

SOYBEAN CYST NEMATODE RESISTANCE– HOW IT ALL COMES TOGETHER IN THE MIDWESTERN UNITED STATES

TYLKA G L, GEBHART G D, MARETT C C & MULLANEY M P

*Department of Plant Pathology and Microbiology, Iowa State University, Ames, Iowa, USA
E-mail: gltylka@iastate.edu*

Soybean varieties that are resistant to the soybean cyst nematode (SCN) allow less than 10% nematode reproduction relative to what occurs on a standard susceptible soybean variety. There are several different breeding lines that can be used as sources of SCN resistance genes to develop resistant soybean varieties. Almost all SCN-resistant soybean varieties in the U.S. have SCN resistance genes from the PI 88788 source of resistance. The prolonged, repeated use of soybean varieties with the PI 88788 source of resistance in the U.S. has resulted in selection of SCN populations with increased reproduction on PI 88788. But the relationship among increased SCN reproduction, soybean yield, and season-long nematode control with SCN-resistant soybean varieties is not well characterized.

The yield and SCN control provided by hundreds of SCN-resistant soybean varieties are evaluated each year in replicated 4-row plots at nine experiments in Iowa. Soil samples are collected from individual plots at planting and again at harvest to determine SCN egg population densities. Commonly grown susceptible varieties are included in each experiment as comparison (control) treatments. A HG type test, which replaced the SCN race test system in 2002, was conducted in the greenhouse on the SCN population at each experimental location to determine how well the nematode population reproduces on PI 88788, Peking, and the other sources of SCN resistance.

SCN-resistant varieties with PI 88788 resistance usually yield significantly more than varieties with other sources of SCN resistance – even when the SCN populations have 35 to 50 % reproduction on PI 88788 and very low (<2%) reproduction on the other resistance sources. Overall, most SCN-resistant varieties keep SCN egg population densities from increasing during the season, but changes in SCN population densities vary significantly among varieties with PI 88788 SCN resistance, with some supporting high SCN reproduction in a single experiment and some allowing high SCN reproduction at multiple locations. Yields of resistant varieties allowing high SCN reproduction are among the lowest in some experiments, but not always.

In summary, soybean varieties with PI 88788 SCN resistance do not necessarily produce low yields or yields lower than varieties with other sources of resistance in fields infested with SCN populations that have greater than 10 % reproduction on PI 88788. The challenge is to identify for farmers the specific conditions (SCN egg population density, rainfall, edaphic factors, etc.) under which soybean varieties with PI 88788 SCN resistance yield well in fields with SCN populations with elevated reproduction on PI 88788.

Soybean Cyst Nematode Resistance - How it All Comes Together in the Midwestern U.S.

**Greg Tylka, Greg Gebhart, Chris Marett, and
Mark Mullaney**

**Department of Plant Pathology and Microbiology
Iowa State University**

e-mail: gltylka@iastate.edu

20 February 2013

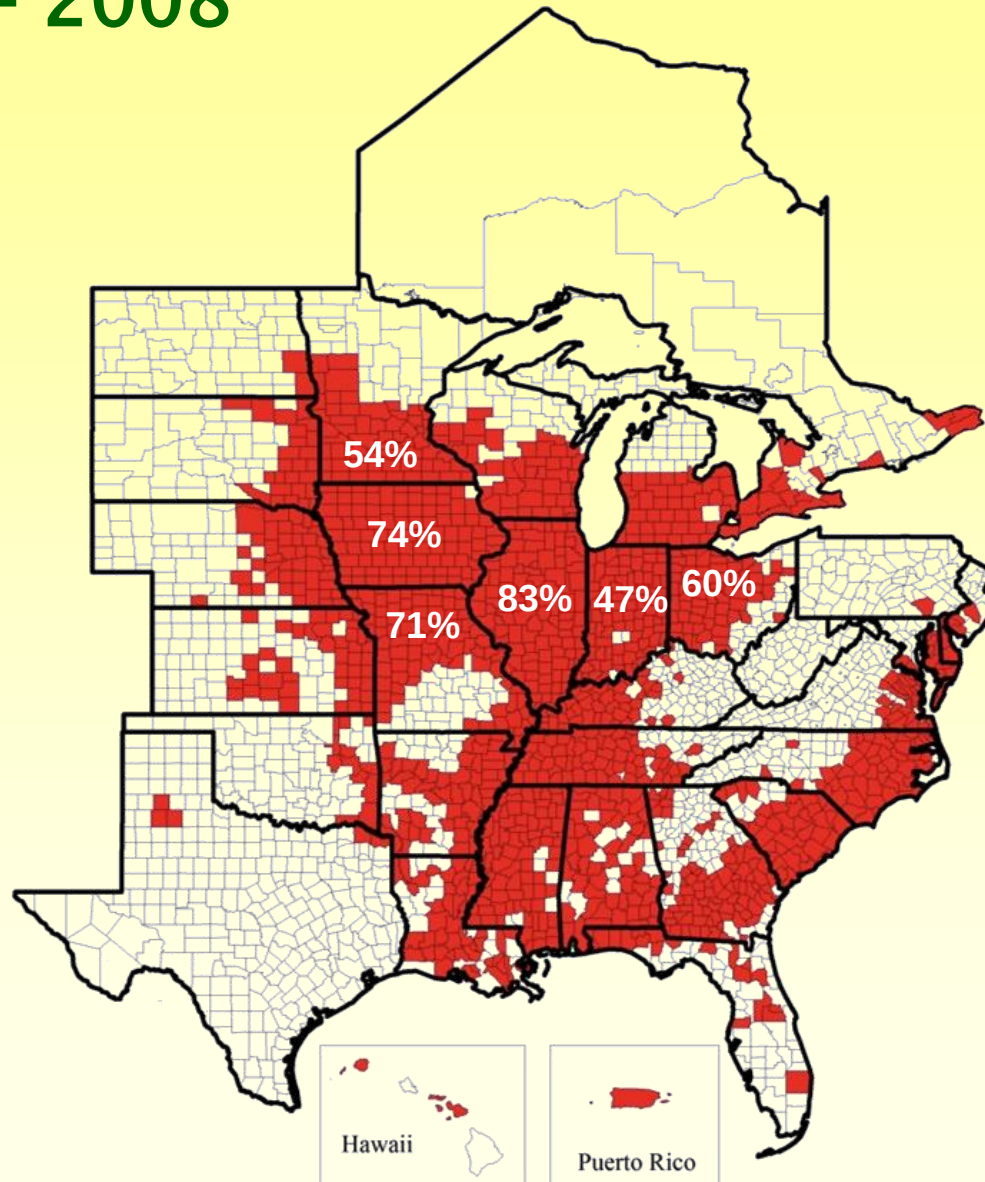


Soybean Cyst Nematode (SCN)

Heterodera glycines

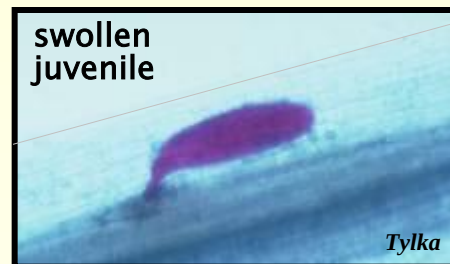


Known Distribution of SCN in the U.S. and Canada – 2008





- ~24 days
- >200 eggs per female
- 3-5 generations per growing season
- some eggs dormant 10 years or more



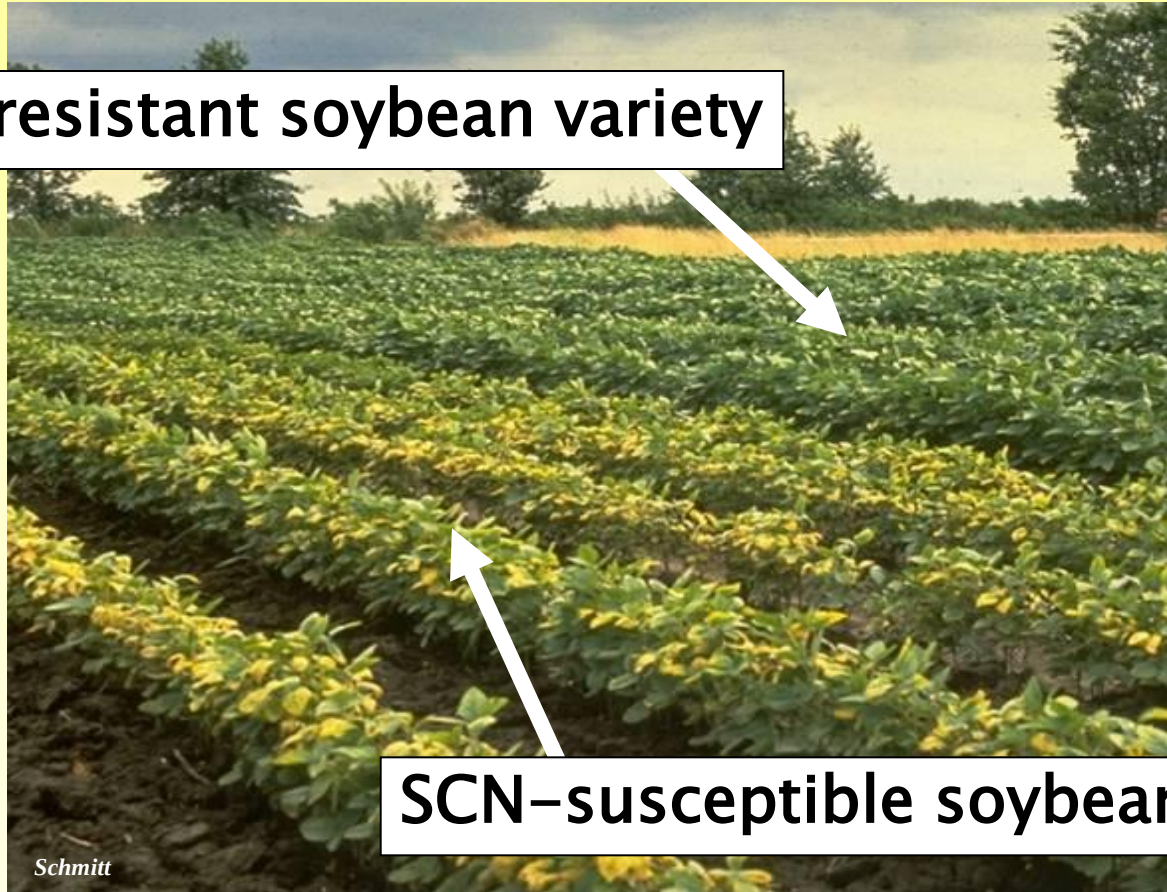
SCN Management Options

- grow nonhost crops
- grow SCN-resistant soybean varieties
- seed treatments



SCN-resistant Soybean Varieties

SCN-resistant soybean variety

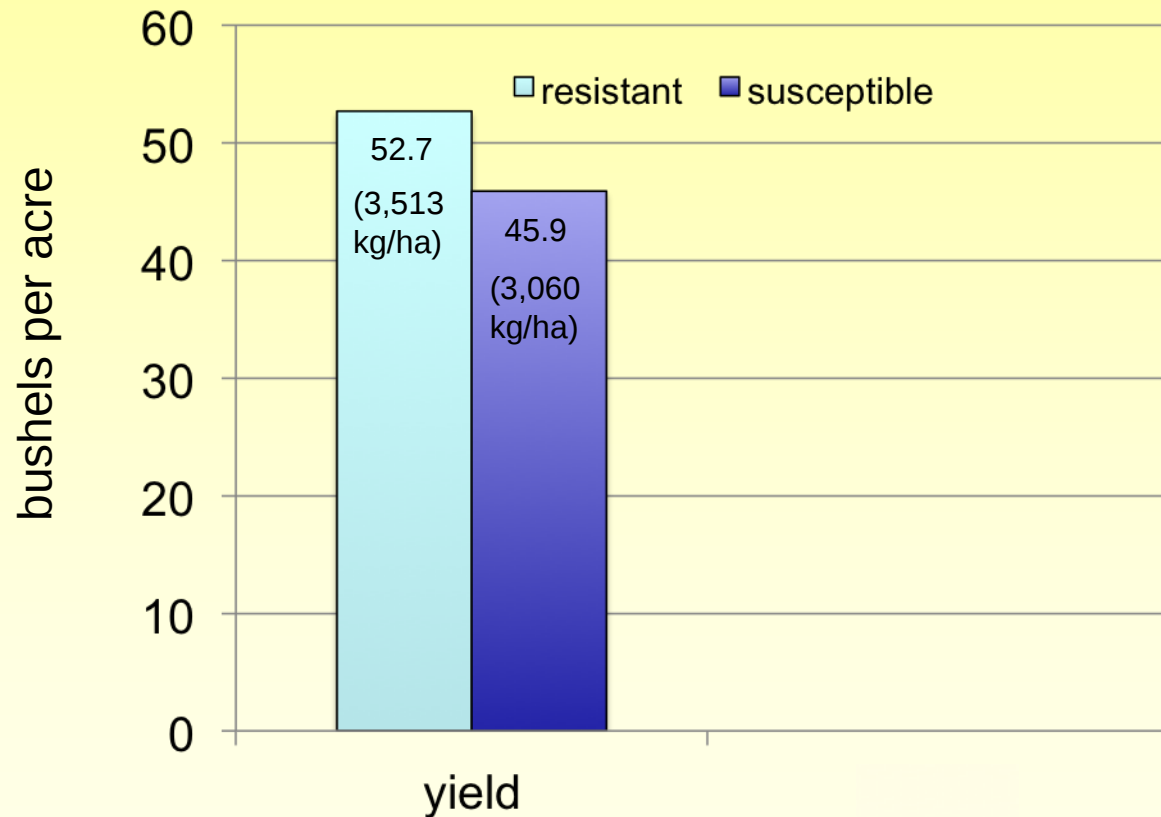


SCN-susceptible soybean variety

Yield and SCN Control

SCN-resistant vs Susceptible Soybean Varieties

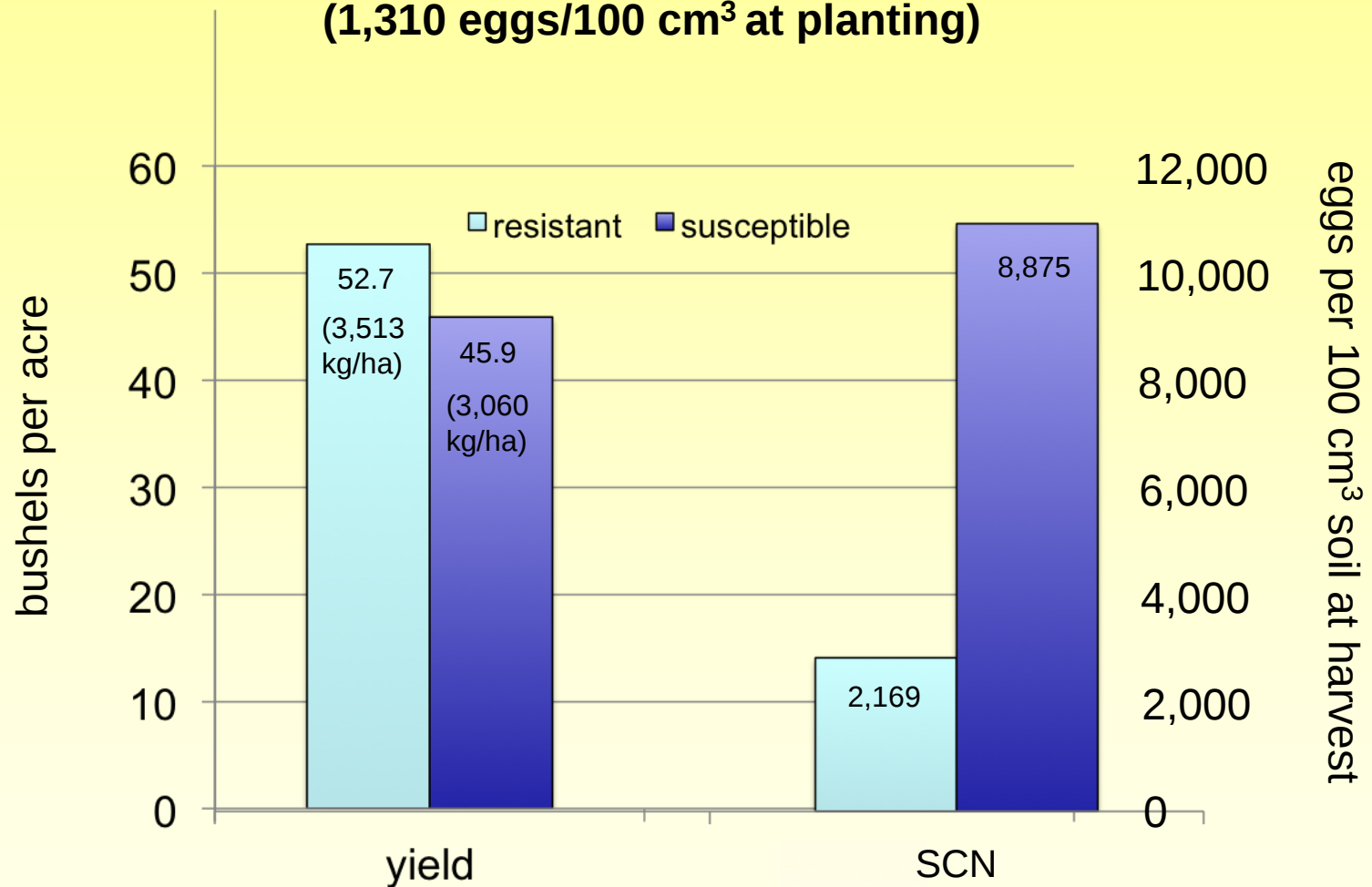
East Central Iowa – 2011
(1,310 eggs/100 cm³ at planting)



Yield and SCN Control

SCN-resistant vs Susceptible Soybean Varieties

East Central Iowa – 2011
(1,310 eggs/100 cm³ at planting)



Sources of SCN Resistance Used to Develop Resistant Varieties

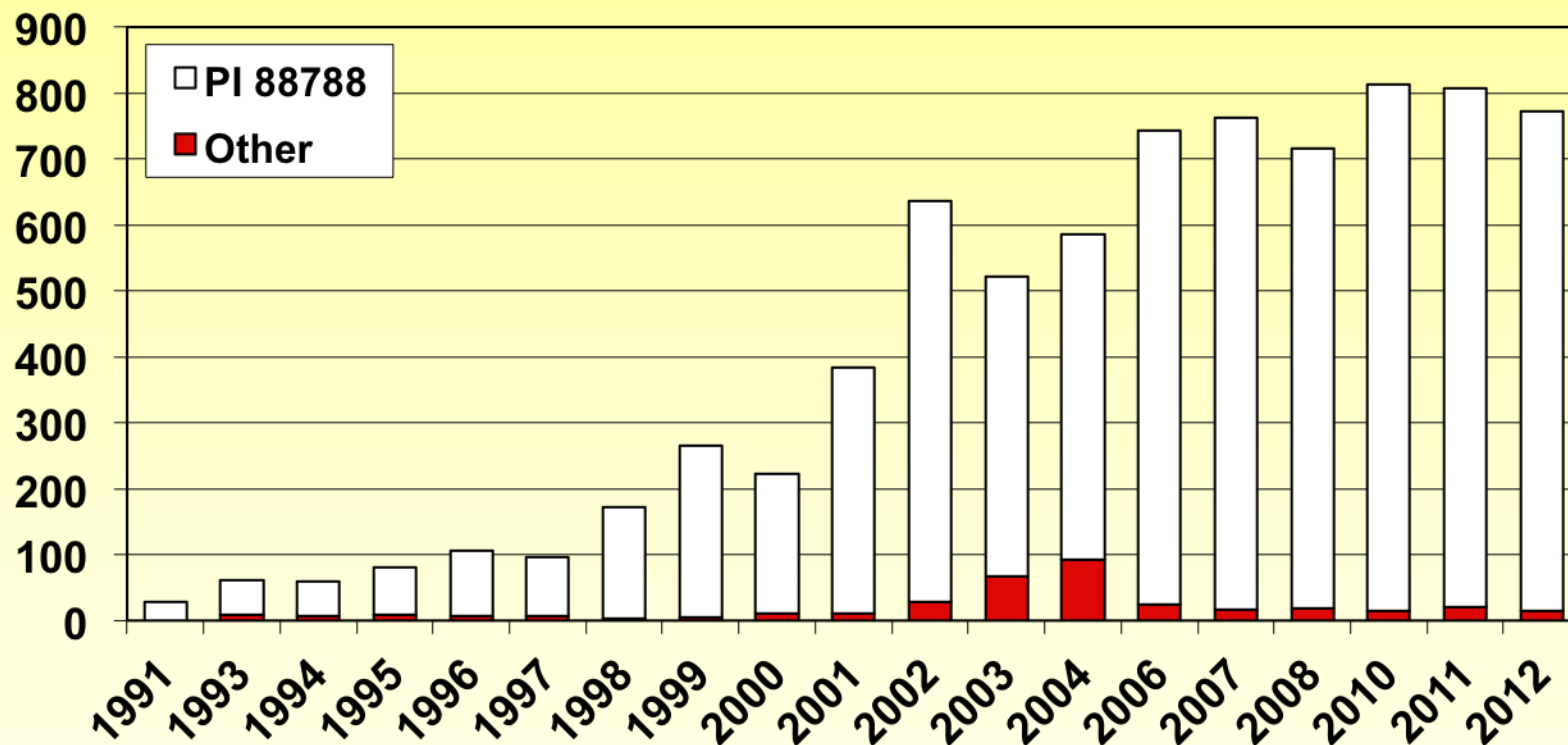
Peking	PI 209332
PI 88788	PI 89772
PI 90763	PI 548316
PI 437654	

- each source of resistance possesses several genes for SCN resistance
- each source of resistance allows a low level of SCN reproduction

the scientific definition of SCN resistance is supporting no more than **10% reproduction**



Number of SCN-resistant Soybean Varieties Available for Iowa 1991 - 2012



HG Type Test Determines The Amount of SCN Reproduction on SCN Resistance Sources



- Peking
- PI 88788
- PI 90763
- PI 437654
- PI 209332
- PI 89772
- PI 548316 (Cloud)

uses 10% reproduction as a critical value in characterizing SCN population on the various sources of resistance



University of Illinois 2006 SCN Race/HG Type Survey

- SCN populations from 260 randomly selected fields from throughout Illinois
- 65% of SCN populations had $>10\%$ reproduction on PI 88788

→ 31% increase from 1990

Niblack et al., Plant Health Progress 2008

University of Missouri 2005 SCN Race/HG Type Survey

- SCN populations from 45 randomly selected fields from throughout Missouri
- 78% of SCN populations had $>10\%$ reproduction on PI 88788

→ 20% increase from 1998

Mitchum et al., Plant Disease 2007



Many (? most ?) SCN populations in the U.S. have
>10% reproduction on PI 88788 resistance.

How does increased SCN
reproduction on PI 88788
resistance affect
soybean yields?



SCN females on roots of a
resistant soybean variety with
PI 88788.

ISU SCN-resistant Soybean Variety Trial Program

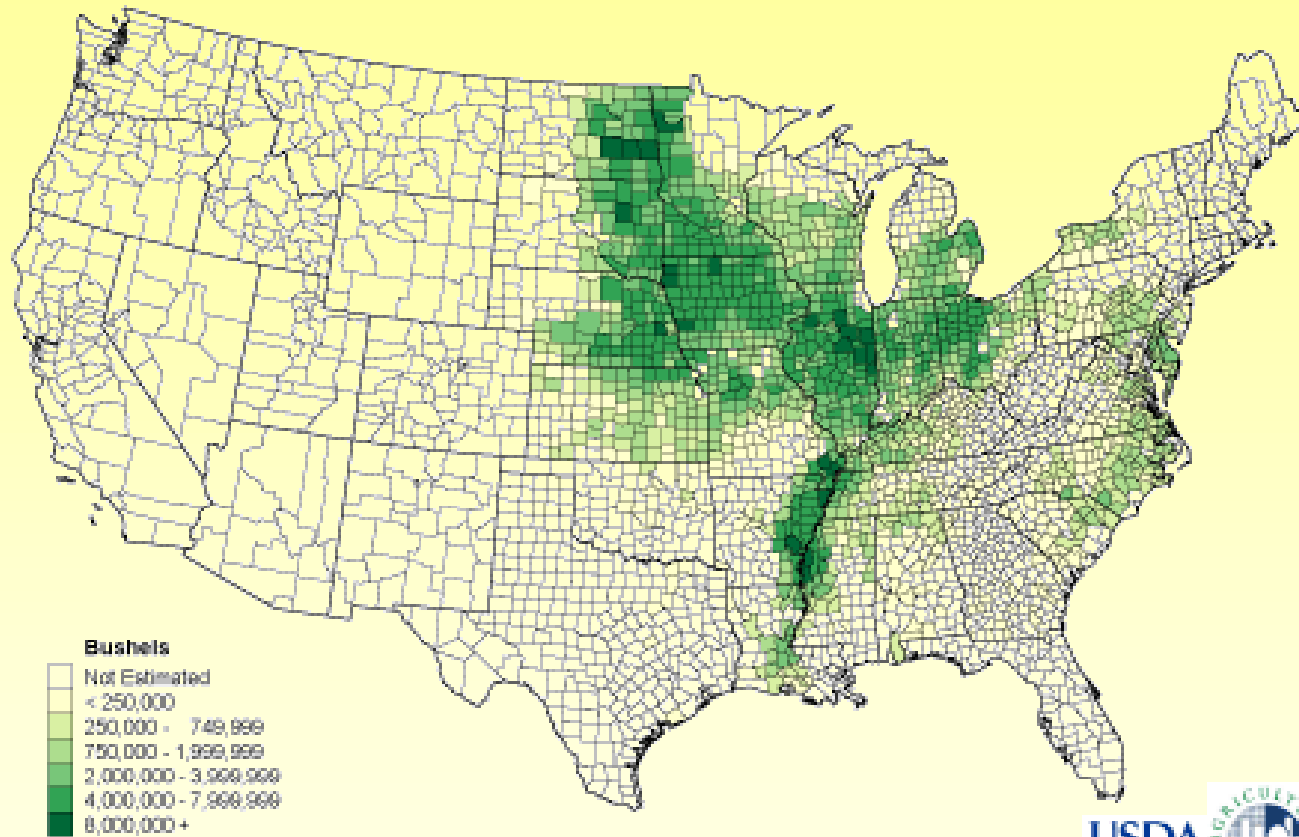
- 4-row, 5.2-meter-long plots replicated 4 times per location (center 4.3 meters harvested)



www.isuscntrials.info



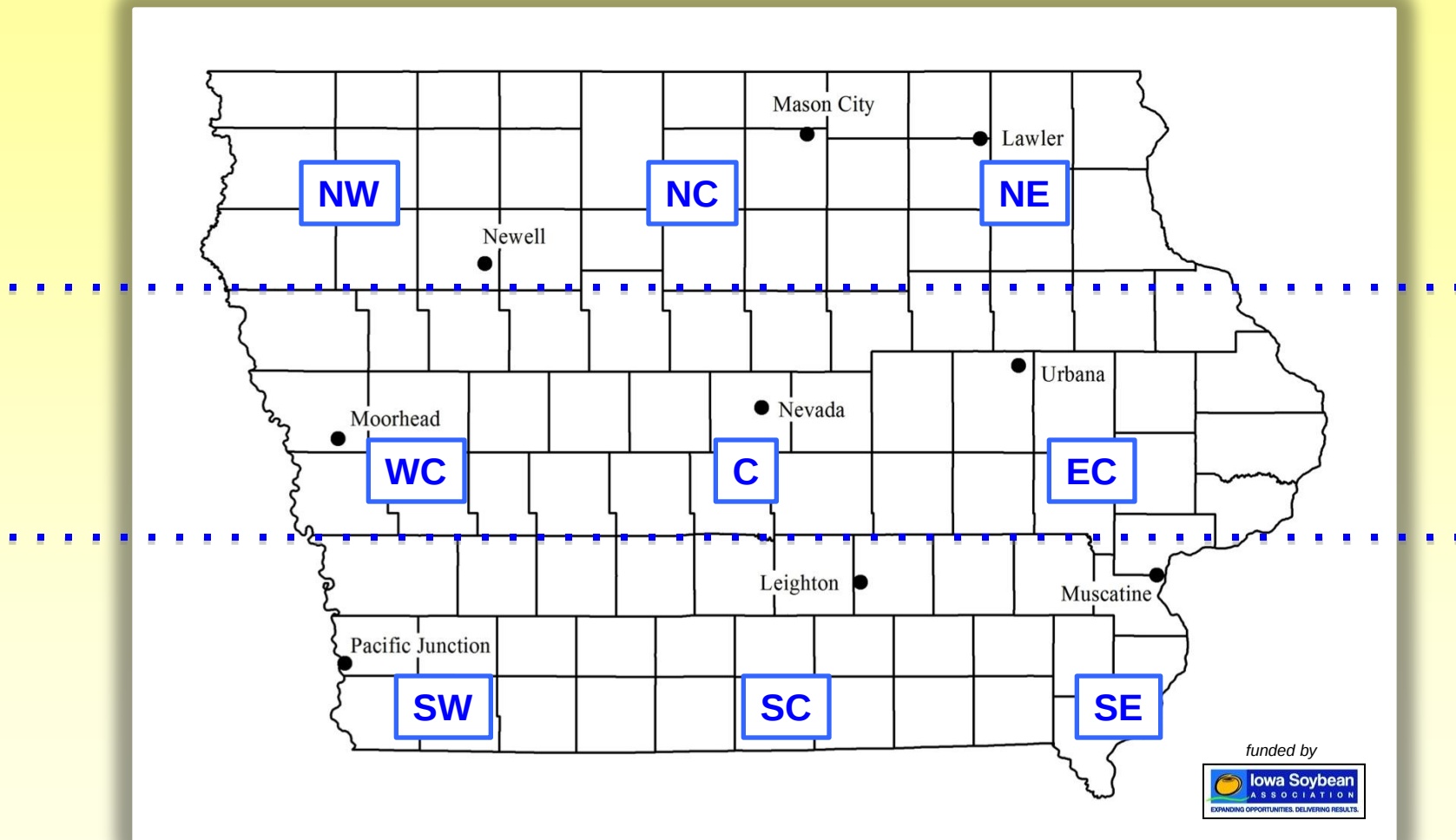
U.S. Soybean Production - 2011 by County



U.S. Department of Agriculture, National Agricultural Statistics Service



ISU SCN-resistant Soybean Variety Trial Program 2012 locations



Iowa State University SCN-resistant Soybean Variety Trial Program

A supplement to Iowa Farmer Today.

Evaluation of Soybean Varieties Resistant to Soybean Cyst Nematode in Iowa—2012

View of the west central Iowa location.



Gregory L. Tylka, Gregory D. Gebhart,
Christopher C. Marett, and Mark P. Mullaney
Department of Plant Pathology and Microbiology
Iowa State University

This report is available online at www.isusentrials.info.

IOWA STATE UNIVERSITY
Extension and Outreach

IPM 52 Revised December 2012



Iowa State University SCN-resistant Soybean Variety Trial Program

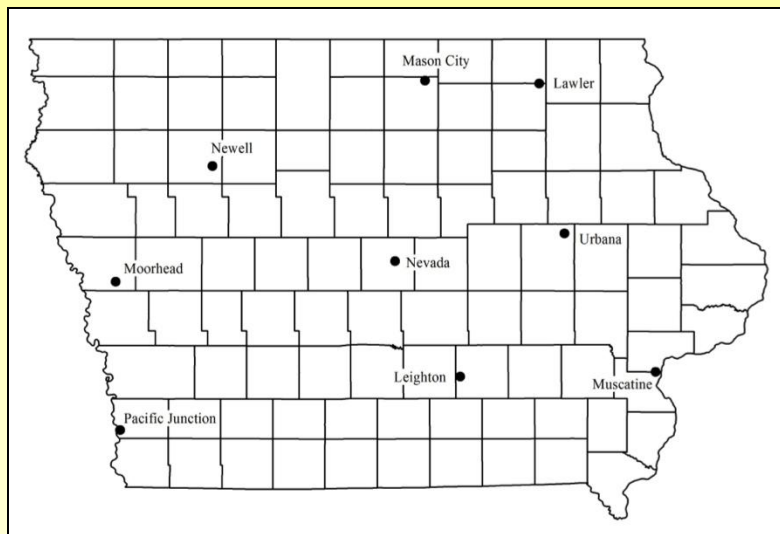


Table 1. Newell (NW Iowa) Glyphosate-resistant.

Brand	Variety	Relative maturity	Resistance	Yield (bu/acre)	Yield rank	SCN # (100cc) ¹	RR
Champion	19R22N	1.9	PI 88788	1.8	17	35.8	1.5
MERSCHMAN	NAVAHO 1220RR2Y	2.0	PI 88788	2.3	17	39.0	1.6
Prairie Brand	PB-2366R2	2.3	PI 88788	3.6	19	37.5	1.6
NK	S20-Y2 Brand	2.0	PI 88788	2.6	18	38.0	1.5
HUSOY	HS 20A22	2.0	PI 88788	3.2	15	33.3	1.4
Jacobson	J721NR2	2.1	PI 88788	2.1	18	33.3	1.3
Northstar Genetics	NS19A0N	1.9	PI 88788	2.1	15	34.8	1.4
NK	S19-A6 Brand	1.9	PI 88788	3.4	19	35.0	1.6
Champion	20R22N	2.0	PI 88788	2.4	21	38.0	1.9
Gold Country	2342RR2Y	2.1	PI 88788	3.3	19	38.3	1.6
Stine	19RA02	1.9	PI 88788	2.4	16	34.3	1.5
G2 Genetics	7213	2.1	PI 88788	2.4	17	36.0	1.8
Asgrow	AG2031	2.0	PI 88788	3.2	18	37.8	1.8
Renze	41862RR2m	1.8	PI 88788	3.3	16	30.8	1.1
LATHAM	L214RR2	2.1	PI 88788	2.4	18	32.5	1.3
Pioneer	92Y20	2.2	PI 88788	2.7	18	33.8	1.6
HUSOY	HS 21A02	2.1	PI 88788	2.3	19	37.5	1.4
MERSCHMAN	MORHEGAN 1222RR2Y	2.2	PI 88788	1.9	19	33.3	1.1
Pioneer	92M40	2.4	PI 88788	3.3	22	36.8	1.3
Footnote Brand	60N21	2.0	PI 88788	2.4	18	35.0	1.3
Jacobson	J710NR2	2.0	PI 88788	2.6	15	34.0	1.5
Prairie Brand	PB-2018RR2	2.5	PI 88788	2.5	19	40.0	1.6
Stine	20R232	2.0	PI 88788	2.5	18	29.8	1.1
Asgrow	AG2232	2.2	PI 88788	3.3	19	41.3	1.6
Federal Hybrids	F202NR2Y	2.0	PI 88788	2.5	20	34.8	1.5
Dairyland Seed	DSR-1710RR2Y	1.7	PI 88788	2.2	12	32.5	1.1
Dairyland Seed	DSR-1808RR2Y	1.8	PI 88788	3.3	15	31.5	1.1
Footnote Brand	59N42	1.9	PI 88788	2.8	16	37.3	1.1
LATHAM	L234RR2	2.0	PI 88788	2.2	16	40.0	1.5
Legend Seeds	LS 20R20N	2.0	PI 88788	2.6	17	34.5	1.4
Kruger	K2-2303	2.3	PI 88788	2.1	23	40.3	1.9
NK	S23-P8 Brand	2.3	PI 88788	1.9	19	36.0	1.1
Kruger	K2-1902	1.9	PI 88788	2.3	18	36.0	1.4
Federal Hybrids	F212NR2Y	2.1	PI 88788	2.2	18	31.5	1.0
LATHAM	L1886R2	1.8	PI 88788	2.4	12	31.8	1.3
Kruger	K2-2002	2.0	PI 88788	3.4	21	36.8	1.5
G2 Genetics	7226	2.2	Peking	1.8	21	32.8	1.4
Pioneer	92Y11	2.1	Peking	3.2	15	35.3	1.3
Pioneer	92Y51	2.5	PI 88788	2.8	22	40.8	1.8
Stine	22R262	2.2	PI 88788	2.0	17	35.8	1.3
Wenman	W 3200NR2	2.0	PI 88788	2.2	18	33.0	1.3
Asgrow	AG1931	1.9	PI 88788	2.5	13	35.0	1.5
Prairie Brand	PB-2143R2	2.1	PI 88788	2.5	18	37.0	1.4
Wenman	W 3210NR2	2.1	PI 88788	2.4	17	31.8	1.3
G2 Genetics	7203	2.0	PI 88788	2.6	15	33.3	1.3
Asgrow	AG1832	1.8	PI 88788	1.6	17	38.0	1.8
G2 Genetics	7186	1.8	Peking	2.7	12	35.8	1.4
Northstar Genetics	NS1726N	1.7	PI 88788	2.4	13	31.3	1.0
Gold Country	2142RR2Y	2.1	PI 88788	1.9	19	37.3	1.5
HUSOY	HS 24A12	2.4	PI 88788	2.8	21	33.5	1.0
Legend Seeds	LS 19R23N	1.9	PI 88788	2.2	14	34.0	1.6
Mean		2.0		2.5	17	35.3	1.4
LSD ² (P = 0.05)		-	-	-	5.1	0.4	NS
LSD ² (P = 0.10)		-	-	-	4.3	0.3	NS
Asgrow	AG2431	2.4	None	2.3	21	35.8	1.8
NK	S21-N6 Brand	2.1	None	3.1	21	38.3	1.8
Pioneer	92Y21	2.2	None	2.1	19	35.5	1.6
Mean		2.3	-	2.9	20	36.5	1.7

Values presented in tables are means. Entries are listed in decreasing order of yield.

Italicized entries are widely grown SCN-susceptible varieties entered by Iowa State University for comparison purposes.

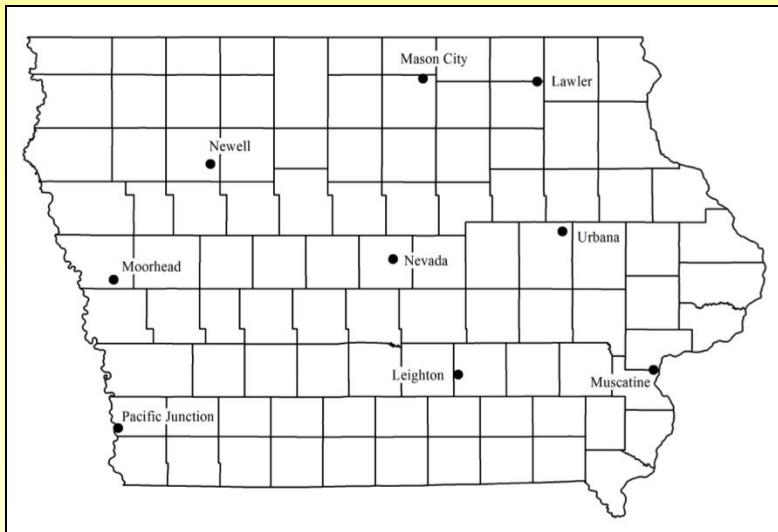
¹ Final SCN egg population density (eggs per 100 cc soil); there were no significant differences among initial SCN population densities; initial SCN population 592 eggs per 100 cc soil; HG Type 2.7 (16.4% on PI 88788, 0.2% on Peking).

² Average final SCN egg population density / average initial SCN egg population density.

³ Least significant difference: values are from Fisher's least significant difference test, NS = no significant differences among the varieties.



Iowa State University SCN-resistant Soybean Variety Trial Program

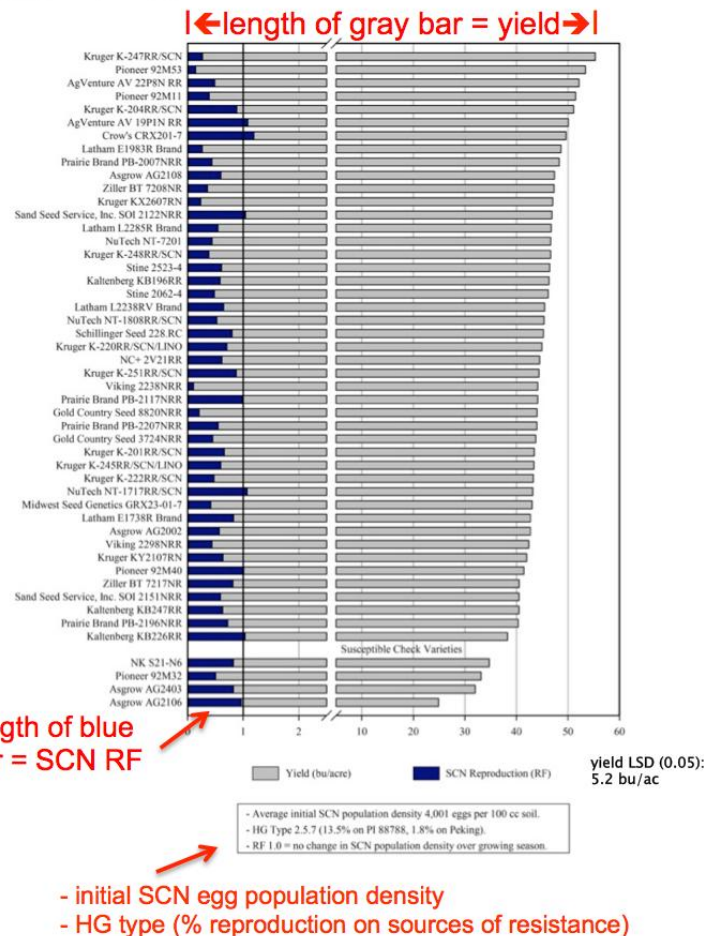


RF = end-of-season SCN number
÷ beginning-of-season SCN
number.

An RF > 1.0 means SCN numbers
↑ during the growing season,
RF < 1.0 means SCN numbers ↓.



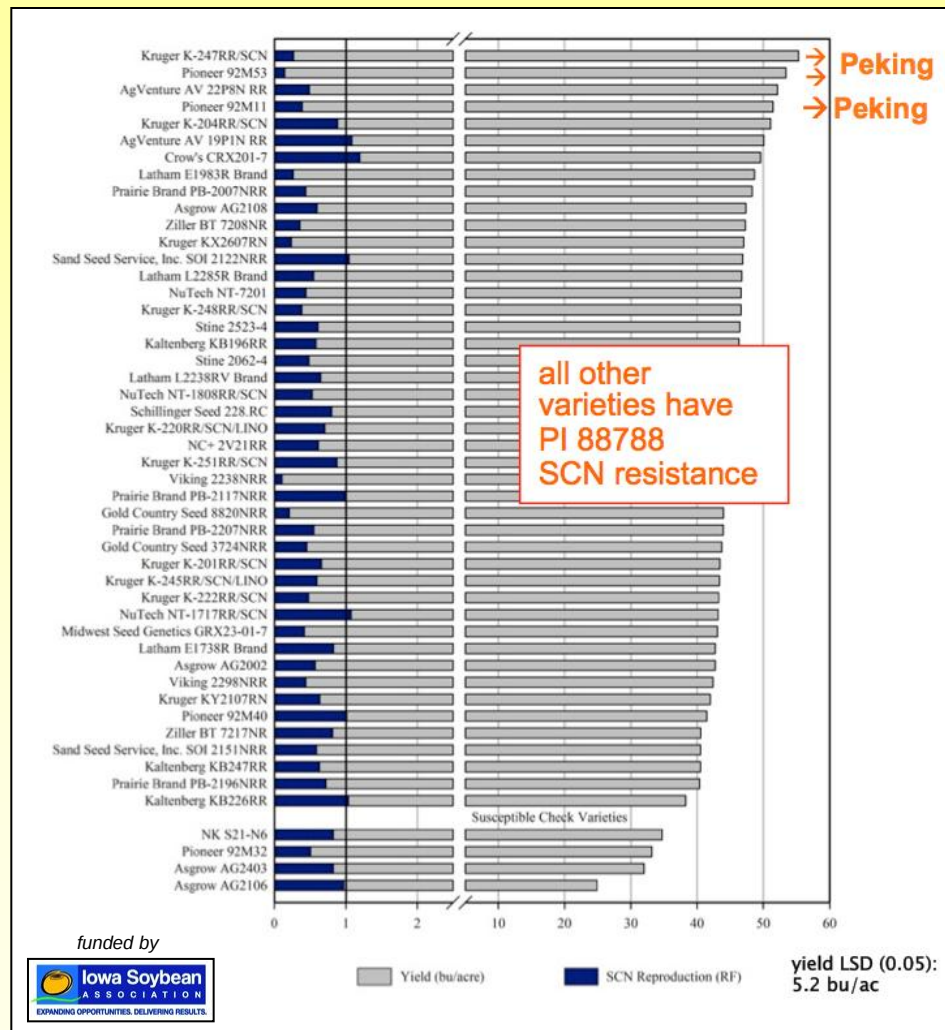
Figure 2. Vincent (NC Iowa) Glyphosate-resistant.



Iowa State University SCN-resistant Soybean Variety Trial Program

In **SOME** fields with SCN populations with >10% reproduction on PI 88788 and <1% reproduction on Peking:

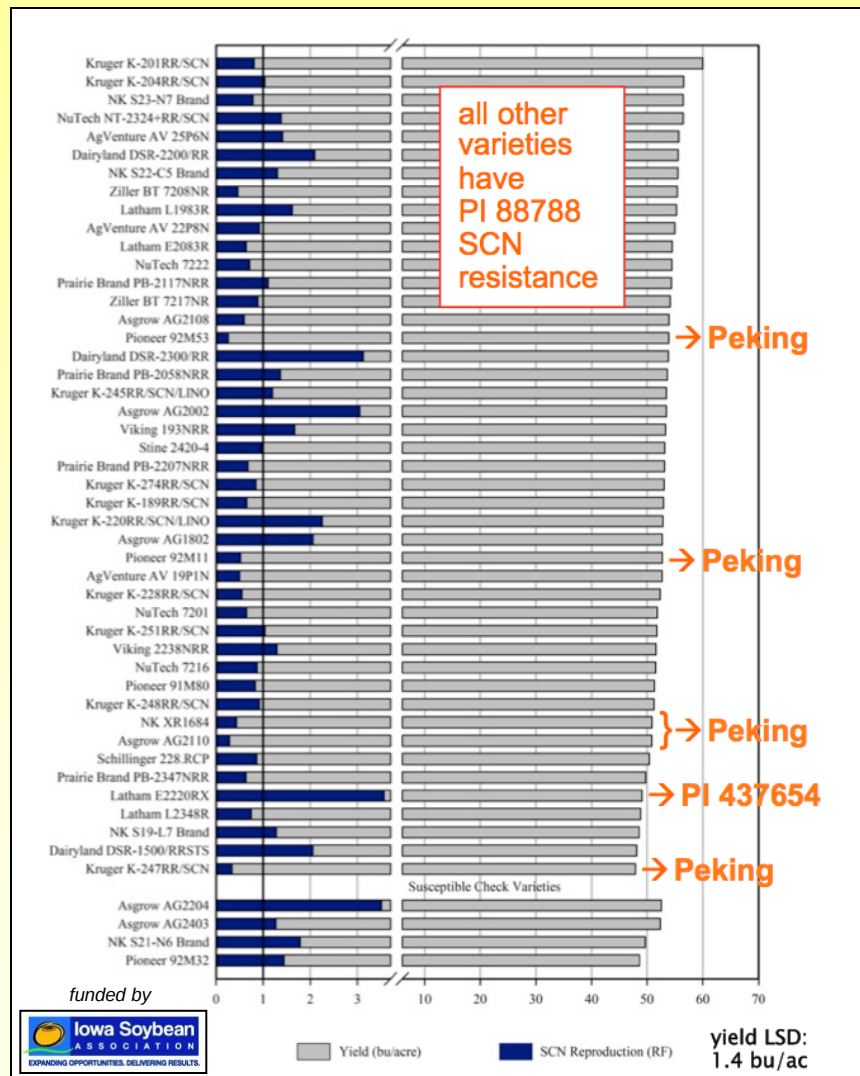
- varieties with Peking resistance yield the best, and varieties with PI 88788 SCN resistance yield significantly less
- SCN numbers do not increase on either source of resistance



Iowa State University SCN-resistant Soybean Variety Trial Program

In **MOST** fields with SCN populations with >10% reproduction on PI 88788 and <1% reproduction on Peking:

- varieties with PI 88788 resistance yield better than varieties with Peking SCN resistance
 - even when reproduction on PI 88788 >35%–50% or more
- SCN numbers increase 2X to 4X on PI 88788, but not Peking



Many (? most ?) SCN populations in the U.S. have
>10% reproduction on PI 88788 resistance.

How does increased SCN
reproduction on PI 88788
resistance affect
soybean yields?

Not
drastically.

HG type test results (or % reproduction)
do not correlate well with yield of SCN-
resistant soybean varieties.



SCN females on roots of a
resistant soybean variety with
PI 88788.

Soybean Cyst Nematode in 2012

U.S. Drought Monitor

Iowa

October 9, 2012

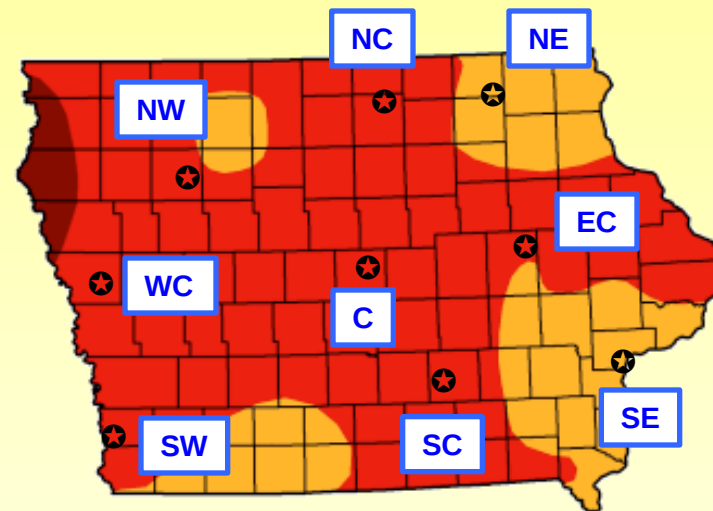
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	100.00	75.31	2.52
Last Week (10/02/2012 map)	0.00	100.00	100.00	100.00	75.31	2.52
3 Months Ago (07/10/2012 map)	0.00	100.00	66.40	12.70	0.00	0.00
Start of Calendar Year (12/27/2011 map)	60.99	39.01	30.33	24.15	0.00	0.00
Start of Water Year (09/25/2012 map)	0.00	100.00	100.00	100.00	65.77	2.52
One Year Ago (10/04/2011 map)	17.09	82.91	43.02	9.92	0.00	0.00

Intensity:

D0 Abnormally Dry	D3 Drought - Extreme
D1 Drought - Moderate	D4 Drought - Exceptional
D2 Drought - Severe	



The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

<http://droughtmonitor.unl.edu>



Released Thursday, October 11, 2012
Matthew Rosencrans, NOAA/NWS/NCEP/CPC



ISU SCN-resistant Soybean Variety Trial Results – – – 2011 versus 2012

	2011				2012			
variety trial location	mean yield (bu/A)		mean SCN RF		mean yield (bu/A)		mean SCN RF	
	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible
NW								
NC								
NE								
<i>district mean</i>								
WC								
C								
EC								
<i>district mean</i>								
SW								
SC								
SE								
<i>district mean</i>								
<i>overall mean</i>								

Approximately 50% of SCN-resistant varieties tested in 2012 were tested in 2011 as well

ISU SCN-resistant Soybean Variety Trial Results – – – 2011 versus 2012

	2011				2012			
variety trial location	mean yield (bu/A)		mean SCN RF		mean yield (bu/A)		mean SCN RF	
	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible
NW	56.8	48.5			44.4	44.3		
NC	49.0	46.2			56.2	46.3		
NE	52.7	45.1			56.8	51.6		
<i>district mean</i>	<i>52.8</i>	<i>46.6</i>			<i>52.5</i>	<i>47.4</i>		
WC	36.2	33.8			62.5	56.6		
C	45.0	43.4			51.0	51.2		
EC	51.2	48.2			57.6	38.2		
<i>district mean</i>	<i>44.1</i>	<i>41.8</i>			<i>57.0</i>	<i>48.7</i>		
SW	---	---			44.1	39.3		
SC	52.6	44.6			46.4	37.6		
SE	45.3	36.2			61.0	50.6		
<i>district mean</i>	<i>49.0</i>	<i>40.4</i>			<i>50.5</i>	<i>42.5</i>		
<i>overall mean</i>	<i>48.6</i>	<i>43.2</i>			<i>53.3</i>	<i>46.2</i>		

ISU SCN-resistant Soybean Variety Trial Results – – – 2011 versus 2012

	2011				2012			
variety trial location	mean yield (kg/ha)		mean SCN RF		mean yield (kg/ha)		mean SCN RF	
	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible
NW	3,787	3,233			2,960	2,953		
NC	3,267	3,080			3,747	3,087		
NE	3,513	3,007			3,787	3,440		
<i>district mean</i>	<i>3,520</i>	<i>3,107</i>			<i>3,500</i>	<i>3,160</i>		
WC	2,413	2,253			4,167	3,773		
C	3,000	2,893			3,400	3,413		
EC	3,413	3,213			3,840	2,547		
<i>district mean</i>	<i>2,940</i>	<i>2,787</i>			<i>3,800</i>	<i>3,247</i>		
SW	---	---			2,940	2,620		
SC	3,507	2,973			3,093	2,507		
SE	3,020	2,413			4,067	3,373		
<i>district mean</i>	<i>3,267</i>	<i>2,693</i>			<i>3,367</i>	<i>2,833</i>		
<i>overall mean</i>	<i>3,240</i>	<i>2,880</i>			<i>3,553</i>	<i>3,080</i>		

ISU SCN-resistant Soybean Variety Trial Results – – – 2011 versus 2012

	2011				2012			
variety trial location			mean SCN RF				mean SCN RF	
			Resistant	Susceptible			Resistant	Susceptible
NW			0.4	1.9				
NC			1.5	3.1				
NE			1.7	7.3				
<i>district mean</i>								
WC			0.5	1.1				
C			12.4	48.3				
EC			2.4	12.7				
<i>district mean</i>								
SW			---	---				
SC			0.6	3.8				
SE			0.8	4.8				
<i>district mean</i>								
			7 of 8 <2.5	6 of 8 <7.5				

RF = end-of-season SCN number ÷ beginning-of-season SCN number.

An RF > 1.0 means SCN numbers ↑
RF < 1.0 means SCN numbers ↓.

The C Iowa experiment in 2011 was in a field with a very unusual HG type or race of SCN that had very high rate of reproduction on resistant and susceptible soybeans. All other 2011 data are representative of what commonly occurs in Iowa.

RF = end-of-season SCN number ÷ beginning-of-season SCN number.

An RF > 1.0 means SCN numbers ↑
RF < 1.0 means SCN numbers ↓.

The C Iowa experiment in 2011 was in a field with a very unusual HG type or race of SCN that had very high rate of reproduction on resistant and susceptible soybeans. All other 2011 data are representative of what commonly occurs in Iowa.

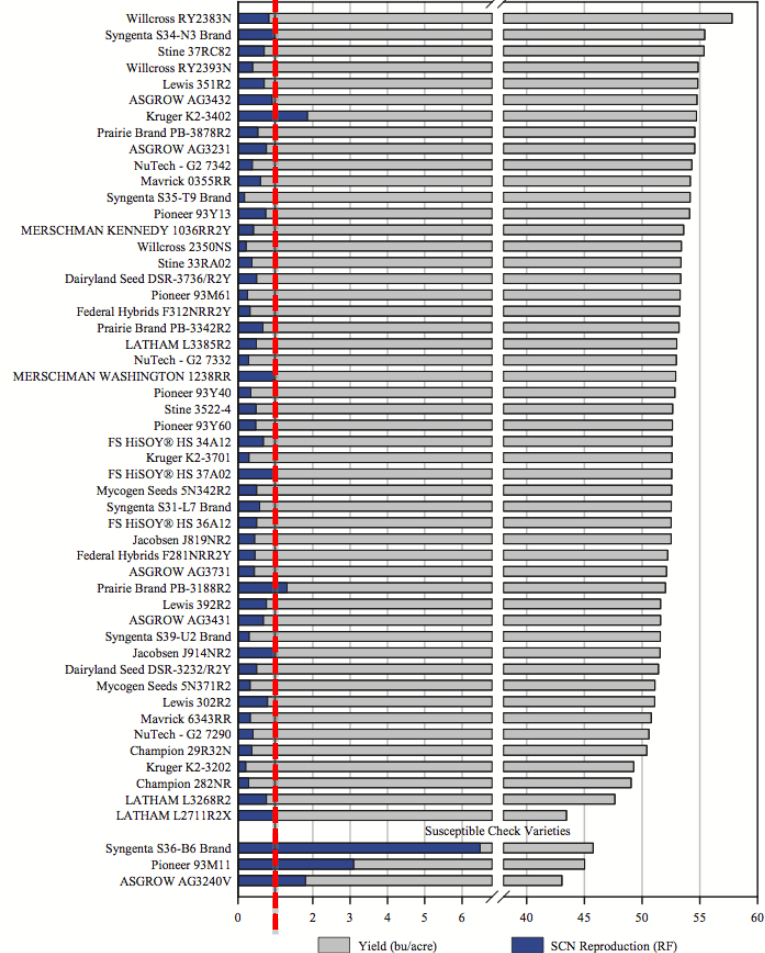
ISU SCN-resistant Soybean Variety Trial Results – – – 2011 versus 2012

	2011				2012			
variety trial location			mean SCN RF				mean SCN RF	
			Resistant	Susceptible			Resistant	Susceptible
NW			0.4	1.9			15.1	43.1
NC			1.5	3.1			8.1	22.7
NE			1.7	7.3			4.0	11.6
<i>district mean</i>								
WC			0.5	1.1			2.1	8.9
C			12.4	48.3			14.7	14.9
EC			2.4	12.7			7.1	41.1
<i>district mean</i>								
SW			---	---			16.6	35.6
SC			0.6	3.8			13.8	15.6
SE			0.8	4.8			6.8	27.3
<i>district mean</i>								
			<i>7 of 8 <2.5</i>	<i>6 of 8 <7.5</i>			<i>8 of 9 ≥4.0 4 of 9 >13.0</i>	<i>7 of 9 >14.9</i>

ISU SCN-resistant Soybean Variety Trial Results – – 2011 versus 2012

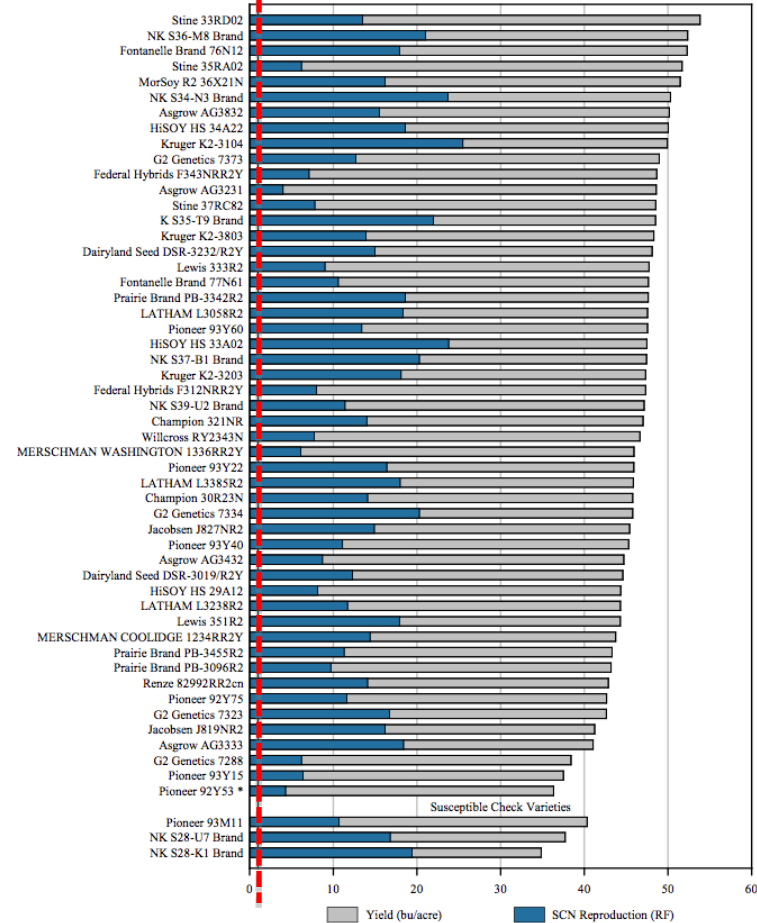
EC Iowa – 2011

~58 bu/Ac or 3,867 kg/ha ↓



EC Iowa – 2012

~52 bu/Ac or 3,467 kg/ha ↓



Soybean Cyst Nematode in 2012

- Yields of SCN–susceptible and SCN–resistant soybean varieties were much, much better than expected in SCN–infested fields during a drought.
- Reproduction of SCN on susceptible and SCN–resistant soybean varieties was EXTREMELY high – much more than observed ever before in field experiments in Iowa.
- The extremely high SCN reproduction did not occur in SCN–resistant soybean varieties with the Peking source of SCN resistance.



Summary

- Many (most) SCN populations in the U.S. have $>10\%$ reproduction on PI 88788.
- Increased SCN reproduction ($>10\%$) on resistant varieties with PI 88788 does not result in serious yield losses.
- SCN reproduction on susceptible and resistant soybean varieties in drought year 2012 in Iowa was extreme.
- Research is being initiated to determine the effects of drought on SCN reproduction.



Thank You

