Breeding for SDS resistance

Dechun Wang, Jason Bond, Pengyin Chen, Silvia Cianzio, Brian Diers, Glen Hartman, Stella Kantartzi, Jim Orf

Outline

- Sources of SDS Resistance
- Quantitative trait loci for SDS resistance
- Methods for SDS resistance evaluation
- Variety Trials in SDS infected fields
- SDS resistant varieties or germplasm developed by public breeding programs

Screen Soybean germplasm for Resistance to Sudden Death Syndrome

Glen L. Hartman

USDA-ARS at the University of Illinois

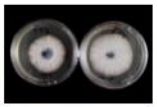
Field plots

Greenhouse tests

Toxin assays

Methods Used in the SDS Field Nursery

- Inoculum increase
- Soil infestation
- Drip irrigation
- Early ratings
- Late ratings
- Root ratings



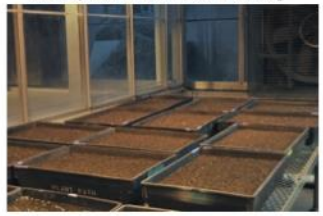



Layering Method Used in the Greenhouse

Use jig to impress furrows and sow seed

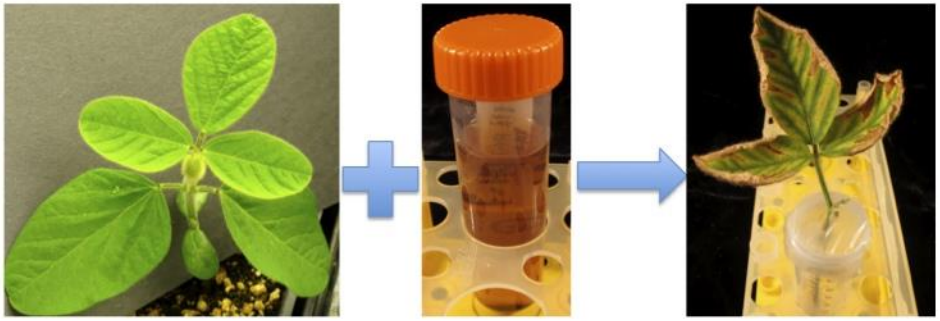
Add more soil and level

2x/day careful overhead watering



Rate in 21-35 days

Stem-Cutting Assay



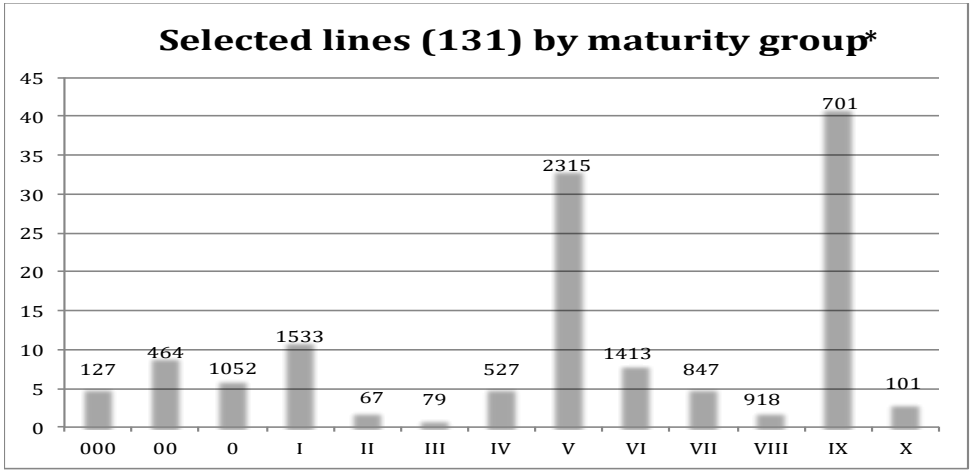
Healthy plants

Cell-free toxic culture filtrate

Stem cutting
SDS foliar symptoms

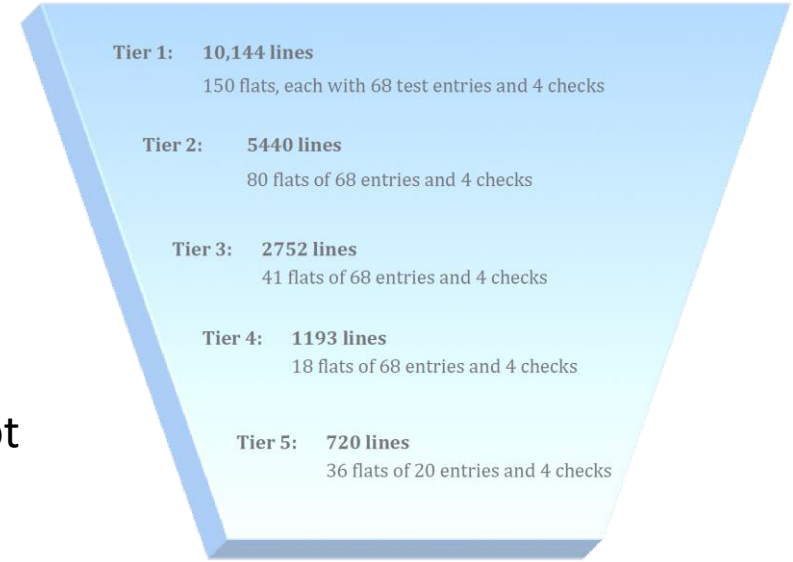
Evaluation of Plant Introductions

- Plant introductions were evaluated in five tiers
- Accessions in the last tier ranged in maturity from early MG 000 to late MG X



*Overlay number is # of lines in each MG in initial set of 10,144 lines

- 131 lines were selected/tested and a list of these lines distributed to cooperators
- A select set of lines is being further tested for root and shoot resistance using the cut-stem assay



Acknowledgements: Theresa Herman and the North Central Soybean Research Program

SDS resistance sources used in public breeding programs

Pengyin Chen (Univ. of AR)	LD06-7862, LS03-4294, LD07-3395bl, LS94-3207, LS09-1803, 5002T PI 594696 A, PI 423760, PI 417166
Silvia Cianzio (Iowa State)	LS94-3207, LS98-0582, LS99-285-2235, RxEF59-70, Ripley, MN1606 PI 594074; PI 592915; PI 189955; PI 253658C; PI 458168; PI 438461
Brian Diers (Univ. of Illinois)	Ripley, PI 88788, Hartwig, PI 567374
Stella Kantartzi (S. Illinois Univ.)	Peking, PI 88788 past SIU lines with SDS resistance
Dechun Wang (Michigan State)	GD2422, E07080, E09014, E09088, LD01-5907, LD02-4485 PI 88788

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- Sources of SDS Resistance
- Quantitative trait loci for SDS resistance
- Methods for SDS resistance evaluation
- Variety Trials in SDS infected fields
- SDS resistant varieties or germplasm developed by public breeding programs

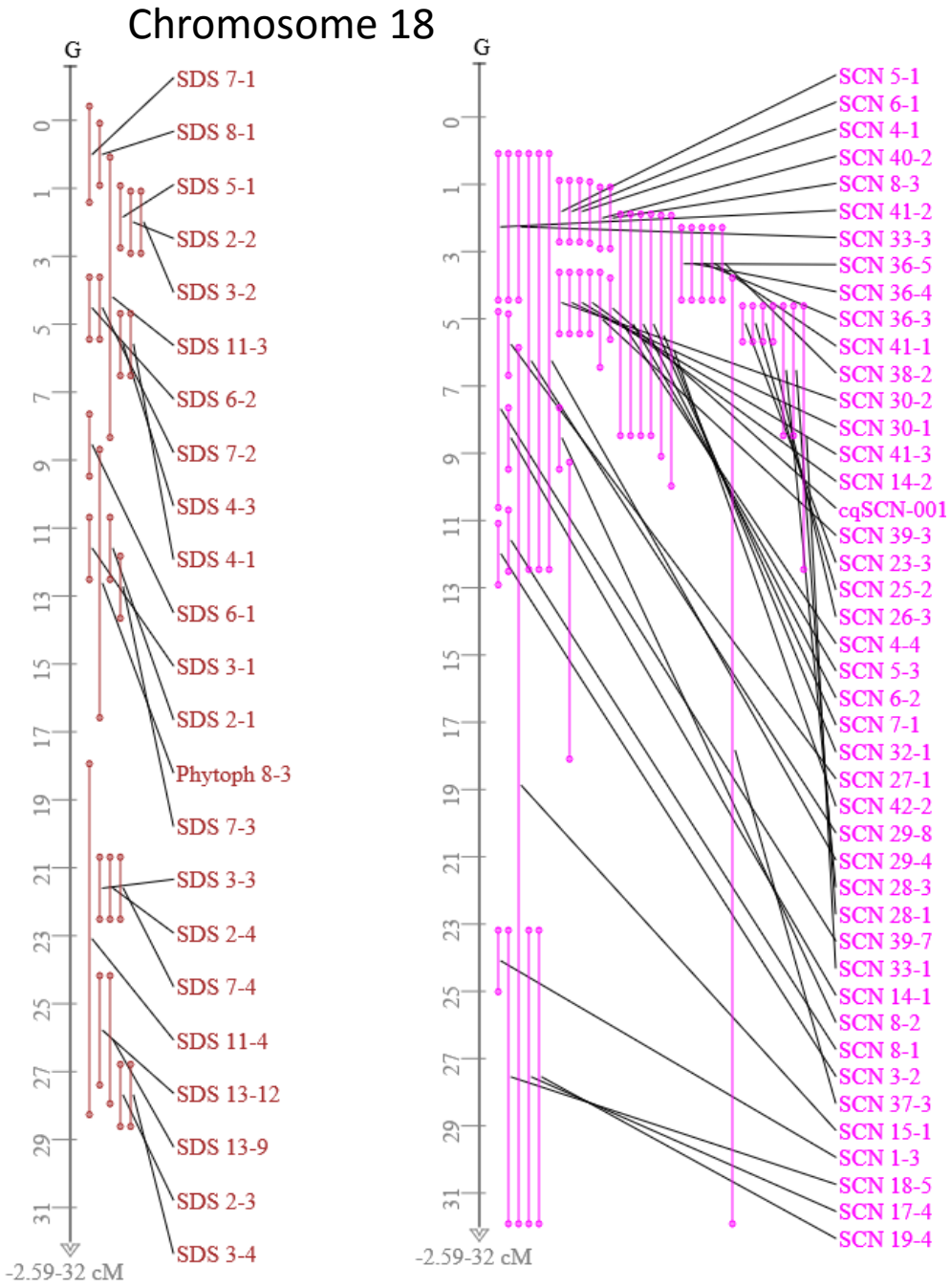
Quantitative trait loci for SDS resistance listed in Soybase

Year published (Authors)	Parents of mapping Populations		Population type	QTL	LG	CHR	Position(cM)	
	Susceptible	Resistant					Start	End
1996 (Hnetkovsky et al.)	Essex	Forrest	F5:7RIL, F5:11 RIL	SDS1-1	C2	6	149.00	151.00
				SDS1-2	N	3	135.00	137.00
				SDS1-3	C2	6	131.00	133.00
				SDS1-4	N	3	113.00	115.00
1996 (Chang et al.)	Essex	Forrest	F5:11 RIL	SDS2-1	G	18	10.60	12.60
				SDS2-2	G	18	1.00	3.00
				SDS2-3	G	18	26.70	28.70
				SDS2-4	G	18	20.60	22.60
				SDS2-5	C2	6	149.00	151.00
				SDS2-6	C2	6	131.00	133.00
				SDS2-7	N	3	135.00	137.00
				SDS2-8	N	3	113.00	115.00
1996 (Chang et al.)	Essex	Forrest	F5:11 RIL	SDS3-1	G	18	10.60	12.60
				SDS3-2	G	18	1.00	3.00
				SDS3-3	G	18	20.60	22.60
				SDS3-4	G	18	26.70	28.70
1998 (Njiti et al.)	Essex	Forrest	F5:13 RIL	SDS4-1	G	18	4.60	6.60
				SDS4-2	G	18	131.00	133.00
				SDS4-3	G	18	4.60	6.60
1999 (Prabhu et al.)	Flyer	Hartwig	F5:6 RIL	SDS5-1	G	18	0.84	2.84
				SDS5-2	A2	8	53.20	55.20
1999 (Meksem et al.)	Essex	Forrest	F5:9:13 RIL	SDS6-1	G	18	7.56	9.56
				SDS6-2	G	18	3.53	5.53
2001 (Iqbal et al.)	Essex	Forrest	RIL,	SDS7-1	G	18	-1.50	1.50
				SDS7-2	G	18	3.53	5.53
				SDS7-3	G	18	11.74	13.74
				SDS7-4	G	18	20.60	22.60
				SDS7-5	C2	6	144.48	146.48
				SDS7-6	I	20	45.22	47.22
2002 (Njiti et al.)	Douglas	Pyramid	F6:10 RIL	SDS8-1	G	18	-1.00	1.00
				SDS8-2	C2	6	120.27	122.27
				SDS8-3	N	3	44.14	46.14

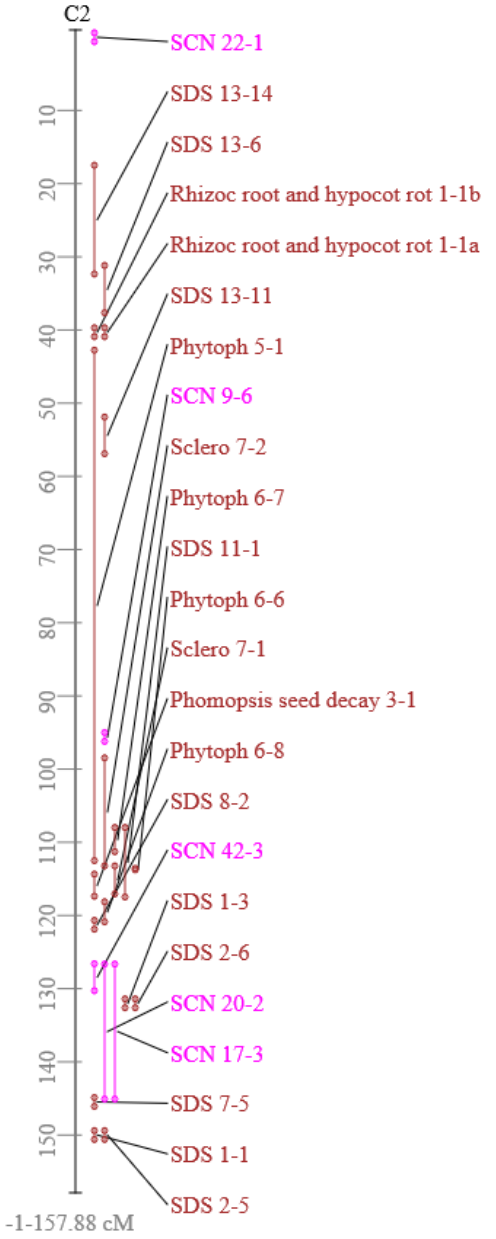
Quantitative trait loci for SDS resistance listed in Soybase (Cont'd)

Year published (Authors)	Parents of mapping Populations		Population type	QTL	LG	CHR	Position(cM)	
	Susceptible	Resistant					Start	End
2006 (Njiti and Lightfoot.)	Minsoy	Nior 1	F7:14	SDS9-1	L	19	77.23	79.23
				SDS9-2	L	19	91.00	93.00
				SDS9-3	C1	4	89.72	91.72
2007 (Neto et al.)	Spencer	Ripley	F5:8 NIL	cqSDS-001	D2	17	76.69	85.15
2008 (Kazi et al.)	Flyer	Hartwig	F5 RIL	SDS11-1	C2	6	107.58	117.87
				SDS11-2	D2	17	87.66	92.12
				SDS11-3	G	18	0.00	8.42
				SDS11-4	G	18	17.85	28.35
				SDS11-5	G	18	43.77	51.68
2012 (Abdelmajid et al.)	Hamilton	PI438489B	F6:13 RIL	SDS13-1	D1a	1	29.15	45.75
				SDS13-2	O	10	13.28	15.06
				SDS13-3	L	19	41.00	49.40
				SDS13-4	D1b	2	18.75	21.44
				SDS13-5	D1b	2	30.23	35.75
				SDS13-6	C2	6	30.79	38.04
				SDS13-7	A2	8	2.00	13.00
				SDS13-8	B1	11	5.07	16.70
				SDS13-9	G	18	24.09	28.03
				SDS13-10	N	3	38.20	42.85
				SDS13-11	C2	6	51.50	57.30
				SDS13-12	G	18	24.09	27.48
				SDS13-13	A2	8	14.99	27.90
				SDS13-14	C2	6	17.10	32.74
				SDS13-15	C1	4	57.30	83.90

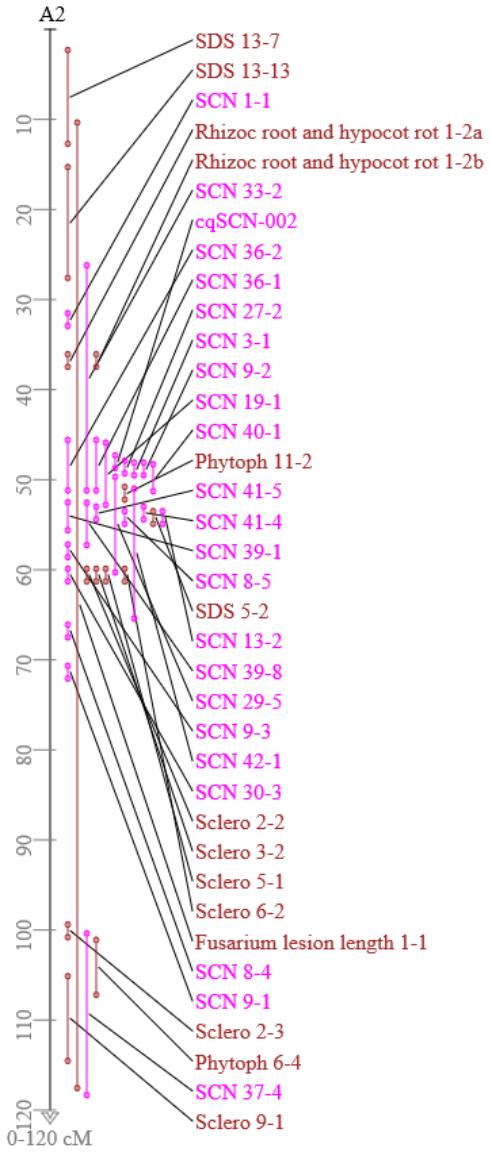
- SDS resistance QTLs were identified
  - in multiple studies on Linkage Groups (Chromosomes) G (18), C2 (6), N (3), C1(4), D1b(2), L(19), D2 (17), and A2(8)
  - in a single study on Linkage Groups (Chromosomes) B1(11), D1a(1), I(20), and O(10).
- SDS resistance QTLs often co-located with QTLs for resistance to SCN or other root diseases



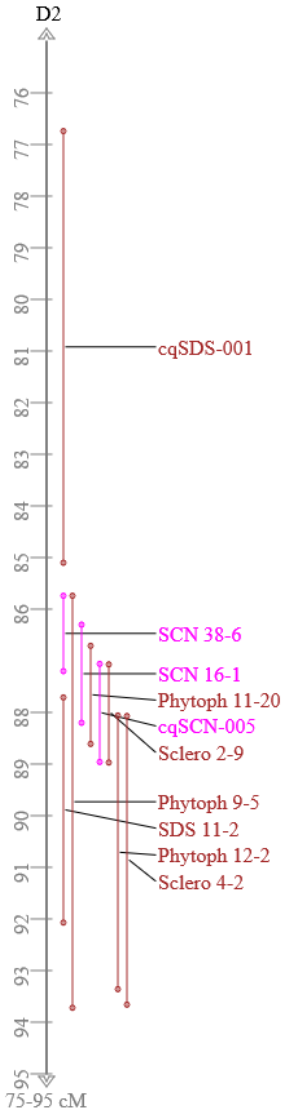
Chromosome 6



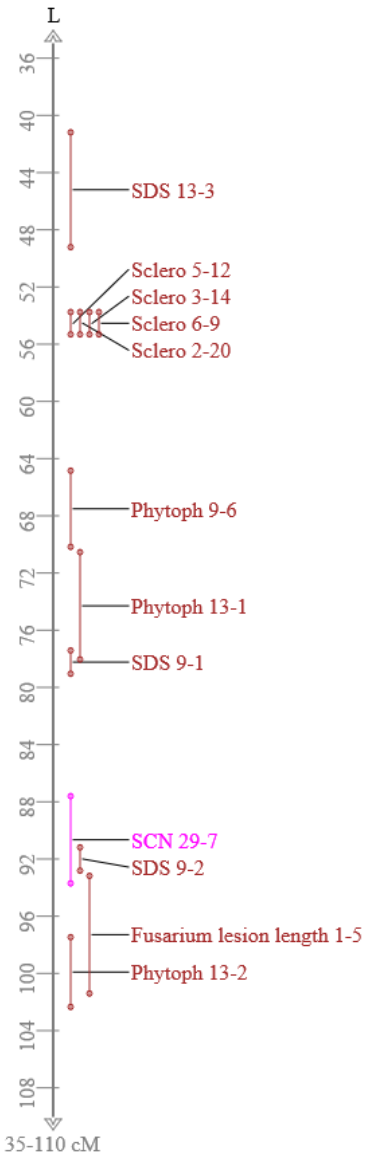
Chromosome 8



Chromosome 17

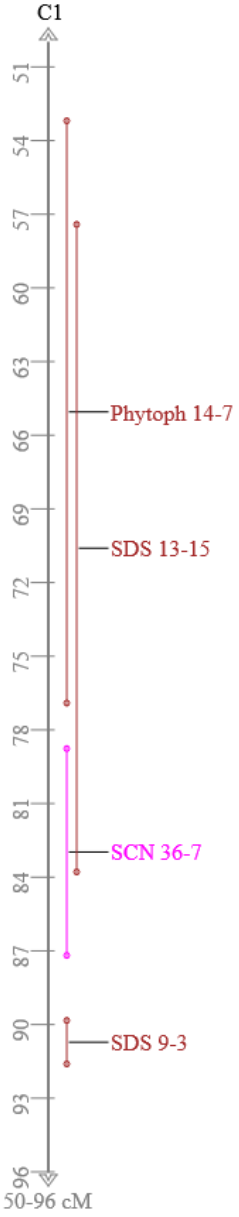


Chromosome 19

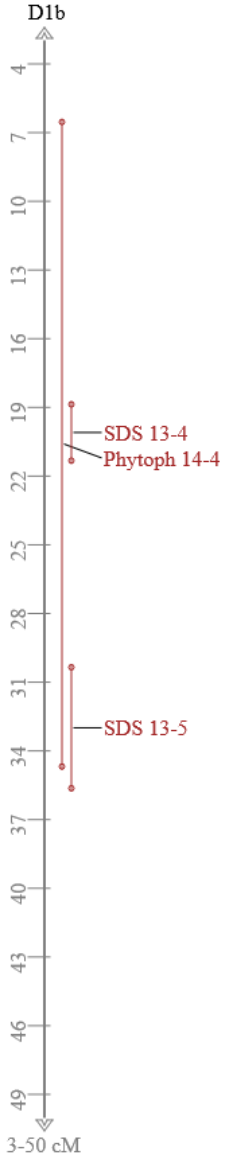


Chromosome 3

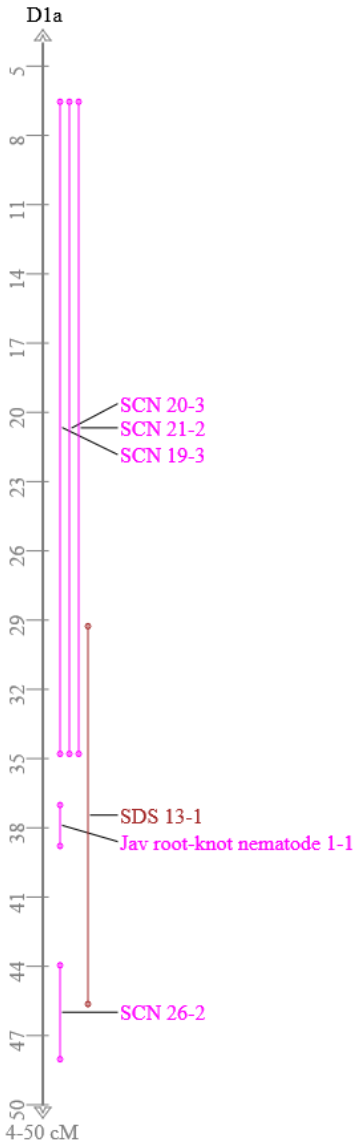
Chromosome 4



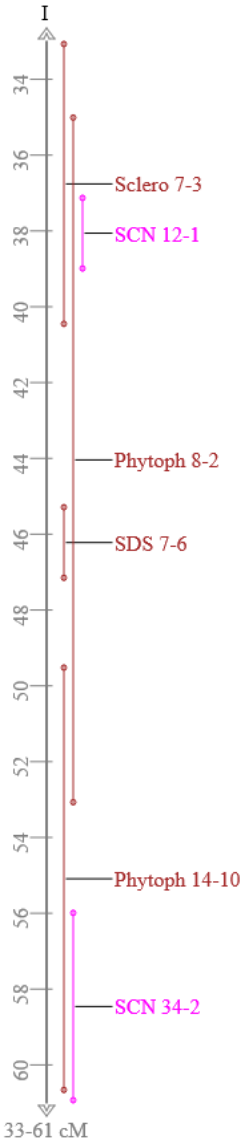
Chromosome 2



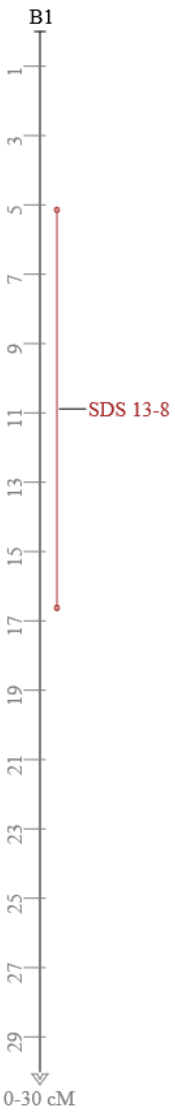
Chromosome 1



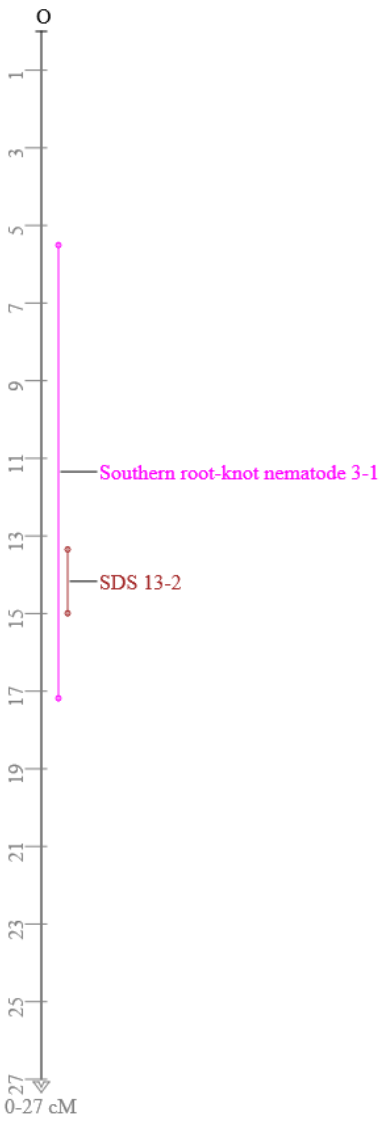
Chromosome 20



Chromosome 11



Chromosome 10



Confirmation of the effect of previously mapped SDS resistance QTL

Lillian Brzostowski (UIUC), Jason Bond (SIU), Brian Diers (UIUC), Glen Hartman (UIUC/USDA-ARS), Dechun Wang (MSU)

Project Overview

- **6 NILs segregating for 4 QTLs of interest have been developed**

Parentage of Test (Elite x Donor)	QTL	MG	Total Entries	Years Planted
LD02-4485(5) x PI567374	chr 17	2.6	40	2012, 2013, 2014
LD02-4485(5) x Ripley	chr 10	2.6	52	2013, 2014, 2015
LD01-5907(5) x PI567374	chr 17	3.8	48	2013, 2014, 2015
Spencer(3) x PI507371	chr 1	4.0	52	2013, 2014, 2015
Spencer(3) x PI507371	chr 18	4.0	38	2013, 2014, 2015
LD00-3309(5) x PI567374	chr 17	4.0	40	2012, 2013, 2014

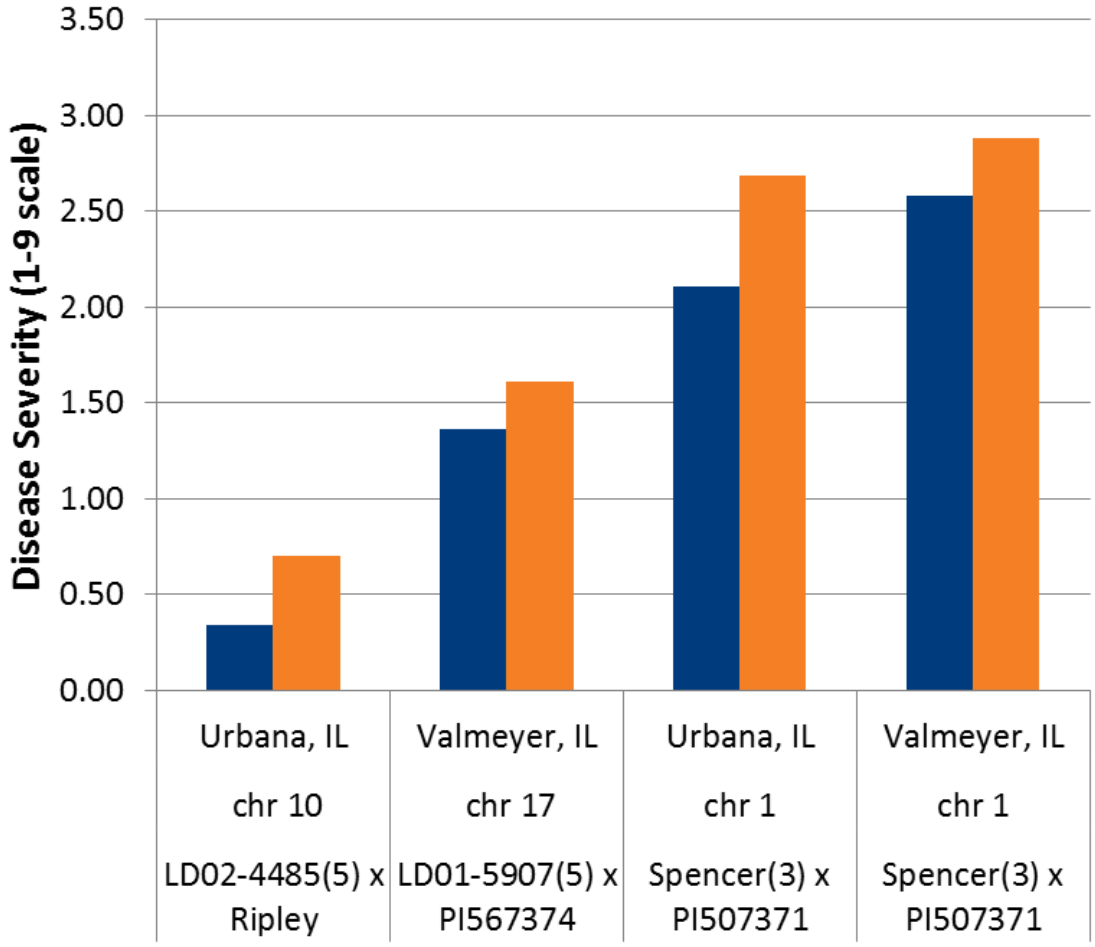
- **Replicated 2 row tests planted at inoculated locations in IL (3 locations) and MI (1 location)according to MG**
- **Foliar symptoms (severity, incidence) rated ~R6**

Results Overview

			# of locations where QTL confirmed (disease severity)			
Parentage of Test	**QTL**	**MG**	**2012**	**2013**	**2014**	**2015**
LD02-4485(5) x PI567374	**chr 17**	**2.6**	**2**	**1**	**0**	**--**
LD02-4485(5) x Ripley	**chr 10**	**2.6**	**--***	**0**	**1**	**0**
LD01-5907(5) x PI567374	**chr 17**	**3.8**	**--**	**0**	**1**	**0**
Spencer(3) x PI507371	**chr 1**	**4.0**	**--**	**2**	**2**	**0**
Spencer(3) x PI507371	**chr 18**	**4.0**	**--**	**0**	**0**	**0**
LD00-3309(5) x PI567374	**chr 17**	**4.0**	**0**	**1**	**0**	**--**

*-- indicates test not planted this year

Significant differences in disease severity between lines in 2014 SDS tests



Score	Description of foliar symptoms (DS)
1	1-10% of leaf surface chlorotic, or 1-5% necrotic
2	10-20% of leaf surface chlorotic, or 6-10% necrotic
3	20-40% of leaf surface chlorotic, or 11-20% necrotic
4	40-60% of leaf surface chlorotic, or 21-50% necrotic
5	>60% of lead surface necrotic or >40% necrotic
6	up to 33% premature defoliation
7	up to 66% premature defoliation
8	>66% premature defoliation
9	premature plant death

Results from SDS QTL mapping studies at Michigan State University

Ruijuan Tan, Paul Collins, Zixiang Wen, Martin Chilvers, Dechun Wang

NCSRP NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

The North Central Soybean Research Program, a collaboration of 12 state soybean associations, invests soybean checkoff funds to improve yields and profitability via university research and extension.

MICHIGAN STATE UNIVERSITY | AgBioResearch

Project GREEEN

MSPC

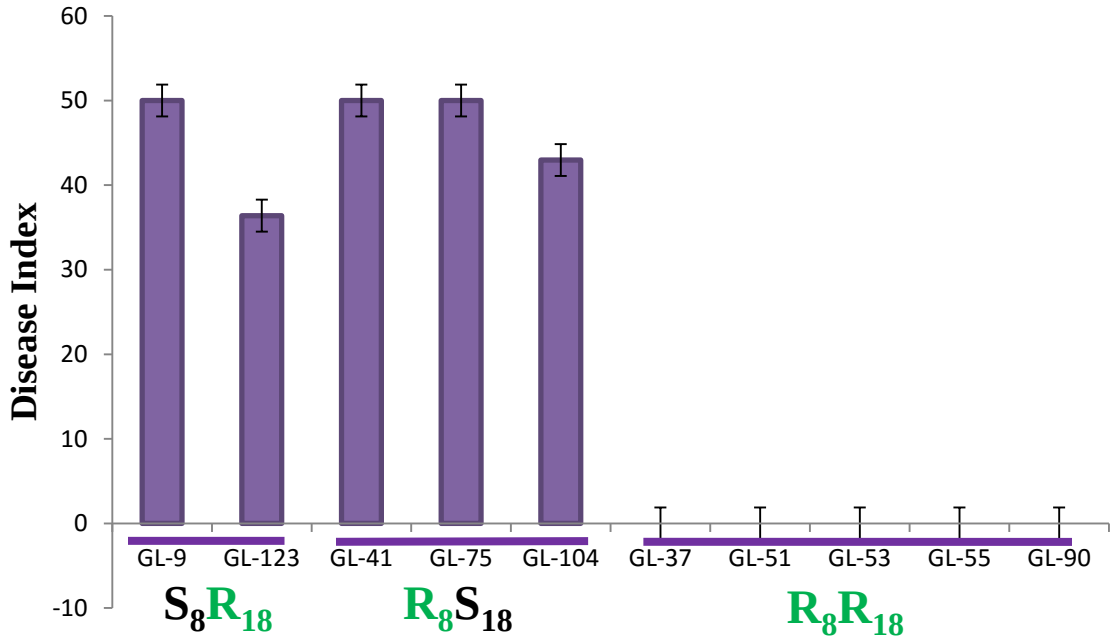
MICHIGAN SOYBEAN PROMOTION COMMITTEE

Two QTLs with interaction were identified from resistance source LD01-5907.

QTL (pair)	Type	LG/Chr.	cM	LOD		R^2(%)	
				DI-2011	DI-2012	DI-2011	DI-2012
QTL-8	A	A2/8	83.51	13.95	13.71	16.1	19.7
QTL-18	A	G/18	6.11	26.52	18.68	40.4	31.9
QTL-8xQTL-18	AA			17.73	14.15	19.5	17.4

76%

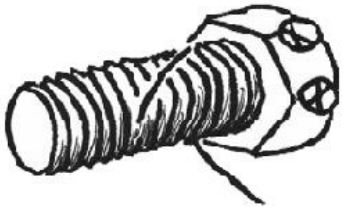
69%



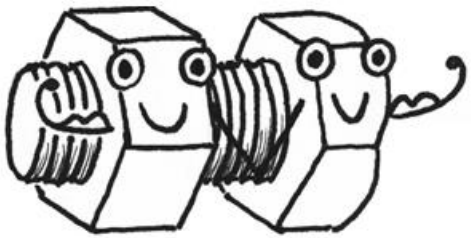
How do they perform in the field?

QTL-8

QTL-18



QTL8+18



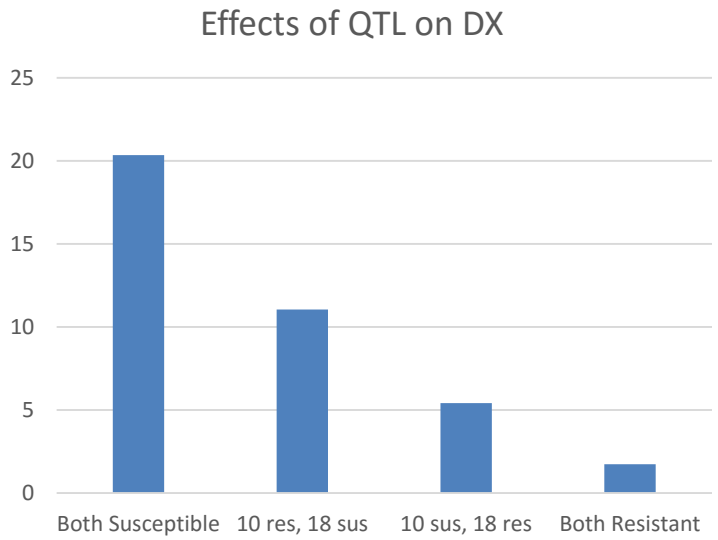
One QTL was identified from resistance source E07080

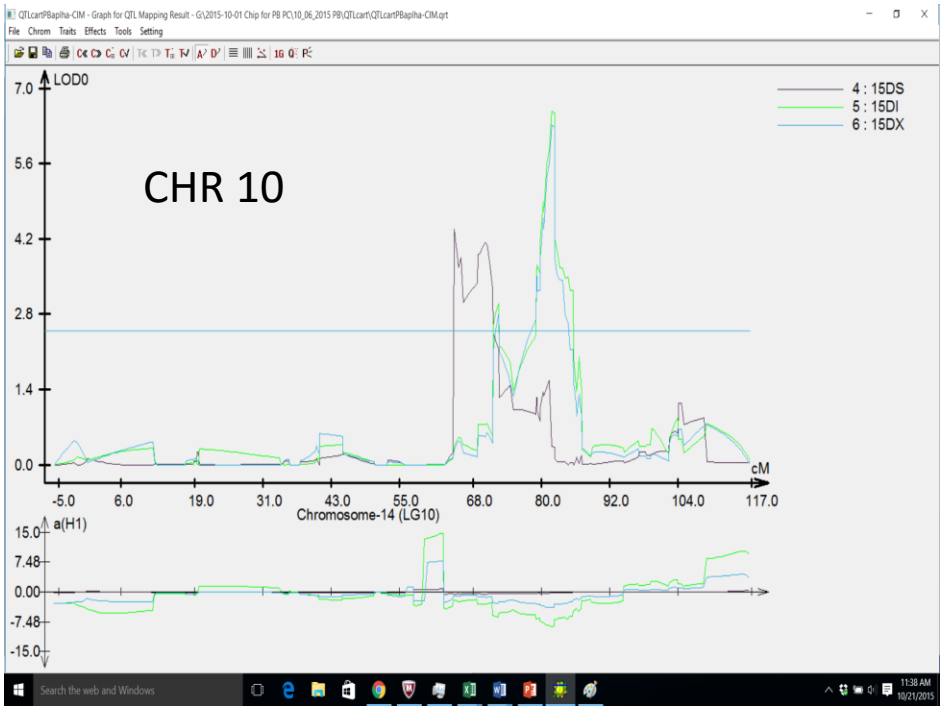
Trait	LG	CHR	SNP-left	Pos	cM	SNP-right	Pos	LOD	A	R2 (%)
DEC-2013 (DX1)	C2	6	ss245879277	14046386	125.91	ss245882767	14422176	3.41	2.53	6.1
DEC-2013(DI2) CAM-2014(DI)	C2	6	ss245882767	14422176	126.31	ss245883126	14452107	9.80	8.76	18.6
DEC-2013(DS1 DI1 DX2) DEC-2014 (DI DX)	C2	6	ss245883126	14452107	126.71	ss245884360	14654119	6.23	3.41	11.2
DEC-2013(DS2)	C2	6	ss245884120	14622806	126.91	ss245885261	14723461	3.60	0.29	7.0
CAM-2013 (DS DI DX) CAM-2014 (DS)	C2	6	ss245885990	14781215	127.71	ss245887495	14903188	7.62	3.84	15.2
DEC-2014 (DX)	C2	6	ss245888974	15037240	135.61	ss245896795	15713384	4.05	3.42	8.1
CAM-2014 (DS DI)	C2	6	ss245896795	15713384	135.81	ss245900960	16039202	6.63	0.42	13.1

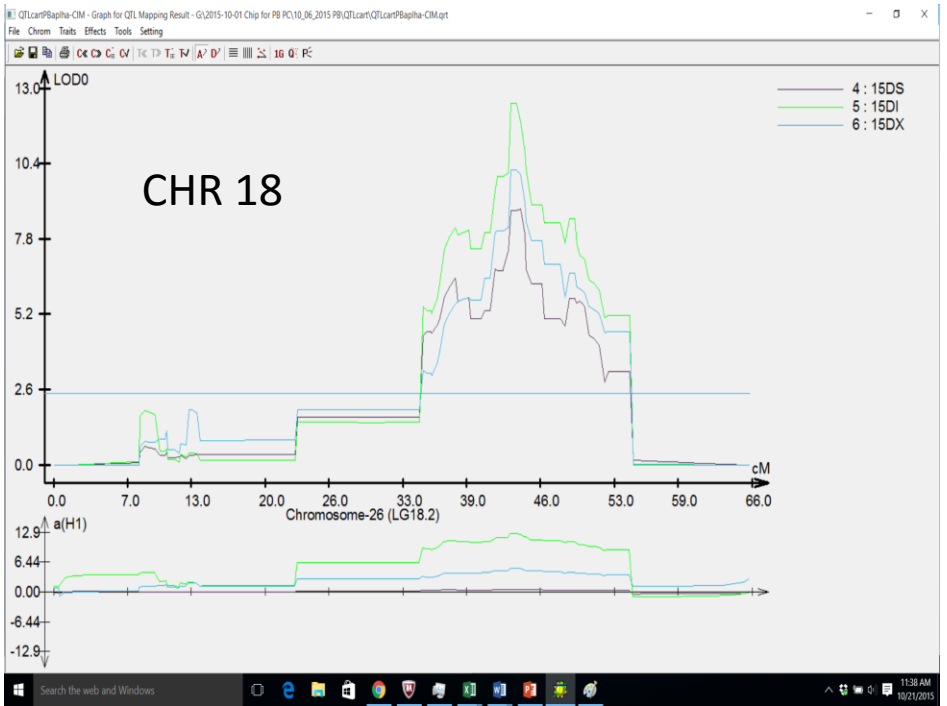
	cM	Mb	Resistance source	R^2(%)
QTL-6	125.91-135.81	14.0-116.0	E07080	6.0-18.6

QTLs from E09014 & E09088

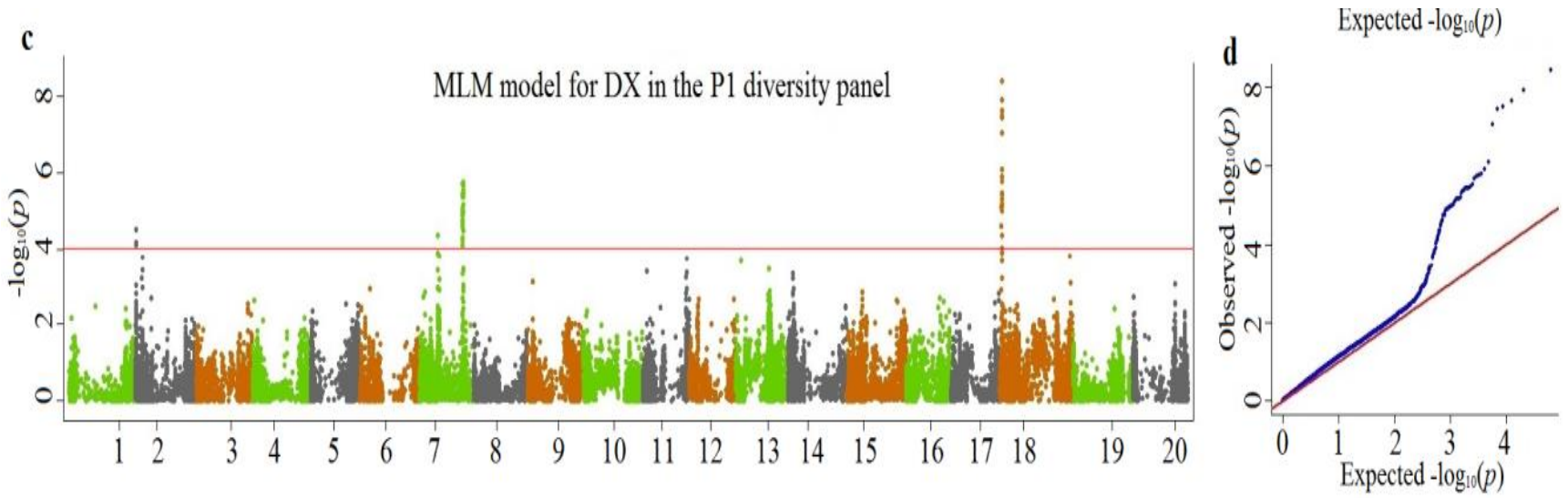
- A total of 34 QTL identified
  - QTLs on Chromosome 10 and 18 identified across multiple years and/or populations
  - Chromosome 10 novel, explains up to 12.5% phenotypic variance
  - Chromosome 18 co-localizes with GmRLK18-1 , a gene cloned by Srour et al. 2012 and demonstrated to provide partial resistance to SDS
    - Confirms our methods
- Lines with both QTLs most resistant to SDS





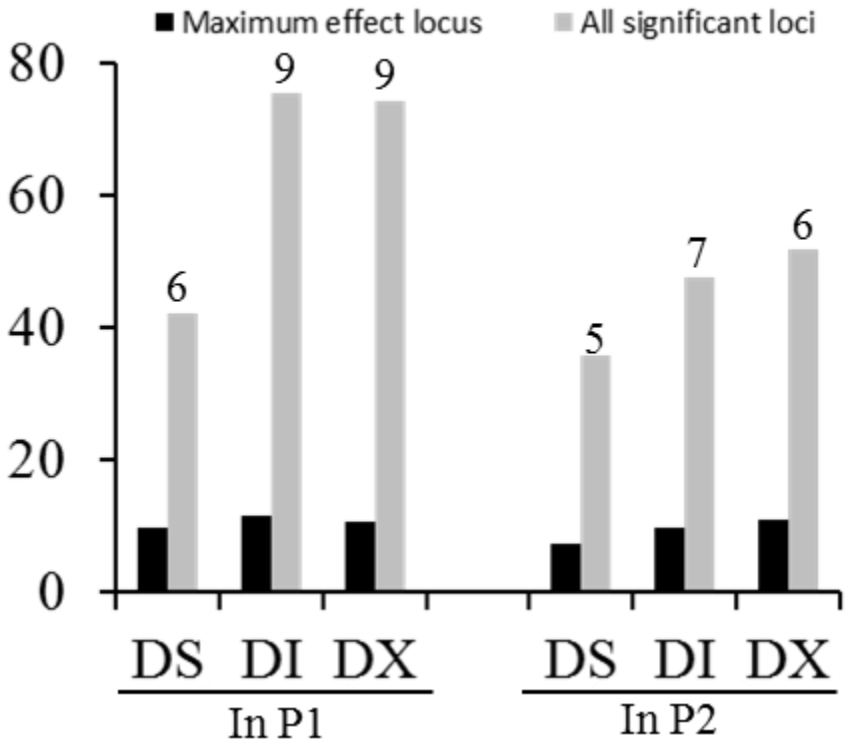


Genome-wide association mapping of quantitative resistance to sudden death syndrome in soybean



56 SNP in nine genomic regions were found significantly associated with DX (disease index)

Wen et al. BMC Genomics 2014, 15:809.



Contributions of identified loci to phenotypic variance of DS, DI and DX. Numbers of loci used to estimate contributions to phenotypic variance are indicated at ends of bars.

The peak SNPs at the identified loci explained approximately 54.5% of the phenotypic variance on average (ranging from 35.7% to 75.4% for different disease assessment criteria)

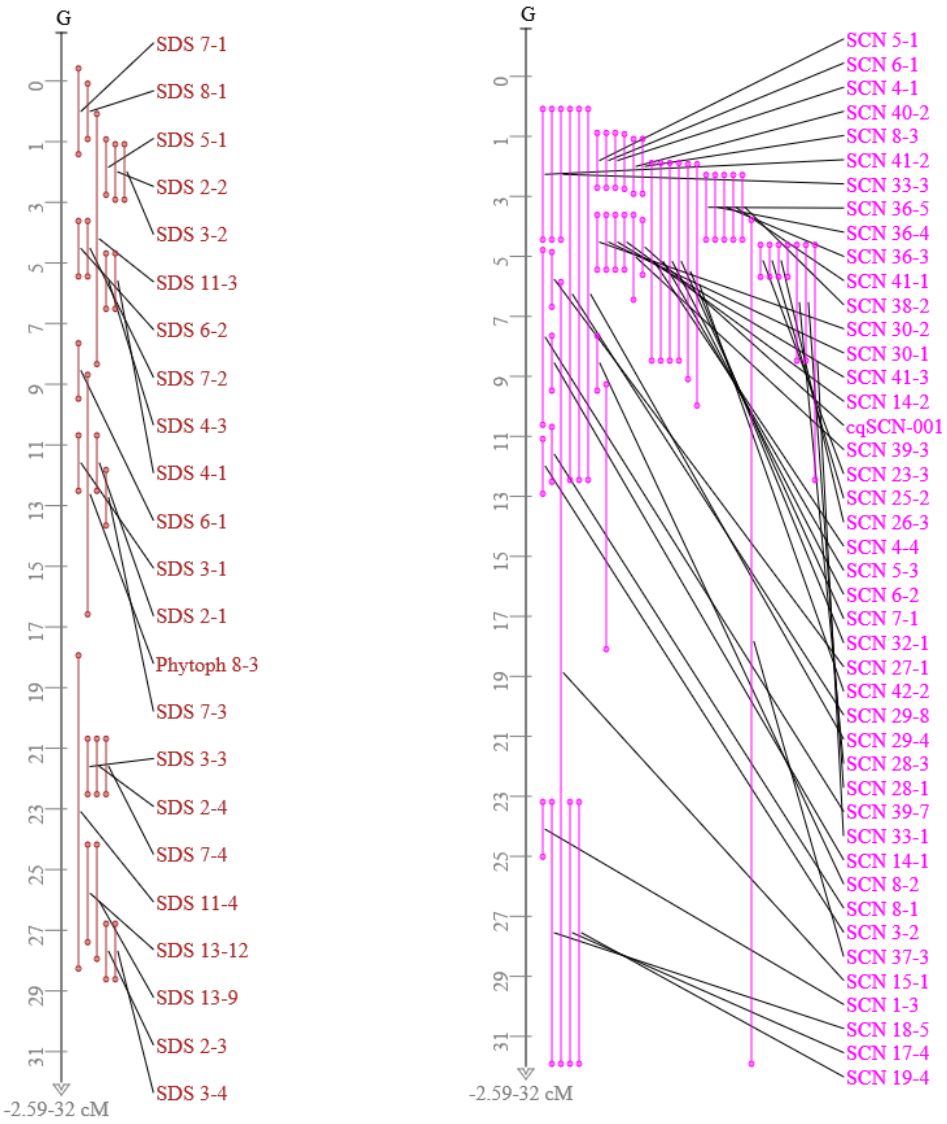
A subset of SNPs significantly associated with SDS resistance and the linked candidate genes

Trait	SNP	Chr[a]	Position[b]	*P*	R^2(%)	QTL[c]	Candidate genes[e]
DX(P1)	Gm02-707483	2	707483	3.07×10^{-5}	5.6	N[d]	PPR repeat [common disease resistance genes,39]
DI(P2)	ss244884978	2	49773810	3.60×10^{-4}	6.4	[40]	Cellulose synthase [disease resistance genes,41]
DX(P2)	ss245842048	6	8979504	8.15×10^{-5}	7.7	N	Phosphatidylinositol kinase [immune responses,42]
DX(P2)	ss246038868	6	43945601	3.37×10^{-5}	5.7	[43]	LRR gene [pathogen recognition,44]
DX(P1)	Gm07-15654480	7	15654480	4.36×10^{-5}	5.5	N	Oxysterol binding protein [upregulated in defense response,45)
DS(P1)	Gm07-36959086	7	36959086	8.86×10^{-6}	6.5	N	Ubiquitin-like protein [upregulated in defense response,46)
DX(P2)	ss246580442	8	18469361	8.85×10^{-7}	10.9	N	Zinc finger [disease resistance genes,47]
DX(P2)	ss246585278	8	18840490	3.55×10^{-5}	8.1	N	F-box [defense response,48]
DI(P1)	Gm09-43648118	9	43648118	6.90×10^{-5}	11.6	N	Phosphopantetheine [disease response,49]
DI(P1)	Gm11-37426559	11	37426559	2.23×10^{-5}	5.6	N	Amino acid transporter [disease resistance genes， 50]
DI(P1)	Gm13-4584015	13	4584015	3.50×10^{-6}	7.2	[51]	LRR gene [pathogen recognition,44]
DX(P2)	ss248117124	13	33655223	86×10^{-4}	5.7	N	Serine/threonine protein kinase [disease defense response,38]
DI(P1)	Gm14-4636247	14	4636247	6.53×10^{-5}	5.3	N	Ascorbate oxidase gene [upregulated in defense response,52]
DI(P2)	ss248566590	15	5978279	7.98×10^{-4}	5.8	N	Molecular chaperone [plant defense response,53]
DX(P1)	ss248698930	15	20239752	6.33×10^{-5}	7.7	N	Serine/threonine protein kinase [disease defense response,38]
DX(P2)	ss249511029	18	1611921	8.04×10^{-6}	9.3	[43]	Hypoxia induced protein [disease defense signaling,54]
DX(P1)	Gm18-1709751	18	1709751	3.79×10^{-9}	10.6	[43]	Receptor like kinase [disease resistance genes,11]
DI(P2)	ss249517154	18	2113196	4.04×10^{-5}	8.3	[43]	unknown
DI(P2)	ss249520656	18	2434513	6.9×10^{-6}	9.5	[55]	Glycosyltransferase [disease resistance genes,56]
DI(P1)	Gm19-34890716	19	34890716	2.16×10^{-5}	5.8	N	Cupins superfamily protein

Wen et al. BMC Genomics 2014, 15:809.

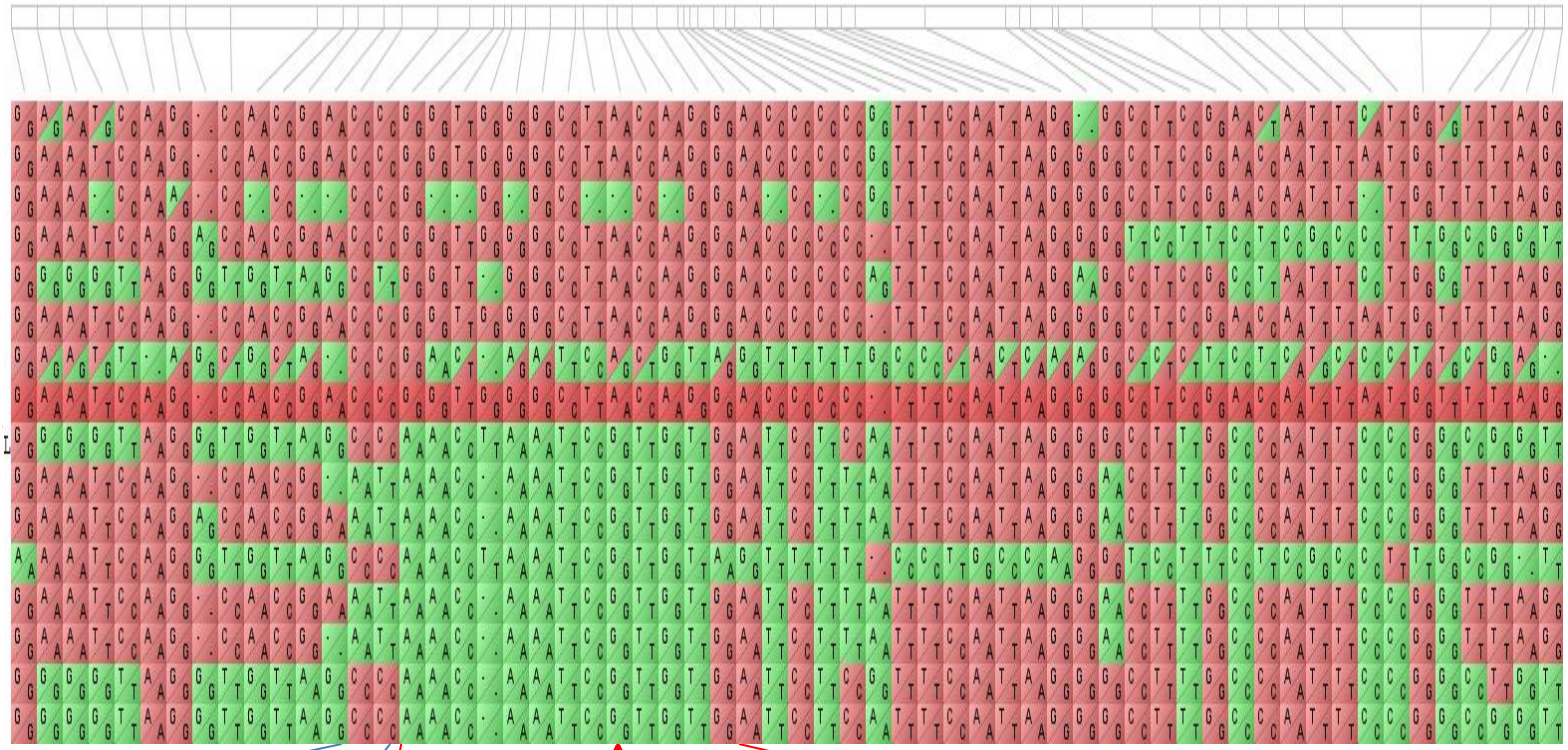
- SDS resistance QTLs often co-located with QTLs for resistance to SCN or other root diseases

Chromosome 18

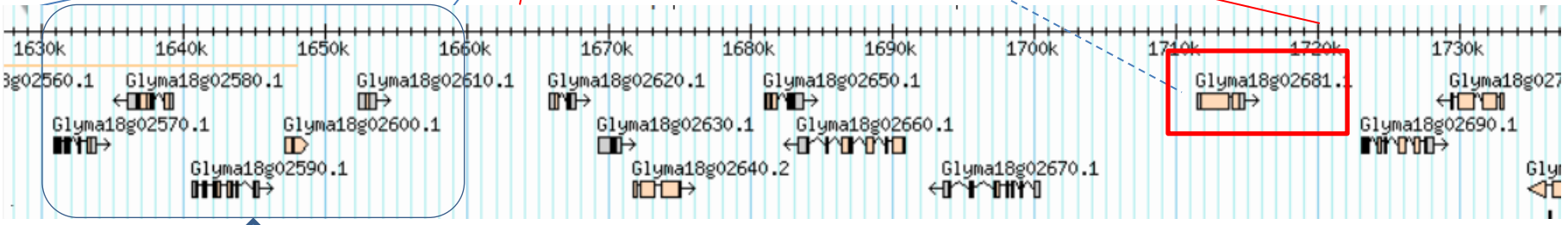


CHR 18: *rhg1* region

Variety	DS	DI	DX
E11131	0	0	0
E11103	0.8	47.5	7.9
E11128	1	7.5	1.7
30Z30	1	13.3	2.2
Strike3012	1.2	6.7	2.6
E09014	1.3	3.8	1.7
E11101	1.3	25	6.9
E07080	1.5	37.5	7.2
3248L	8	100	88.9
HS24RY05	8	100	88.9
SR-2411	8	100	88.9
E10152	8	100	88.9
RS241R2	8.2	100	90.7
GL2345R2	8.2	100	90.7
E11255	8.5	100	94.4
DF9261LL	8.7	100	96.3



Peak SNP for SDS Resistance



rhg1 SCN resistance gene

Outline

- Sources of SDS Resistance
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- Methods for SDS resistance evaluation
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- SDS resistant varieties or germplasm developed by public breeding programs

Roadblocks to good SDS Phenotypes - Brian Diers

- **Don’t always get ratable symptoms**
  - **Too light to rate or no symptoms**
  - **Confounded with other foliar disease (Bacterial Blight, BSR, etc.)**

Methods of evaluating soybeans for SDS resistance by public breeding programs

- Greenhouse screening
  - Used by Iowa State Univ, Univ. of Illinois, Southern Illinois Univ.
- Inoculated field test
  - Used by Iowa State Univ, Univ. of Illinois, and Michigan State Univ.
- Naturally SDS infected field test
  - Used by Michigan State Univ. and Southern Illinois Univ.

Greenhouse Fungal Inoculum Assay

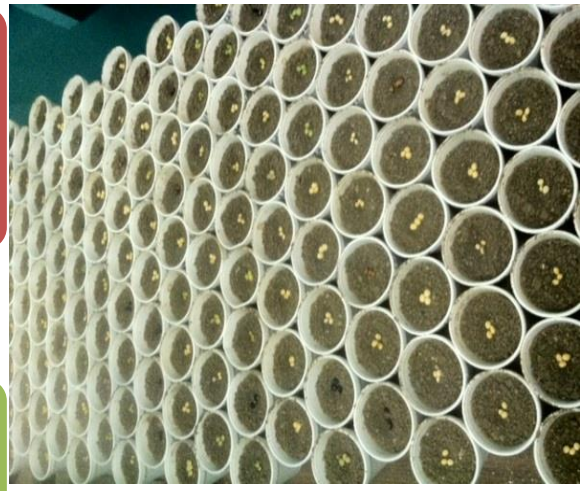
Iowa State University

Weighed 500 g of sorghum and soaked in water overnight.

Autoclaved twice before fungal spore inoculation.

Fungus was harvested after 3 weeks.

150 mL of fungus:soil mixture was placed in 8 oz. Styrofoam cups.

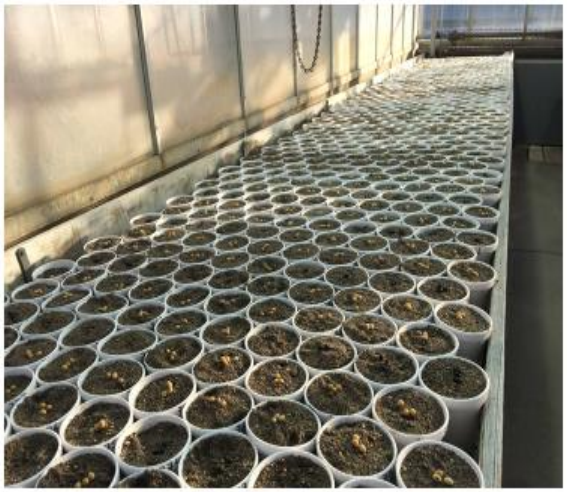


3 seeds per germplasm line placed in each cup.

Covered seeds with 30 mL of fungus:soil mixture.

Screening: GH/Growth Chamber using modified protocol (Luckew et al., Crop Sci. 52:2215-2223)

Green house SDS screening experiment



Green house SDS screening experiment

Green house SDS screening experiment

Inoculated Field test

Artificial inoculation at planting time, & irrigation to favor symptom development. Method used was developed by B. Diers and, modified by ISU group and Luckew et al.

Field SDS screening experiment

Highly susceptible "Spencer" (in the middle) surrounded by resistant RILs

Field SDS screening experiment

Michigan State University inoculated field SDS test

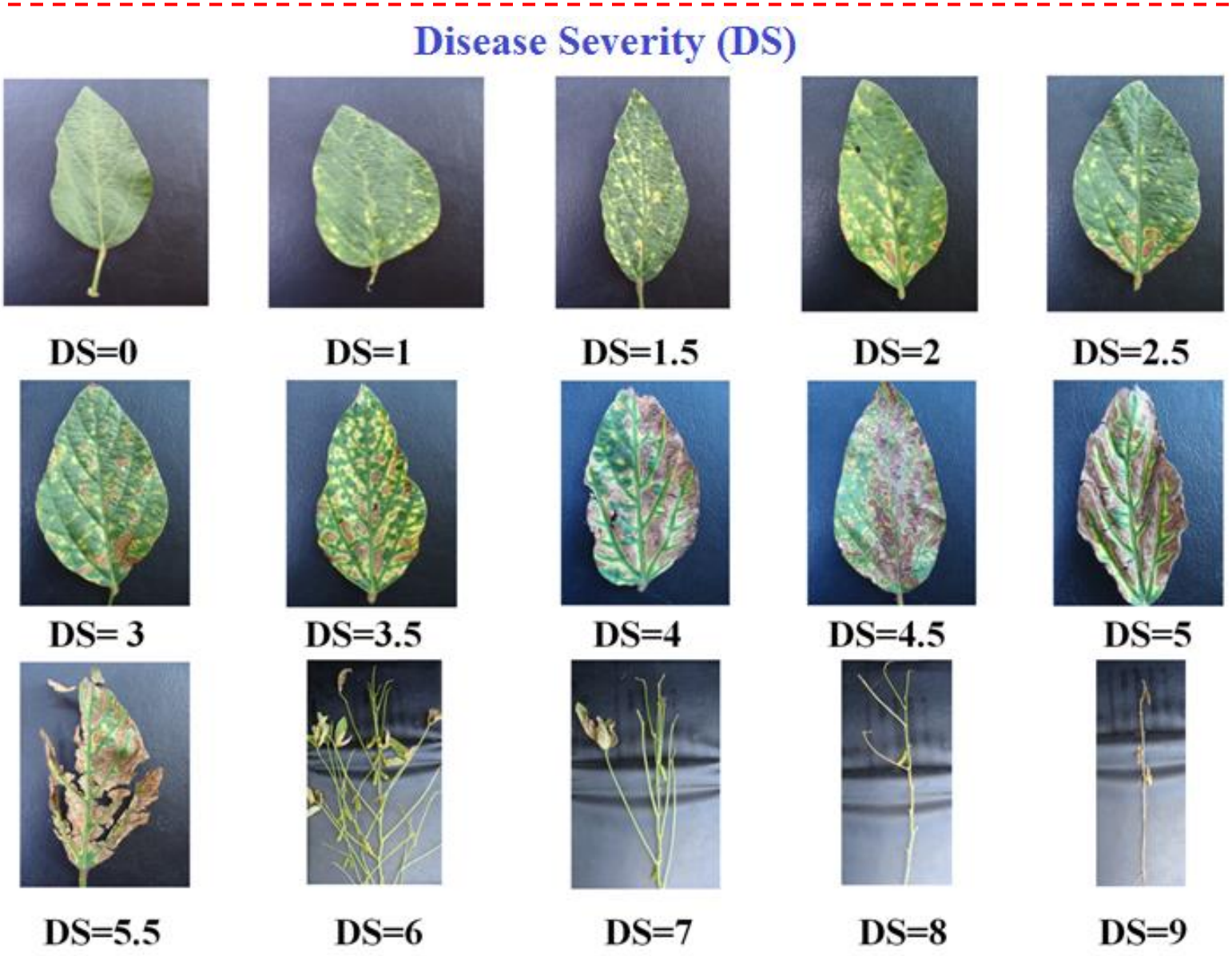
Naturally Infected Field test

Michigan State University

Section of MSU SDS disease nursery at Decatur, Michigan

Picture taken on August 21, 2015 by Martin Chilver's group with a drone

SDS disease Rating scale



Outline

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SDS Commercial Trial and the Regional SDS Trials

SIU Southern Illinois University
CARBONDALE

USB
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NCSRP NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

The North Central Soybean Research Program, a collaboration of 12 state soybean associations, invests soybean checkoff funds to improve yields and profitability via university research and extension.

SDS Commercial Trials

2015

Soybean Sudden Death Syndrome

Commercial Variety Test Results

Cathy Schmidt, Peter Lundeen, Maxine Shenaut, Jason Bond, Silvia Cianzio

For further information contact:

Cathy Schmidt – 618.559.3501 – wheee@siu.edu

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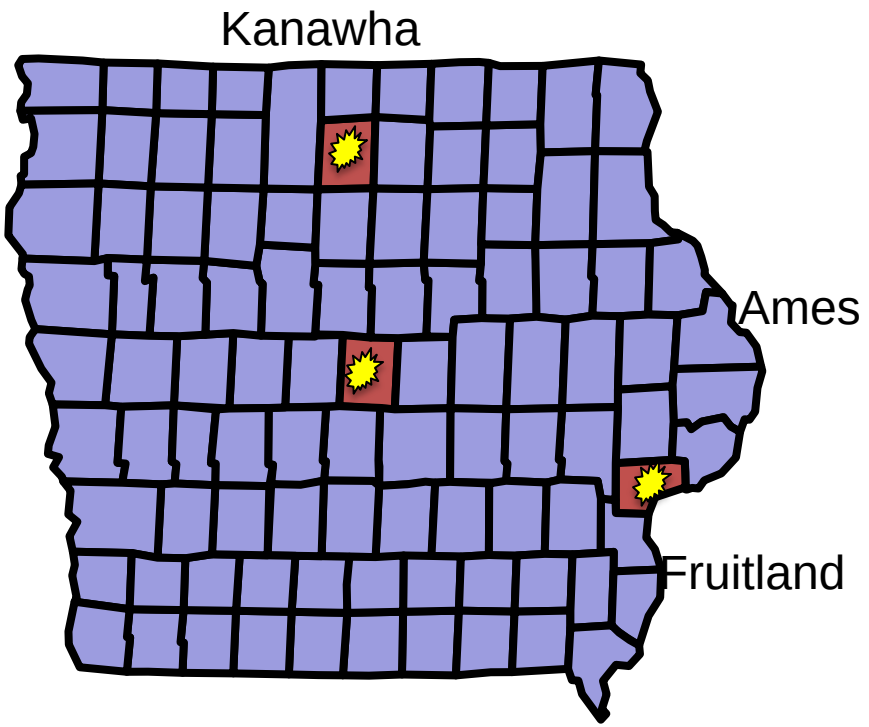
SIU CARBONDALE Southern Illinois University

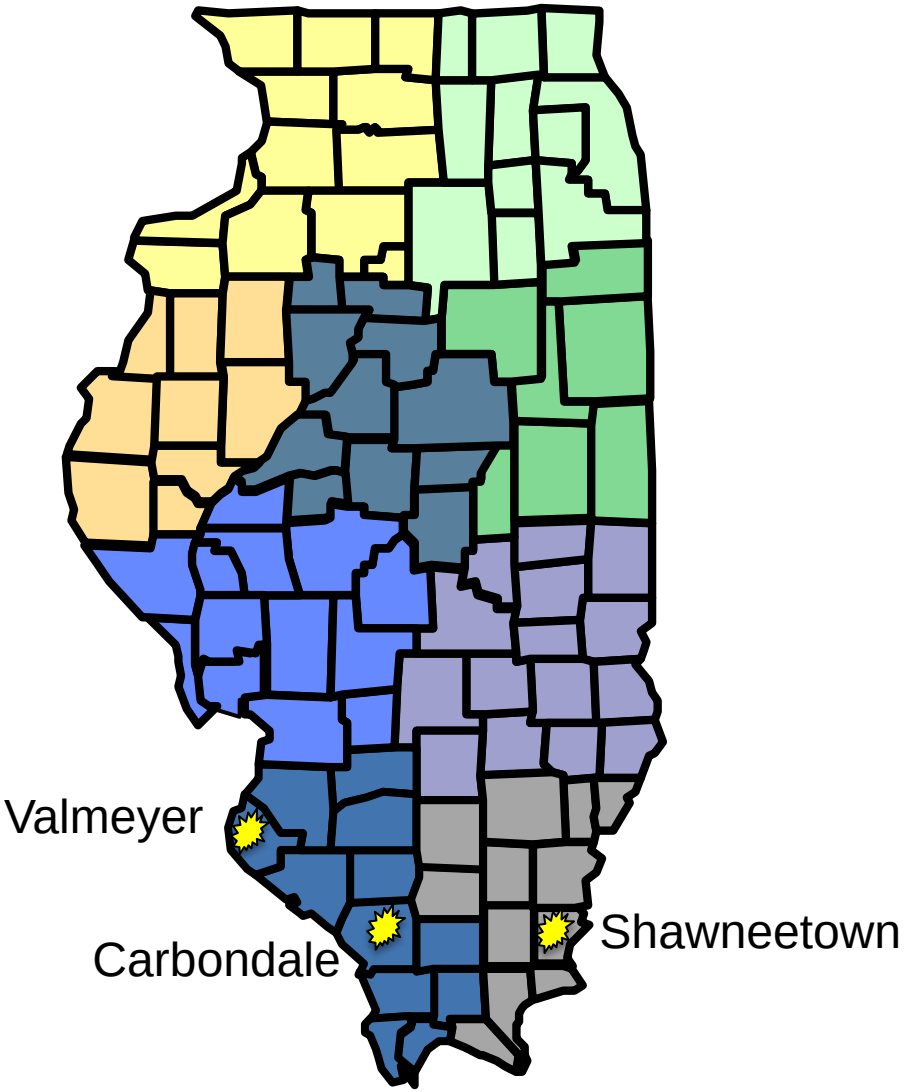
IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

USB Commercial Trial Locations



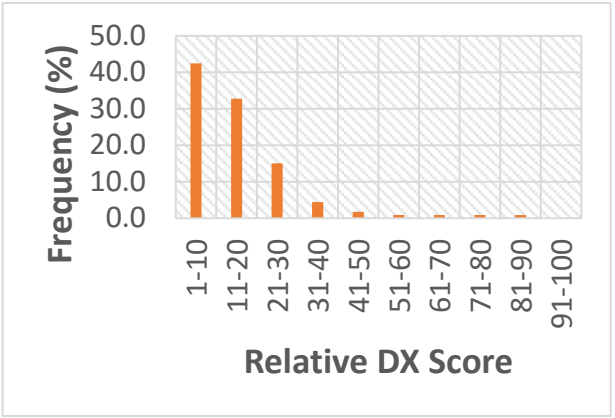
2015 – 481 varieties

2016 – 2017 700+ varieties each year

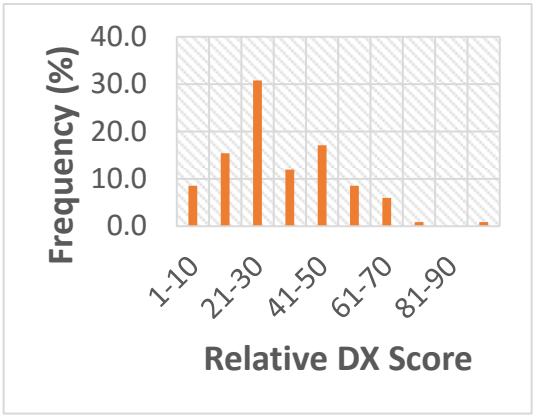


Commercial Variety Performance 2005 – 2014

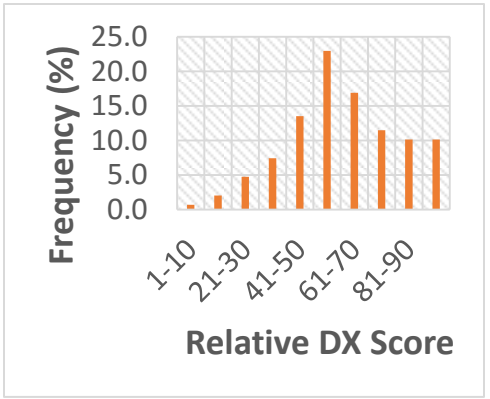
2005 Valmeyer, SIU (early IV)



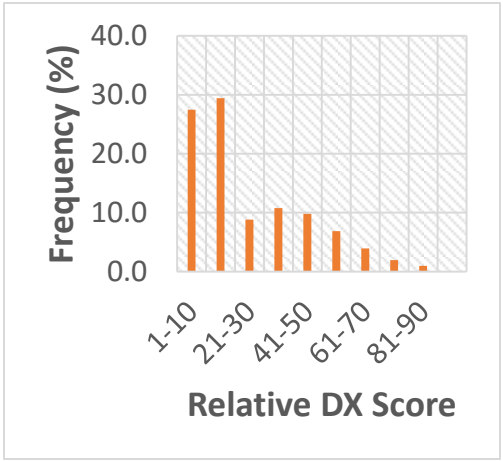
2007 Carbondale, SIU (early IV)



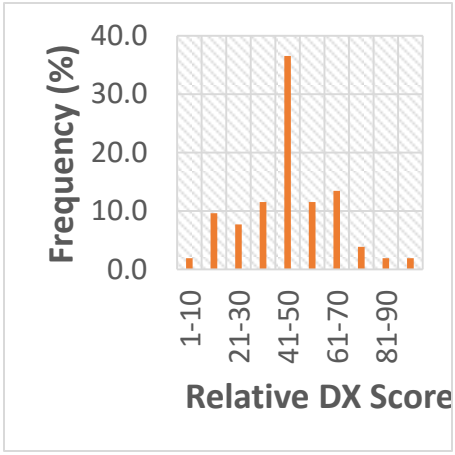
2009 Valmeyer, SIU (early IV)



2011 Valmeyer, SIU (early IV)



2014 Valmeyer, SIU (early IV)



Making progress?

- Yes, but still many susceptible varieties on the market
- As new germplasm enters the market, consistent levels of SDS resistance are not always retained

Data Summary: Carl Bradley, UKY

Commercial Variety Performance in 2015

Relative DX	Rating	% of Entries (197 varieties) MG 2 - 3.4	% of Entries (231 varieties) MG 3.5 - 5.0
0 - 20	Res.	54	47
21 - 40	Mod. Res.	25	27
41 - 60	Mod. Susc.	10	12
61+	Susc.	11	14

NCSRP Germplasm Trials

- Regional Trials – Varieties that were developed specifically for SDS resistance
  - 100 - 150 varieties each year, subsets at 12 locations (7 states and Canada)
- USDA trials – Varieties nearing release, may or may not have been bred for SDS resistance

Regional Collaboration

Jason Bond, Illinois	Glen Hartman, Illinois
Ray Cerkauskas, Canada	Stella Kantartzi, Illinois
Pengyin Chen, Arkansas	Dean Malvick, Minnesota
Martin Chilvers, Michigan	Leah McHale, Ohio
Silvia Cianzio, Iowa	James Orf Minnesota
Brian Diers, Illinois	Hari Ramasubramaniam, Syngenta
Anne Dorrance, Ohio	Dechun Wang Michigan

Regional Test Locations 2015

2015 SDS Regional Test Locations

Location	Group	Inoc.*	Irr.*	Sufficient Disease Pressure	MG I	MG II	MG III	MG IV	MG V
Waseca MN	UM	√	√	Yes	X				
Harrow, ONT	Ag. Canada				X	X			
Kanawha IA	ISU	√	√		X	X			
Manito IL	SIUC		√		X	X			
Fairbury IL	SIUC		√		X	X			
Decatur MI	MSU		√	Yes		X			
Urbana IL	UIUC	√	√	Yes		X	X		
Ames IA	ISU	√	√	Yes		X	X		
Sandusky OH	OSU			Yes			X		
Shawneetown IL	SIUC		√				X	X	X
Valmeyer IL	SIUC		√	Yes			X	X	X

*Inoc. - indicates location was inoculated. *Irr. - indicates the location was irrigated.

Regional Variety Performance 2015

Maturity Group	Varieties Tested	DX Range	# Varieties Relative DX < 40	# Varieties Relative DX < 10
I	15	0 - 19	12	6
II	19	0 - 16	18	6
III	16	0 - 10	11	5
IV	14	5 - 44	9	1
V	30	9 - 46	12	0

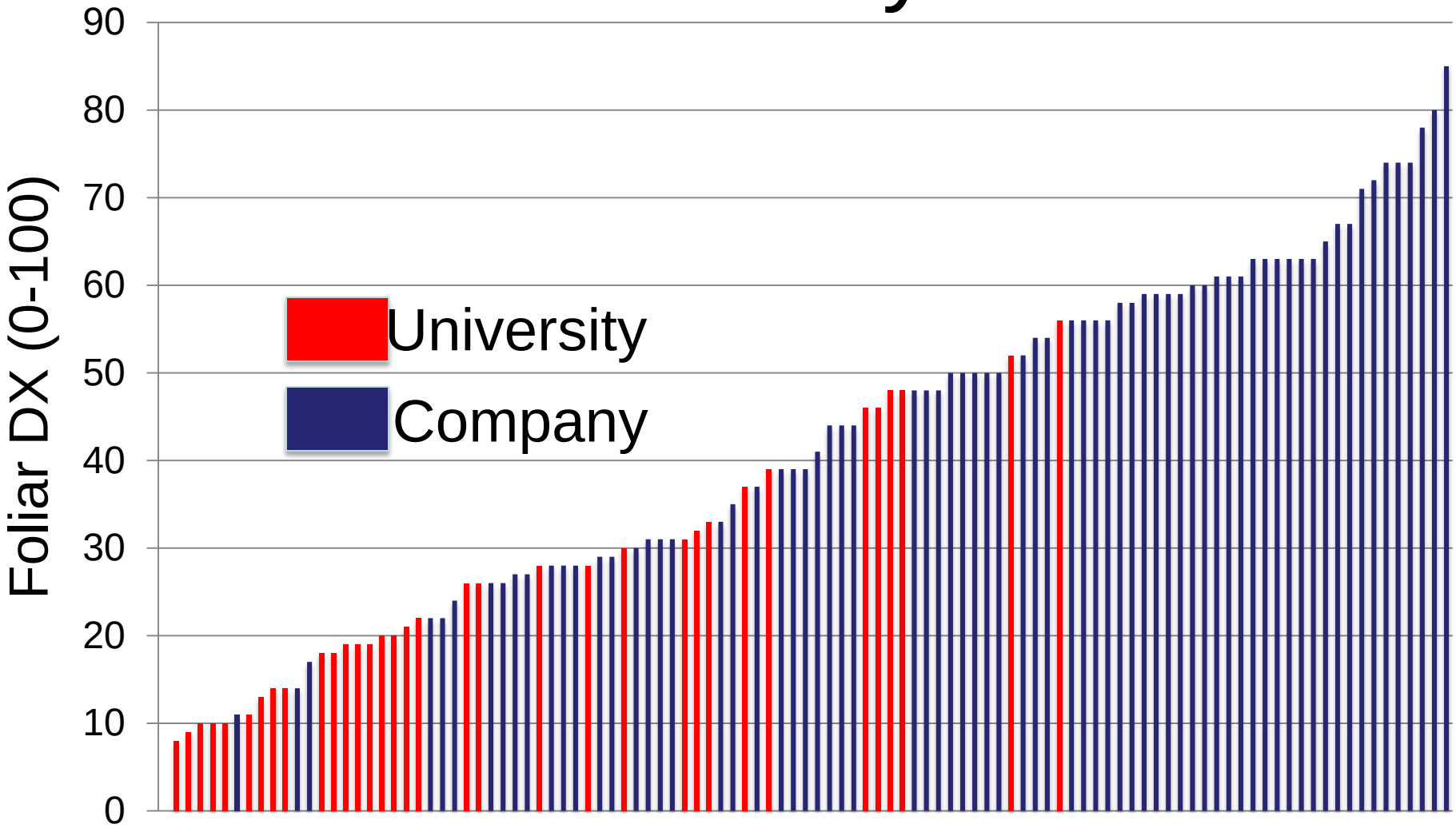
Resistant and susceptible checks not included.

Regional Variety Performance 2014

Maturity Group	Varieties Tested	DX Range	# Varieties Relative DX < 40	# Varieties Relative DX < 10
I	11	5 - 41	5	0
II	31	1 - 24	29	13
III	31	1 - 70	26	18
IV	28	1 - 61	18	5
V	31	3 - 89	3	0

Resistant and susceptible checks not included.

Public and Private Performance MG IV – Valmeyer 2014



Outline

- Sources of SDS Resistance
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SDS resistant varieties and germplasm recently released by public breeding programs

Pengyin Chen (Univ. of AR)	UA 5014C, UA 5414RR
Silvia Cianzio (Iowa State)	AR10SDS, AR11SDS
Brian Diers (Univ. of Illinois)	LD02-4485, LD01-5907, LD00-3309
Stella Kantartzi (S. Illinois Univ.)	Saluki 4910, 4411, 4313, 4916 SIU4915 A, B & C
Dechun Wang (Michigan State)	E07051, E12076-T

Newly Released Cultivars from Pengyin Chen at Univ. of Arkansas

Cultivar	Yield (bu/ac)*
UA 5014C	63.1
5002T / Ellis	61.8
Osage	61.9
Check Mean	59.8
Test Mean	58.7

* Data from tests of 26 location over 9 years

Genotype	2010	2011	2012	2013	Mean (2010-13)
UA 5414RR	58.7	55	54.2	66.4	58.6
AG 5606	53.8	62.2	64.8	70	62.7
AG 4907	.	60.8	61.6	70.1	64.2
Check Mean	52.5	55.6	63.2	70.1	57.8

Newly released E12076-T at Michigan State University

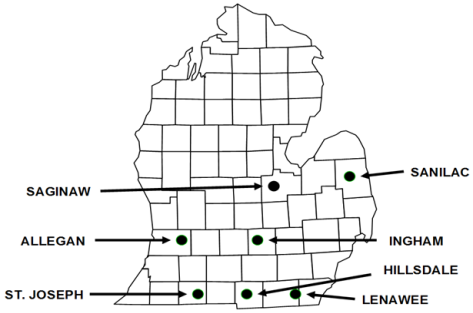
Maturity	2.9
Seeds per lb.	2350
Plant Type	Bush
Target Market	Food and Grain
Hilum Color	Yellow
Flower Color	White
Pubescence Color	Gray
Pod Color	Tan
Phyto Res	-
SCN Res	R
SDS Res	R
White Mold Res	MR
Aphid Res	S


E12076-T

E12076-T Performance data

Trial	Yield (Bu/Ac)	% of Mean	Rank	Trial Mean	Trial Max	Trial Min	LSD	Trial CV	Height	Lodging	Protein	Oil
2015 Central Conv	72.1	109.6	1 of 54	65.8	72.1	57.4	5.3	9.5	35	2.7	37.4	17.7
2015 South Conv	72.4	102.4	18 of 47	70.7	76.7	61.3	4.8	8.2	36	2.7	37.4	17.7
2014 Organic	46.4	109.7	7 of 52	42.3	48.6	33.3	5.3	13.1	29.1		35.7	16.7
2014 Central Conv	62.8	105.0	13 of 53	59.8	65.9	51.8	5.6	9.9	39.7	3.8	35.8	15.9

E12076-T yielded above the trial means in all 4 trials and ranked among the top 10 in 2 of the 4 trials.



Sudden Death Syndrome (DX*)

Trials	2015 Decatur MI	2014 Decatur MI	2013 Decatur MI	2012 Decatur MI	2015 Kanawha IA	2015 Ames IA	2015 Sandusky OH	2015 Harrow ONT, Canada	2014 Urbana IL	2014 Sandusky OH	2014 Harrow ONT, Canada
E12076-T	3.8	3.9	0.0		1.0	4.0	6.0	0.0	2.0	20.0	1.0
Most susceptible	63.8	58.3	77.8	94.4	7.0	27.0	0.3	16.0	43.0	50.0	24.0
Mean	22.0	20.1	27.3	36.1	1.0	4.0	5.0	4.0	5.0	7.0	5.0
LSD	22.0	10.9			4.0	5.0	5.0		10.0	39.0	12.0
No. of entries	39	31	80	298	23	23	23	23	36	36	36

* DX = disease index ranging from 0 to 100; 0 =no disease symptom and 100=all plants dead.

E12076-T showed strong resistance to soybean sudden death syndrome.

Acknowledgement

Funding for public research on SDS resistance:

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MINNESOTA SOYBEAN
RESEARCH & PROMOTION COUNCIL

Project GREEEN

Michigan State University
AgBioResearch