MICHIGAN STATE UNIVERSITY | College of Agriculture and Natural Resources

Integrated management of soilborne disease for enhanced soil health in potato production in Michigan, USA

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European Association for Potato Research (EAPR) Pathology and Pests Section Meeting 2019, Neuchâtel – Switzerland

September 2, 2019

Michigan Potato Production

- Michigan ranks seventh in potato production (~$208 million) in the US
- Approximately 70% of production goes towards chipping
- Soilborne diseases annual production concern due to environment
- Effective disease management chemicals are inconsistent due to endemic soilborne pathogens

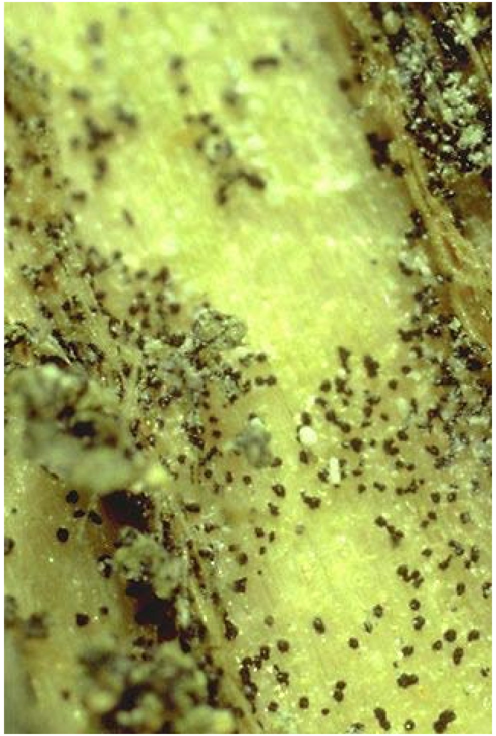
Current potato production challenges

- Tuber quality issues reduce marketable output
- Soil borne diseases are recognized as the major cause of yield declines
  - Verticillium wilt (Early Die) caused by *Verticillium* spp.
  - Potato common scab (PCS) caused by *Streptomyces* spp.
- Alternatives disease management strategies are needed

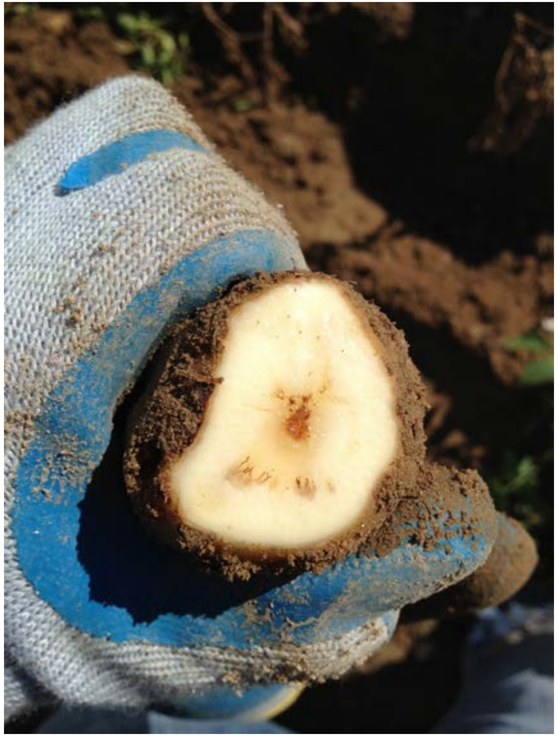
Verticillium wilt

Courtesy M. Powelson

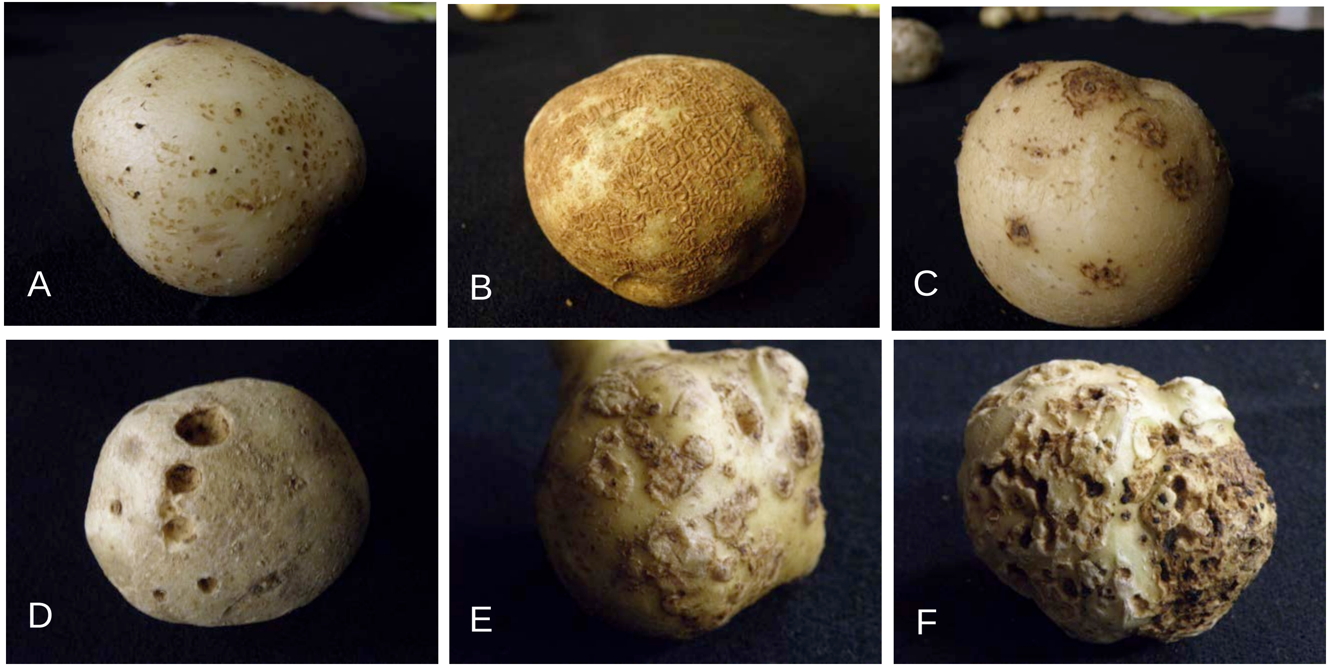
Verticillium wilt



Courtesy M. Powelson



Potato Common Scab



A: superficial discrete; B: coalescing superficial; C: raised discrete; D: raised coalescing; E: pitted discrete; F: pitted coalescing surface area of tuber covered with tuber lesions (surface and pitted)

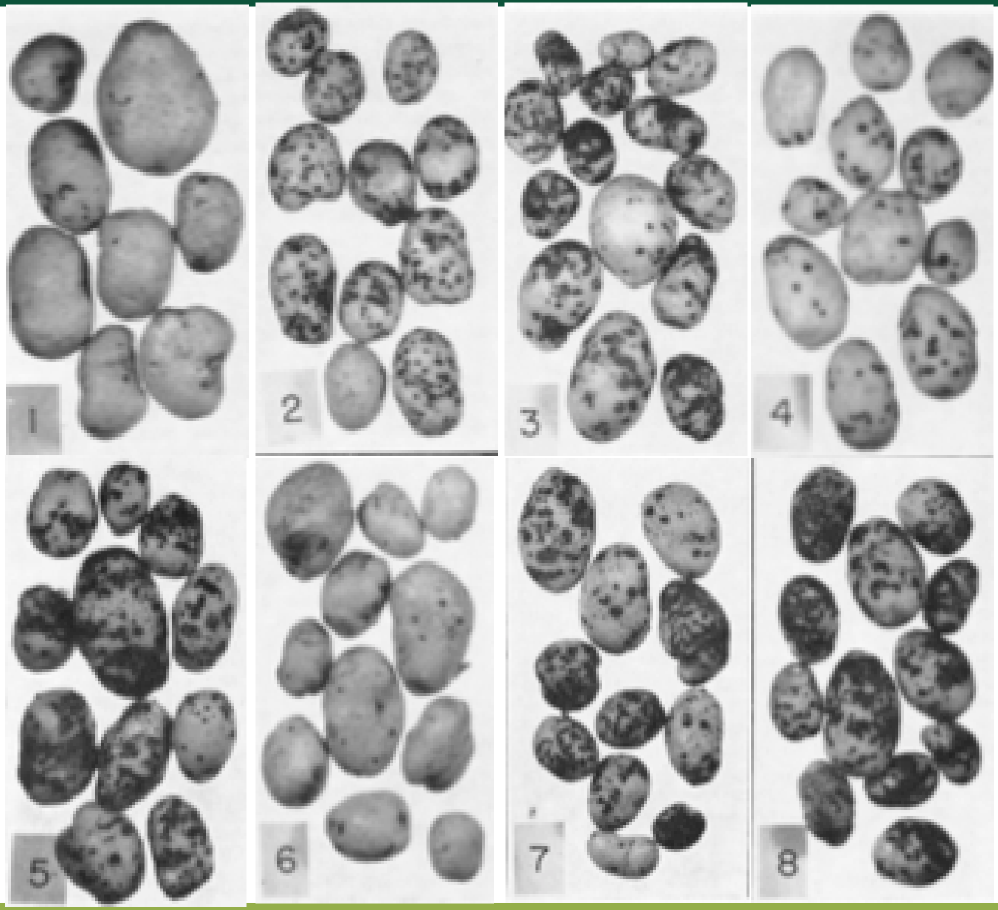
Common scab and suppressive soil

- PCS is an annual production concern
- Effective management of PCS and chemicals are inconsistent due to endemic soilborne pathogens
- Alternatives to PCS control strategies are needed (e.g. disease suppressive soil)
- Examples of disease suppressive soils (Atkinson, 1892; Walker, 1934; Cook, 1976) and PCS suppressive soils (Menzies, 1959; Lorang and Anderson, 1994; Liu, 1995; Bowers, 1996; Rosenzweig, 2012 and Meng, 2012)

Occurrence and transfer of a biological factor in soil that suppresses potato scab (Phytopathology 49:648-652)

- Soils in central WA scab-free from biological suppression
- Biological suppression could be transferred to infested soils
- Erratic distribution of scab in similar soil types in new irrigated acreage
- Older irrigated fields relatively scab-free compared to adjacent fields
- Continuous potato production in old and new fields resulted in scab-free and uniform scabby tubers respectively

Treatment
1. Suppressive soil (SS)
2. Suppressive soil steamed
3. Non-suppressive soil (NSS)
4. NSS + 10% SS
5. NSS + (10% SS steamed)
6. NSS + 10% SS + 1% alfalfa meal
7. NSS + 1% alfalfa meal
8. NSS steamed



Conclusions and summary

- Pot experiments on-farm showed older fields exerted persistent suppressive effect on scab
- Scab was controlled when heavily infested soil was mixed with SS
- Suppression was lost when steamed
- Control of scab was reduced with SS and alfalfa meal, but were not consistent alone

A biological factor, possibly microbial, appears to have developed naturally in these older farmed soils, and can be established in other soils by mass soil inoculation fortified with a microbial food source

Culture-Based Assessment of Microbial Communities in Soil Suppressive to Potato Common Scab

Qingxiao Meng, Jingfang Yin, and **Noah Rosenzweig,** Department of Plant Pathology; **David Douches,** Department of Crop and Soil Sciences; and **Jianjun J. Hao,** Department of Plant Pathology, Michigan State University, East Lansing

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Abstract

Meng, Q. X., Yin, J. F., Rosenzweig, N., Douches, D., and Hao, J. J. 2012. Culture-based assessment of microbial communities in soil suppressive to potato common scab. Plant Dis. 96:712-717.

Microbial Communities Associated with Potato Common Scab-Suppressive Soil Determined by Pyrosequencing Analyses

Noah Rosenzweig, Department of Plant Pathology, **James M. Tiedje,** Department of Crop and Soil Science and Center for Microbial Ecology, **John F. Quensen, III,** Department of Crop and Soil Science and Center for Microbial Ecology, **Qingxiao Meng,** Department of Plant Pathology, and **Jianjun J. Hao,** Department of Plant Pathology, Michigan State University, East Lansing 48824

Abstract

Rosenzweig, N., Tiedje, J. M., Quensen, J. F., III, Meng, Q., and Hao, J. J. 2012. Microbial communities associated with potato common scab-suppressive soil determined by pyrosequencing analyses. Plant Dis. 96:718-725.

Common scab and suppressive soil

- Field in East Lansing, MI that exhibited natural suppression to PCS after consecutive years of potato production
- Used as a scab nursery by MSU Potato Breeding Program
- Reduction in scab severity from biological suppression
- Scab suppression could be transferred to infested soils

Research methods

- Soil samples collected from potato plants associated with fields of conducive soil (**CS**) and suppressive soil (**SS**)
- Greenhouse assay of SS diseases of radish and potato
- Transfer of scab suppression to inoculated soil (greenhouse)
- Characterization of CS and SS microbial communities by DNA technologies

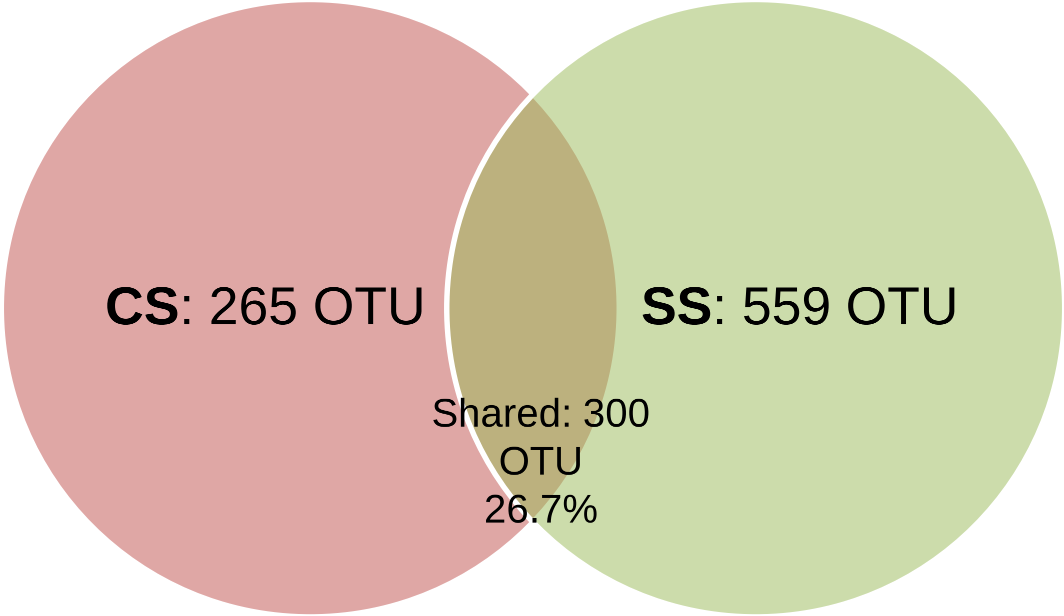
Effect of soil mixing on disease suppression

0 | 40 | 100

% Suppressive soil

Meng, 2012

OTU-based analysis



OTUs based 10% dissimilarity. CS: disease conducive-soil and SS: disease suppressive-soil. The total OTUs among groups are 1,124.

Conclusions and summary

- Impact on disease control
- Biological control agents
- Cultural practices: green manure, rotation, etc.
- Understanding the potential impacts of these SS soil communities on plant fitness will help to develop management practices to reduce soilborne disease
- Determining the function of bacteria will be required to for disease suppression essential
- Taxa that dominate in abundance may be key in maintaining disease levels in SS systems

Soilborne disease management efficacy trials

Product Name	Active Ingredient	Rate	Chemical Family
Not-Treated Control	—	—	—
Vapam	Metam Sodium (Sodium N-methyldithiocarbamate)	45 gal/a	Dithiocarbamates
Dominus	Allyl isothiocyanate	20 gal/a	Organo sulphurs
PIcPlus	Chloropicrin (Trichloronitromethane)	98 lb/a	Malonitroalkanes
PicPlus	Chloropicrin (Trichloronitromethane)	116 lb/a	Malonitroalkanes
PicPlus	Chloropicrin (Trichloronitromethane)	140 lb/a	Malonitroalkanes

Materials and methods

- RCBD with six replications
- 4-row by 50 ft plots
- Potato cultivar “Snowden”
- Four soil sampling times for microbial community analysis

Emergence and disease data

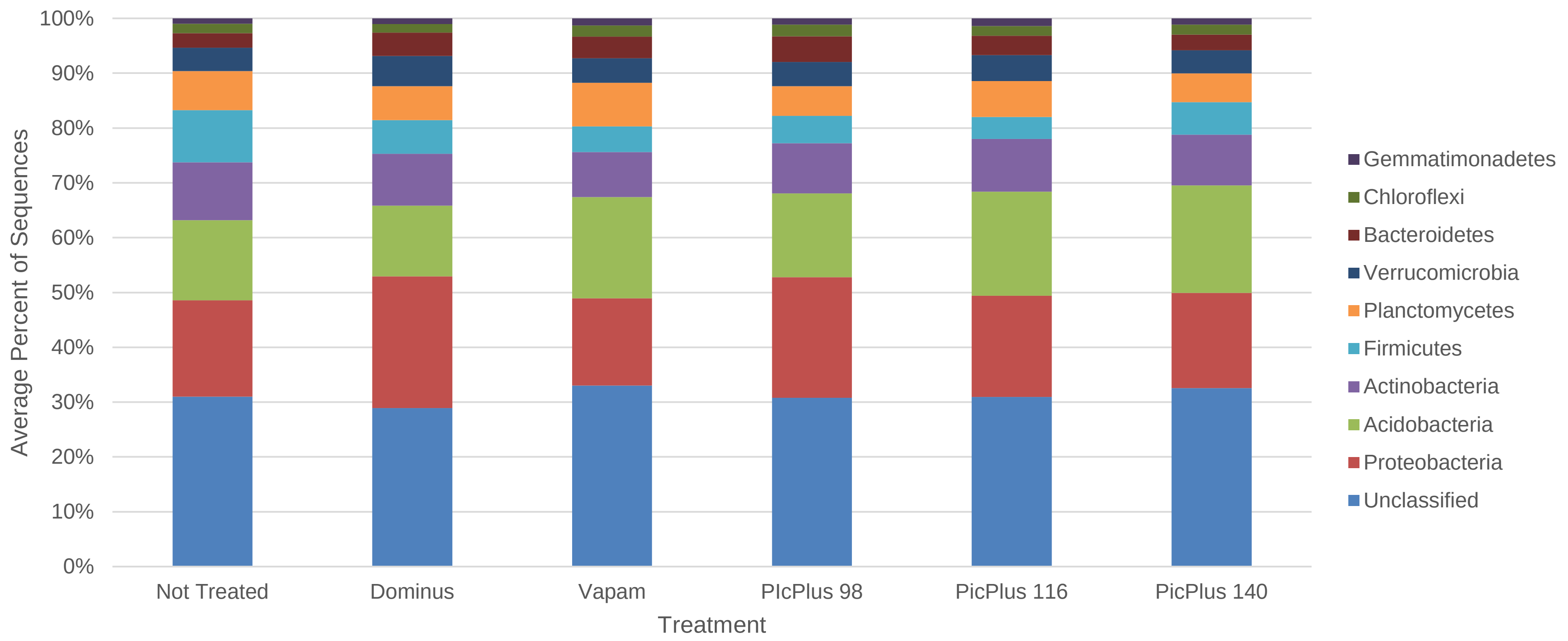
Treatment	Rate	Emergence	Potato Early Die (0-5) scale 8/6	Potato Early Die (0-5) scale 8/20	Potato Common Scab (%)
Non-treated Check	N/A	81.7	3.5 a	4.0 a	69.1 a
Vapam	45 (gal/A)	84.3	3.0 a	3.7 a	74.1 a
Dominus	20 (gal/A)	84.8	3.2 a	3.8 a	65.8 a
PicPlus	98 (lb/A)	83.0	2.2 b	2.7 b	44.5 b
PicPlus	116 (lb/A)	82.8	2.3 b	2.8 b	44.6 b
PicPlus	140 (lb/A)	81.8	1.8 b	2.3 b	45.4 b

Inverse Simpson Index

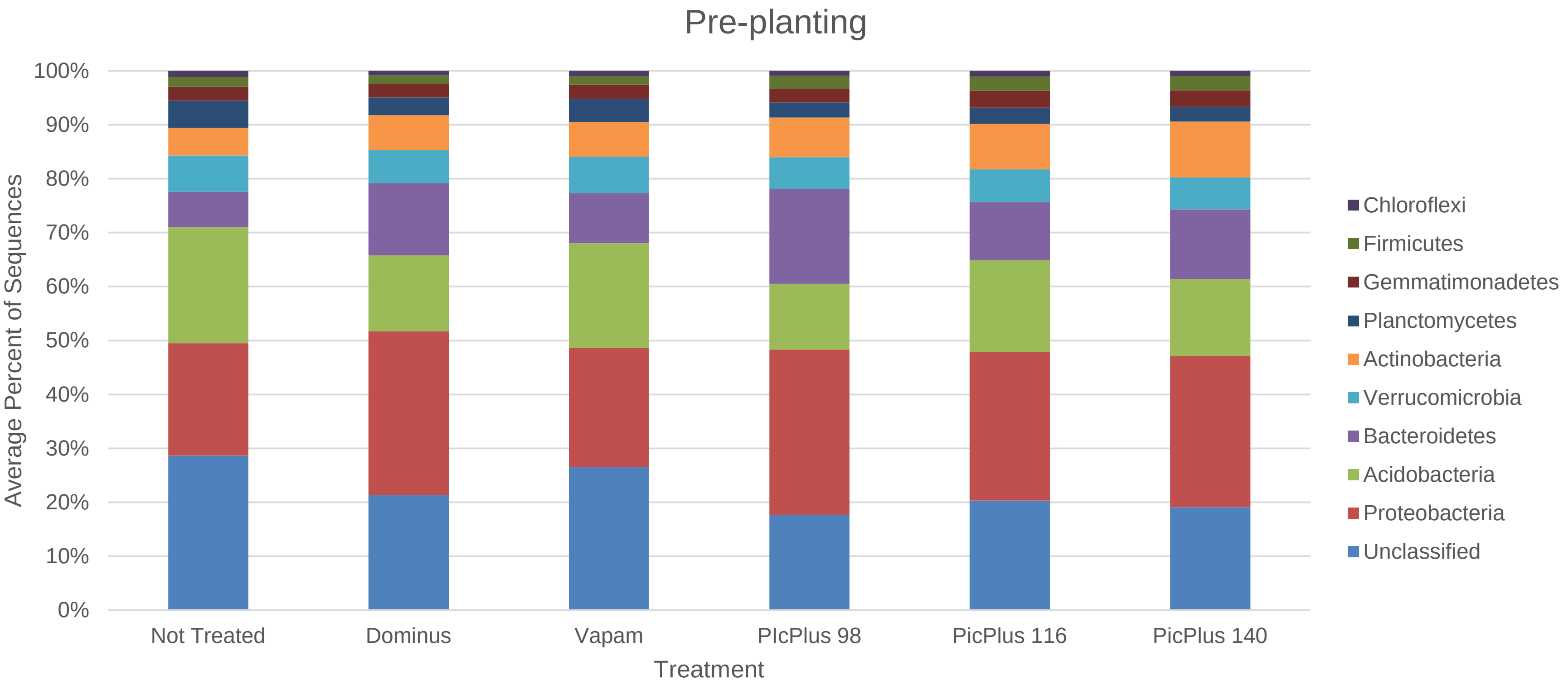
Treatment	Pre-fumigation	2 weeks post	Pre-plant	Mid-season
Not-Treated Control	280.9 bc	238.7	455.5 a	327.1 ab
Vapam	381.3 ab	230.6	330.9 b	327.1 ab
Dominus	286.0 bc	212.6	233.9 bc	338.9 a
PicPlus 98 lb/a	345.5 abc	177.9	194.3 c	180.9 c
PicPlus 116 lb/a	417.2 a	189.9	214.6 c	237.3 bc
PicPlus 140 lb/a	268.4 c	157.4	186.8 c	156.0 c

Phyla abundance

Pre-treatment



Phyla abundance



Conclusions and summary

- PCS and PED severity was significantly lower in all PicPlus treatments
- Total yield and marketable yield (cwt/a) was highest for PicPlus at 116 lb/a
- Lower bacterial diversity observed in PicPlus at 98 and 140 lb/a
- Phylum level abundance did not significantly change throughout the season
- Genus level abundance information may show how certain beneficial and pathogenic microorganisms are affected by soil fumigation

Enhancing soil health in U.S. potato production systems

"Enhance potato health, productivity, and quality via management-based optimization of soil microbiomes and physiochemical characteristics"

Personnel

Project Director (PD)

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Background

- Soil health - the condition of a soil to function as a vital living ecosystem that sustains plants, animals and humans
  - A major focus of soil health is on maintaining and enhancing soil organic matter and a beneficial soil microbial community
- Soilborne pathogens are a major concern requiring a more integrated approach for disease management
- Enhancing soil health in potato cropping systems remains a challenge
  - Soil disturbance during potato planting and harvest, lack of organic residue and difficulty in establishing a cover crop
- Focus is to identify management practices that enhance soil health while reducing the impact of soilborne diseases

Personnel (PIs by state)

Colorado
Courtney Jahn (Plant Pathology)
Jane Stewart (Plant Pathology)

Maine
Jay Hao (Plant Pathology)
Robert Larkin (Plant Pathology)

Michigan
Kurt Steinke (Soil Fertility and Nutrient Management)
Lisa Tiemann (Soil Biology)

Montana
Kate Binzen Fuller (Economics)

North Dakota
Neil Gudmestad (Plant Pathology)
Andy Robinson (Agronomy)

Oregon
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Amber Moore (Soil Fertility and Nutrient Management)

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Mike Thornton (Physiology)
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Ann MacGuidwin (Nematology)

Washington
Cynthia Gleason (Nematology)

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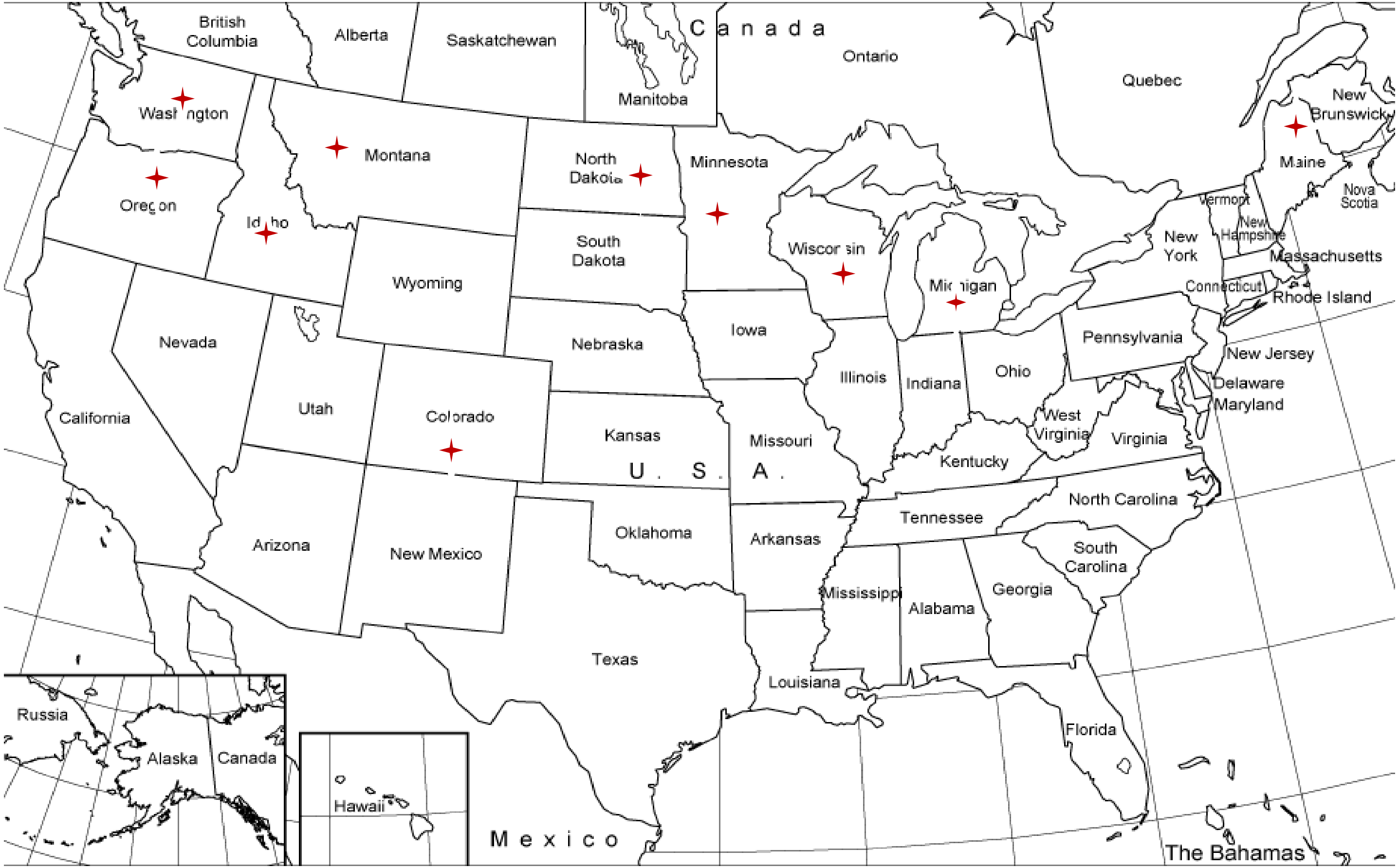


Developing soil health metrics

Project seeks to determine abiotic or biotic soil factors associated with plant health (i.e. plant productivity, yields, and quality)

Are there physical, chemical or biological soil properties that might serve as indicators of “soil health” or plant productivity?

Why soil microbes:

- Respond quickly to changes and adapt rapidly to environmental conditions and stress
- They affect the physical properties of soil
- Changes in their population sizes or activity can precede detectable changes in soil physical and chemical properties

They may be positive indicators/sentinels

Project Objectives

1. Enhance potato health, productivity, and quality via management-based optimization of soil microbiomes and physicochemical characteristics (Linda Kinkel – U of MN)
2. **Determine on-farm soil health-based indicators associated with potato crop health, yield and quality (Noah Rosenzweig, MSU)**
3. Identify the incentives, impediments, and determinants of adopting practices and technologies that encourage practices to improve soil health in potato production (Chris McIntosh, U of ID)
4. Facilitate adoption of soil health best management practice systems by the potato industry (Matt Ruark, U of WI)

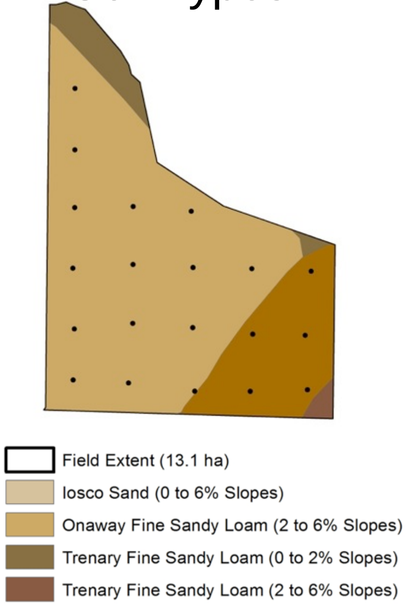
Objective 2: On-farm sampling

- At what scale do biological, chemical, physical properties and plant health/productivity vary? Do they vary at the same scale or not?
- Methods will used systematic sampling and geo-statistics to evaluate spatial variability of soil physical and biological measurements
- The goal is to determine if subfield management may be feasible and determine if we can identify locations in the field where crop protection is most needed.

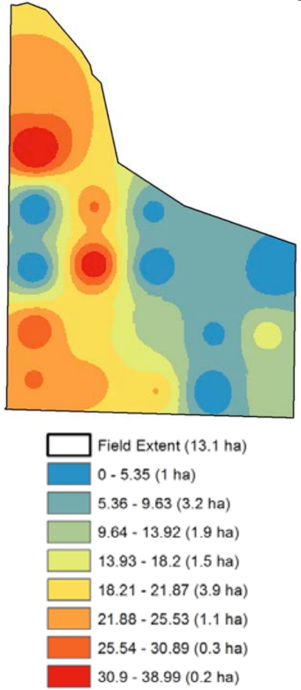
Objective 2: On-farm sampling

Sample Locations

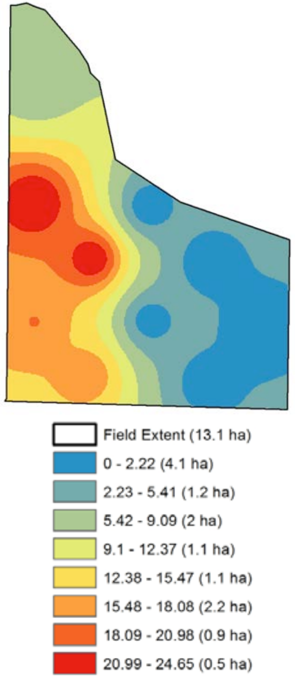
Soil Types



Streptomyces spp.



Scab severity (%)



Acknowledgements

- Michigan Potato Industry Commission
- MDARD USDA Specialty Crop Block Grant
- Michigan State University Project GREEEN
- Michigan State University AgBio Research
- TriEst Ag Group, Inc.
- USDA-ARS National Potato Council State Cooperative Agreement
- USDA-NIFA Specialty Crop Research Initiative

Thank you!

Questions?