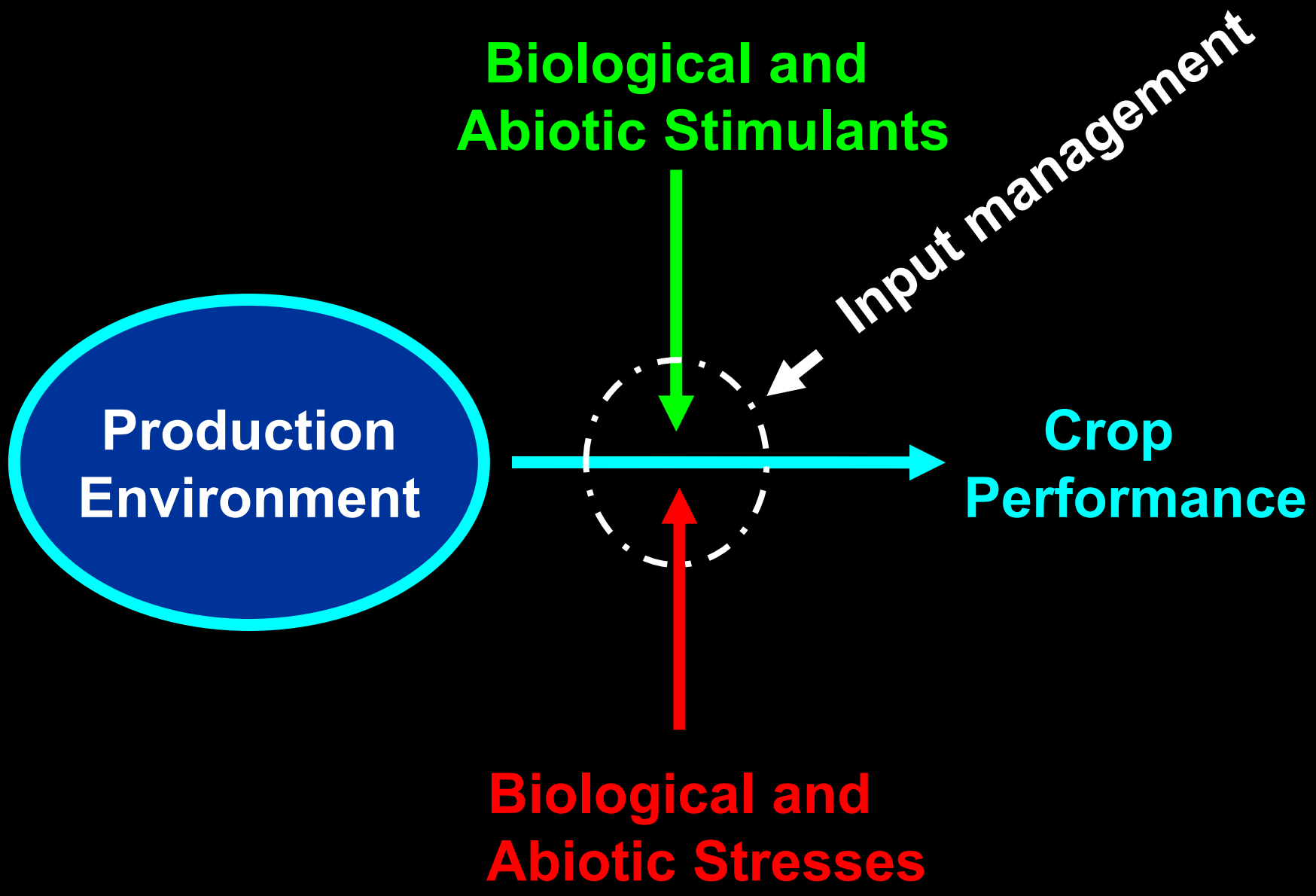
Biorational Management of Soilborne Diseases in Annual and Perennial Crops

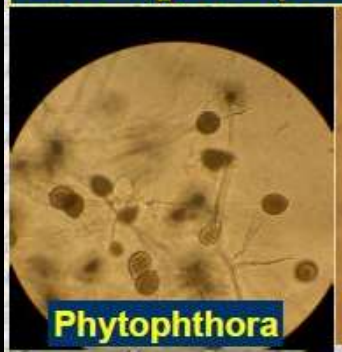
Soum Sanogo, Department of Entomology, Plant Pathology, and Weed Science New Mexico State University

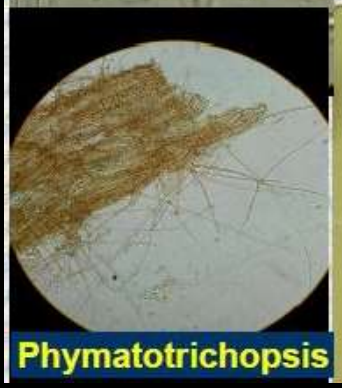
Centrality of Production Environment



Soilborne Disease Research

Pathogens (Fungi/others)





Etiology

Identification of Pathogens

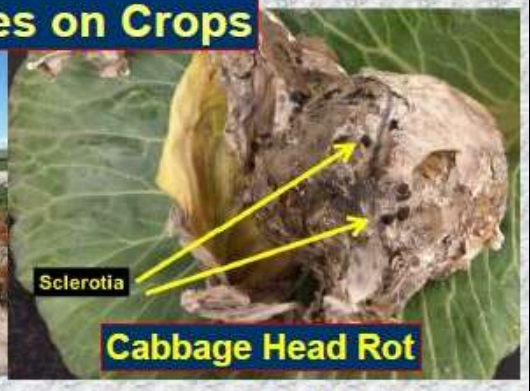
Epidemiology

Factors Affecting Pathogens

Management

Strategies for Controlling Pathogens

Damages on Crops



Green

Red

Soilborne Diseases

Early → Mid → Late

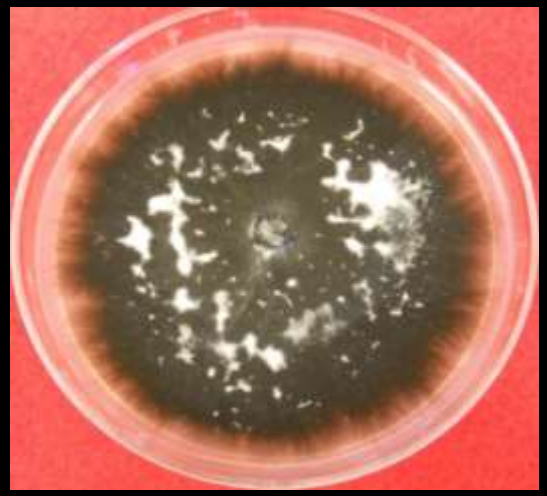
- Root and stem dysfunction
- Vascular dysfunction

Fusarium/Rhizoctonia root rot

Phytophthora blight

Verticillium wilt

Verticillium wilt



Phytophthora blight

Fusarium/Rhizoctonia root rot

Vascular dysfunction

Root and stem dysfunction

Spatial Pattern/Verticillium wilt

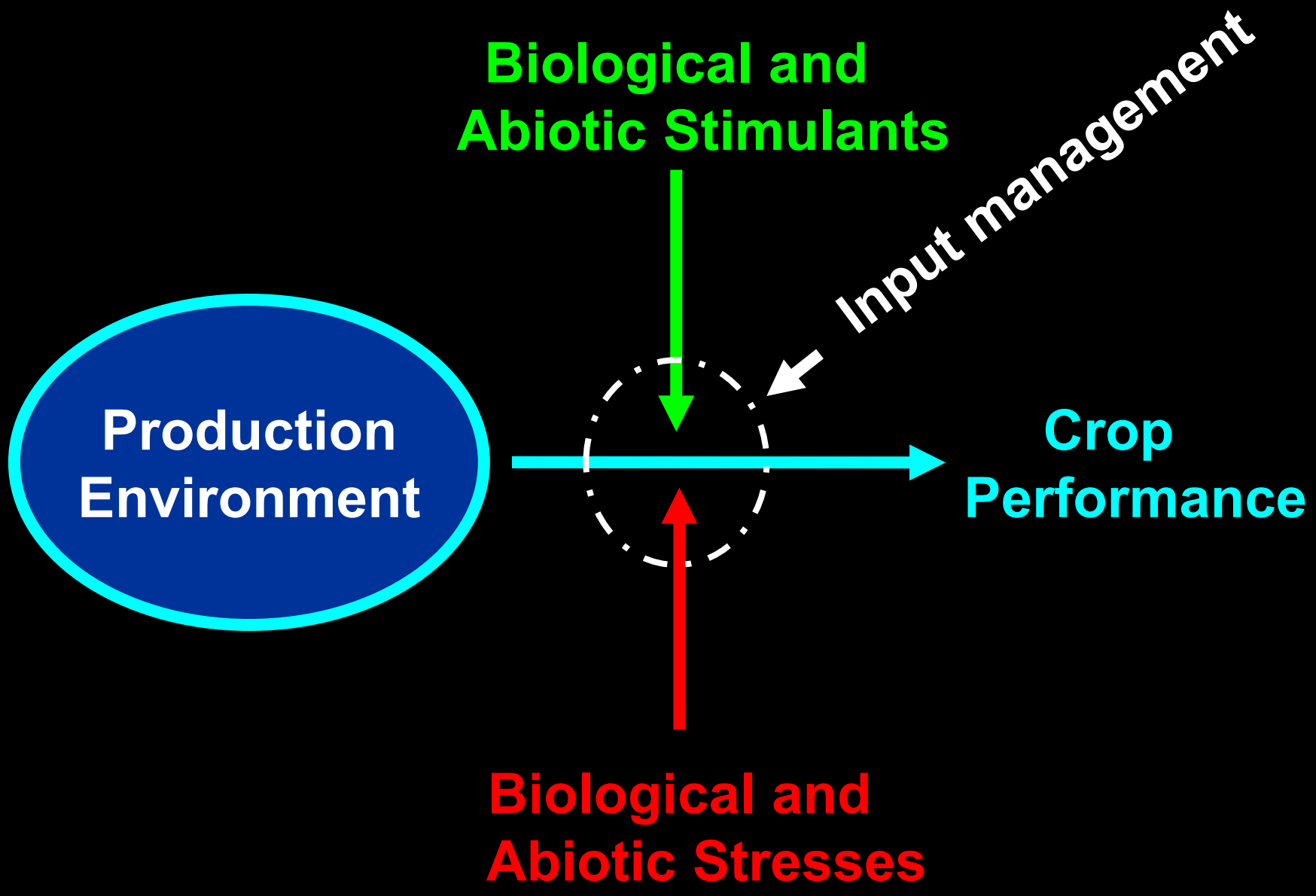
Spatial Pattern/Phytophthora blight

Spatial Pattern/Phytophthora blight

Alfalfa root rot/ *Phymatotrichopsis omnivora*

Fruit & Nut tree root rot/ *Phymatotrichopsis omnivora*

Centrality of Production Environment



Managing Production Environment to Reduce Disease Problems

Biological (pests)
- *Weeds*
- *Arthropods*

Edaphic
- *Soil temperature*
- *Soil moisture*
- *Soil salinity*
- *Soil chemical composition*
- *Soil texture*
- *Soil hydraulic conductivity*
- *Soil microorganisms*

Physical aerial
- *Temperature*
- *Humidity*
- *Rainfall*
- *Wind*

Management inputs
- *Irrigation*
- *Soil amendments*
- *Cover crops*
  - Bioactive
  - Poaceous
- *Crop rotation*
- *Genetic resistance*
- *Induced resistance*
- *Grafting*
- *Solarization*
- *Pesticides*
  - Fungicides (Fumigants)
  - Insecticides
  - Herbicides
- *Biorational products*
  - Microbial
  - Botanical

VALENT®

Back

HOW THE NEXT GENERATION OF BIORATIONAL CROP PRODUCTION TECHNOLOGIES WILL CHANGE FARMING

Search for a biorational alternative program to chemical soil fumigation for control of wilt diseases in chile pepper in New Mexico

S. Sanogo (1), P. LUJAN (1), and J. Idowu (2,3);
(1) Dept. of Entomology, Plant Pathology, and Weed Science;
(2) Dept. of Extension Plant Sciences; (3) Dept. of Plant and Environmental Sciences
New Mexico State University, Las Cruces

Biorational Components

Bacteria
Bacillus
Streptomyces

Fungi
Trichoderma
Mycorrhizae

Biorational Components

Bioactive crop residues

Biostimulant crop residues

Microbial/Botanical

Enhanced host nutrition

Increased population of antagonistic microorganisms

Induced Resistance

Microbial and Plant Interactions

Microbial interactions that reduce activities of pathogens

Microbial interactions that boost crop's response to pathogens

Synthetic microbiota

Single Microbe versus Multiple Microbes

F

Fungicide use: Some fungicides should not be used as a drench with MycoApply EndoMaxx at planting or for the first 4 weeks following seed germination. Many fungicides do not adversely affect mycorrhizae. (For more information, visit www.mycorrhizae.com)

CONTAINS NON-PLANT FOOD INGREDIENTS:
Soil Amending Guaranteed Analysis
Active Ingredients: ..... 6.6 w/w%
Glomus intraradices ..... (5,600 viable prop/g)
Glomus aggregatum ..... (5,600 viable prop/g)
Glomus mosseae ..... (5,600 viable prop/g)
Glomus etunicatum ..... (5,600 viable prop/g)
Inert Ingredients: Clay ..... 93.4 w/w%

"This Product is not a Plant Food" Information regarding the contents and levels of metals in this product is available on the internet at: http://www.aapfco.org/metals.htm

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B

DoubleNickel™ LC

BIOFUNGICIDE

Aqueous Suspension Biofungicide/Bactericide

RGANIC PRODUCTION

OM LIST

ns strain D747* 98.85%
S: 1.15%
..... 100.00%
of 1×10¹⁰ colony-forming units (cfu) per milliliter

Net Cont
2.5 Gallo
EPA Reg.
EPA Est.
Lot No:

F

RootShield PLUS+ WP

Biological Fungicide

ACTIVE INGREDIENTS:
Trichoderma harzianum Rifai strain T-22* 1.15%
Trichoderma virens strain G-41** 0.61%
OTHER INGREDIENTS: 98.24%
TOTAL: 100.00%
* Contains at least 1.0 X 10⁷ colony forming units per gram dry weight.
**Contains at least 5.3 x 10⁶ colony forming units per gram dry weight.

ers may be in the area during application. For a
to your State or Tribe, consult the State or Triba
pesticide regulation.

AGRICULTURAL USE REQUIRE
Use this product only in accordance with its abe
Protection Standard, 40 CFR part 170. This Sta
ments for the protection of agricultural workers

B

ACTINOVATE ® AG

ACTIVE INGREDIENT:
*Streptomyces lydicus** 00.0371%
OTHER INGREDIENTS: 99.9629%
End-use product contains not less than 1 X 10⁷ colony forming units
Streptomyces lydicus WYEC 108

nformation regarding the contents and levels of metals in this product is avail
nternet at http://www.aapfco.org/metals.htm

KEEP OUT OF REACH OF CHILDREN
CAUTION
See back panel for additional precautionary statements.

US Patent Number: 5,403,584

F,B

VITALYZE 3-0-0

Guaranteed Analysis
Total Nitrogen (N) 3.0%
0.9% Ammoniacal Nitrogen
0.9% Nitrate Nitrogen
1.2 % Urea Nitrogen
Derived From: Urea Ammonium Nitrate

ALSO CONTAINS NON-PLANT FOOD INGREDIENTS:
SOIL AMENDING GUARANTEED ANALYSIS
Bacillus amyloliquefaciens 10,000,000 CFU per ml
Bacillus licheniformis 10,000,000 CFU per ml
Bacillus pasteurii 10,000,000 CFU per ml
Bacillus pumilus 10,000,000 CFU per ml
Paenibacillus durum 10,000,000 CFU per ml
Streptomyces griseus 4,300,000 CFU per ml
Trichoderma reesei 4,300,000 CFU per ml
Azotobacter vinelandii 6,000,000 CFU per ml
Bacillus subtilis 10,000,000 CFU per ml
Bacillus coagulans 10,000,000 CFU per ml
Bacillus megaterium 10,000,000 CFU per ml
Paenibacillus polymyxa 10,000,000 CFU per ml
Streptomyces lydicus 4,300,000 CFU per ml
Trichoderma harzianum 4,300,000 CFU per ml
Azotobacter chroococcum 6,000,000 CFU per ml

Inert as a Soil Amending Ingredient
Fertilizer 3.00%
Water-based culture medium 97.00%

CFU - Colony Forming Units/Milliliter

B

SERENADE® SOIL

anic Production
AL USE

IENT:
f dried *Bacillus subtilis** 1.34%
IENTS 98.66%

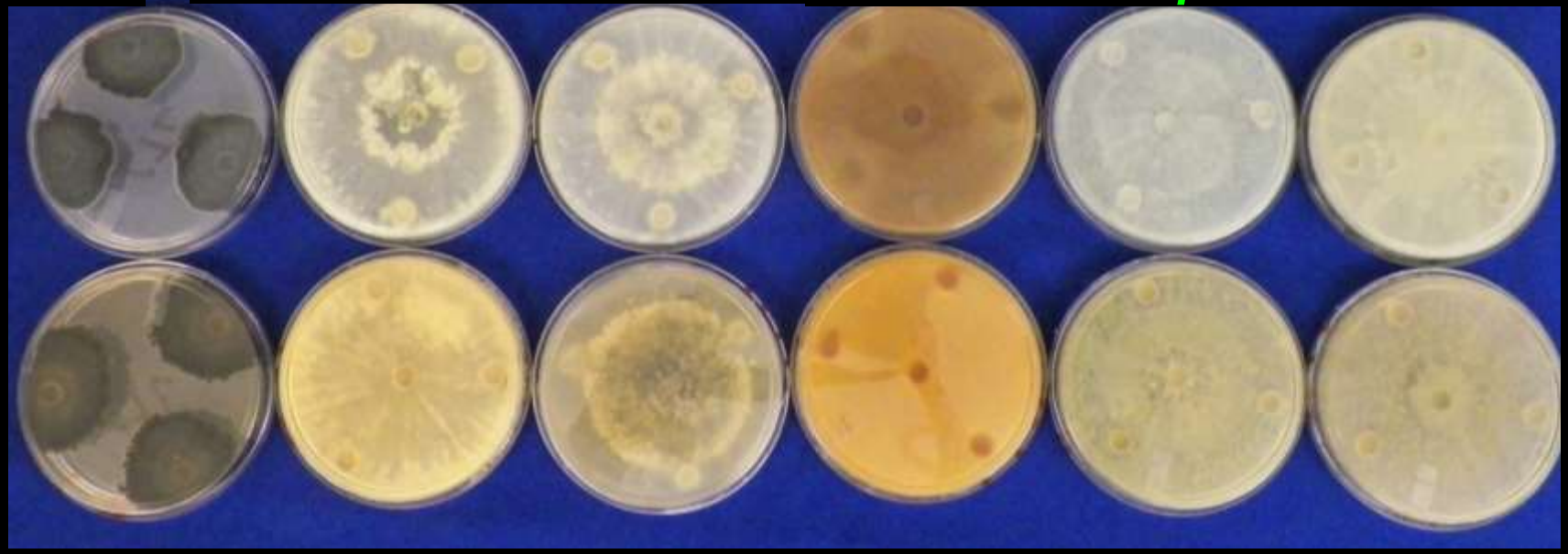
Bacteria-based products

Serenade
(Bacillus subtilis QST 731)

No Serenade

(Fungi) Trichoderma-based products

Control — *atroviride* *citronoviride* *harzianum* *asperellum* *virens*

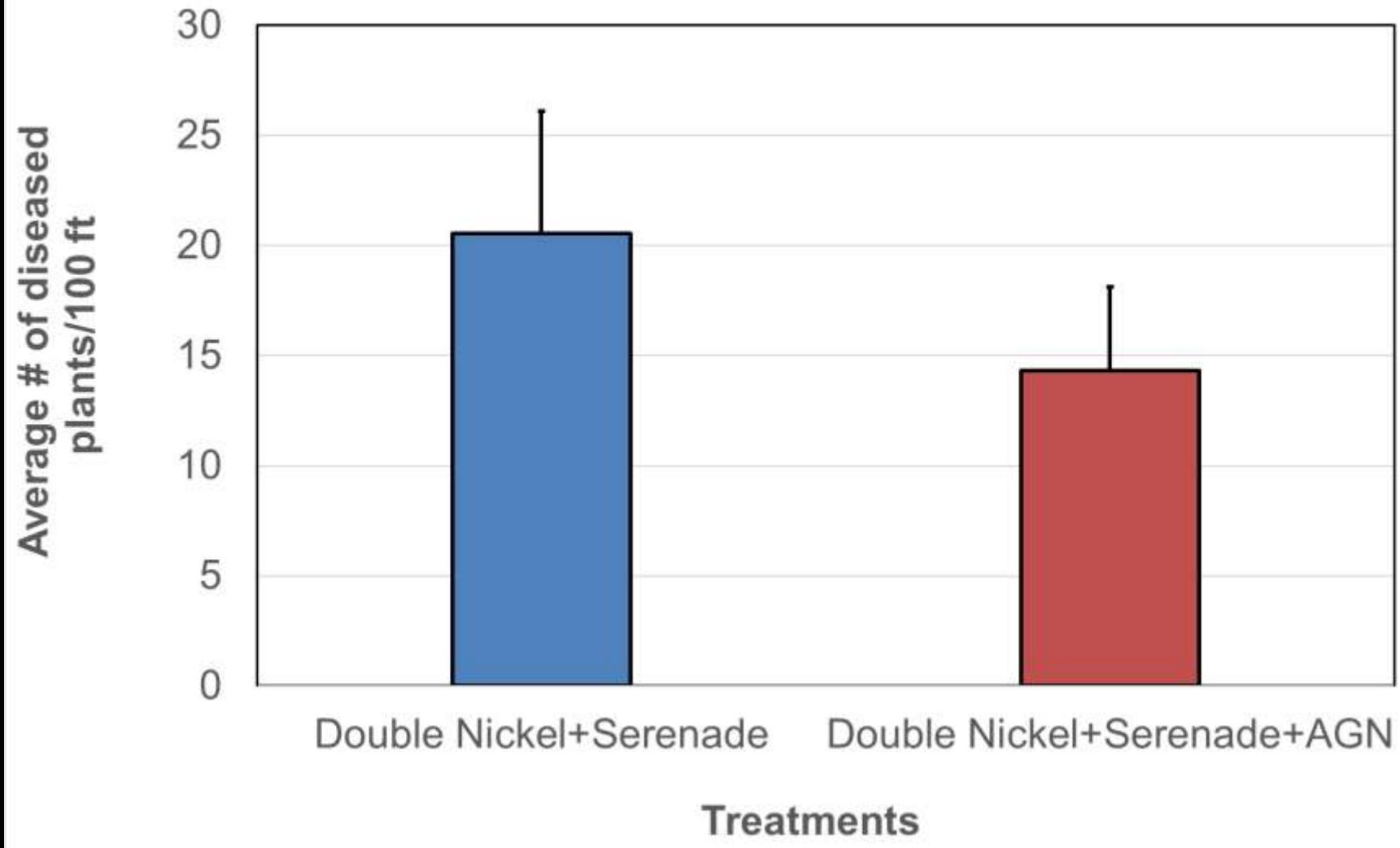


Commonalities in Microbial Formulations

Active ingredients	Double Nickel	Serenade	Root Shield	Actinovate	AGN	Terra Grow
Bacillus licheniformis						X
Bacillus subtilis		X			X	X
Bacillus pumilis					X	X
Bacillus amyloliquefaciens	X				X	X
Bacillus megaterium					X	X
Trichoderma harzianum			X			X
Trichoderma reesei						X
Trichoderma virens			X			
Streptomyces lydicus				X		

Chile wilt/ Verticillium

Reduce activities of pathogens



Viramontes Farms

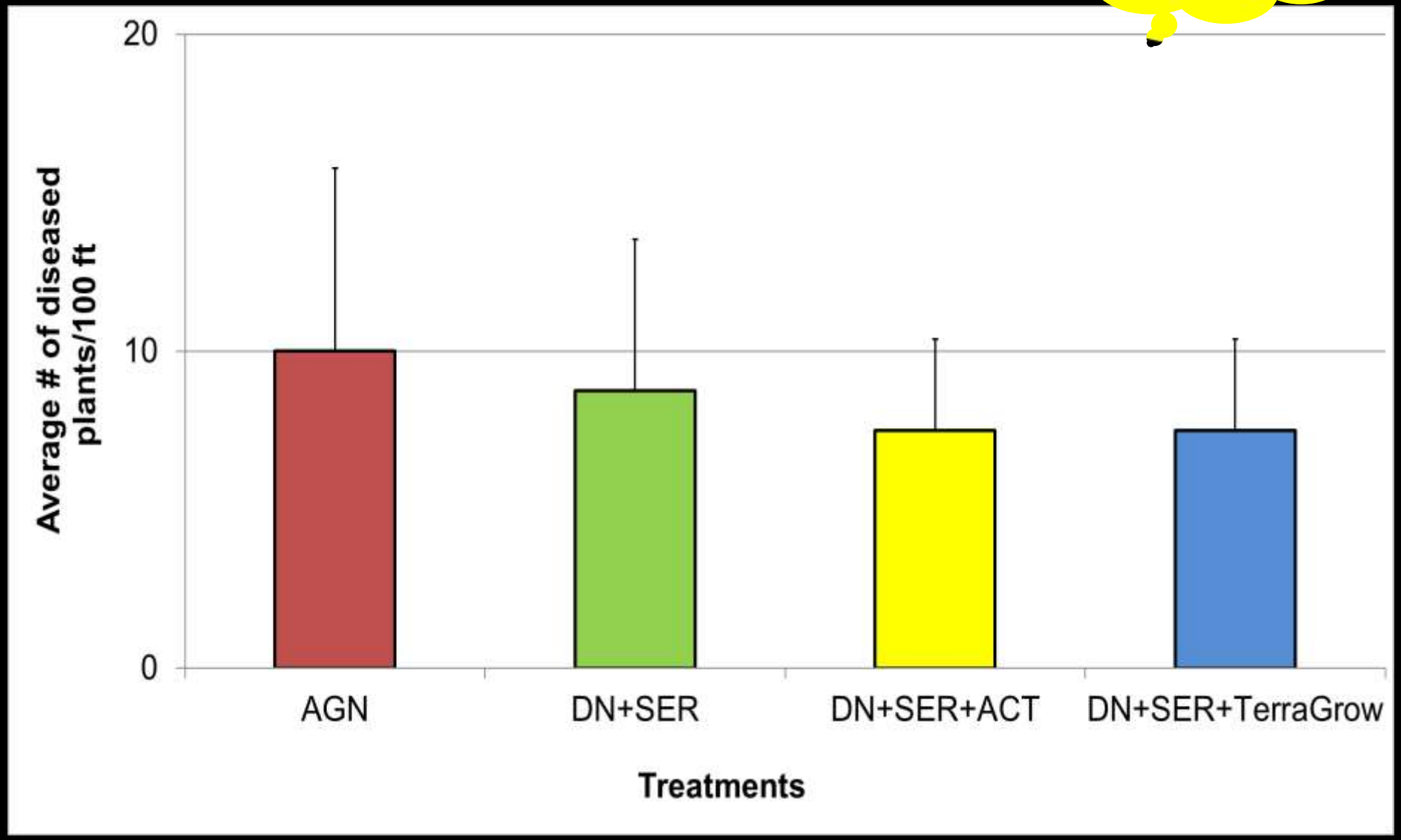
Microbial combinations

Application time	Double Nickel (DN) + Serenade (SER)	DN+SER + Actinovate	AGN	DN+SER +TerraGrow
May	2 qts + 2qts	2 qt +2 qts + 6 oz	2 qts	2 qts + 2 qts + ¼ lb
June	2 qts + 2qts	2 qt +2 qts + 6 oz	2 qts	2 qts + 2 qts + ¼ lb
July	2 qts + 2qts	2 qt +2 qts + 6 oz	2 qts	2 qts + 2 qts + ¼ lb
August	2 qts + 2qts	2 qt +2 qts + 6 oz	2 qts	2 qts + 2 qts + ¼ lb
September	2 qts + 2qts	2 qt +2 qts + 6 oz		

Diaz Farms

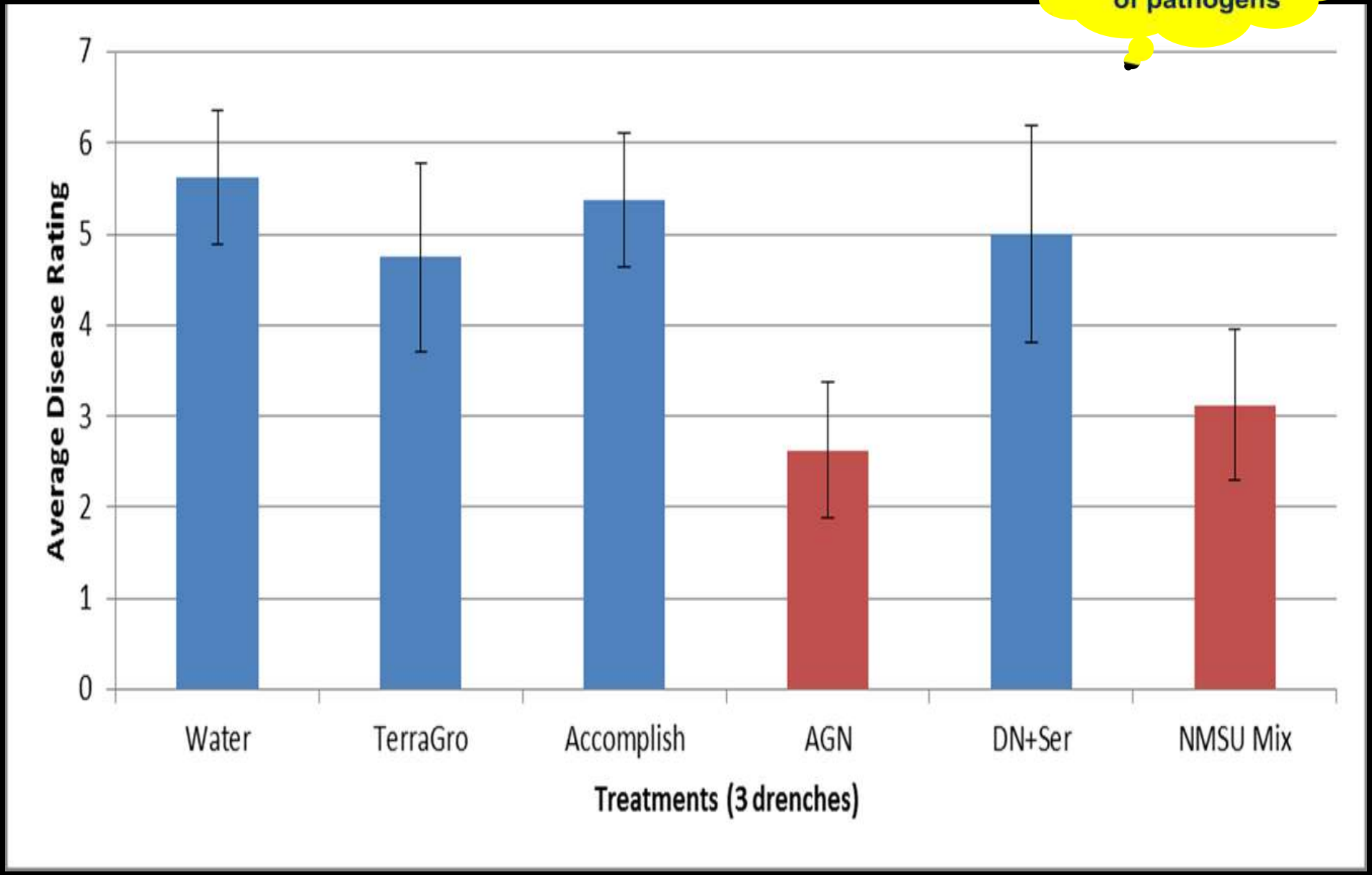
Chile wilt/ Verticillium

Reduce activities of pathogens



Diaz Farms

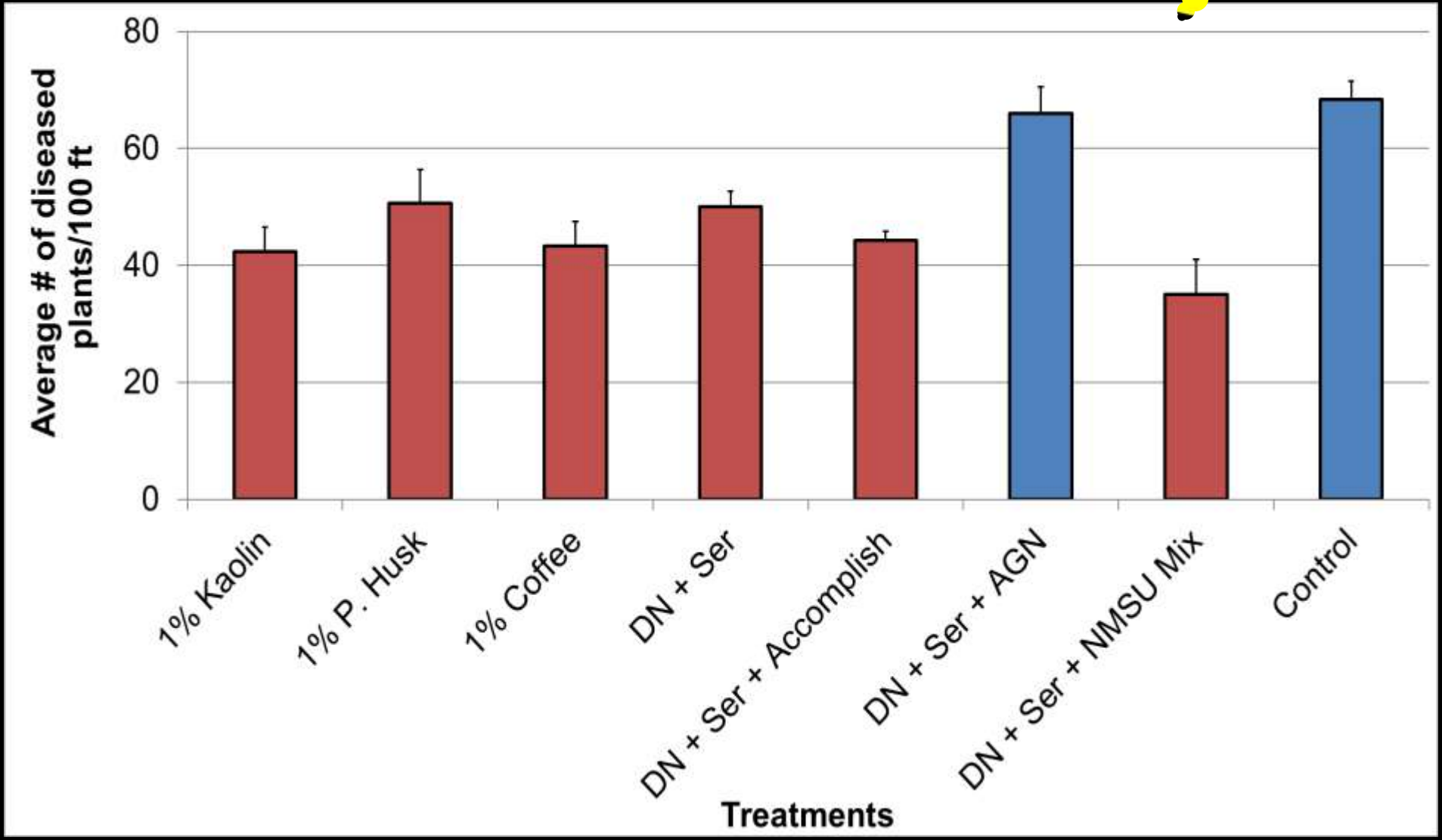
Chile wilt/Phytophthora



NMSU Campus, Las Cruces

Chile wilt/Phytophthora-Rhizoctonia

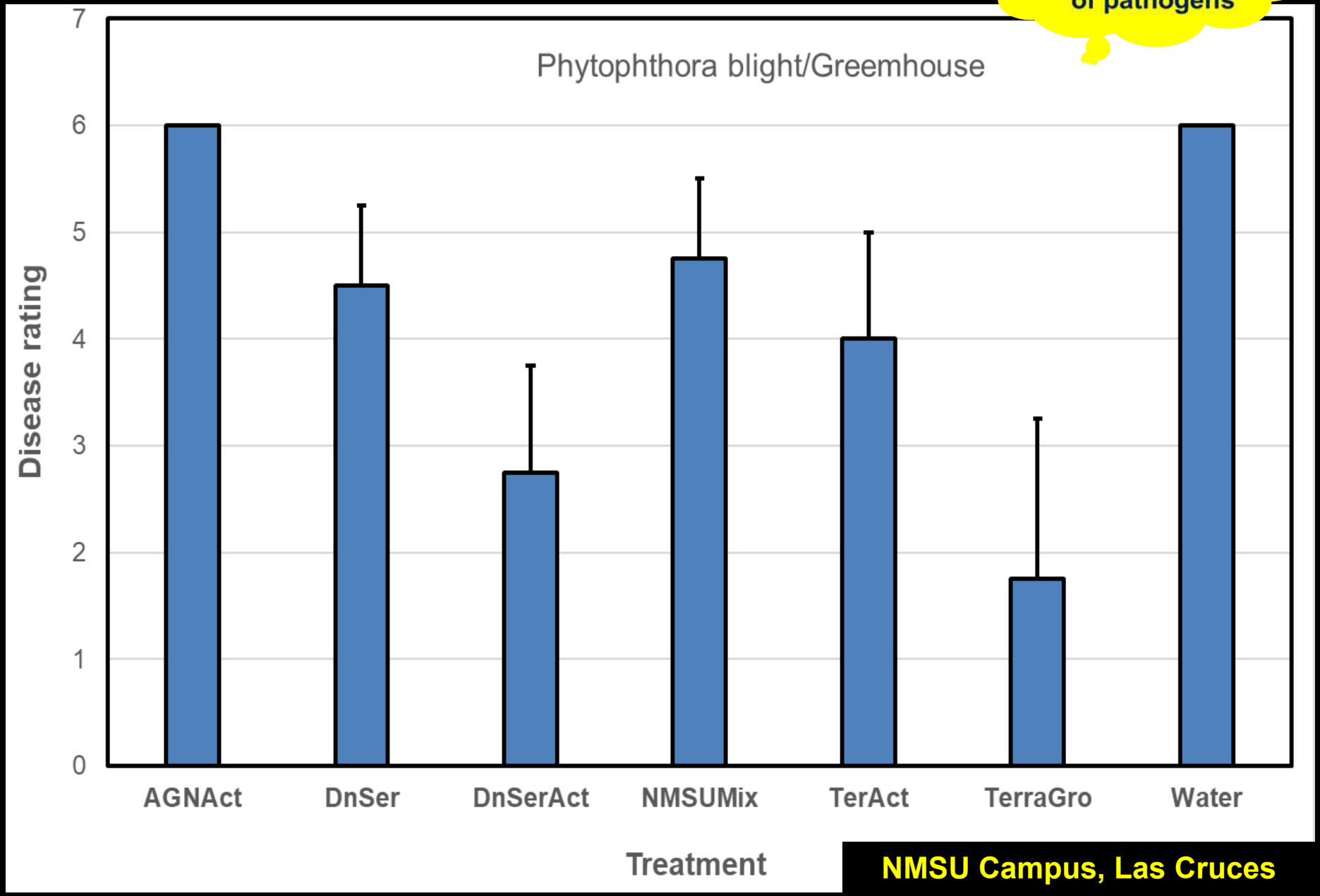
Reduce activities of pathogens



Biad Chili Co.

Chile wilt/Phytophthora

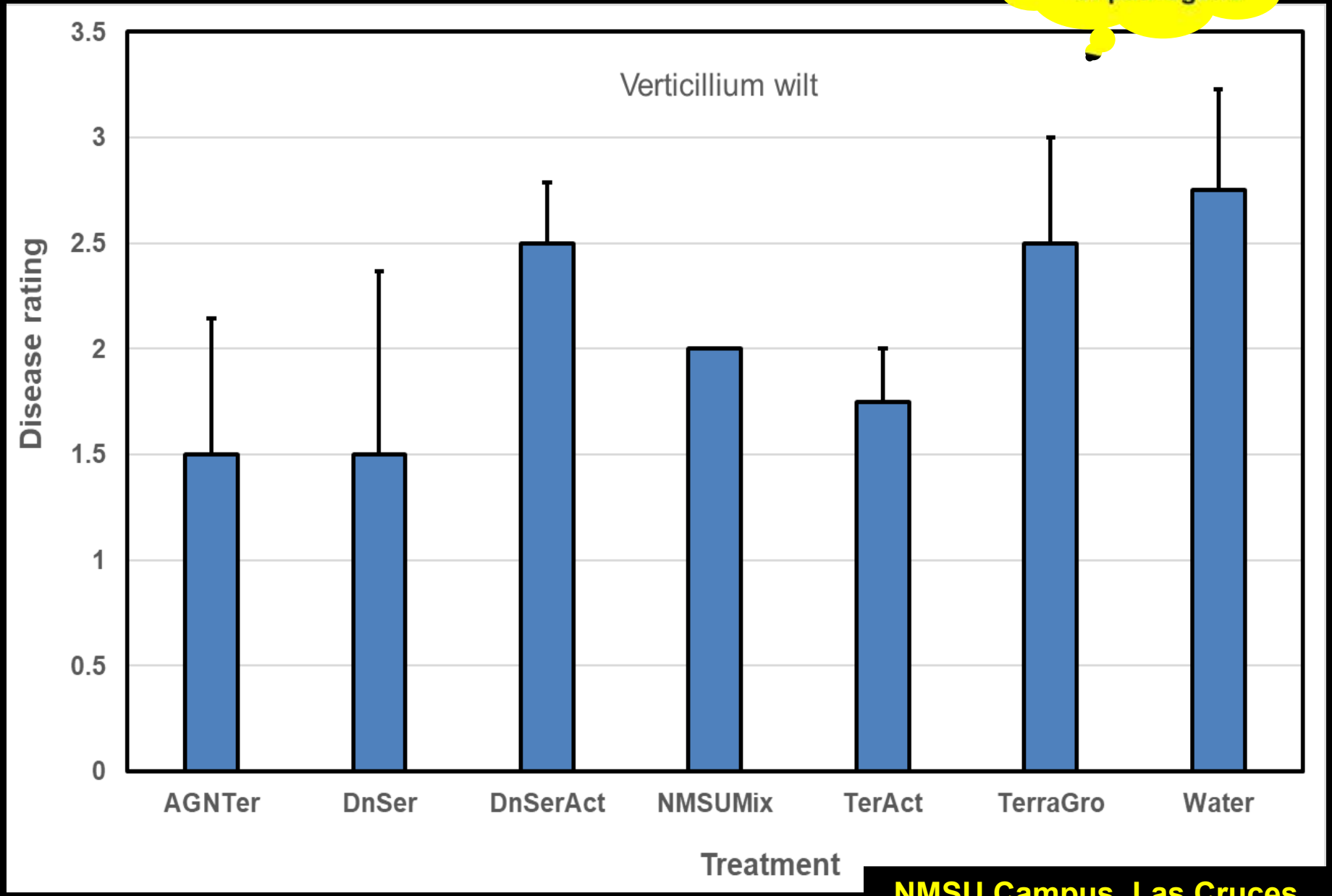
Reduce activities of pathogens



NMSU Campus, Las Cruces

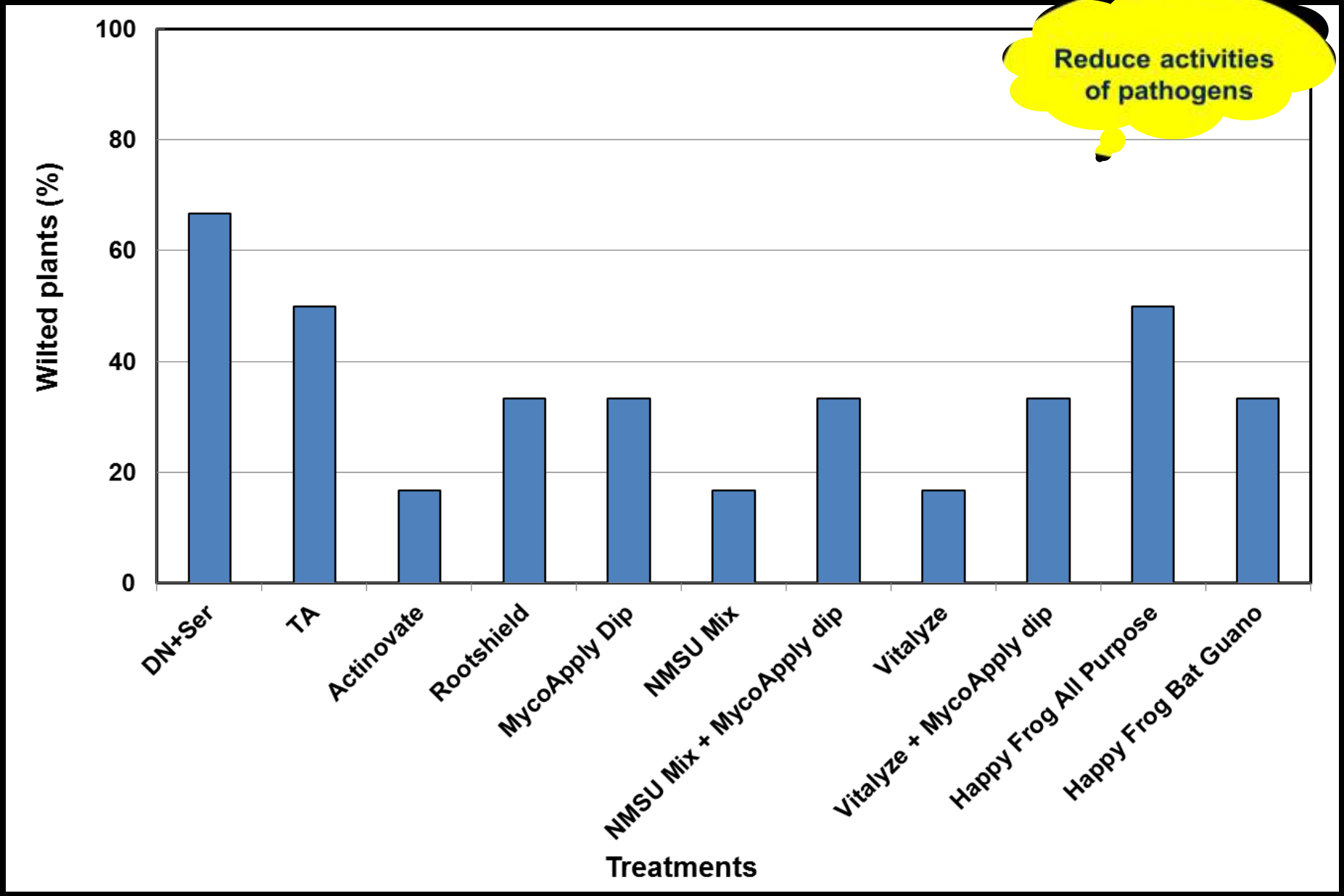
Chile wilt/Verticillium

Reduce activities of pathogens



NMSU Campus, Las Cruces

Phytophthora Trial _ NMSU Leyendecker Science Center, Las Cruces



Phymatotrichopsis Root Rot_ Tree Replant Management

Treatments

1. Ammonium sulfate (AMS*; 1 pound per 10 square feet) + Compost
2. AMS + Compost + Trichoderma-based product (TerraGrow or RootShield Plus)
3. AMS + Compost + Gliocladium-based product (SoilGard)
4. AMS + Compost + Trichoderma + Gliocladium

*AMS may be strengthened with elemental sulfur. Work these materials into the soil and then water (soak the soil to 2-3 feet deep)

Phymatotrichopsis Root Rot_ Tree Replant Management

Products	Rate/acre (or/100 gallons)*	Timing of applications after First application (weeks)				
		First	2	4	6	8
Double Nickel	1 quart **(9.5 ml/gal)**	x	x	x	x	x
+ Serenade	1 quart **(9.5 ml/gal)**	x	x	x	x	x
+ Actinovate	6 oz **(2 grams/gal)**	x	x	x	x	x
+ Terragrow	1lb **(4.55 grams/gal)**	x	x	x	x	x

NOTE: Rate per 100 gallons converted to rate per gallon (shown in BLUE)

Apply the mixture to the base of the vine into the soil, and keep spraying to get a good drench.

Cropping Systems, Crop Residues and chile wilt pathogens

Justification

Residues from biostimulant and bioactive crops reportedly reduce the incidence of soilborne pathogens. No previous systematic studies in chile cropping systems.

Experimental Approach

Soil amendments with residues or by-products from biostimulant and bioactive crops.

Crop residues

Poaceous
Cruciferous
Leguminous

Enhanced host nutrition

Increased population of antagonistic microorganisms

Toxicity of byproducts released during decomposition

Activity of Bioactive Crop Residues

Degradation Products

Bioactive crops Glucosinolates (isothiocyanates or mustard oils) → Allyl isothiocyanates or AITC

Chemical fumigants KPAM → Methyl isothiocyanates or MITC

Biofumigation Using Mustard Seed Meal (*Brassica juncea*)

Application Methods

Site 1 (drip-irrigated field)

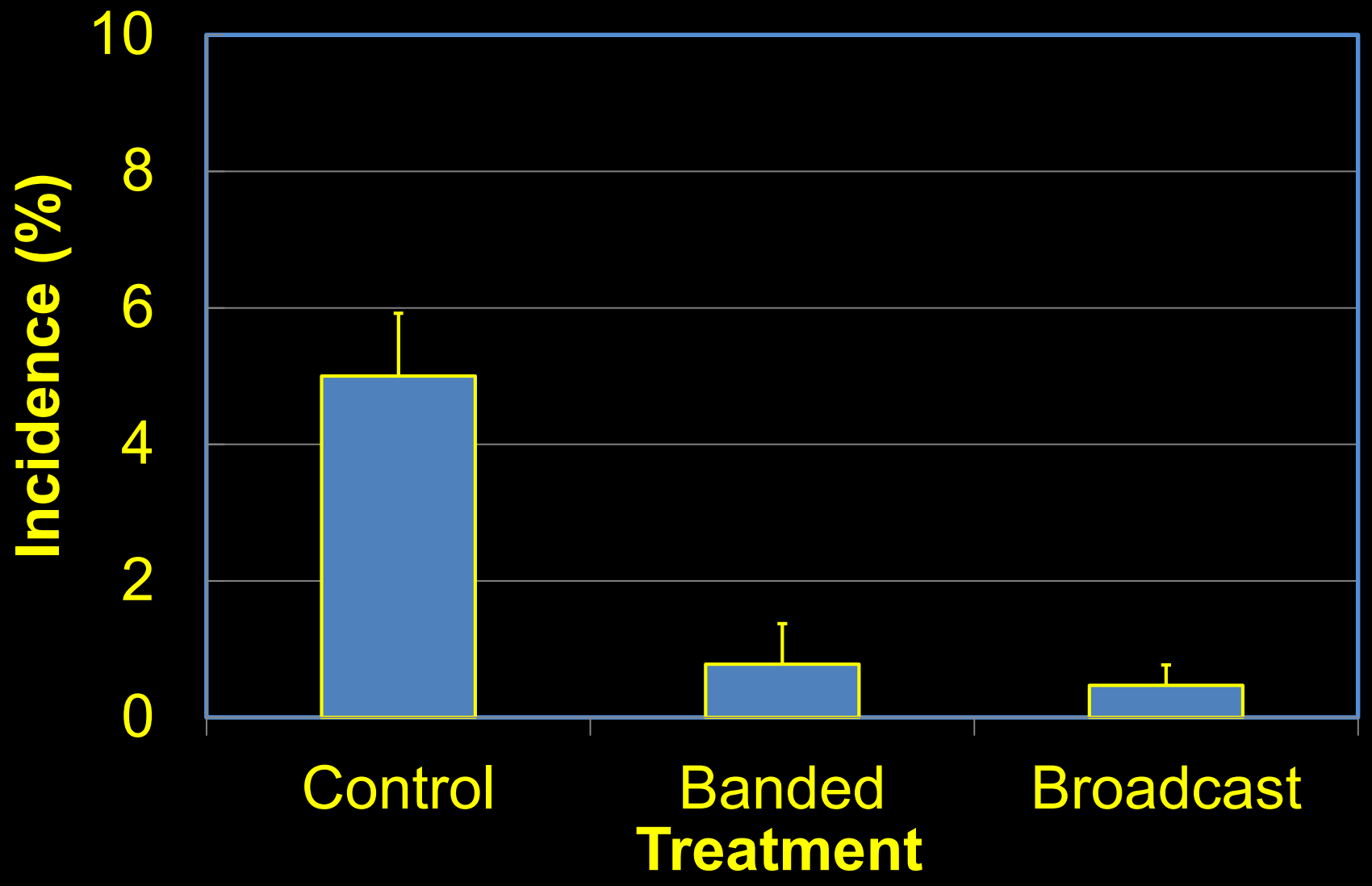
1) Broadcast followed by bed shaping
2) Banded followed by bed shaping

Site 2 (furrow-irrigated field)

1) In furrow application in beds already shaped
2) Broadcast
3) Side dress of slurry

Application Methods

Application Mustard Seed Meal _ Verticillium Control



Question

Do mustard weeds have activity against chile pathogens?

London rocket (*Sisymbrium irio*)

London rocket
(*Sisymbrium irio*)

Flixweed
(*Descurainia sophia*)

London rocket (*Sisymbrium irio*)

London rocket (*Sisymbrium irio*)

Effect of mustard weed meal volatiles on growth and germination of *Phytophthora capsici*/*Verticillium dahliae*/*Rhizoctonia solani*

Treatments	Temperature (°C)	Duration (hours)		
		24	48	72
No Mustard Weed Meal	20	+	+	+
	25	+	+	+
	30	+	+	+
Mustard Weed Meal	20	-	-	-
	25	-	-	-
	30	-	-	-

+ = growth/germination - = no growth/germination

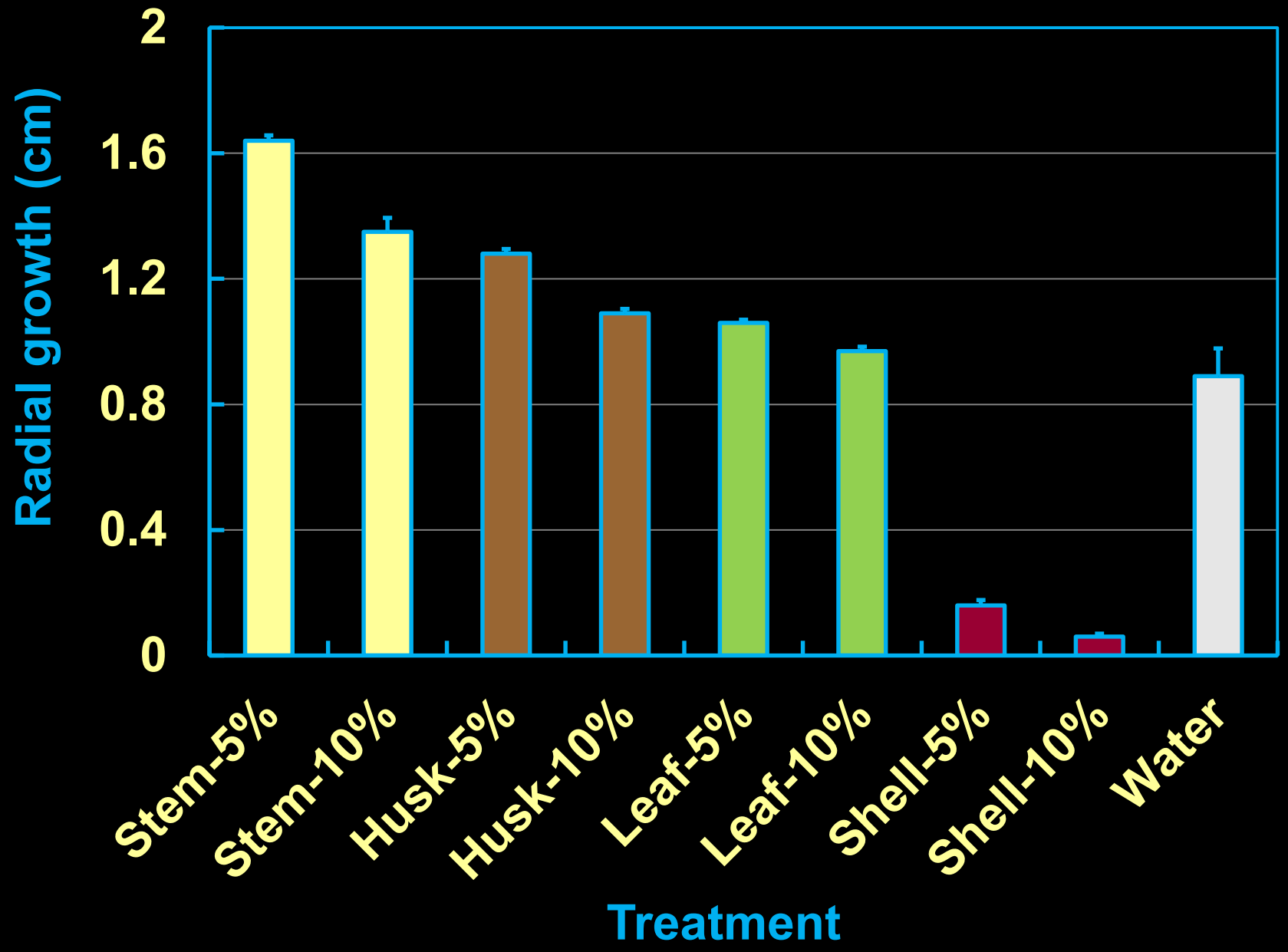
- Demonstration of activity of London rockect and flixweed against *Phytophthora capsici, Rhizoctonia solani*, and *Verticillium dahliae*

- Implications:

Host for beet curly top virus and its insect vector (beet leafhopper)

Potential of pecan by-products for control of soilborne diseases

Pecan by-products and *Phytophthora capsici*



Pecan by-products and *Phytophthora capsici*

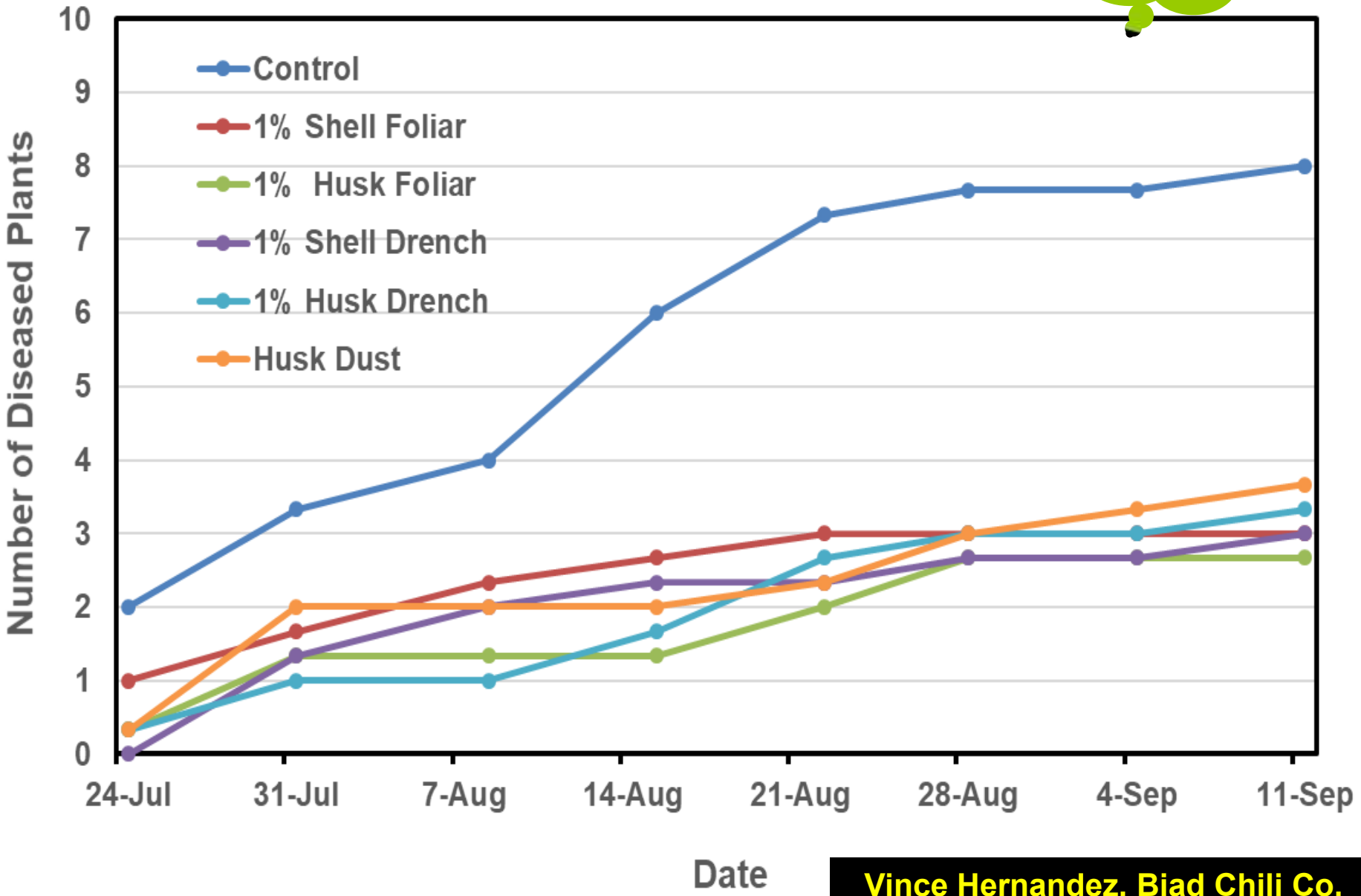
Extract	pH	Sporangia Production
Stem-5%	5.1	None
Stem-10%	5.1	None
Leaf-5%	4.9	None
Leaf-10%	5	None
Husk-5%	5.9	None
Husk-10%	5.9	None
Shell-5%	5	None
Shell-10%	5	None
Distilled water	-	Abundant

Soil Amendment with Pecan Husk and Chile Wilt

Sample ID #	----------paste- pH	EC mmhos/cm	% OM	---------- NO_3-N	P	K	-------ppm---------- Zn	Fe	Mn	Cu	C:N Ratio
PHU2	5.8	8.8	47.9	5.1	375	32230	23.5	11.9	69.4	17.5	40.55
PSH	5.0	1.1	71.5	1.5	409	4509	7.5	0.08	69.8	2.9	97.54
PHU1-SD	5.7	4.7	60.4	5.6	684	13450	19.3	1.3	48.0	8.9	35.23

Chile wilt/Verticillium

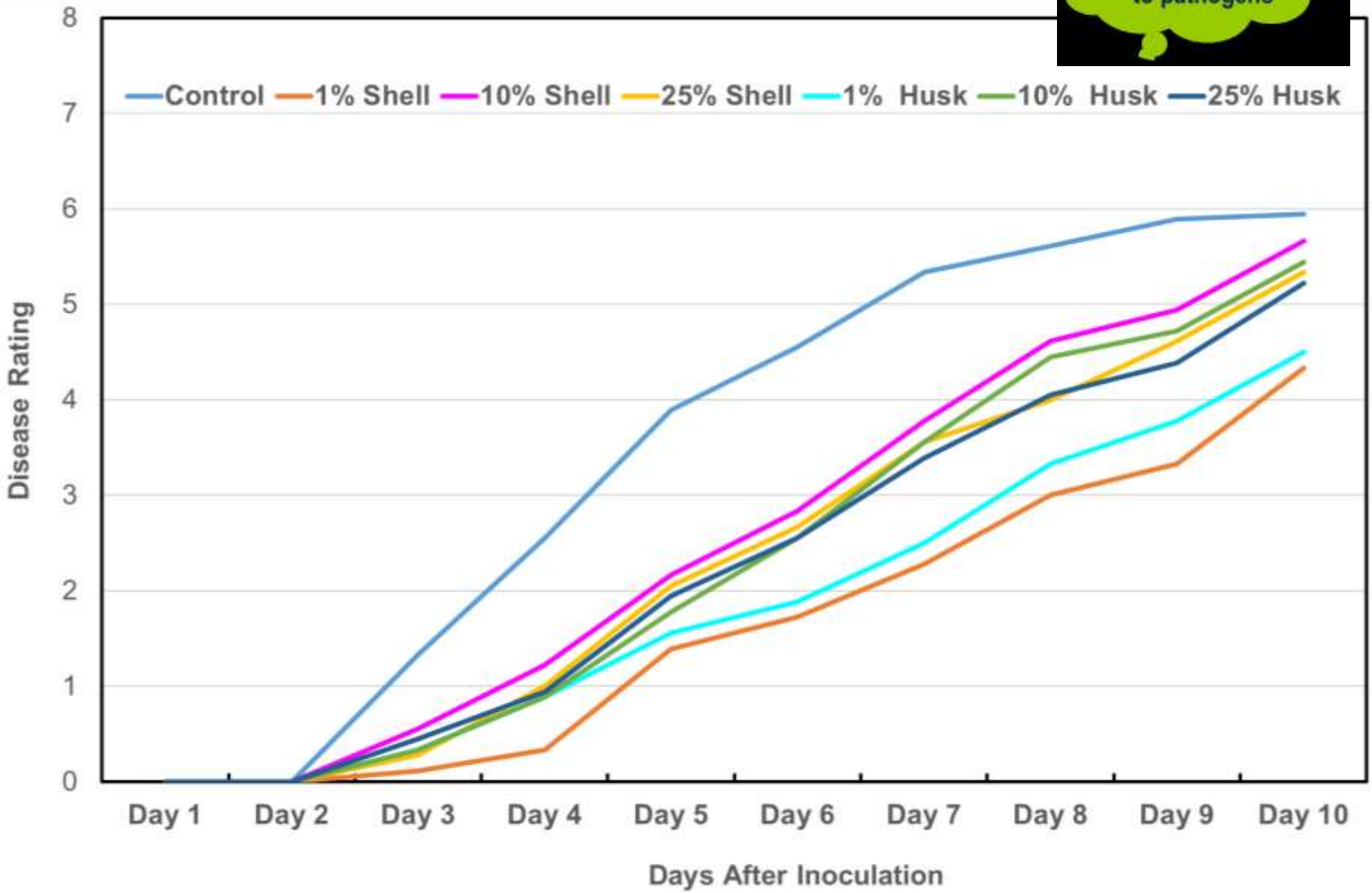
Boost crop's response to pathogens



Vince Hernandez, Biad Chili Co.

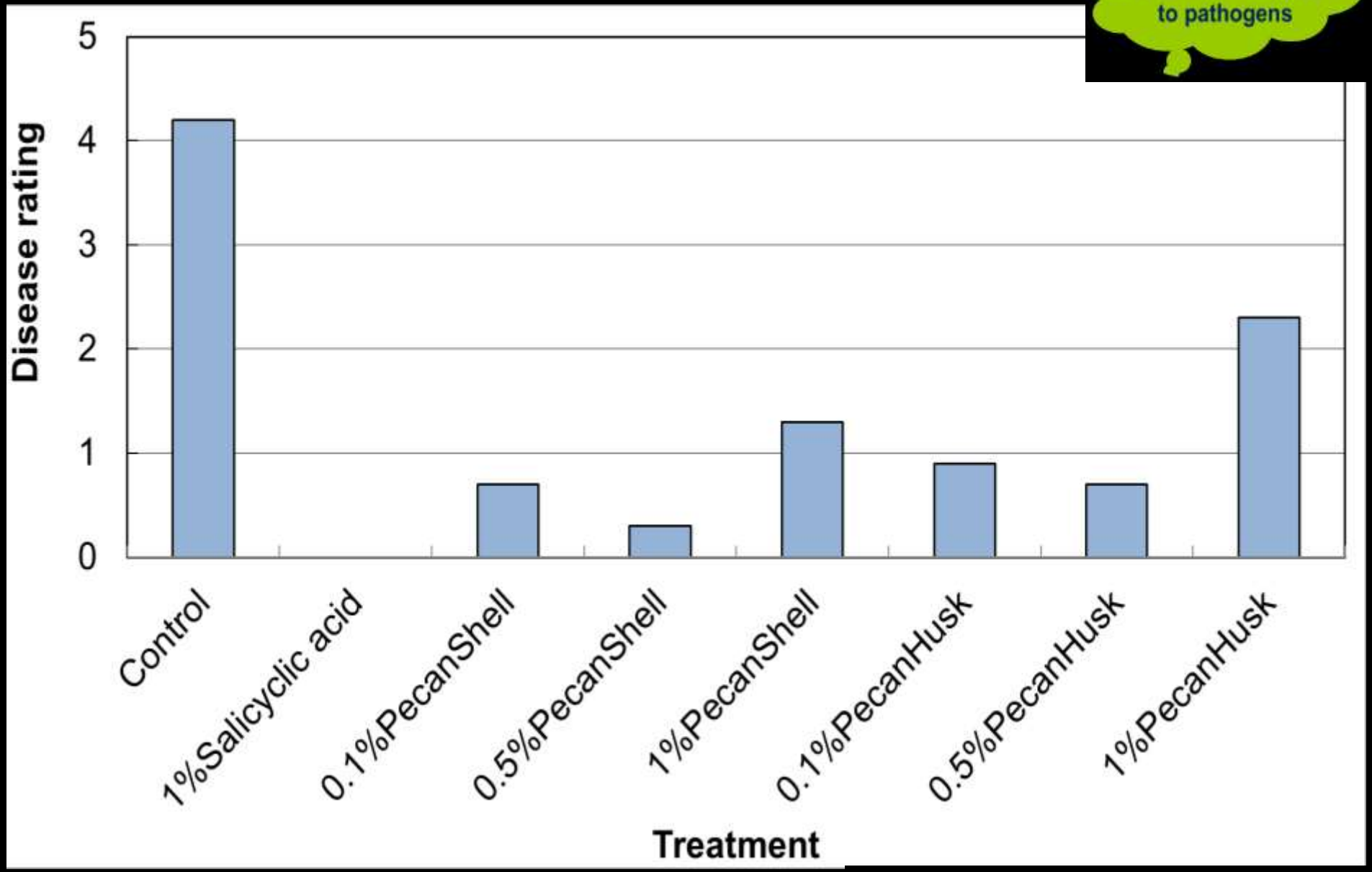
Chile wilt/Phytophthora

Boost crop's response to pathogens



Lujan/Guzman/Sanogo

Chile wilt/Phytophthora



Lujan/Guzman/Sanogo

Chile wilt/Phytophthora

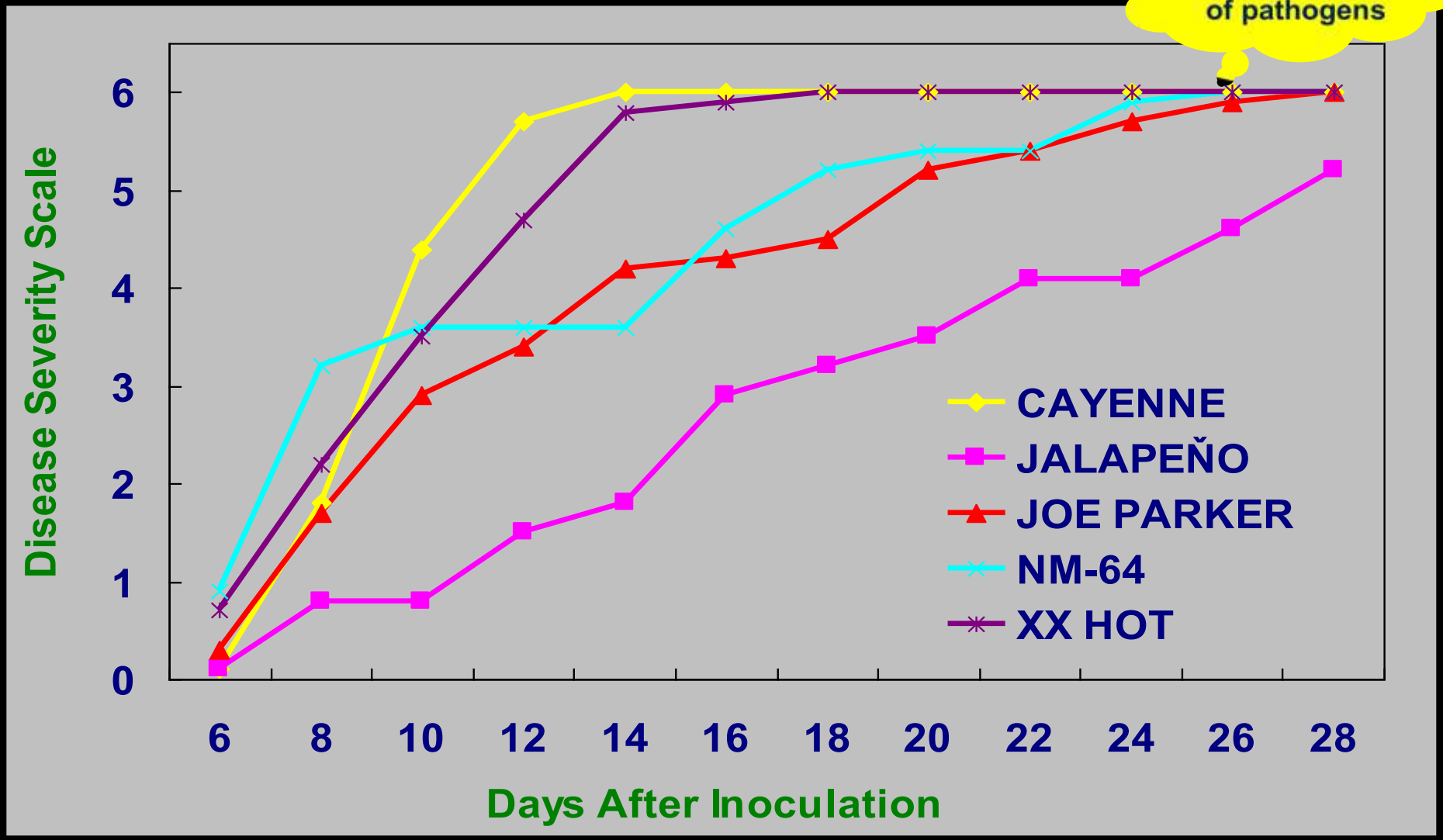
Boost crop's response to pathogens

Lujan/Guzman/Sanogo

Jalapeño Factor

Reduction of Phytophthora blight in chile?

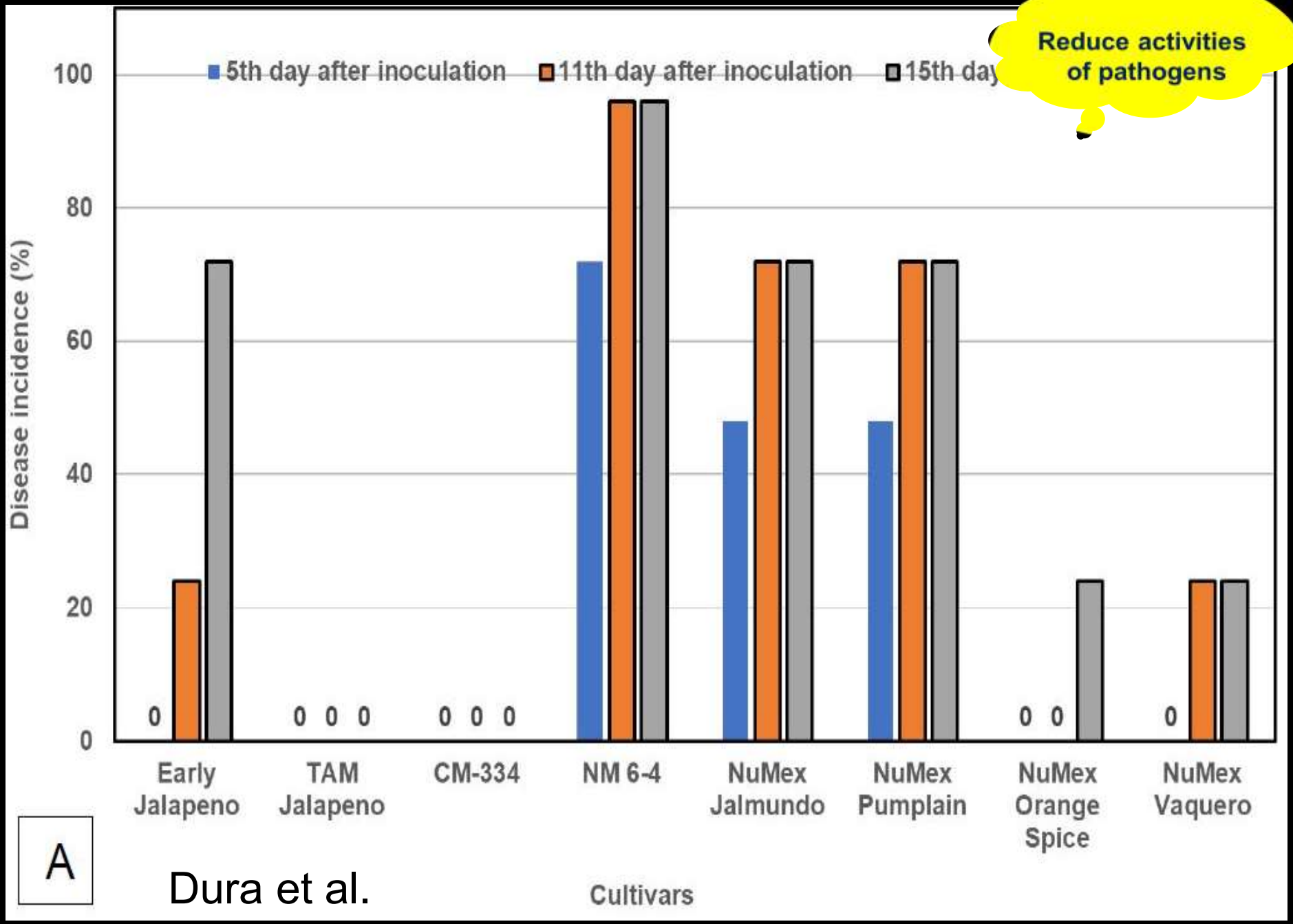
Cultivar pungency-Phytophthora blight



Little or no relationship between heat level and chile pepper root and fruit infection by *Phytophthora capsici*

(Tahboub, Sanogo et al. 2008)

Reduce activities
of pathogens


Reduce activities of pathogens
5th day after inoculation
11th day after inoculation
15th day
Disease incidence (%)
100
80
60
40
20
0
0
0 0 0
0 0 0
Early Jalapeno
TAM Jalapeno
CM-334
NM 6-4
NuMex Jalmundo
NuMex Pumplain
NuMex Orange Spice
NuMex Vaquero
Cultivars
A

Dura et al.

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Review Article

Journal of Agriculture and Horticulture Research

Genetic Soil Disinfestation, A Conceptual Framework to Reduce Inoculum Potential of Soilborne Plant Pathogens

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- Willie Villegas, Hatch
- David Garcia, Doña Ana
- Jimmy & Faron Lytle, & Jerry& Shane Franzoy, Salem
- Brent Tanzy, Arrey
- Darren Gillis, Salem
- Phillip Lujan, EPPWS, NMSU

Questions?