Potato

Tuesday afternoon 2:00 pm

Where: Gallery Overlook (upper level) Room A & B
MI Recertification credits: 2 (1B, COMM CORE, PRIV CORE)
OH Recertification credits: 1 (presentations as marked)
CCA Credits: SW(0.5) PM(1.0)
Moderator: Fred Springborn, Field and Vegetable Crops Educator, MSU Extension, Stanton, MI

2:00 pm	Soil Health • Luke Steere, Plant, Soil and Microbial Sciences Dept., MSU
2:30 pm	Potato Pathology Update (OH: 2B, 0.5 hr) • Noah Rosenzweig, Plant, Soil and Microbial Sciences Dept., MSU
3:00 pm	Resistance in Insect Pests: What Growers Need to Understand (OH: 2B, 0.5 hr) • Alan Schreiber, Executive Director, Washington Asparagus Commission
3:40 pm	Session Ends

Potato Soil Health

Luke Steere, Noah Rosenzweig, and Willie Kirk
Michigan State University

Potatoes (*Solanum tuberosum*) are mainly consumed as fresh, chipping, frozen, or starch products and require tubers that meet a high quality standard in either cosmetic appearance or structural integrity from producers. Michigan ranks eighth nationally in potato production with a farm gate value of nearly $208 million annually. Approximately 70% of production in the state goes towards the chip processing industry. Over the last decade Michigan growers have been experiencing a period of declining yields and issue with tuber quality that have further reduced marketable output. Nearly 90% of major diseases that impact crops (including potato) are caused by soilborne pathogens. Soilborne disease complexes such as potato early die (PED) caused by *Verticillium dahliae* (Figure 1) and potato common scab (PCS) caused by *Streptomyces* spp. (Figure 2) are recognized as a major cause of yield and quality declines. Though soilborne disease complexes are recognized as a cause of yield and quality declines, soil ecology is not adequately understood. To better understand soil ecology, a soil health project was initiated to expand baseline information about pathogen interaction with biotic and abiotic soil factors.

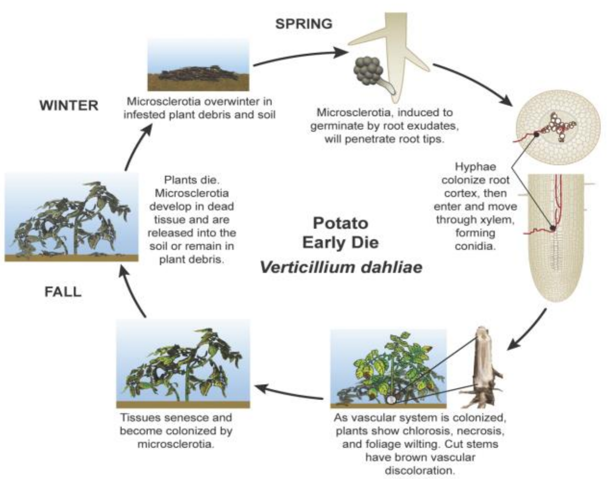

Figure 1. Disease cycle of *Verticillium dahliae*, the causal agent of potato early die.

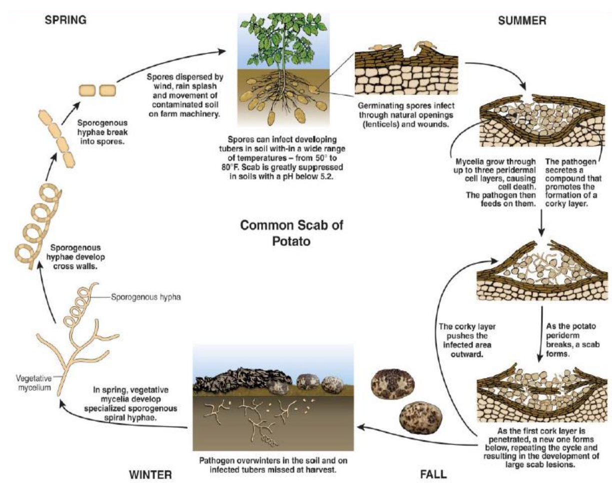

Figure 2. Disease cycle of *Streptomyces* spp., the causal agent of potato common scab.

The activity of microorganism with in the soil is concentrated in the top soil which makes up less that 1% of the total soil volume. Soil microorganisms are important in carbon, nitrogen, sulfur, and phosphorous cycling, decomposition of organic matter, and degradation of waste and pollutants. Microorganisms affect the physical properties of soil, help maintain soil structure, and can affect water holding capacity, infiltration rate, crusting, erosion and compaction. Bulk soil (the soil outside of the rhizosphere) contains approximately 10,000 bacterial species per gram of soil.

The zone of soil influence by the roots, or the rhizosphere, can contain as many as 30,000 bacterial species per gram, of which less than 1% can be isolated in the laboratory. Soilborne pathogens which reside in the rhizosphere impact plant health and the host-pathogen interaction ignores other soil organisms that affect disease. Many of the soil organisms in the rhizosphere are beneficial to plant health and can have significant impacts on disease control (Figure 3).

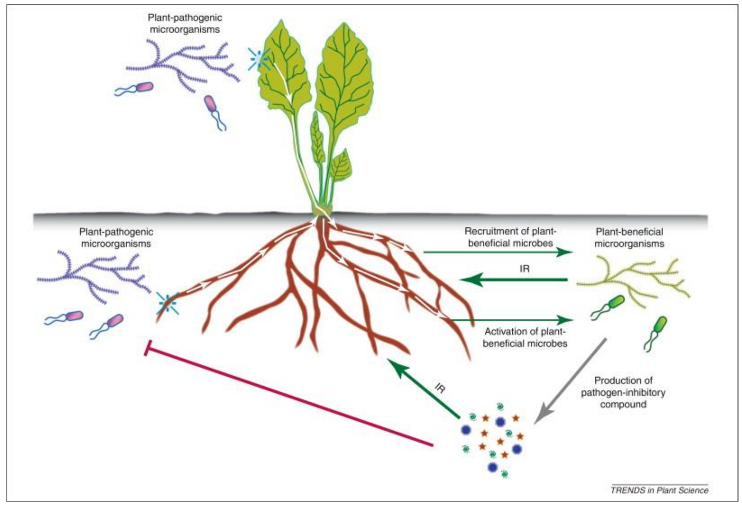

Figure 3. Soil Microorganisms can act as pathogens, as a direct defense mechanisms against pathogens, or as an indirect defense mechanisms through the chemical induction of resistance in the plant.

These interactions between plants and microorganisms are a growing field of study for plant pathologists and the American Phytopathological Society has organized a worldwide phytobiome initiative which targets an understanding of how the associated microbial community influences or is influence by the plant and how that information can be used to improve crop productivity. Having a better understanding of plant-associated microorganisms will lead to a better understanding of soil health because microbes can serve as indicators of soil health. Soil microorganisms respond quickly to changes, and rapidly adapt to environmental conditions and stress. Changes in microbial populations or activity can precede detectable changes in soil physical and chemical properties.

The potato pathology lab at Michigan State University has been at the forefront of soil microbial analysis with two separate soil health studies which have been ongoing since 2012. In the fall of 2012 and early spring of 2013, 26 separate fields with varying levels of potato history were sampled on a grid sampling scheme and analyzed for both biotic and abiotic soil properties including pH, buffer pH, cation exchange capacity, organic matter, calcium, potassium, magnesium, phosphorous, *Verticillium* spp., root-lesion nematodes, and soil microbial structure of collected samples using DNA technology. This project was used to develop baseline data on soil interactions to serve as a foundation for future research to improve soil ecology in Michigan potato fields and strengthen Michigan's potato industry's competitive position by increasing yields. This baseline information served as an anchor for future research with substantiated data on soil health factors as they affect soilborne diseases that in turn negatively impact potato yield and quality.

One project that stemmed from the initial soil health research was the potato crop rotation management research trial at Michigan State University's Montcalm Research Center. The objectives of this trial were to establish a long-term potato crop management research trial at the Montcalm Research Center, determine the impact of crop rotation on soilborne disease of potato, and determine the relationship between organic/inorganic soil fertility programs and crop rotation on soil health and potato production. The trial was set up as a randomized complete split-block design with four replications (4-row by 50 feet plots). The split-block included organic and inorganic fertilizer treatments and the plots were managed according to conventional grower management practices. The four rotation treatments are as follows:

1. Potato (2013-16)
2. Potato (2013), Corn (2014-2015), and Potato (2016)
3. Corn (2013), Potato (2014), Corn (2015), and Potato (2016)
4. Corn (2013-2015), and Potato (2016)

At the end of the season potato crops were weighed, graded and assessed for PCS using a severity rating which was determined by the percent surface area affected. Bacterial community analysis was performed on bulk soils and rhizosphere soils from each plot. As expected there were no significant differences between organic and inorganic treatments or microbial communities in year one (Table 1). Field results from year two saw a significant decrease in scab severity in the corn-potato organic fertilizer plot (Table 2). Bacterial diversity results from year two revealed significant differences between bulk soil vs. rhizosphere soil, late vs. early sampling, and organic vs. inorganic fertility (Table 3).

Soil health and soil ecology has become a focus of the potato pathology laboratory at Michigan State University. As new molecular tools become available and costs decrease, the ability to understand the soil molecular ecology will increase. These molecular tools along with geostatistical and geographical tools have aided researchers in looking at soil ecology from a whole field perspective. The long-term goals of these projects include using the baseline data to develop a trans-disciplinary tool combining DNA technologies, GIS and computational biology at the subfield management scale so that growers can easily monitor soil conditions, soil biodiversity, and pathogen levels. This technology will improve productivity, reduce chemical inputs, and improve soil quality for disease-free and sustainable high-quality crop production.

Table 1. Field Results from Year One of Crop Rotation trail at Michigan State University's Montcalm Research Center.

Treatment	Rate	Scab Incidence	Scab Severity	% Emergence	Total Potato Yield CWT/A
Potato Inorganic MAP 11-52-0 K2O 0-0-62 AS 21-0-0-24 Urea 46-0-0	120 lb ai/A 150 lb ai/A 66 lb ai/A 134 lb ai/A	96.1	58.6	76.5	299.1
Potato Organic Herbrucks AS 21-0-0-24 Urea 46-0-0	2 ton/A 40 lb ai/A 80 lb ai/A	94.3	51.4	72.5	297.6

Table 2. Field Results from Year Two of Crop Rotation trail at Michigan State University's Montcalm Research Center.

Treatment	Rate	Scab Incidence	Scab Severity	% Emergence	Total Potato Yield CWT/A
PP Inorganic					
MAP 11-52-0	120 lb ai/A	97.6	66.7a	95.4	232.9
K2O 0-0-62	150 lb ai/A				
AS 21-0-0-24	66 lb ai/A				
Urea 46-0-0	134 lb ai/A				
PP Organic					
Herbrucks	2 ton/A	98.3	56.1ab	92.5	288.4
AS 21-0-0-24	40 lb ai/A				
Urea 46-0-0	80 lb ai/A				
CP Inorganic					
MAP 11-52-0	120 lb ai/A	99.2	58.1ab	92.9	251.5
K2O 0-0-62	150 lb ai/A				
AS 21-0-0-24	66 lb ai/A				
Urea 46-0-0	134 lb ai/A				
CP Organic					
Herbrucks	2 ton/A	89.4	43.6b	92.5	291.5
AS 21-0-0-24	40 lb ai/A				
Urea 46-0-0	80 lb ai/A				

Table 3. Bacterial Diversity Results from Year Two of Crop Rotation trail at Michigan State University's Montcalm Research Center.

Treatment	Rate	Diversity (Inverse Simpson)			
		Bulk Soil (early)	**Rhizosphere Soil (early)**	**Bulk Soil (late)**	**Rhizosphere Soil (late)**
PP **Inorganic** MAP 11-52-0 K2O 0-0-62 AS 21-0-0-24 Urea 46-0-0	 120 lb ai/A 150 lb ai/A 66 lb ai/A 134 lb ai/A	273.1abcd	284.8 abcd	241.5 cde	188.2 ef
PP **Organic** Herbrucks AS 21-0-0-24 Urea 46-0-0	 2 ton/A 40 lb ai/A 80 lb ai/A	309.5 abc	285.7 abcd	253.9 cde	197.9 ef
CP **Inorganic** MAP 11-52-0 K2O 0-0-62 AS 21-0-0-24 Urea 46-0-0	 120 lb ai/A 150 lb ai/A 66 lb ai/A 134 lb ai/A	342.3 a	269.5 bcd	223.2 def	187.4 ef
CP **Organic** Herbrucks AS 21-0-0-24 Urea 46-0-0	 2 ton/A 40 lb ai/A 80 lb ai/A	328.8 ab	334.1ab	167.9 f	250.7 cde

Potato Pathology Update

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Introduction

Potato (*Solanum tuberosum* L.) is among the world's most important food crops and is the highest-volume vegetable grown in the U.S. Moreover potato comprises the largest harvested acreage of vegetables. Potato production in Michigan (MI) is ranked eighth (~$208 million) in the US. It is also one of the most intensively managed crops. Potato production systems have long been plagued by a multitude of recurrent and persistent soil-borne, seed, foliar and storage diseases. Potato production in Michigan is no exception (Table 1). During the 2015 growing season Michigan potato production faced management challenges with recurrent, sporadic and emerging diseases that included stem canker and black scurf, late blight and aerial stem rot respectively.

Rhizoctonia stem canker and black scurf of potato

Rhizoctonia diseases of potato are caused by the fungus *Rhizoctonia solani* Kühn (teleomorph *Thanatephorus cucumeris* (A. B. Frank) Donk) and can be found on all underground parts of the plant at different times during the growing season. In the US, *Rhizoctonia solani* has been associated with disease on legumes (peas, beans), cereals, sugarbeet and potato. *Rhizoctonia solani* has many synonyms and is divided into subgroups called anastomosis groups (AG's), in which isolates are categorized according to the ability of their hyphae to anastomose (fuse) with one another. *Rhizoctonia* AG-4 has typically been associated with legumes. *Rhizoctonia* AG-8 is typically associated with cereals (wheat & barley). *Rhizoctonia* AG2-2 111b and IV and AG-4 with sugarbeet stem canker and damping off. *Rhizoctonia* AG-3 is associated with potato stem canker and black scurf. In Michigan, *R. solani* causes black scurf on tubers (Figure 1), and stem and stolon canker on underground stems and stolons (Figure 2), and occurs wherever potatoes are grown. However, *R. solani* causes economically significant damage only in cool wet soils. In the more southern temperate areas of Michigan, losses from *Rhizoctonia* are sporadic and only occur when the weather is cold and wet in the weeks following planting. In northern areas, where growers often must plant in cold soils, *Rhizoctonia* is a more consistent problem. Poor stands, stunted plants, reduced tuber number and size, and misshapen tubers are characteristic of diseases caused by *R. solani*. Chemical seed treatment management is accomplished through the use of products specifically developed for control of seed-borne potato diseases and offer broad-spectrum control for Rhizoctonia, silver scurf, Fusarium dry rot and to some extent Black dot (*Colletotrichum coccodes*). These include Tops MZ, Maxim MZ (and other Maxim formulations + Mancozeb) and MZ. Application of fungicide in-furrow at planting has resulted in significant improvement in control of Rhizoctonia disease of potatoes. Products such as Moncut and Quadris applied in-furrow at planting have given consistent and excellent control of Rhizoctonia diseases of potatoes in trials at MSU. However, both seed treatments and in-furrow applications on some occasions have resulted in poor control of Rhizoctonia. This sporadic failure may be due to extensive periods of wet and cold soil shortly after planting or planting in fields with plentiful inoculum. Quadris applied in-furrow has been reported to reduce the symptoms of Black Dot on lower stems and tubers.

Late blight of potato

Late blight, caused by the water mold (oomycete) *Phytophthora infestans*, has the potential to be a very destructive disease of potato in Michigan. Over the past growing seasons late blight has no longer been a sporadic disease and as such has been reported throughout the United States from multiple production areas (Figure 3). Potato late blight was found in in Montcalm and St. Joseph

County in southern Michigan in 2015. Some crops in southern Michigan were in early decline and ready to be desiccated or already being harvested. The amount of disease was generally light in southern counties. Areas in fields that were vulnerable were field margins, especially those close to tree lines, raised cable lines and where water accumulated, such as around pivot tracks and tractor wheel lines. The genotype of the *Phytophthora infestans* isolate responsible for all late blight confirmations in potatoes have been the US-23 genotype. Conditions remained conducive for late blight in potato crops and the risk of tuber blight is high, especially in fields in areas that experienced heavy rain during August. Late blight protection programs should be based on a residual protectant fungicide such as chlorothalonil or mancozeb. Under high disease pressure situations, the programs incorporating Revus products, Forum, Curzate 60DF, Ranman, Tanos, Gavel, Ariston, Zing! or Previcur Flex should be used. Ridomil-based products have proved very effective in recent years where the genotype of *P. infestans* has changed to one that is metalaxyl-sensitive as with US-23, which has predominated in Michigan since 2013. In Michigan, Headline and Quadris have been effective in late blight management, but these products should be used in strict adherence with anti-resistance development strategies, i.e., always mix with a protectant fungicide. These products must be used in combination with protectant materials such as EBDC or chlorothalonil-based products. Destruction of areas within crops with late blight should follow the rules that 30 rows either side of the newest lesions at the border of the late blight locus and 100 feet along the row (either side) are killed with Reglone or with Gramoxone.

Aerial blackleg of potato

Dickeya spp. and *Pectobacterium* spp. are commercially important seed-borne soft rot bacteria that cause aerial blackleg of potato. Aerial and lower stem blackleg in potatoes has emerged as an important disease of potato and have increased in prevalence in certain European countries and Israel. Direct crop loses primarily occurs is cases of downgrading or rejection of seed by certification programs. The disease has not been a major issue in the US until a recent outbreak this past growing season. A wet June resulted in a high incidence of aerial stem rot in parts of Michigan. Effective management starts with proper identification and diagnosis and growers should only plant certified seed. Seed is only certified if it is within the incidence tolerance of tuber presence with soft-rot symptoms (0.05 percent), but the seed is unlikely to be completely free of *Dickeya* spp. and *Pectobacterium* spp. contamination. *Dickeya* spp. and *Pectobacterium* spp. does not survive well outside of the potato, therefore rotational programs of two or more years may help control this disease. Seed cutting can also spread inoculum, therefore sanitation and disinfesting potato-cutting equipment and careful seed handling post-cutting reduces the risk of this disease. Prevention of seed piece decay with fungicidal seed treatments can indirectly prevent seed contamination, especially during the cutting operation. Seeds should be planted during conditions that favor fast emergence, and planting into cool and wet soils should be avoided.

Summary

The first step in effective disease management of potato is accurate identification and diagnosis. It is important to adhere to manufacturer's label recommendations when implementing disease management programs. We will continue to evaluate the effectiveness of promising biologically based and conventional treatments on common scab management, tuber yield and quality, under multiple field conditions and locations over the coming growing seasons.

More information available at: http://www.potatodiseases.org/

Acknowledgements

This project was partially supported by the Michigan Potato Industry Commission, and the Michigan State University Project GREEEN.

Table 1. Major seed-borne, foliar and storage diseases in Michigan potato production systems.

Type	Common name	Pathogens	Type of organism	Symptoms
Seed-borne (soil)				
	Late blight	*Phytophthora infestans*	Oomycete	Irregularly shaped, slightly depressed brown to purplish areas on skin
	Fusarium dry rot	*Fusarium sambucinum*	Fungus	Delayed or non-emergence
	Stem canker and black scurf	*Rhizoctonia solani*		Black scurf on tubers
	Black dot	*Colletotrichum coccodes*	Fungus	Black dots form on tubers
	Bacterial soft rot	*Pectobacteria* spp. *Dickeya* spp. 2015	Bacteria	Decaying seed piece
	Common scab	*Streptomyces scabies*	Bacteria	Cork-like or russeted lesions
	Corky ringspot/TRV	*Tobacco rattle virus*	Virus	Small prominent brown flecks
	PVY and variants	*Potato virus Y*	Virus	Sometimes brown rings
Field (foliar)				
	Late blight	*P. infestans*	Oomycete	Dark, circular to irregularly shaped lesions
	Early blight	*Alternaria solani*	Fungus	Dark concentric rings
	Brown leaf spot	*Alternaria alternata*	Fungus	Small, round, dark brown spots
	White mold	*Sclerotinia sclerotiorum*	Fungus	Lesions with white cottony growth
	Gray mold	*Botrytis* cinerea	Fungus	Tan lesions
	Black leg	*Pectobacterium* and *Dickeya* spp.	Bacteria	Brown to black water-soaked lesions extending from the base of the stem
	Early die	*Verticillium dahliae* /*Pratylenchus penetrans*	Fungus/nematode	Vascular discoloration and premature senescence
	Corky ringspot/TRV	*Tobacco rattle virus*	Virus	Ring spot or stem mottle
Storage (tuber)				
	Late blight	*P. infestans*	Oomycete	Entire tuber becomes blighted and discolored
	Fusarium dry rot	*F. sambucinum* and others	Fungus	Dark depressions on tuber surface
	Pink rot	*P. erythroseptica*	Oomycete	Tuber decay that begins at or near the stem or stolon end
	Pythium Leak	*Pythium ultimum*	Oomycete	Darkening of tissue and presence of liquid exudates
	Soft rot	*Pectobacterium* and *Dickeya* spp.	Bacteria	Cream colored to tan, soft and granular
	Silver scurf	*Helminthosporium solani*	Fungus	Tan or grey, circular lesions on periderm
	Black dot	*C. coccodes*	Fungus	Small abundant black dots (sclerotia)

Figure 1. Brown, sunken lesions on underground stems and stolons caused by *Rhizoctonia solani*

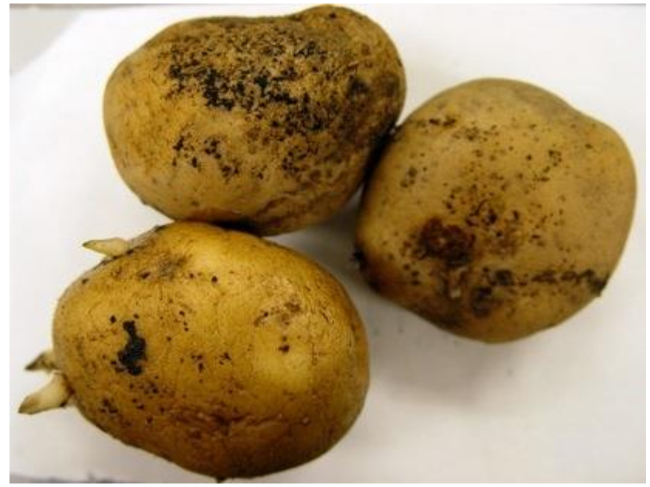

Figure 2. *Rhizoctonia solani* sclerotia on the surface of tubers

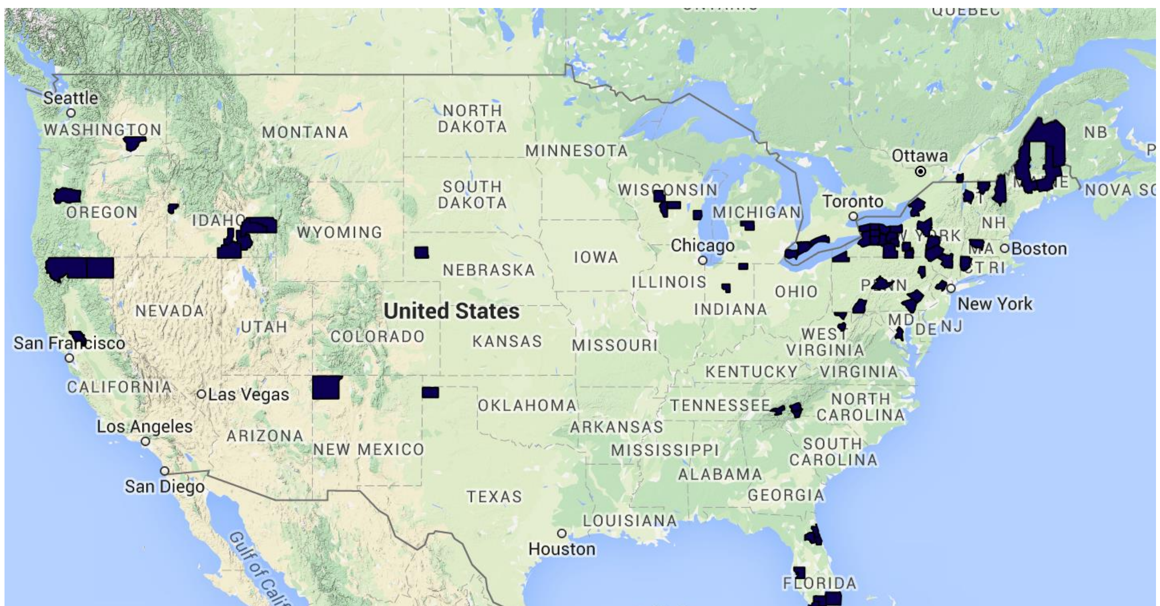

Figure 3. Late blight across the US (2015), source http://usablight.org