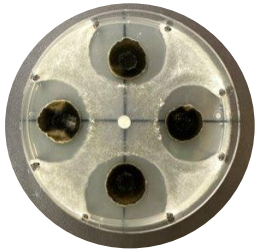
Physical MOA



- Biochemical fungicides
- K-bicarbonate: Desiccates fungal spores, destroys cell membranes
- Polyoxin D zinc salt: Inhibits the formation of chitin (fungal cell walls).

Competitive Exclusion

- *Ulocladium oudemansii* strain U3
- Primary MOA: Out-competes *Botrytis* and bacterial leaf spot (BLS) for nutrients and space at sites where infections start
- Secondary MOA: Secretion of enzymes that break down pathogen cell walls.



Induced Resistance

- Botanical extracts.
- Induce plant defenses
- Plants produce and accumulate specialized proteins and other compounds
- Inhibit bacterial and fungal diseases.

BIOFUNGICIDES FOR FOLIAR DISEASES: PRODUCTS

Antagonism

Bacillus spp.

- Serifel® (BASF), Serenade (Bayer), Double Nickel (Certis), CEASE® (BioWorks), Stargus (ProFarm)

Streptomyces spp.

- Actinovate SP

Physical MOA

Biochemical fungicides

- K-bicarbonate: MilStop-SP, Kaligreen
- Polyoxin D zinc salt: OSO 5% SC

Competitive Exclusion

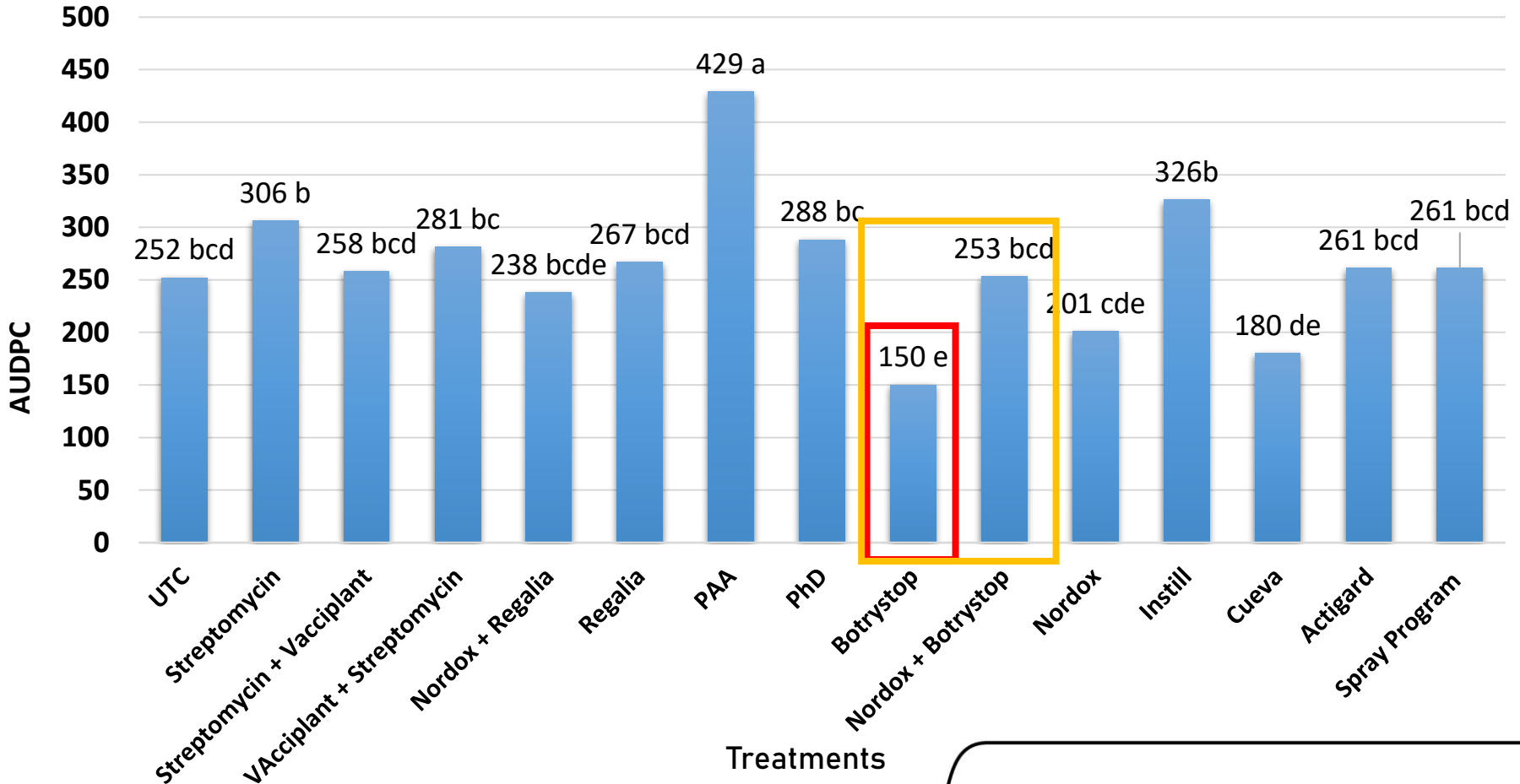
- *Ulocladium oudemansii* strain U3 (BotryStop WP)

Induced Resistance

- Botanical extracts
- Regalia, Ecoswing

WHAT HAPPENS WHEN YOU DON'T CHECK FOR COMPATIBILITY?

BOTRYSTOP FOR ANGULAR LEAF SPOT IN TOBACCO



- BotryStop was the best-performing product vs ALS
- Nordox is a Cu-oxide fungicide/bactericide
- Incompatible with BotryStop
- Significant (negative) impact on efficacy

Data courtesy of Dr. W.A. Bailey

College of Agriculture, Food and Environment

THE FUTURE OF FOLIAR BIOFUNGICIDES?

MICROBIAL BIOFUNGICIDES FOR SOILBORNE DISEASES: MULTIPLE MOAs

Trichoderma, Clonostachys spp. – RootShield *PLUS*$^{+}$, Asperello, Lalstop G46

Bacillus species – Cease, Stargus, Double Nickel, Serenade, Serifel

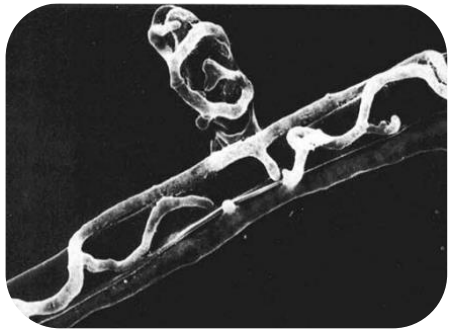
Streptomyces species – Actinovate, Mycostop, Lalstop K61

- **Competition:** Colonize roots, outcompete pathogens for resources
- **Antagonism:** Metabolites/enzymes kill or inhibit other microorganisms
- **Parasitism:** Microbial agent attacks or consumes the pathogen
- **Induced resistance:** Activate plant defenses

Excellent products for prevention of soilborne diseases like Phytophthora, Pythium, Fusarium, Rhizoctonia, Berkeleyomyces

Bacillus subtilis vs *Fusarium*

Inhibition of *Fusarium* by *Trichoderma*

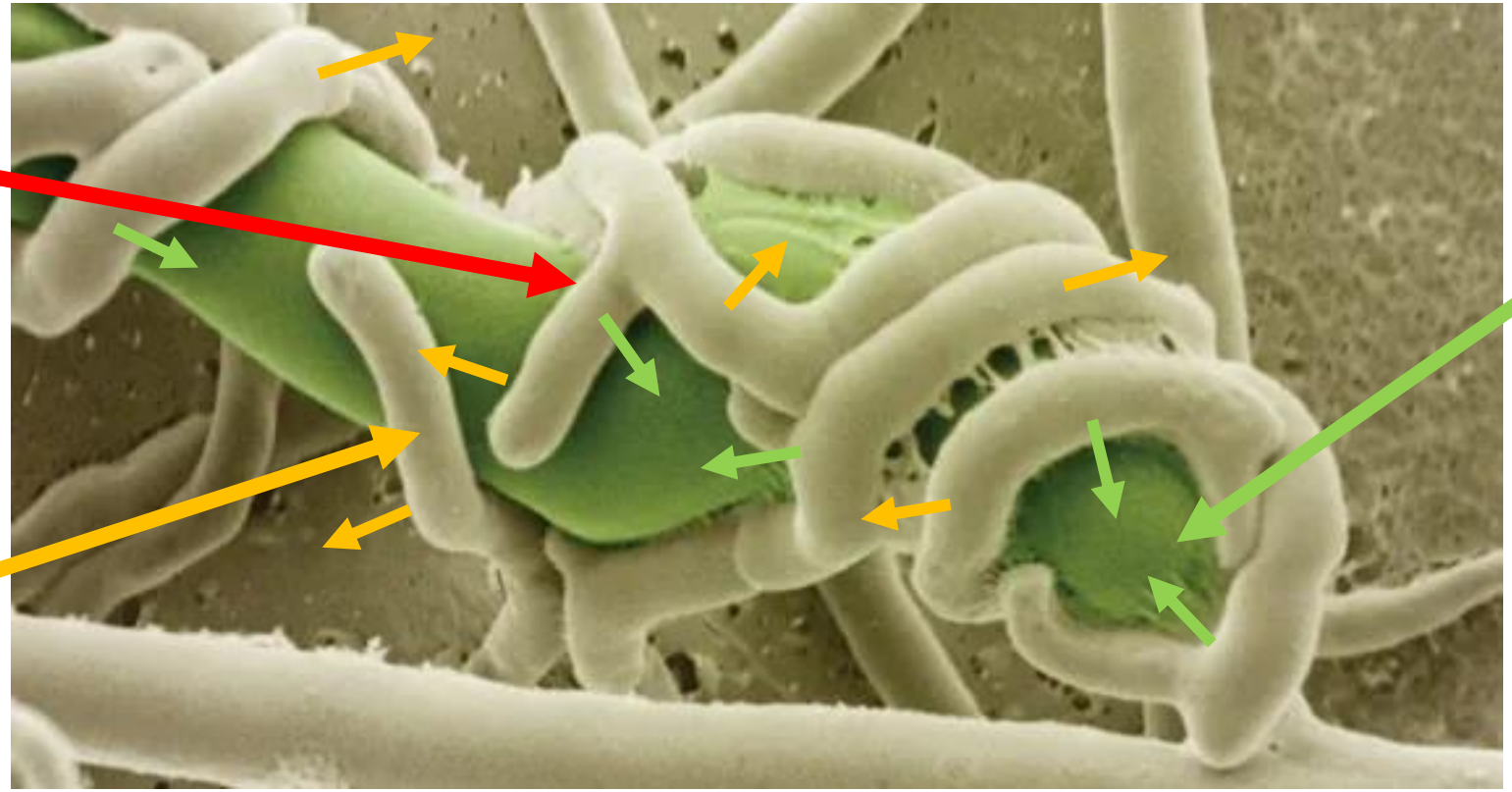


Parasitism of *Rhizoctonia solani* by *T. harzianum* T22

TRICHODERMA: HOW DOES IT WORK?

COMPETITION
Colonization of root surface

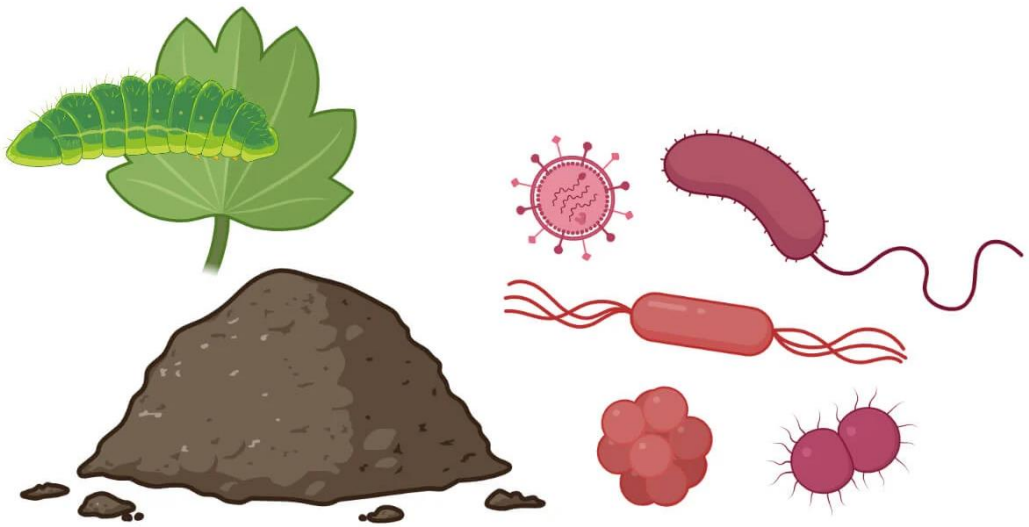
ANTAGONISM
Production of anti-fungal metabolites



INDUCED RESISTANCE
Produces biochemicals which 'prime' plant defenses; and phytohormones that stimulate root development

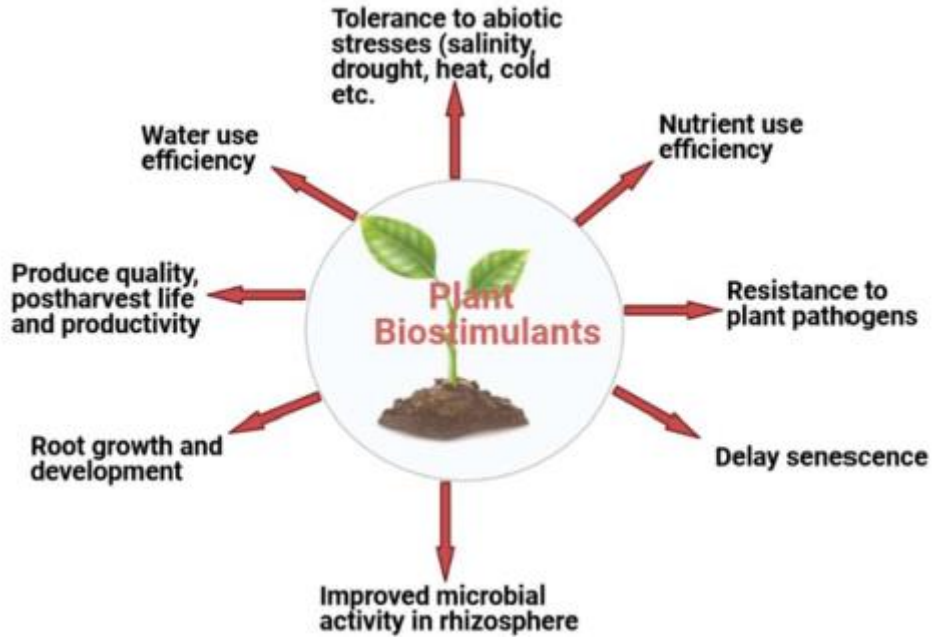
MANY MICROBIAL SPECIES THAT WORK AS BIOFUNGICIDES ALSO HAVE BIOSTIMULANT EFFECTS

BIOPESTICIDE



Trichoderma spp., *Bacillus* spp., *Streptomyces* spp.

BIOSTIMULANT

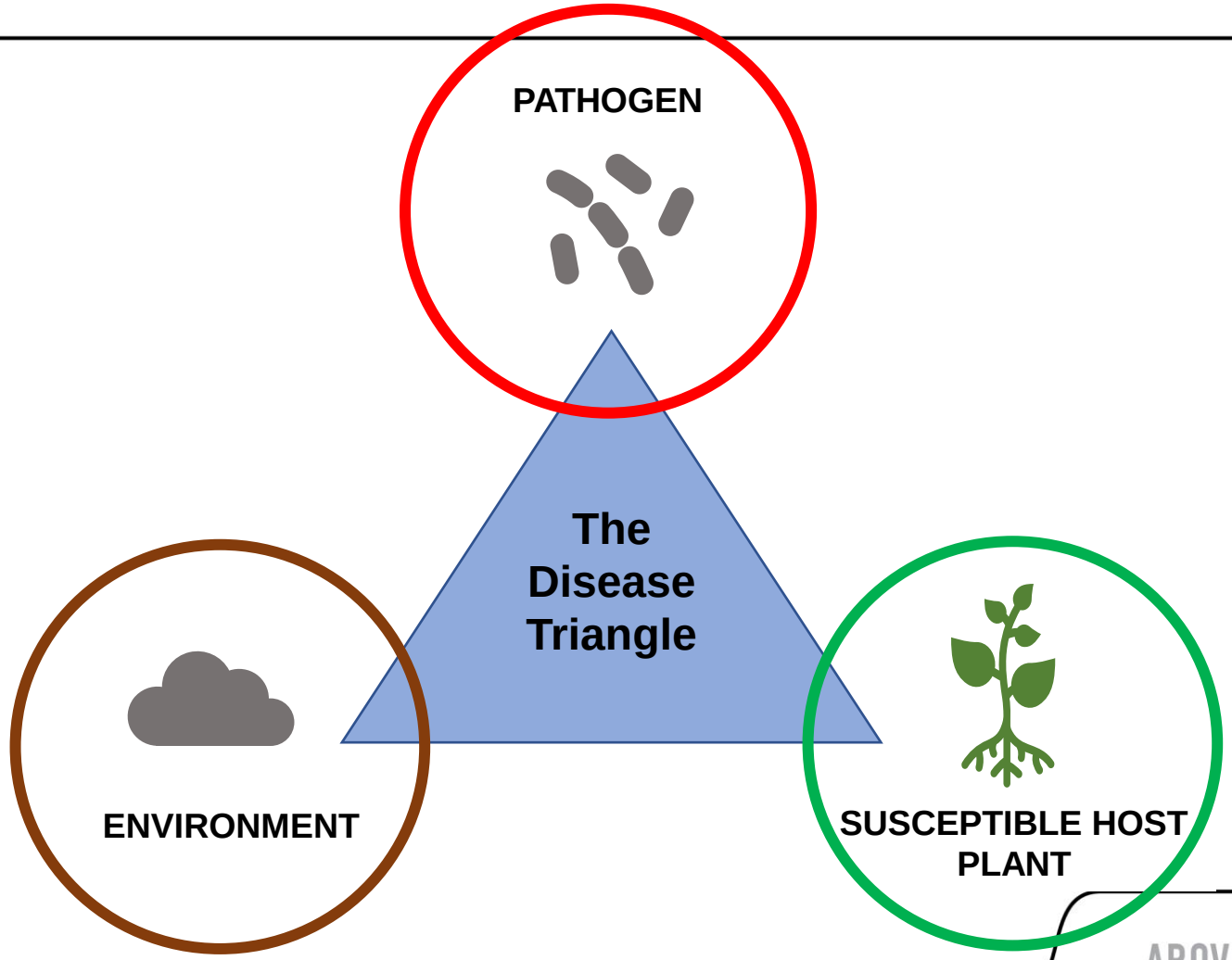


ARE ALL MICROBES CREATED EQUAL?

NO! NEE! NON! ¡NO! NEIN!

- Strains are important
- Just because a product contains '*Bacillus*' or '*Trichoderma*' or '*Streptomyces*' **does not** mean they all deliver the same benefits
- Different strains have different characteristics that affect efficacy and other plant health functions
- Importance of **registered** products vs any old powder/suspension?

THE INFAMOUS disease TRIANGLE



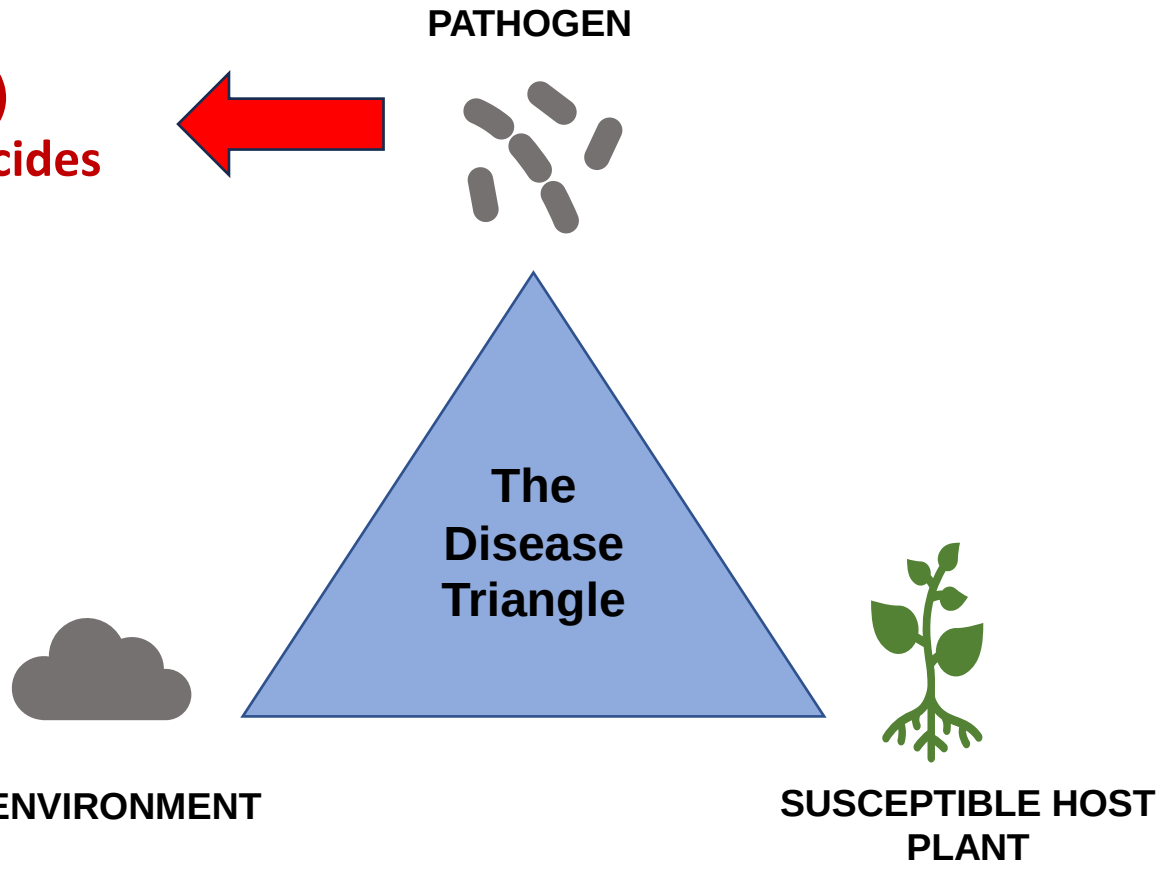
Plant infection depends on these three factors:

- Disease causing organism (the pathogen)
- Susceptible host
- Favorable environment for disease

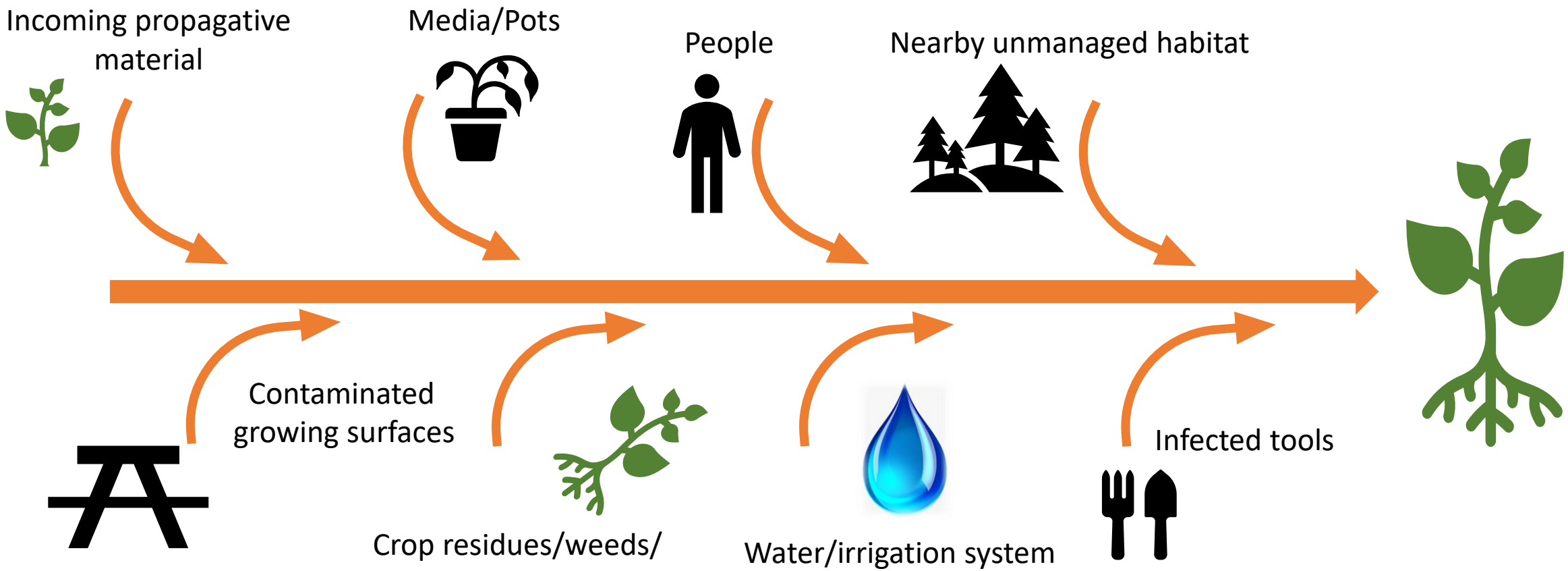
Disease results ***only*** if all three occur simultaneously

THE INFAMOUS disease TRIANGLE

Reduce/manage (sanitation)
Chemical or biological fungicides



THERE ARE MANY SOURCES OF INFECTION



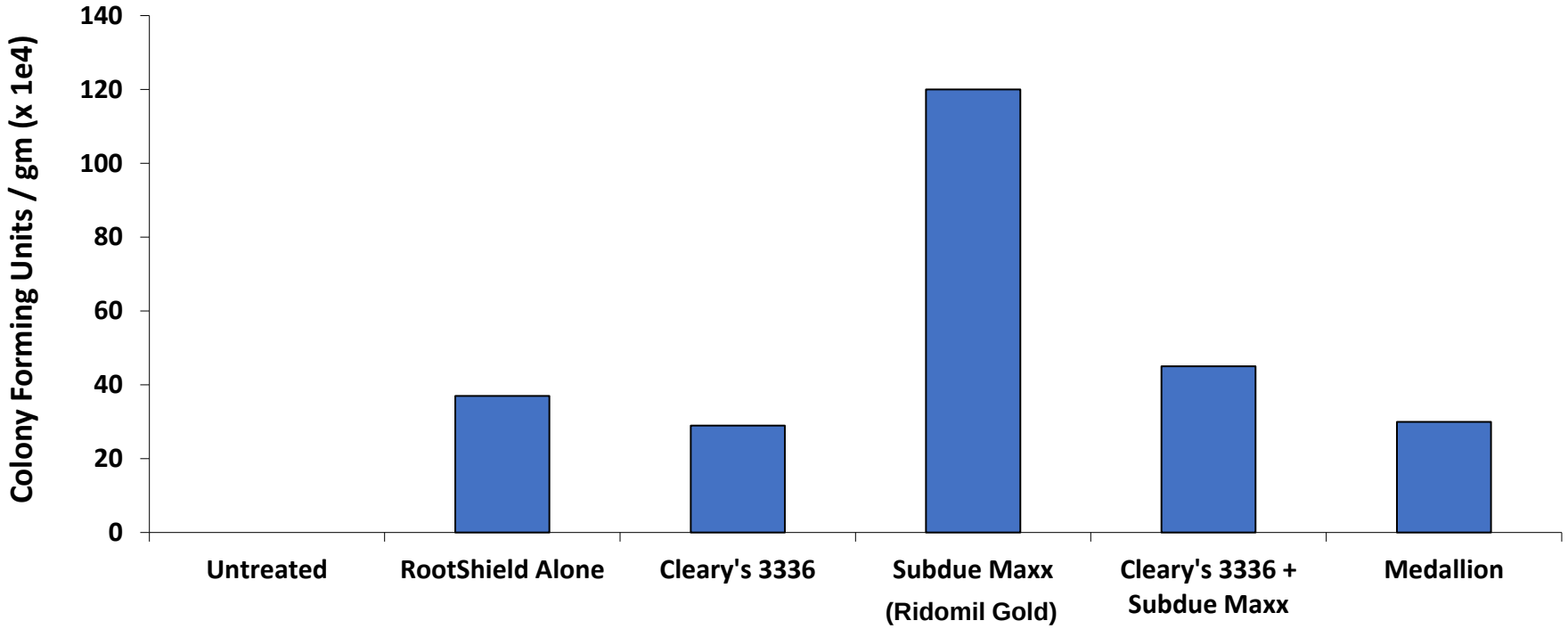
INTEGRATION OF ROOTSHIELD *PLUS*

COMPATIBILITY WITH CHEMISTRY *AND* BIOLOGY

Brand Name	Active Ingredient	Compatibility
CEASE	*B. subtilis* QST713	Yes (soil)
Heritage	Azoxystrobin	Yes
Mural	Azoxystrobin + Benzobindiflupyr	Yes
Pageant	Pyraclostrobin + Boscallid	Yes
Pristine	Pyraclostrobin + Boscalid	Yes
Subdue-Maxx	Mefenoxam	Yes
Medallion	Fludioxonil	Yes (at rates < 4oz/100 gal)
Natural enemies		
NemaShield, Nemasys	*Steinernema feltiae*	Yes
Predatory rove beetle	*Dalotia coriaria*	Yes
Predatory mite	*Stratiolaelaps scimitus*	Yes

RootShield compatibility tool: https://bioworksinc.com/ask-us/product-compatibility/

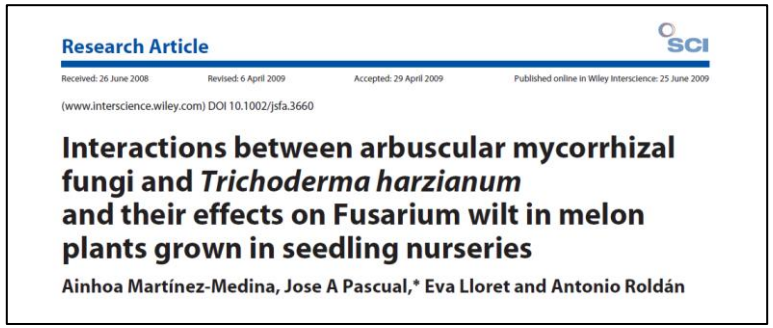
EFFECTS OF CHEMICAL FUNGICIDES ON COLONIZATION OF EASTER LILY ROOTS BY *Trichoderma harzianum* T-22



Mid-American Growers
Granville, IL (Feb. 2000)

USE OF MICROBIAL BIOFUNGICIDES FOR ROOT DISEASES: COMPATIBILITY WITH MYCORRHIZAE?

Trichoderma and *Bacillus:* YES



Research Article

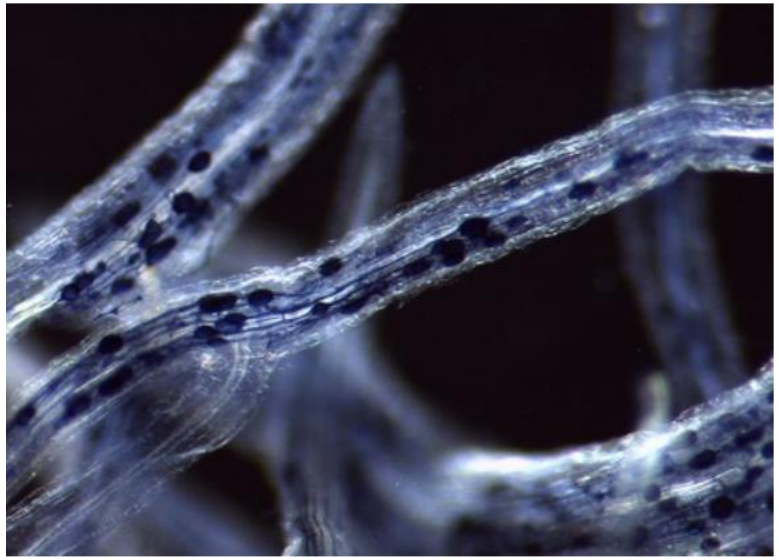
SCI

Received: 26 June 2008 Revised: 6 April 2009 Accepted: 29 April 2009 Published online in Wiley Interscience: 25 June 2009

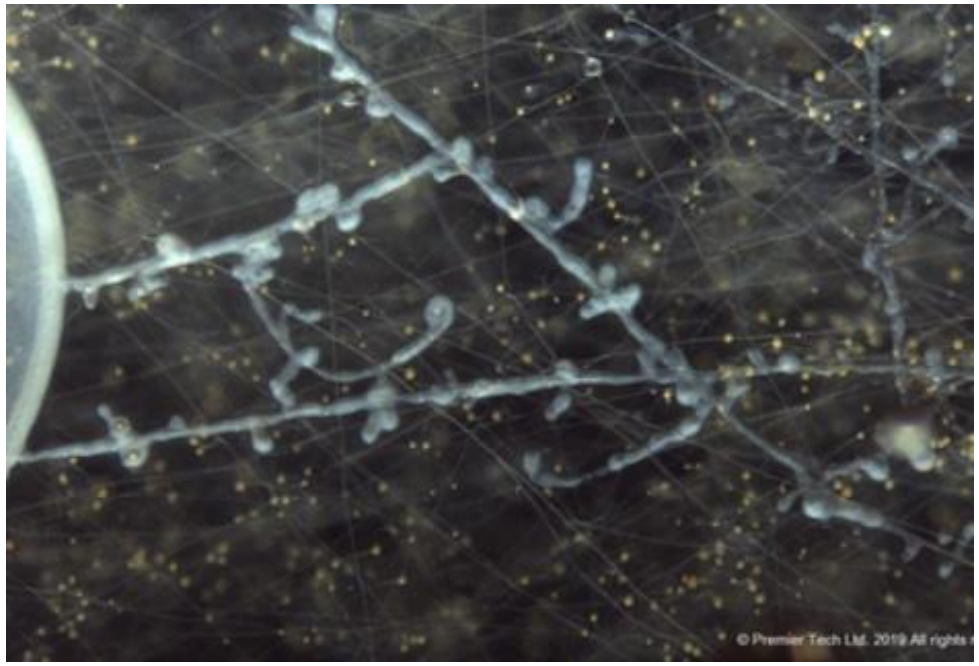
(www.interscience.wiley.com) DOI 10.1002/jsfa.3660

Interactions between arbuscular mycorrhizal fungi and *Trichoderma harzianum* and their effects on Fusarium wilt in melon plants grown in seedling nurseries

Ainhoa Martínez-Medina, Jose A Pascual,* Eva Lloret and Antonio Roldán



Plant roots colonized by MYCORRHIZAE (*Glomus intraradices*, PTB297)



Bacillus sp. forming a biofilm along mycorrhizal hyphae

Images: Premier Tech

COMPATIBILITY WITH BIOSTIMULANTS?

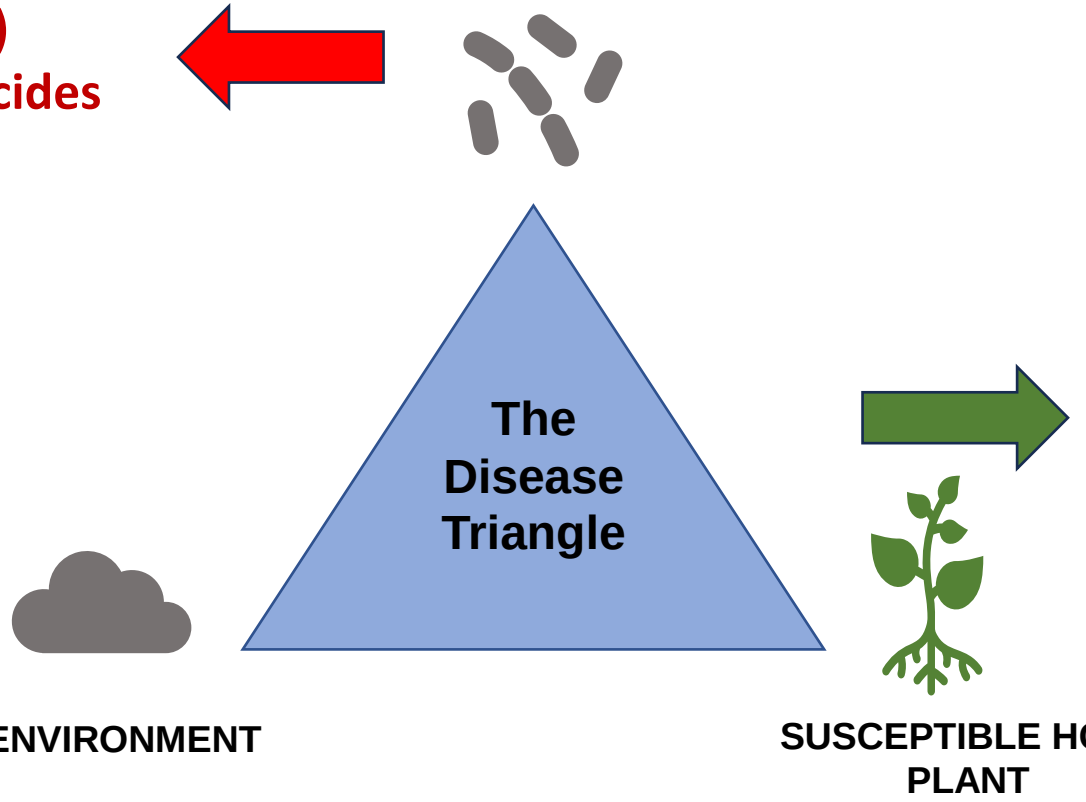
Example: Protein hydrolysate

- Application of protein hydrolysates to stock plants/cuttings
  - Helps plants cope with stress
  - Promotes rooting
- Benefits
  - Faster recovery of stock plants (hibiscus, mandevilla)
  - Faster establishment of cuttings
  - Improved tolerance to abiotic stress
- Combine with *Trichoderma* for best results

THE INFAMOUS disease TRIANGLE

PATHOGEN

Reduce/manage (sanitation)
Chemical or biological fungicides



Resistant varieties
Reduce abiotic stress

ENVIRONMENT

SUSCEPTIBLE HOST
PLANT

Stress

- A **normal human reaction that happens to everyone**… when you experience changes or challenges (stressors). Stress responses help your body adjust to new situations.
- **Chronic stress** can cause or worsen many serious health issues…

PLANTS GET STRESSED TOO!

Abiotic factors

- Heat / Cold
- Drought / Flooding
- Nutrient deficiency / excess
- Soil pH, Salt

Biotic factors

- Diseases, Pests

Plant factors

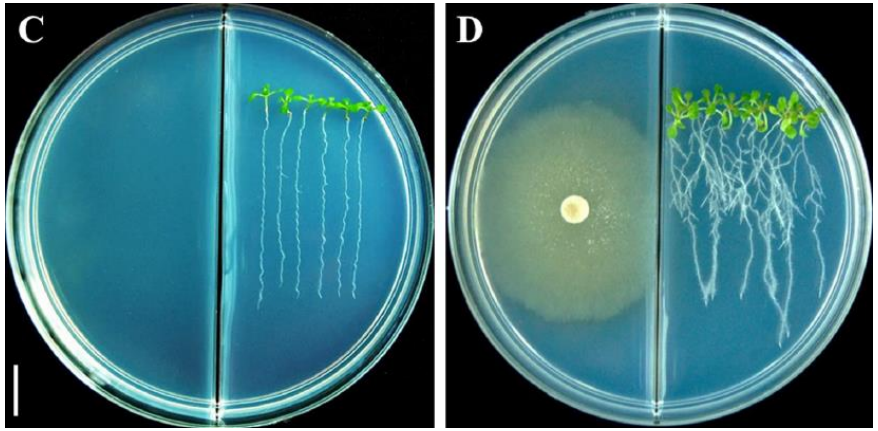
- Re-planting
- Flowering
- Fruiting

HOW CAN BIOLOGICAL MATERIALS HELP?

***Bacillus* and *Trichoderma spp.* can:**

- Promote seed germination
- Stimulate root growth, proliferation of root hairs
- Aid uptake and use of nutrients from soil
- Help plants cope with abiotic/biotic stress
- ***As well as*** protecting plants against diseases

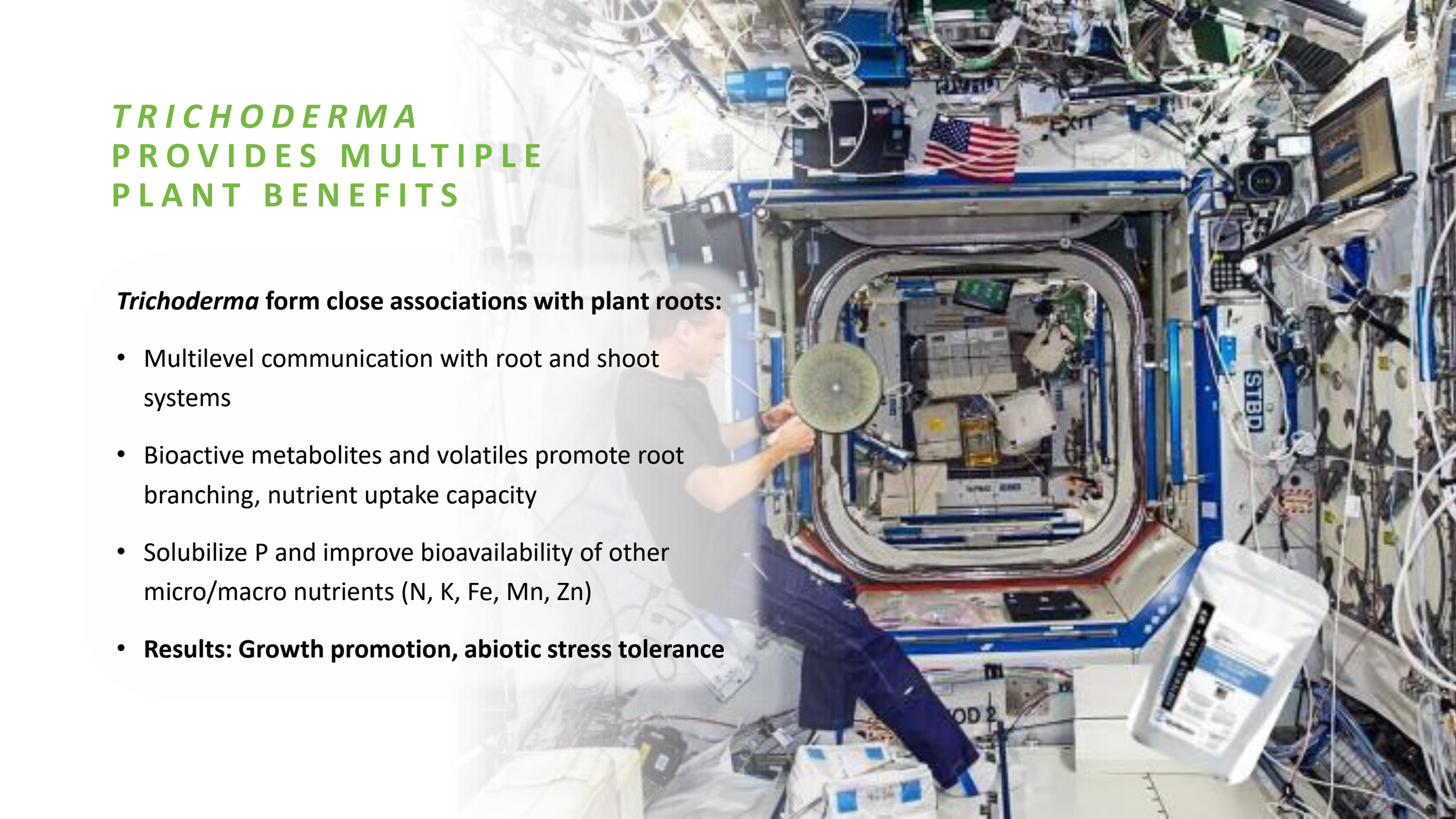
Seedlings treated with sterile water **(C)** or exposed to volatiles produced by *T. virens* **(D)**



TRICHODERMA PROVIDES MULTIPLE PLANT BENEFITS

***Trichoderma* form close associations with plant roots:**

- Multilevel communication with root and shoot systems
- Bioactive metabolites and volatiles promote root branching, nutrient uptake capacity
- Solubilize P and improve bioavailability of other micro/macro nutrients (N, K, Fe, Mn, Zn)
- **Results: Growth promotion, abiotic stress tolerance**



MICROBIALS ARE KNOWN FOR BENEFITS IN EDIBLES AND ORNAMENTALS

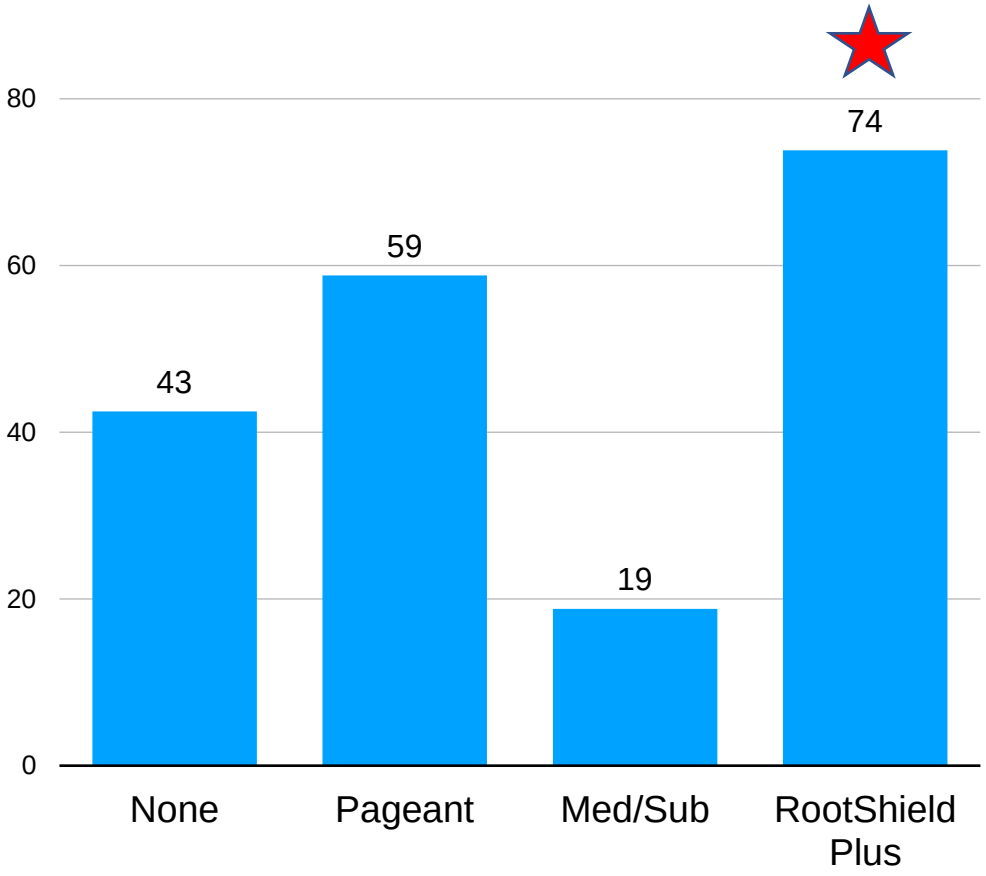
Strawberry transplants after treatment with Serenade (*Bacillus subtilis* QST713)

- *Bacillus* colonizes roots
- Larger, healthier roots and shoots

Lettuce and poinsettia treated with RootShield *PLUS*

- *Trichoderma* colonize and protect developing roots
- Promote root / root-hair growth, improve nutrient access
- Better plant performance and resilience

TRICHODERMA, NOT ONLY FOR DISEASE CONTROL…
IMPROVED SEED GERMINATION



Improved Seed Germination: Ranunculus

- Applied by drench at seeding
- **Highest germination/growth with RootShield Plus**
- Better than Pageant Intrinsic

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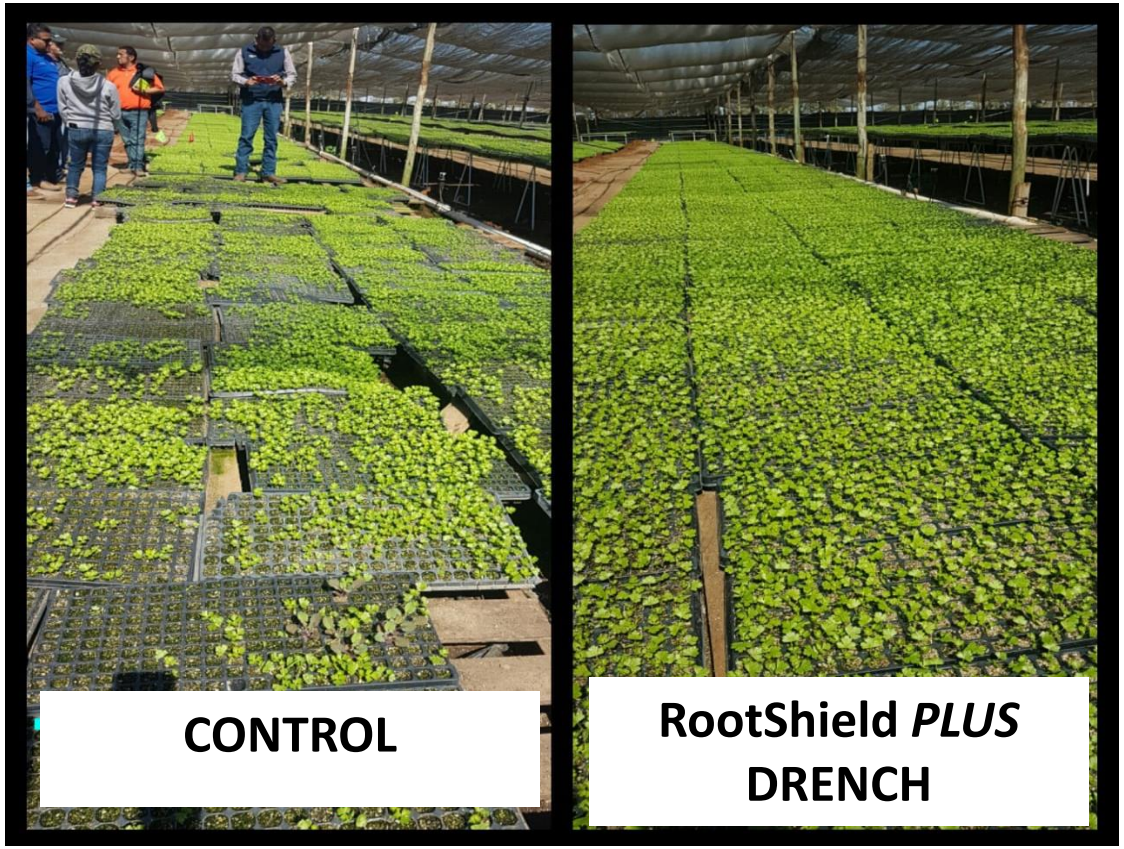
Practical Solutions for Growers

ROOTSHIELD *PLUS*, NOT ONLY FOR DISEASE CONTROL…
IMPROVED SEED GERMINATION AND EARLY GROWTH



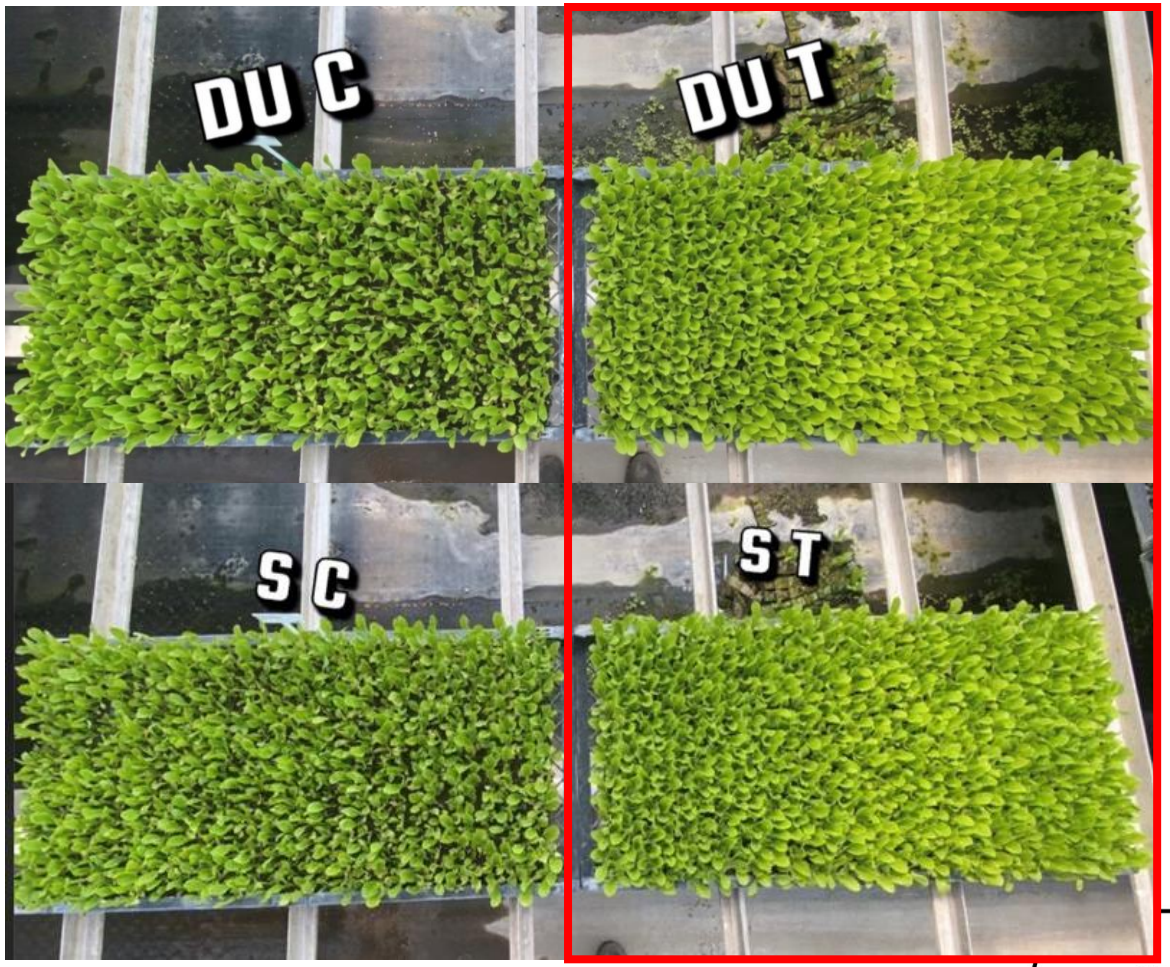
Celery plug production

THE IMPORTANCE OF ROOT DENSITY:

VALUE IN AUTOMATED TRANSPLANTING SYSTEMS

(PLANT TAPE®)

THE IMPORTANCE OF ROOT DENSITY AND…
ENHANCED SEED GERMINATION AND SEEDLING GROWTH



- *Trichoderma harzianum* T-22 as a seed inoculant to Romaine lettuce seeds in **Plant Tape®**
- Two romaine varieties: Duquesne and Stampede

Seed treated with T-22 (DU T and S T)

- Synchronous germination
- More even growth, development
- Better root system
- Better establishment

Images courtesy of Alejandro Palma, Dole Fresh

ADDITIONAL BENEFITS PROVIDED BY *TRICHODERMA*…

IMPROVED ROOTING IN PROPAGATION: EXAMPLES FROM THE NURSERY

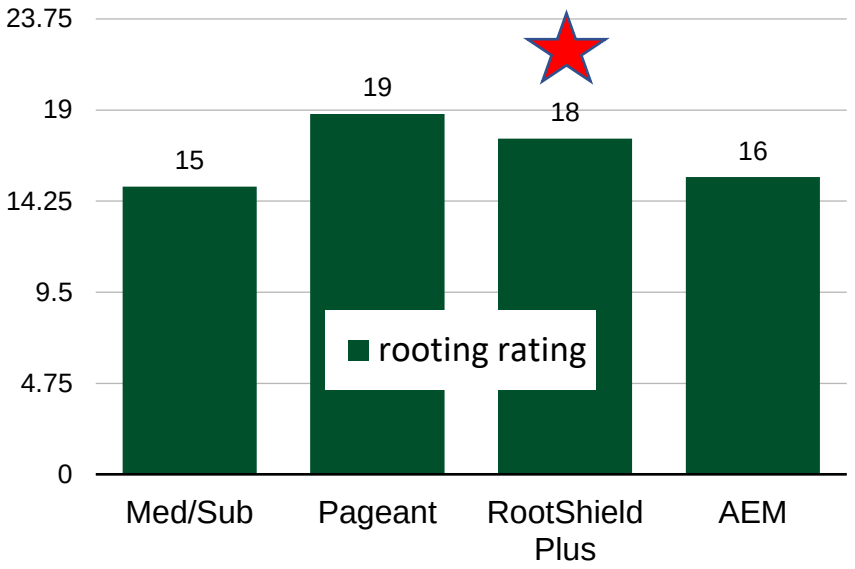
Sedum (bottom) propagated in *Trichoderma*-amended media

Viburnum ‘Spring Lace’ rooted in *Trichoderma*-amended medium

Cacti grown in media amended with *Trichoderma*

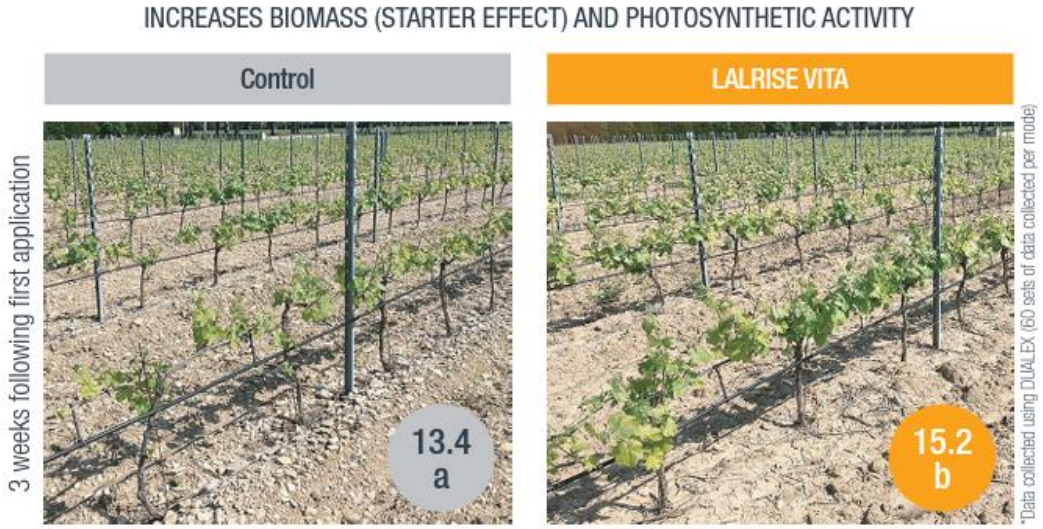
Hellebore – 9-d from TC planting in RootShield-amended media

TRICHODERMA AND *BACILLUS*, NOT ONLY FOR DISEASE CONTROL… IMPROVED ROOTING AND PERFORMANCE IN WOODY PLANTS



RootShield PLUS

- Applied to Crepe Myrtle by sprench at sticking
- Superior rooting success



LALRISE VITA

- Activates root growth early for rapid establishment and rooting
- Actively releases fixed P in plant-available forms

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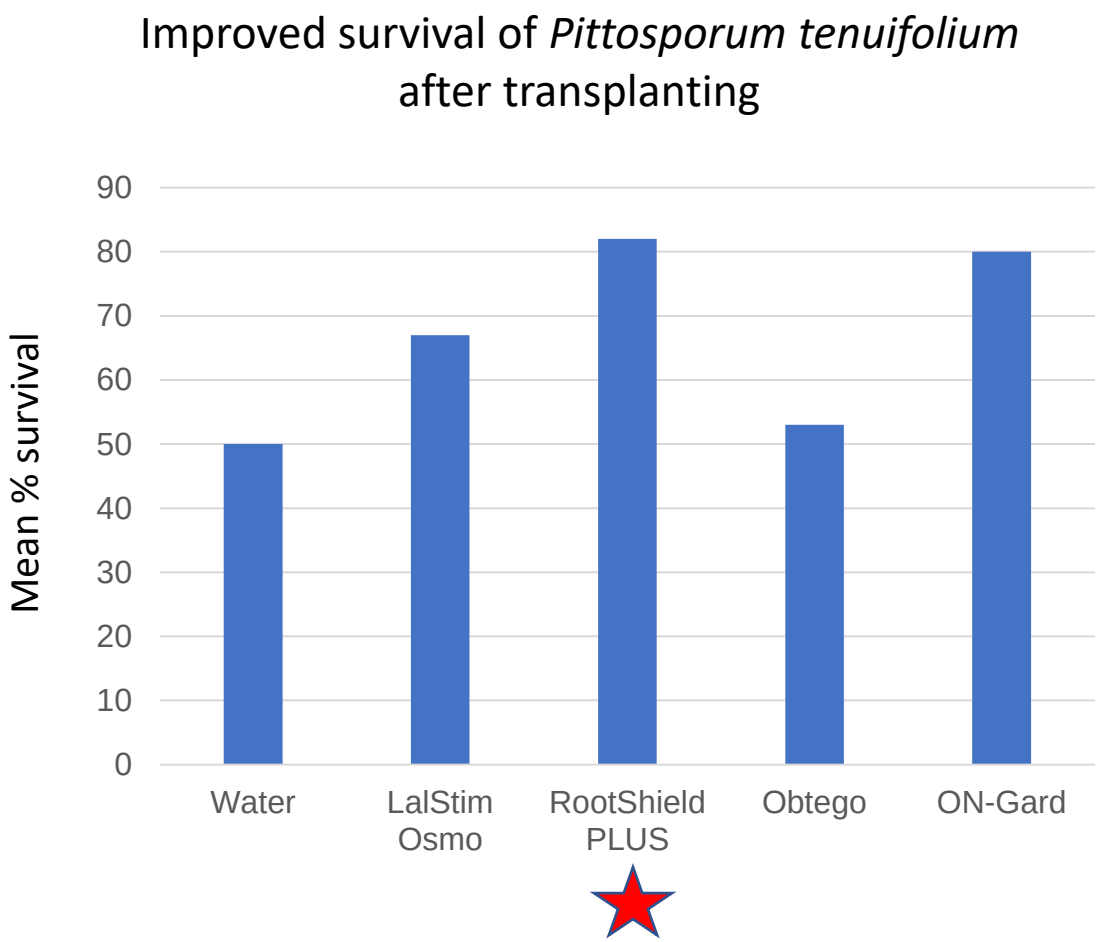
TRICHODERMA AND *BACILLUS* CAN ALSO HELP WOODY PLANTS THROUGH PERIODS OF STRESS



Trial conditions very stressful

- Dry, hot days to cool/ cold nights

Best treatments for top quality were

- RootShield Plus
- ON-GARD
- All other treatments did not promote plant growth over the water control.

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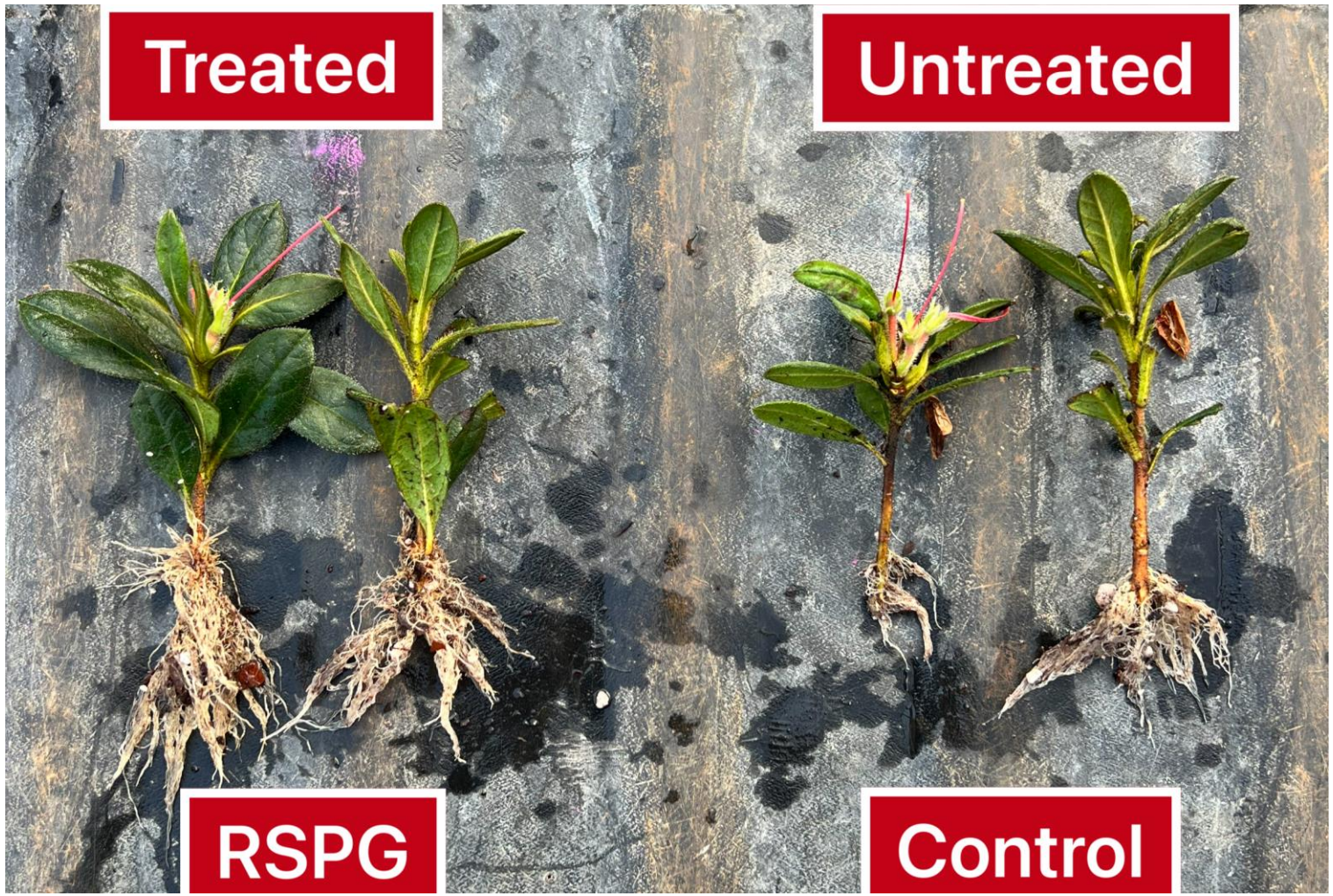
TRICHODERMA, NOT ONLY FOR DISEASE CONTROL…

ENHANCED ROOT PERFORMANCE, STRESS TOLERANCE IN BOXWOOD

Baby Gem boxwoods, Alabama

- Productivity affected by diseases (*Fusarium*, *Phytophthora*, *Rhizoctonia*) and heat stress
- Media pre-treated with *Trichoderma* granules, or post transplant with a WP

Boxwoods, Texas



ENHANCED ROOT PERFORMANCE IN AZALEA

THE ROLE OF BIOFUNGICIDES IN PLANT HEALTH

- Educate yourself, know which product(s) to use
- Apply biopesticides preventatively
  - Not rescue treatments (aka. ‘synthetic pesticide’)
- Know the label, know your diseases: understand the ***how,*** the ***when*** and the ***where***
- Consider the whole program – ensure compatibility of ***all*** the parts
- Don’t forget about the additional benefits and value these materials bring
  - Pesticide reduction, safety
  - Resistance management
  - Plant health and performance

ABOVE AND BEYOND IS WHERE WE BEGIN

BIOWORKSINC.COM

THANK YOU FOR LISTENING

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SR. TECHNICAL SERVICES MANAGER

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BioWorks®