Relationship Between SDS and SCN in Commercial Soybean Fields in Wisconsin

David Marburger[1], John Gaska[1], Shawn Conley[1], Paul Esker[3], Ann MacGuidwin[2], and Damon Smith[2]

(1)Agronomy, University of Wisconsin-Madison, Madison, WI
(2)Plant Pathology, University of Wisconsin-Madison, Madison, WI
(3)Universidad de Costa Rica, San Jose, Costa Rica

2014 Wisconsin Crop Management Conference, Madison, WI
January 16, 2014

Outline

- Introduction to SCN and SDS
- Cross Relationships
- WI Study
- Management Recommendations
- Questions

SCN

- Soybean cyst nematode (*Heterodera glycines*)
  - Non-segmented roundworm in the soil
  - Females form cysts which contain eggs
  - 1 cyst may contain 40 to 700 eggs

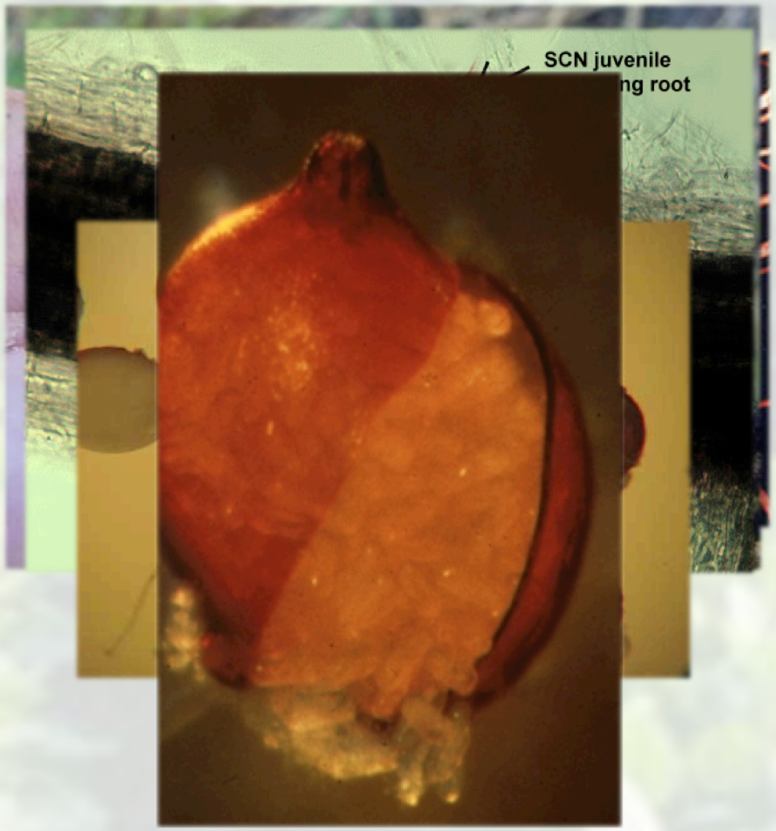


Image Sources: University of Missouri Extension, Iowa St. University Extension, University of Maryland

SCN

- Symptoms
  - Stunting
  - Chlorosis
  - Uneven canopy closure
  - Early maturity

  - **Symptoms might not always be visible!!!**

Image sources: University of Nebraska-Lincoln Extension, Purdue University Extension

SCN in Wisconsin

- First found in Racine County in 1981
- Has spread to >90% of soybean producing counties in the state

SDS

- Sudden death syndrome (SDS)

- Causal agent:
  - *Fusarium virguliforme*
    - Fungus which inhabits the soil

SDS

- Symptoms
  - Interveinal chlorosis and necrosis

- Signs
  - Blue to purple colored spores on the roots

F. virguliforme spores

Image source: Iowa St. University

SDS in Wisconsin

- Soybean plants with typical SDS symptoms collected in 6 counties
- SDS confirmed in 5 counties
  (Bernstein et al. 2007)

Cross Relationships

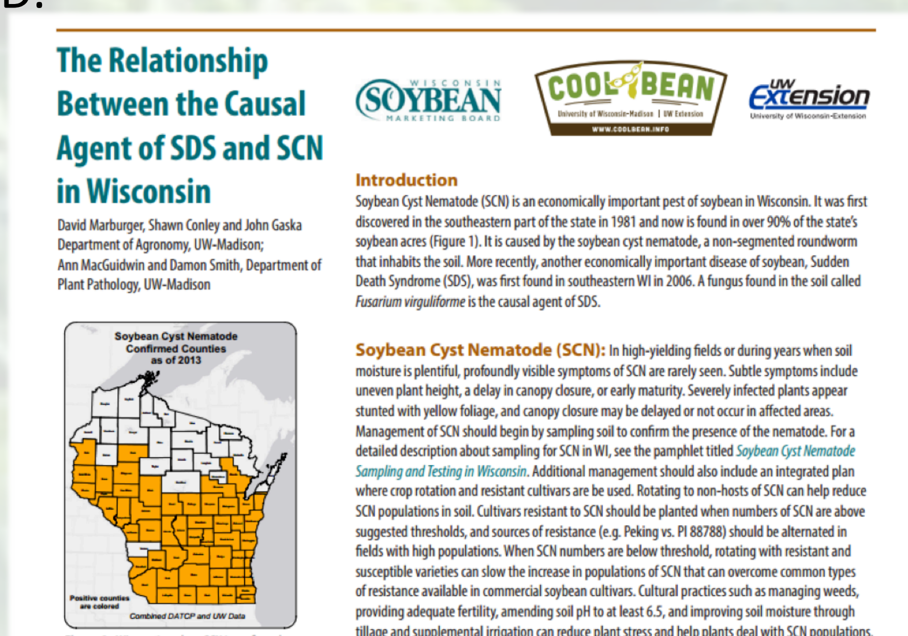
- Relationship between SCN and SDS has been examined for about 30 years
  - Survey found SCN was associated with 70-80% of SDS infected plants in 30 fields across 4 states (Hirrel, 1983)
  - Studies have shown positive correlation between populations of SCN and SDS foliar symptoms
    - For example, McLean and Lawrence (1993) showed SDS symptoms occurred 3 to 7 days earlier and were more severe in plots infested with SCN and *F. virguliforme* than plots infested with *F. virguliforme* alone

Cross Relationships

- On the other hand.....
  - Weak to no correlation between SCN and SDS
    - Gao et al. (2006) reported the presence of both pathogens reduced soybean growth, but SCN did not increase SDS symptoms
    - Sherm et al. (1998) did not always observe significant correlations between SCN and *F. virguliforme* population densities

Wisconsin Study

- Relationship Between *Fusarium virguliforme* and *Heterodera glycines* in Commercial Soybean (*Glycine max*) Fields in Wisconsin
- Recently accepted in Plant Health Progress
  - Authors: Marburger, D., Conley, S., Esker, P., MacGuidwin, A., and Smith, D.



The Relationship Between the Causal Agent of SDS and SCN in Wisconsin

David Marburger, Shawn Conley and John Gaska Department of Agronomy, UW-Madison; Ann MacGuidwin and Damon Smith, Department of Plant Pathology, UW-Madison

Figure 1. WI counties where SCN is confirmed as

Introduction

Soybean Cyst Nematode (SCN) is an economically important pest of soybean in Wisconsin. It was first discovered in the southeastern part of the state in 1981 and now is found in over 90% of the state's soybean acres (Figure 1). It is caused by the soybean cyst nematode, a non-segmented roundworm that inhabits the soil. More recently, another economically important disease of soybean, Sudden Death Syndrome (SDS), was first found in southeastern WI in 2006. A fungus found in the soil called *Fusarium virguliforme* is the causal agent of SDS.

Soybean Cyst Nematode (SCN): In high-yielding fields or during years when soil moisture is plentiful, profoundly visible symptoms of SCN are rarely seen. Subtle symptoms include uneven plant height, a delay in canopy closure, or early maturity. Severely infected plants appear stunted with yellow foliage, and canopy closure may be delayed or not occur in affected areas. Management of SCN should begin by sampling soil to confirm the presence of the nematode. For a detailed description about sampling for SCN in WI, see the pamphlet titled *Soybean Cyst Nematode Sampling and Testing in Wisconsin*. Additional management should also include an integrated plan where crop rotation and resistant cultivars are be used. Rotating to non-hosts of SCN can help reduce SCN populations in soil. Cultivars resistant to SCN should be planted when numbers of SCN are above suggested thresholds, and sources of resistance (e.g. Peking vs. PI 88788) should be alternated in fields with high populations. When SCN numbers are below threshold, rotating with resistant and susceptible varieties can slow the increase in populations of SCN that can overcome common types of resistance available in commercial soybean cultivars. Cultural practices such as managing weeds, providing adequate fertility, amending soil pH to at least 6.5, and improving soil moisture through tillage and supplemental irrigation can reduce plant stress and help plants deal with SCN populations.

Objectives

1. Determine the incidence of SCN and *F. virguliforme* (SDS fungus) in commercial soybean fields in WI

2. Determine if establishment of these pathogens is interrelated

Source: Marburger et al. (in press)

Materials and Methods

- Study was possible through the check-off funded Wisconsin Soybean Marketing Board (WSMB) program which offers FREE SCN soil testing for Wisconsin growers

- Soil samples that were voluntarily submitted during 2011 and 2012 were tested for SCN and *F. virguliforme*

Source: Marburger et al. (in press)

Materials and Methods

- SCN screening
  - 100 cm^3 subsample
  - Wet-sieving and centrifugal-flotation methods
  - Counted the number of eggs

Source: Marburger et al. (in press)

Image source: UW-Madison and Iowa St. University

Materials and Methods

- *F. virguliforme* screening
  - Used real-time quantitative polymerase chain reaction (qPCR)
  - Selected a *F. virguliforme*-specific primer set from the literature (Mbofung et al., 2011)
  - Spores g soil^{-1} = $[10^{((\text{Cq value} - 45.721) / -3.393)}] * 2$.

Source: Marburger et al. (in press)

Statistical Analyses

- Divided our data into two sets
  1. Samples where neither pathogen was found (n=311)
  2. Samples where at least 1 or both pathogens were detected (n=124)

- Used the second data set to measure the correlation between presence of both pathogens (Kendall tau rank correlation)

Source: Marburger et al. (in press)

2011 Results

- 135 samples submitted
- 56 positive for SCN
- 10 positive for *F. virguliforme*

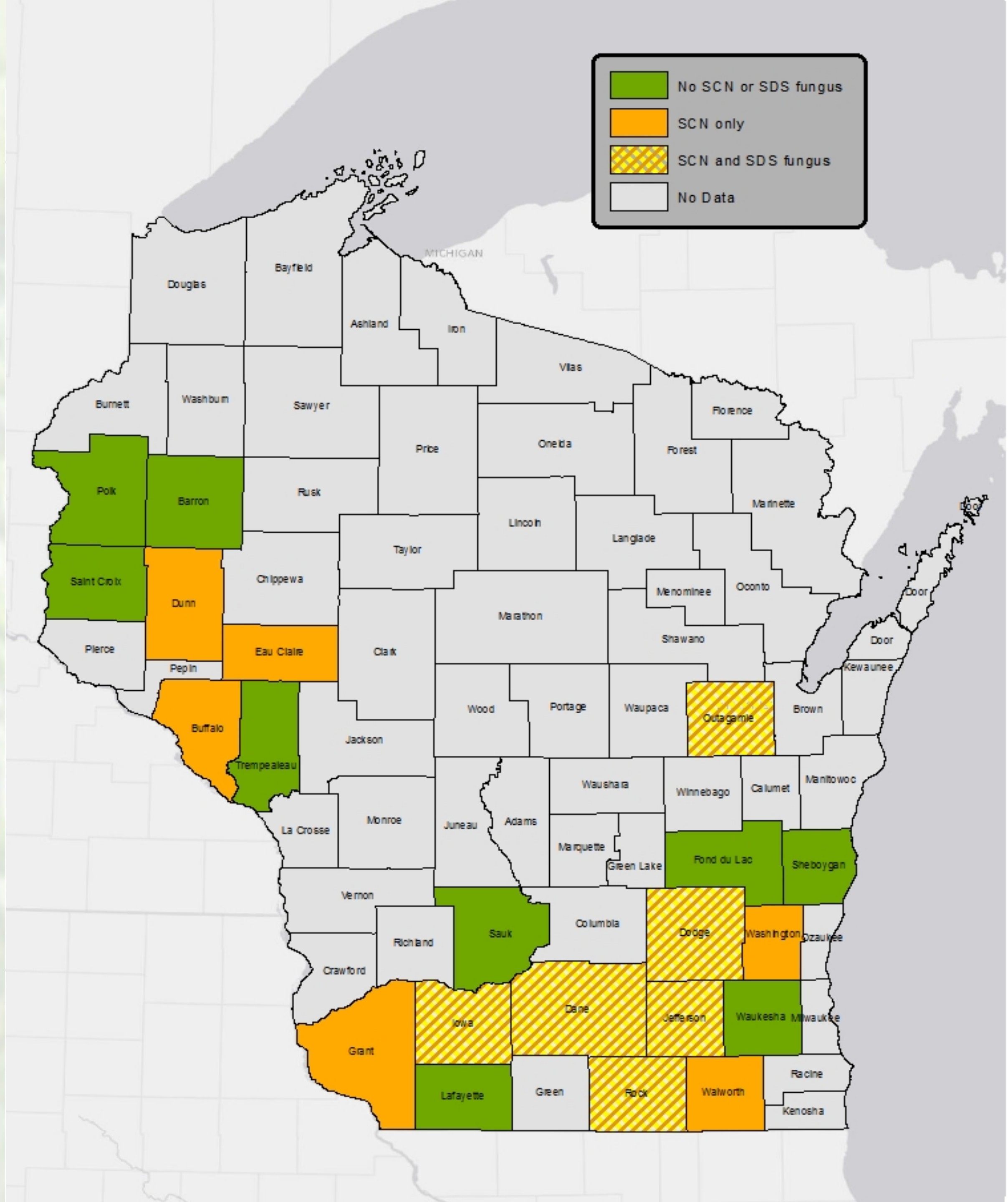


Table modified from Marburger et al. (in press)

Figure from Marburger et al. (in press)

2012 Results

- 318 samples submitted
- 64 positive for SCN
- 13 positive for *F. virguliforme*

Figure from Marburger et al. (in press)

Table modified from Marburger et al. (in press)

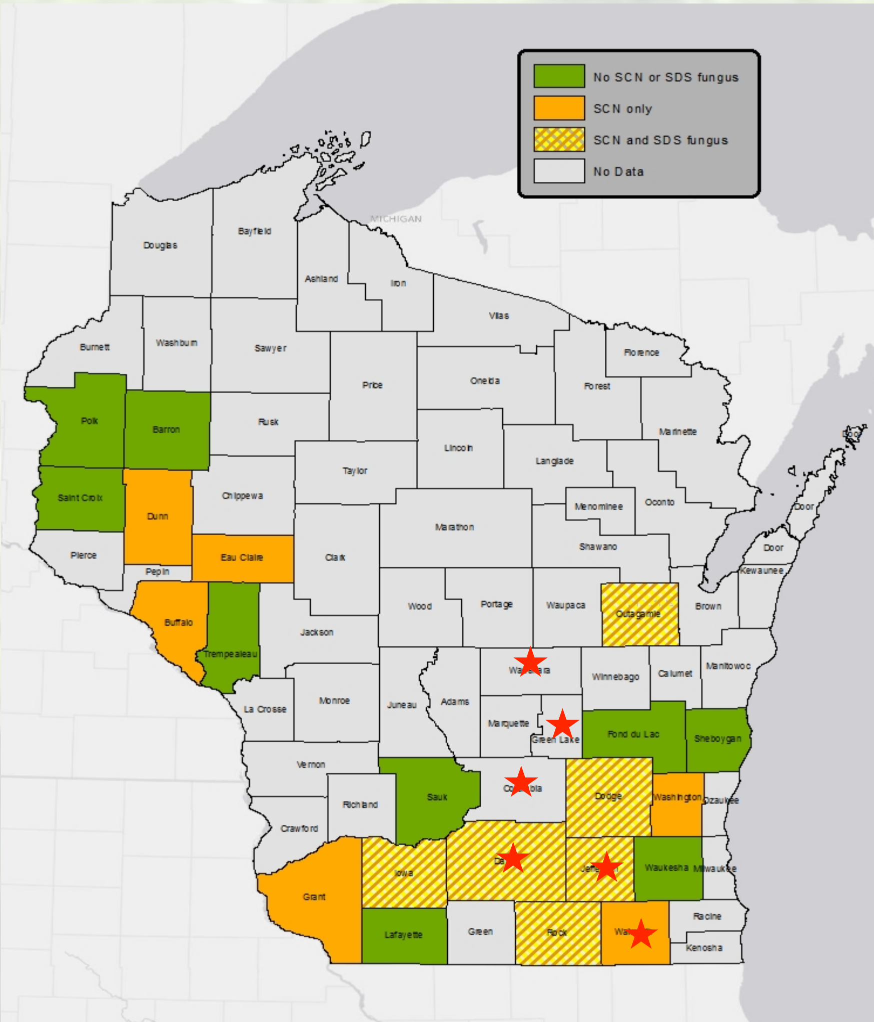
		H. glycines		F. virguliforme	
County	#Samples	#Detected	Population[b]	#Detected	Population[b]
Brown	45	14	5 – 20,500	3	D – 10,778
Fond du Lac	36	12	5 – 37,200	0	0
Dodge	34	6	5 – 3,650	0	0
Rock	27	4	5 - 825	4	D – 11,226
Sheboygan	22	1	5	1	D
Manitowoc	21	0	0	1	D
Green	14	5	5 – 3,375	2	D
Chippewa	11	1	5	0	0
Outagamie	11	3	5 - 75	0	0
Jackson	8	1	5	0	0
Trempealeau	8	1	200	0	0
Waupaca	8	0	0	1	D
Calumet	7	1	10	0	0
Dunn	6	4	5 - 275	0	0
Jefferson	6	2	5 - 150	0	0
Walworth	6	3	5 – 3,250	1	10,705
Eau Claire	5	0	0	0	0
Grant	5	1	5,025	0	0
Pierce	5	0	0	0	0
Oconto	4	1	5	0	0
St Croix	4	0	0	0	0
Winnebago	4	1	200	0	0
Columbia	3	0	0	0	0
Green Lake	3	0	0	0	0
Pepin	3	0	0	0	0
Adams	2	2	4,450 – 15,000	0	0
Dane	2	0	0	0	0
Richland	2	0	0	0	0
Vernon	2	0	0	0	0
Barron	1	0	0	0	0
Clark	1	0	0	0	0
La Crosse	1	1	1,275	0	0
Lafayette	1	0	0	0	0
Totals	318	64	0 – 37,200	13	0 – 11,226

[a]County-wide range in number of eggs/100 cc soil from samples where H. glycines was detected

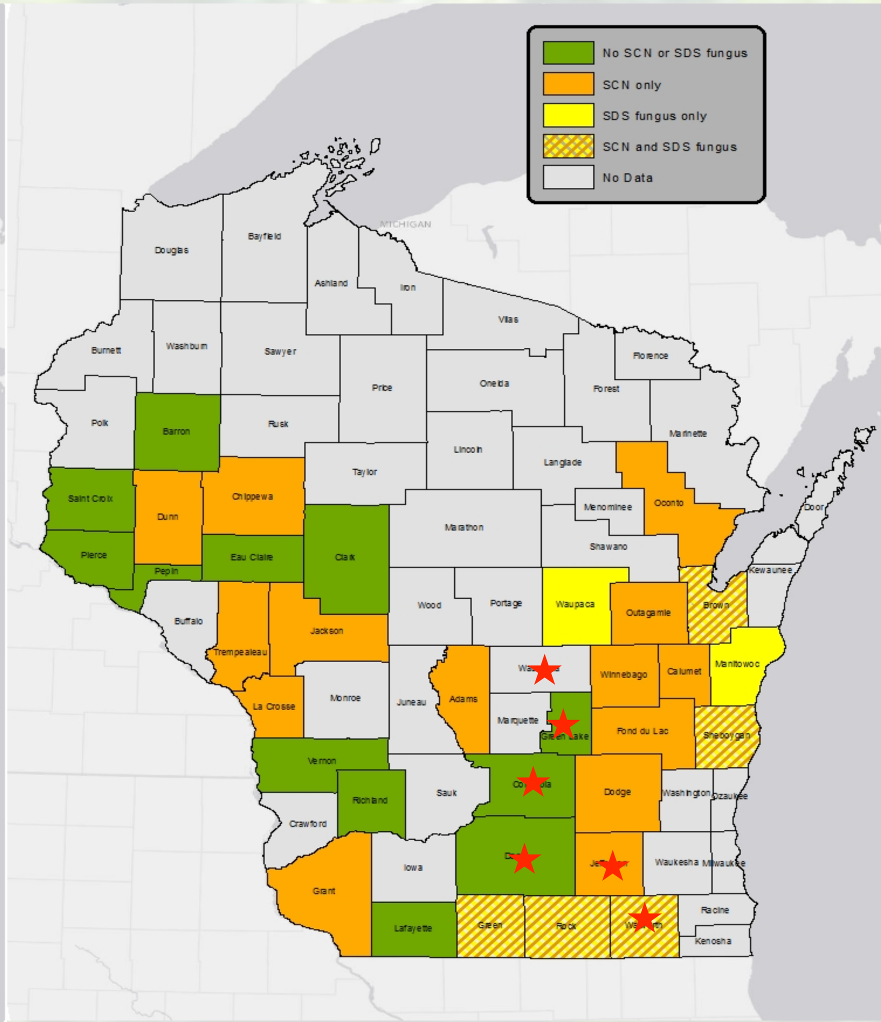
[b]County-wide range of estimated number of spores/g soil from detected samples; D: detected but not quantifiable; N/A: sample not screened for F. virguliforme

Where has *F. virguliforme* spread?

2011



2012



Is establishment interrelated?

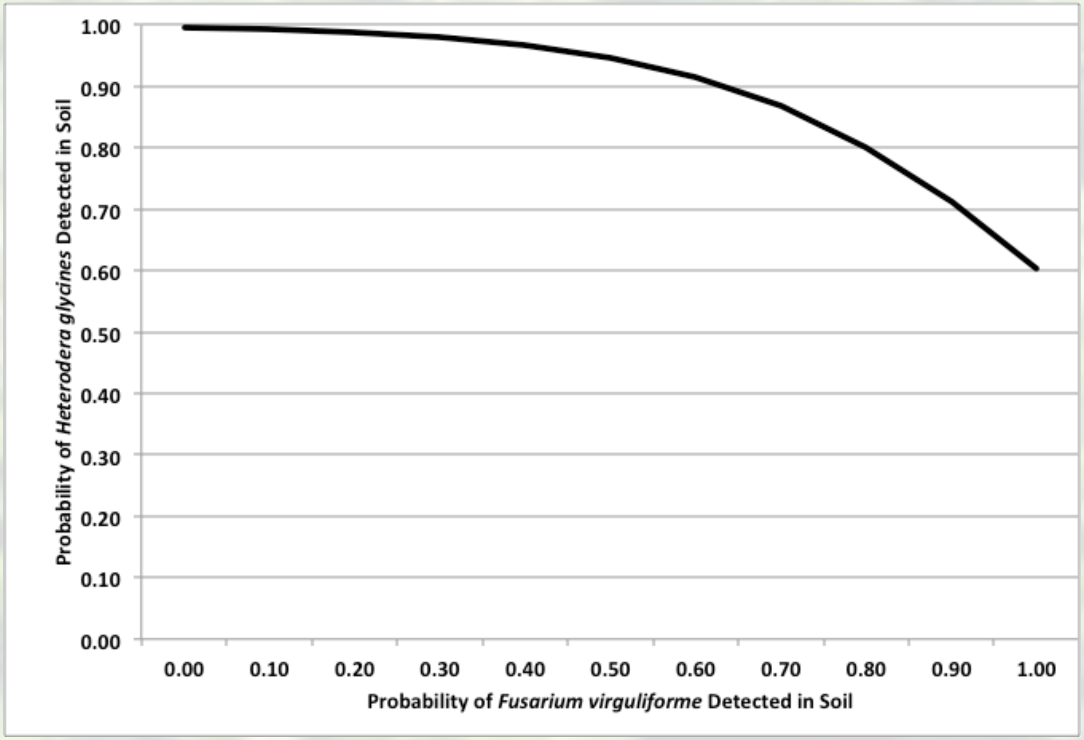
- Percentage of counties where both pathogens were found (orange and yellow crosshatch)
  - ~30% in 2011
  - ~15% in 2012

- Number of soil samples where both pathogens were found in the same sample was low

- Found a negative association between SCN and *F. virguliforme* (τ= -0.59, $P < 0.01$, n=124)
  - Presence of *F. virguliforme* most often corresponds to the absence of SCN in the same soil sample and vice versa

Source: Marburger et al. (in press)

Is establishment interrelated?



Predicted probabilities are based on the logistic model: Probability of *Heterodera glycines* in a 100 cc soil sample= exp (5.31 – 4.89 *Fusarium virguliforme*) / [1 + exp (5.31 – 4.89 *Fusarium virguliforme*)]; Max-rescaled $R^2 = 0.56$; Area under the receiver operator curve (ROC) = 0.94; n=124.

- Suggested SCN and *F. virguliforme* do not rely on each other for colonizing fields

Source: Marburger et al. (in press)

Conclusions from WI Study

- Counties testing positive for SCN were representative of the SCN-confirmed counties in the state
- *F. virguliforme* has spread farther north, east, and west than the area from which it was originally found in the state
- Counties where both pathogens were found occurred infrequently
- Number of soil samples where both pathogens were found in the same sample was low
- Found a negative correlation between detecting SCN and *F. virguliforme*
    - As the odds of detecting *F. virguliforme* in soil approach 100%, the likelihood of finding SCN in Wisconsin soybean fields is estimated at just 60%.
- This negative correlation suggested that SCN and *F. virguliforme* do not rely on each other to colonize fields.

Source: Marburger et al. (in press)

Future plans

- Continue this work to include the 2013 season
  - Over 700 samples collected thus far
  - Where else has *F. virguliforme* spread to?
  - Is there still a negative relationship?

WISCONSIN SOYBEAN MARKETING BOARD

Management Recommendations

- First thing to do?

- **Soil sample!!**

Image source: University of Kentucky

SCN Management

- Begins with the 3 R's
  - Rotate crops
  - Rotate with resistant varieties
  - Rotate the resistant varieties you use
- Some seed treatments are available
- Maintain good cultural practices
  - Managing weeds
  - Adequate fertility
  - Soil pH

Table from: Soybean Cyst Nematode Sampling and Testing in Wisconsin

Table 2. Potential risk of yield loss due to SCN as a function of soil type and egg count.

Soil Type	Egg count range (per 100 cm3 soil)	Potential Yield Loss for SCN susceptible variety	Risk
Silt or clay	0 eggs	None	None
Silt or clay	1-500 eggs	0-10%	Low
Silt or clay	500-2000 eggs	10-20%	Moderate
Silt or clay	2000-5000 eggs	10-50%	High
Silt or clay	>5000 eggs	Significant: likely >50%	Very High
Sand	0 eggs	None	None
Sand	1-500 eggs	5-20%	Low
Sand	500-5000 eggs	10-50%	Moderate
Sand	>5000 eggs	Significant: likely >50%	Very High

Source: coolbean.info

SDS Management

- SDS-resistant varieties
- Avoid planting into cool, wet soils
  - Delay planting?
- Improve soil drainage
- Reduce compaction
- Crop rotation

What if both are present?

- Choose variety with the best resistance/tolerance to both pathogens
- Continue maintaining good cultural practices
- http://fyi.uwex.edu/fieldcroppathology/

Acknowledgements

- Dr. Shawn Conley's program
- Dr. Damon Smith's program
- Dr. Ann MacGuidwin's program

- Funding

WISCONSIN SOYBEAN MARKETING BOARD

COOL BEAN
University of Wisconsin-Madison | UW Extension
WWW.COOLBEAN.INFO

Questions?

References

- Bernstein, E.R., Atallah, Z.K., Koval, N.C., Hudelson, B.D., and Grau, C.R. 2007. First report of sudden death syndrome of soybean in Wisconsin. Plant Dis. 91:9, 1201-1201.
- Gao, X., Jackson, T.A., Hartman, G.L., and Niblack, T.L. 2006. Interactions between the soybean cyst nematode and *Fusarium solani* f. sp. *glycines* based on greenhouse factorial experiments. Phytopathology 96: 1409-1415.
- Hirrel, M.C. 1983. Sudden death syndrome of soybean: A disease of unknown etiology. (Abstr.) Phytopathology 73: 501-502.
- Marburger, D., Conley, S., Esker, P., MacGuidwin, A., and Smith, D. Relationship between *Fusarium virguliforme* and *Heterodera glycines* in commercial soybean (*Glycine max*) Fields in Wisconsin. Plant Health Progress. In press.
- Mbofung, G.C.Y, Fessehaie, A., Bhattacharyya, M.K., and Leandro, L.F.S. 2011. A new TaqMan real-time polymerase chain reaction assay for quantification of *Fusarium virguliforme* in soil. Plant Dis. 95: 1420-1426.
- McLean, K.S. and Lawrence, G.W. 1993. Interrelationship of *Heterodera glycines* and *Fusarium solani* in sudden death syndrome of soybean. J. Nematology 25(3): 434-439.
- Scherm, H., Yang, X.B., and Lundeen, P. 1998. Soil variables associated with sudden death syndrome in soybean fields in Iowa. Plant Dis. 82: 1152-1157.