

Final Report: Executive Summary
“MU Certified” Strip Trial: Soybean Response to ILeVO™

- Soybean cyst nematode (SCN) and sudden death syndrome (SDS) are the top two pathogens reducing soybean yield.
- The seed treatment ILeVO™, when applied at the high rate, is labelled for control of both pathogens.
- The “MU Certified” strip trial program initiated 29 trials on Missouri farmer fields in 2017 and 2018. This analysis used data from 20 locations.
- The trials compared the farmer seed treatment (no ILeVO) versus the farmer seed treatment plus the high rate of ILeVO.
- The trials evaluated yield response and impact on SCN reproductive factor.
- Iowa Soybean Association provided yield data from 23 trials on Iowa farms in 2015 and 2016.
- SDS was confirmed at four of the MO locations and four of the IA locations.

Key Results:

1. ILeVO increased yield in the Missouri trials. On sites with SDS there was a 50% chance of a response of 3.5 bushels per acre or more. On sites with no SDS, there was a 50% chance of a response of one bushel per acre or more.
2. There was evidence that the high ILeVO rate reduced the SCN reproductive factor; the effect of ILeVO was greater at locations with higher SCN reproduction.
3. In Iowa, there was no evidence that ILeVO increased yields on fields with SDS and the potential response on other fields was less than on Missouri fields.

This on-farm research documents the importance of testing management practices locally.

This on-farm research was generously supported by the Missouri Soybean Merchandizing Council (award No. 17-408) and University of Missouri Extension. This on-farm research was only possible with the cooperation of Missouri Soybean farmers who volunteered to implement trials on their fields and the Regional MU Extension faculty that supported them.



Final Report

“MU Certified” Strip Trial: Soybean Response to ILeVO™

Introduction:

Soybean cyst nematodes (*Heterodera glycines*; SCN) are widespread throughout the Midwest and Missouri and considered the most damaging pathogen in soybean. A 2015-2016 survey of Missouri fields found SCN in 88% of the 393 samples analyzed and in all counties with significant soybean production (Howland et al., 2018). Yield loss up to 30% is possible from SCN damage to the root system, diversion of plant resources for SCN growth, and from secondary infections by other pathogens infecting damaged plants.

Soybean sudden death syndrome (SDS), caused by *Fusarium virguliforme*, is the second most damaging pathogen of soybean in the state of Missouri. SDS infects soybean seedlings early in the season through the roots and results in the yellowing and death of foliar tissue which can begin in the early flowering stages. Presence of SCN can increase the severity of SDS.

The seed treatment ILeVO™ (active ingredient 48.4% Fluopyram) is a fungicide labeled for control of both SDS and SCN when applied at the highest recommended rate of 1.18 to 1.97 ounces per 140,000 soybean seeds. ILeVO was first available to Missouri farmers in 2015 and was the first commercial seed treatment that suggested it could control SDS.

In late 2016, the “MU Certified” Strip Trial farmer panel recommended prioritizing a strip trial testing ILeVO. In early 2107, Missouri Soybean Merchandizing Council (MSMC) funded a two-year project comparing the high rate of ILeVO with an untreated control. The objectives of the project were:

1. Evaluate the effect of ILeVO on soybean yield.
2. Evaluate the effectiveness of ILeVO on reducing reproduction of SCN.
3. Compare results from Missouri farmer fields with similar trials in Iowa.

This report summarizes the results from 29 Missouri trials during this two-year project conducted in the 2017 and 2018 growing seasons.



What we did:

Twenty-nine strip trials were initiated on Missouri farmer fields (Fig. 1). Strip trials are focused and easily implemented experimental tests that farmers can perform on their fields using their equipment.

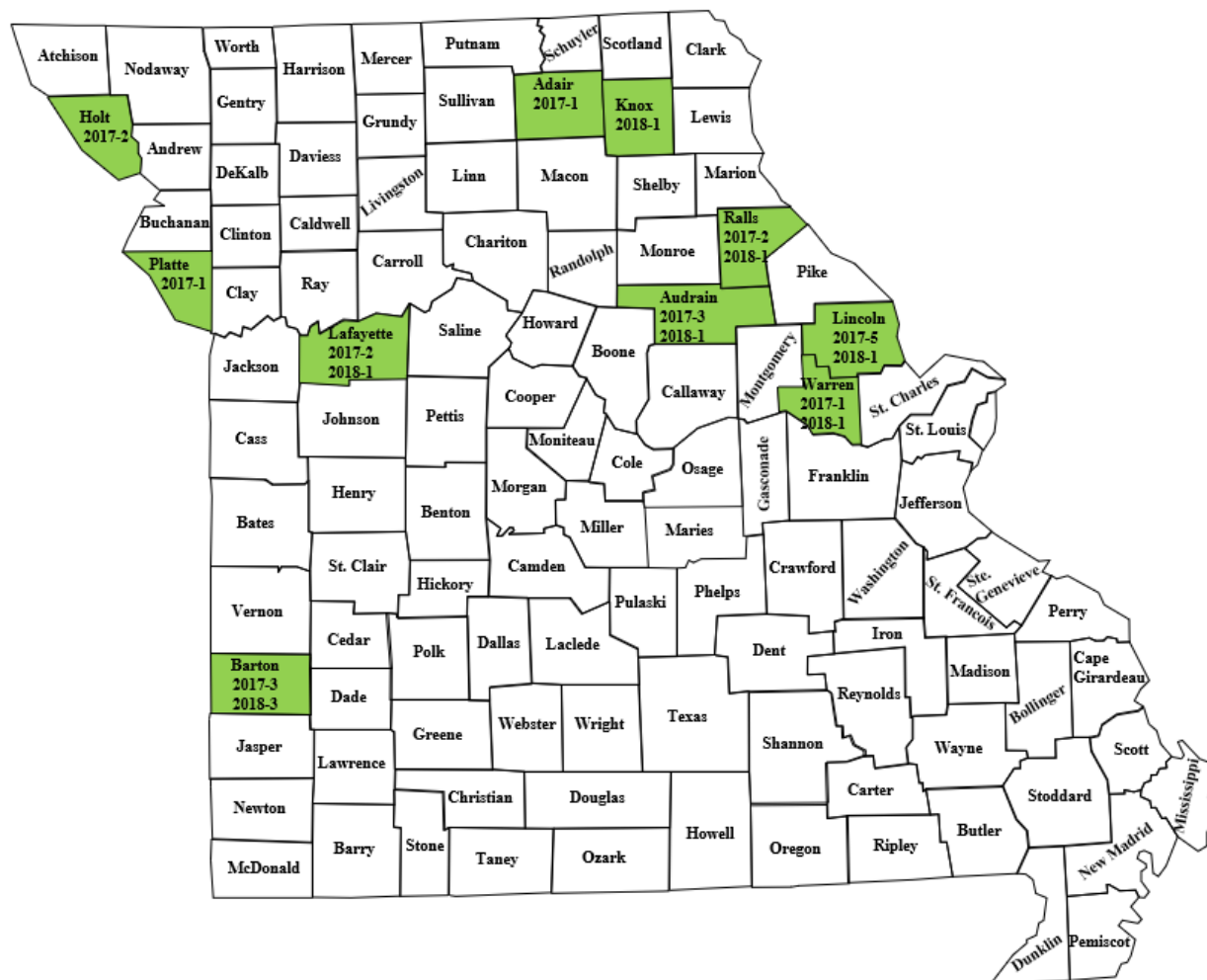


Figure 1. Location of 29 strip trials testing the high ILeVO™ rate, initiated in 2017 and 2018.

Key elements of the protocol for each trial included:

1. All cooperating farmers volunteered to have a trial and selected the field for the trial.
2. All trials compared the high rate of ILeVO versus a control that was not treated with ILeVO. Other seed treatments were allowed, at the farmer’s discretion, but had to be applied to both treatments. The ILeVO rate was at least 1.5 ounces per 140,000 seed.
3. Farmer was responsible for selecting soybean variety and for all other soybean management decisions and management including planting and harvest dates, seeding rates, fertilizer applications and other plant protection applications.
4. Farmers used their equipment to apply all treatments and other management activities including planting and harvest. Farmers were expected to harvest field with a combine outfitted with a yield monitor and global positioning system (GPS) allowing for geolocated yield map. We relied on farmer calibration of the yield monitor.
5. All locations were soil sampled twice for SCN. Once just prior or just after planting and a second time just after harvest. Between 10 and 24 soil sampling points were distributed along one or two

transects perpendicular to treatment direction. All soil sampling points were geolocated with a handheld GPS with an accuracy of less than 1 foot and the same points were sampled in spring and fall. At each sampling point, 20 1-inch cores to a six-inch depth were randomly obtained within a 6.3-foot diameter circle around the sampling point; in 2018, samples were taken only in the soybean rows. All samples were placed in plastic bags and kept in a cooler for transport to the lab for analysis. All soil samples were submitted the University Missouri SCN Diagnostic Lab for determination of SCN cyst numbers using standard methods.

6. All locations were scouted for presence of SCN. In 2017, all locations were visited between 23 Aug and September 7. A research specialist walked two transects across the field as well as visiting any areas of the field that looked diseased to determine if SDS was present. In 2018, the same two points in every strip were scouted twice during the growing season for SDS; scouting was done in late July and mid-August. In 2017, an unmanned aerial vehicle (drone) obtained high-resolution images from 15 to 20 feet above the ground at the scouted points. In both years, aerial imagery was obtained of the whole field (drone flight 325 feet above the ground) at each scouting visit (1X in 2017; 2X in 2018).
7. Farmers shared yield monitor data which was processed using SMS Advanced software by Ag Leader®. Data processing was used to address flow delay issues related to grain yield and moisture content and to remove yield points below five and above 200 bushels/acre. All gridded aerial imagery collected by the drone was processed into a full-field image using PiX4D® Mapper software. All collected data has been cataloged in an ArcGIS geodatabase.
8. All data geoprocessing including field layouts and obtaining treatment yields from yield maps was done using ArcMap 10.5.1 software. Data was statistically analyzed with Bayesian methods using the MCMC procedure in SAS software using weak priors.

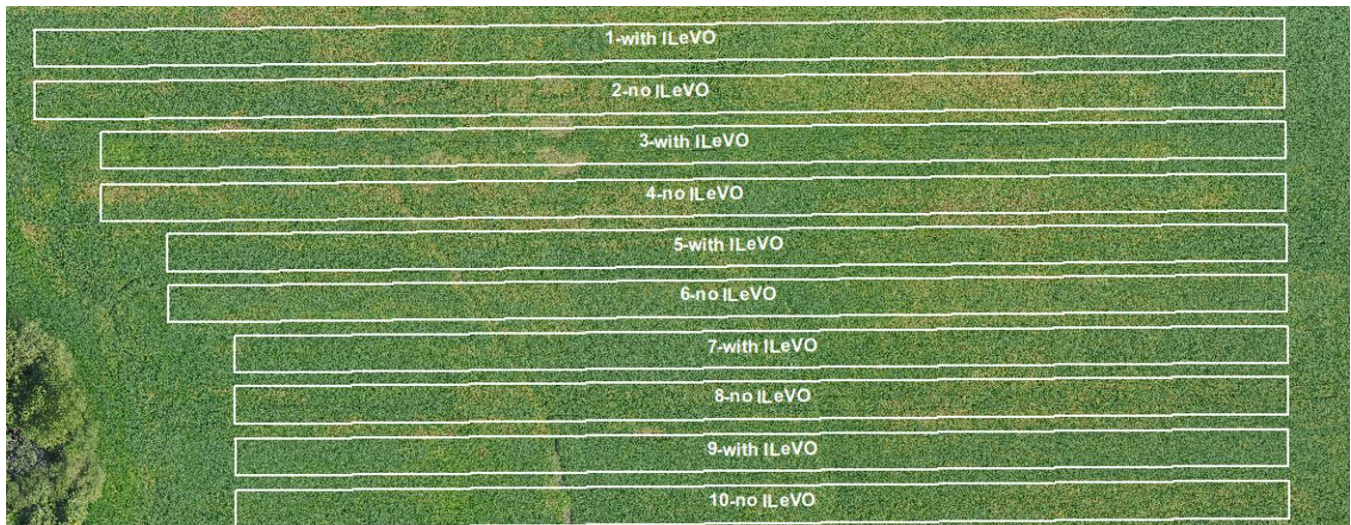


Figure 2. Layout of an ILeVO strip trial in Lafayette County, MO. Sudden death syndrome was confirmed at this location. Imagery was taken Sept. 1, 2017.

Missouri results: Site information

Of the 29 strip trials initiated, results from 20 trials were used in this analysis. Reasons for lost trials included: no usable data collected from six trials due to planting problems (2), crop failure (1), or harvest issues (3); and three trials were eliminated for having less than four replicates. Table 1 summarizes key information about the 20 trials. Additional information is in Appendix 1.

Table 1. Key location data for 20 Missouri strip trials.

ID	Year	County	Previous Crop	Resistance ¹		SDS history	SCN rating ⁴	SDS present	Strips	Mean Yield (B/A)
				SDS ²	SCN ³					
1	2017	Lincoln	Soybean	H	Yes	N	L	N	10	50.4
2	2017	Ralls	Corn	H	Yes	N	L	N	10	68.0
3	2017	Lafayette	Corn	M	Yes	N	H	Y	8	55.3
4	2017	Barton	Corn	H	Yes	Y	M	N	10	72.8
5	2017	Lincoln	Corn	H	Yes	Y	L	N	14	56.5
6	2017	Holt	Soybean	H	Yes	Y	M	N	10	56.2
7	2017	Warren	Corn	H	Yes	N	H	N	14	66.7
8	2017	Adair	Corn	H	Yes	N	M	N	10	70.6
9	2017	Lincoln	Corn	H	Yes	Y	M	N	16	53.0
10	2017	Barton	Corn	H	Yes	Y	M	Y	10	67.0
11	2017	Audrain	Soybean	H	Yes	N	H	N	10	66.6
12	2017	Audrain	Corn	H	Yes	Y	M	N	10	73.7
13	2017	Barton	Corn	H	Yes	Y	- ⁵	Y	8	66.4
14	2017	Ralls	Corn	H	Yes	Y	L	N	10	62.3
15	2017	Holt	Corn	H	Yes	Y	L	N	8	69.4
16	2018	Ralls	Corn	H	Yes	Y	M	N	8	63.0
17	2018	Barton	Corn	M	Yes	Y	L	Y	10	73.9
18	2018	Lincoln	Corn	M	Yes	Y	L	N	14	58.6
19	2018	Warren	Corn	H	Yes	Y	M	N	12	60.6
20	2018	Knox	Corn	M	Yes	Y	M	N	10	45.9

¹ Soybean variety resistance rating. ² SDS=Sudden Death Syndrome. ³ SCN=Soybean Cyst Nematode. ⁴ SCN rating at planting. ⁵ “-”=no data.

Key points:

- 12 of 20 sites had a history of SDS.
- SDS was observed in the strip trial at four of the 20 sites.
- SCN rating was moderate to high at 65% of the locations.
- All but two of these sites were on silt-loam soils. Site 6 was a silty-clay and site 20 was a clay soil. Twelve of the studies were from the clay-pan region of Missouri.

Missouri results: Soybean yield

Tabular yield results for Missouri locations are in Appendix 2.

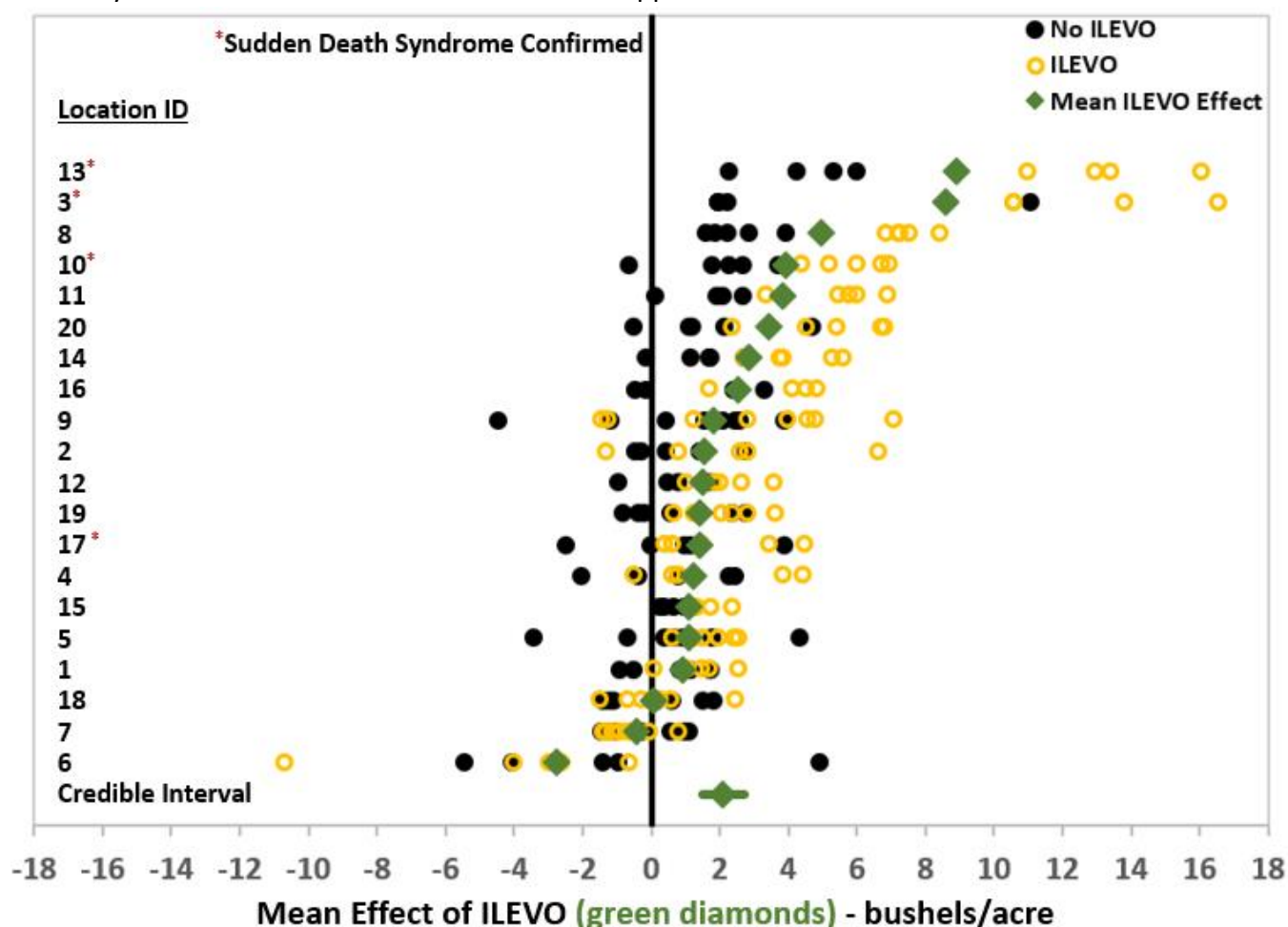


Figure 3. Summary of the impact of ILeVO on soybean yield on 20 Missouri farms.

- Green diamonds are the mean effect of ILeVO for each location; diamonds right of the center line indicate the mean effect at that location was positive.
- Black (no ILeVO) and gold (ILeVO) symbols are strip yields for each location, represented as the difference from the location mean difference.
- The credible interval is the expected yield effect of ILeVO based on these 20 farms (5% to 95% probability).

Key points:

- On these 20 farms there is over a 50% chance that ILeVO increased yield at least 2.0 bushels per acre and a 95% chance that ILeVO increased yield 1.5 bushels per acre.
- On fields where SDS was confirmed, there was a 50% chance of at least a 3.9 bushel per acre response. On fields with no SDS, it is unlikely yield benefit exceeded 1.5 bushels per acre.

Missouri results: SCN reproductive factor

Table 2. Summary of soybean cyst nematode (SCN) egg count data. Difference is the effect of ILeVO on the reproductive factor (Rf) compared to the no-ILeVO control. Negative numbers imply reduced reproduction.

ID	Year	County	SDS history	SDS present	Initial SCN ¹ (STD ²)	Rf ⁴ (STD)		
						No ILeVO	ILeVO	Difference
1	2017	Lincoln	N	N	230 (414)	0.6 (1.0)	0.2 (0.4)	-0.4
2	2017	Ralls	N	N	- ³	-	-	-
3	2017	Lafayette	N	Y	20,953 (17,668)	1.2 (0.7)	0.8 (0.9)	-0.4
4	2017	Barton	Y	N	5,438 (4,820)	48 (55)	13 (15)	-35
5	2017	Lincoln	Y	N	14 (44)	0.2 (0.4)	1.2 (1.3)	1.0
6	2017	Holt	Y	N	1,875 (3,011)	4.8 (7.4)	2.8 (3.6)	-2.0
7	2017	Warren	N	N	17,700 (10,462)	6.6 (3.6)	5.7 (3.5)	-0.9
8	2017	Adair	N	N	3,514 (1,835)	1.0 (0.4)	2.5 (3.4)	1.5
9	2017	Lincoln	Y	N	3,688 (4,638)	26 (41)	12 (5.6)	-14
10	2017	Barton	Y	Y	9,600 (5,5,316)	4.6 (2.7)	2.5 (1.0)	-2.1
11	2017	Audrain	N	N	19,275 (9,123)	1.7 (0.8)	1.8 (0.7)	0.1
12	2017	Audrain	Y	N	5,354 (6,871)	4.2 (3.6)	4.4 (3.8)	0.2
13	2017	Barton	Y	Y	-	-	-	-
14	2017	Ralls	Y	N	293 (323)	0.5 (0.6)	0 (0)	-0.5
15	2017	Holt	Y	N	94 (152)	3.0 (6.0)	1.5 (1.5)	-1.5
16	2018	Ralls	Y	N	985 (663)	0.8 (1.0)	2.0 (1.8)	1.2
17	2018	Barton	Y	Y	394 (176)	121 (122)	57 (24)	-65
18	2018	Lincoln	Y	N	47 (49)	0.3 (0.4)	0.2 (0.3)	-0.1
19	2018	Warren	Y	N	1,461 (1,247)	19.2 (28)	16.5 (18)	-2.7
20	2018	Knox	Y	N	3,075 (985)	14.8 (15)	9.8 (4.2)	-5.0

¹SCN=Soybean Cyst Nematode egg count per cup. ²STD=standard deviation. ³“-“=no data; ⁴Rf=SCN reproductive factor calculated as the ratio of harvest SCN egg numbers divided by initial SCN egg numbers.

Key points:

- SCN data, both egg counts and Rf, were highly variable within locations. This is common with SCN data.
- There was evidence that ILeVO reduced the SCN reproductive factor (Rf). The credible interval for the mean response across all locations was -0.8 to -14.8 (mean -7.5) reduction in SCN reproduction.

Missouri results: SCN reproductive factor continued

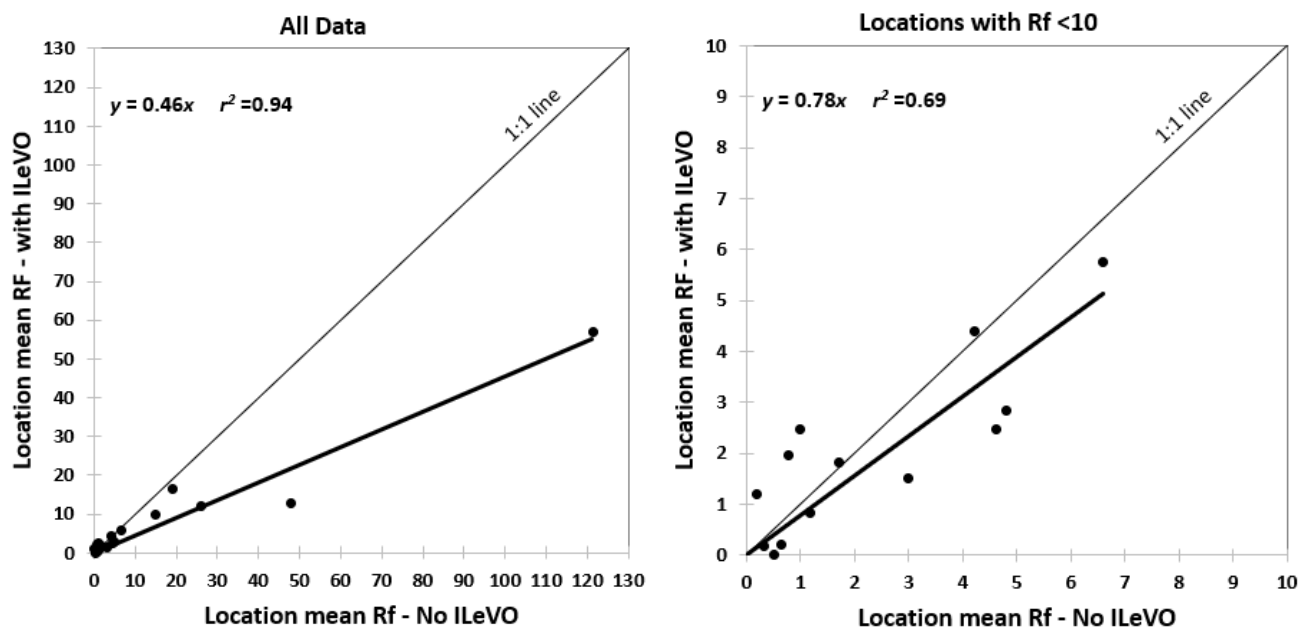


Figure 4. Effect of ILeVO on SCN reproductive factor (Rf).

Key points:

- At locations with higher SCN reproduction, the effect of ILeVO was greater.
 - Using all data, ILeVO reduced Rf over 50%.
 - For locations with Rf <10, ILeVO reduced Rf about 20%.

Iowa results: Soybean yield

Iowa Soybean Association shared strip yield data from 23 trials comparing the high rate of ILeVO with a no-ILeVO control treatment. Data was from trials in 2015 (locations 1-13) and 2016 (locations 14-23).

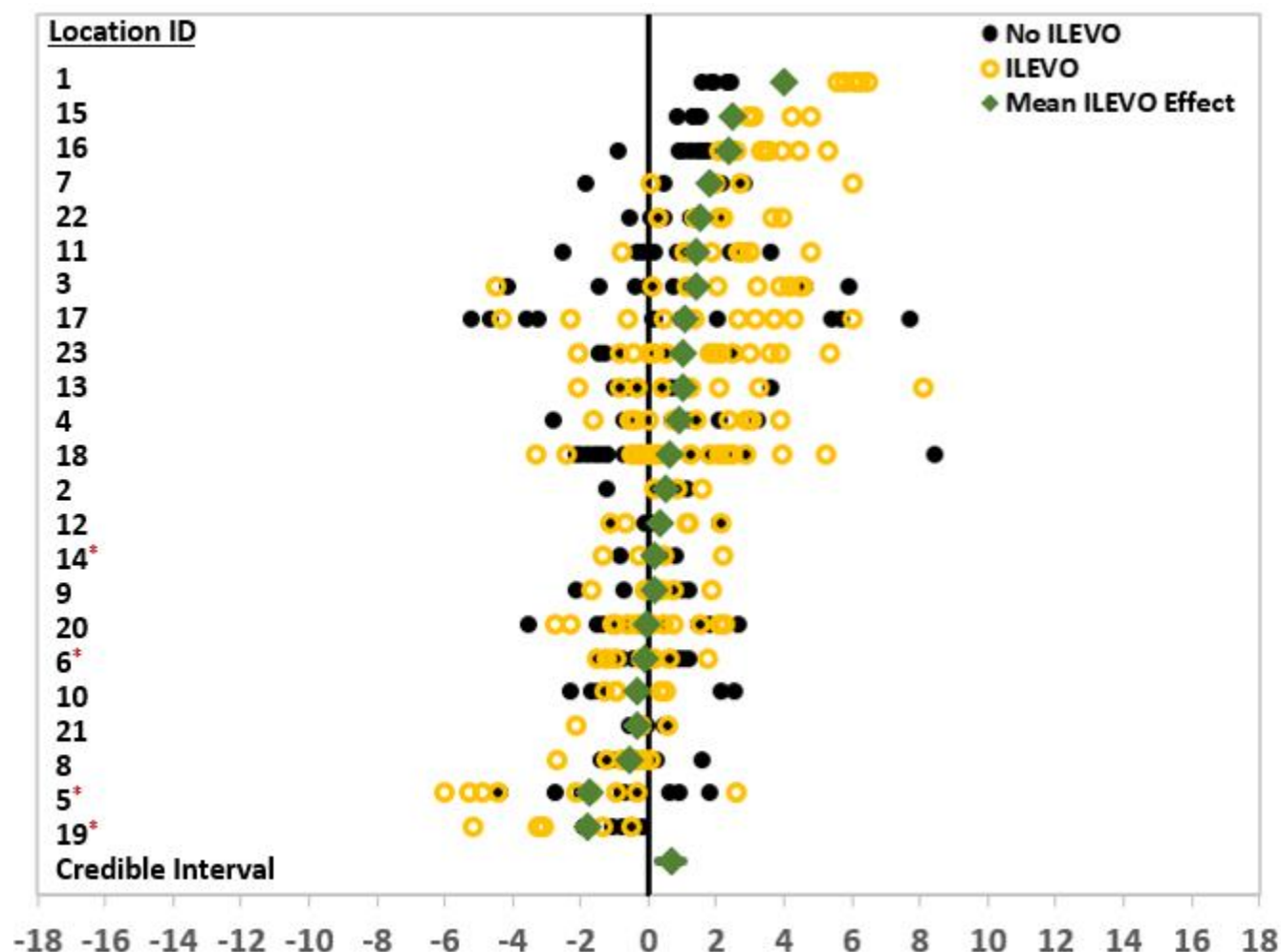


Figure 5. Summary of the impact of ILeVO on soybean yield on 23 Iowa farms. See figure 3 for notes on interpretation of the figure.

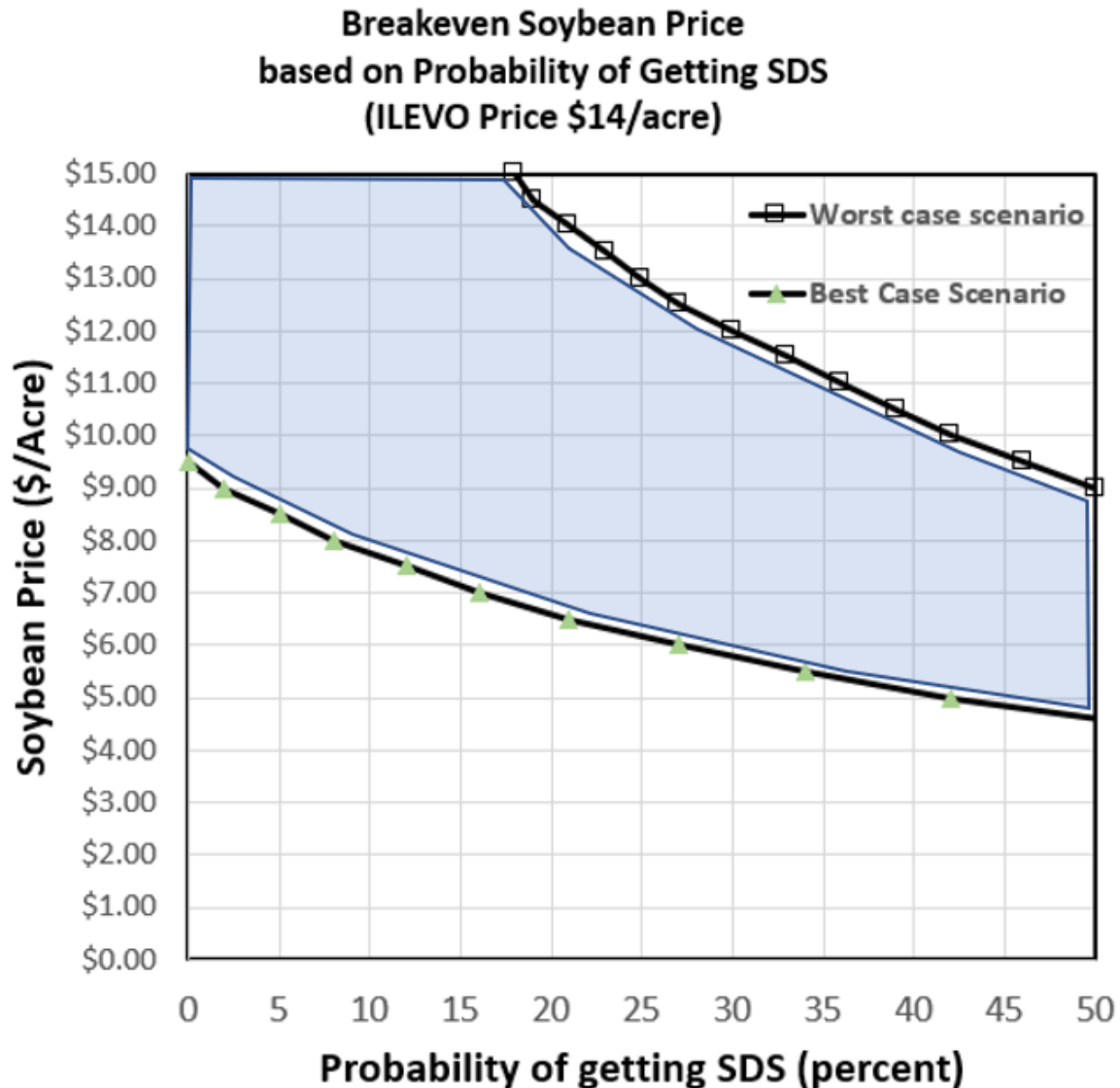
Table 2. Comparison of soybean response to ILeVO in Missouri versus Iowa strip trials.

State	n	SDS	Median	Credible Interval (95% to 5%)
			- - Bushels per Acre - -	
Missouri	4	Yes	3.5	2.5 to 4.6
	16	No	1.1	0.6 to 1.5
Iowa	5	Yes	-0.1	-0.7 to 0.5
	18	No	0.6	0.3 to 0.9

Key points:

- Iowa response (2015-16 data) to ILeVO was less than response on Missouri fields.
- In contrast to Missouri sites, there was no evidence in Iowa that ILeVO increased yield at sites where SDS was confirmed.

Economics of ILeVO on Missouri farms (see Appendix 4 for analysis with ILeVO price = \$10/acre)



Interpretation:

- Select the probability that you will get SDS on your farm. If you expect SDS once every five years, select 20%.
- The best- and worst-case scenarios are based on Missouri results in Table 2 (previous page). For example, the best-case scenario line assumes a yield benefit of ILeVO of 1.5 bushels per acre with no SDS and 4.6 bushels per acre with SDS.
- The y-axis represents the break-even price of soybean for ILeVO assuming ILeVO costs \$14 per acre.
- If you expect SDS 20% of the years and the best-case scenario, the break-even price of soybean is about \$6.50 per bushel.

Key points:

- A high expectation of having SDS and an expectation benefits are on the upper limit of Missouri response, ILeVO always pays.
- If SDS occurs infrequently and/or there is no expectation of a big yield benefit from ILeVO, it will not pay at today's prices.

Appendix 1.

Additional site information about the 20 Missouri strip trials.

ID	Year	Soil Type ¹	Soybean Variety	Maturity Rating	Planted	Harvest	Other Seed Treatments
1	2017	SL	Beck's 424L4	4.2	5/16/17	10/18/17	Escalate
2	2017	SL	Stine 41LF32	4.1	5/18/17	10/18/17	Accelaron
3	2017	SL	Lewis 4572X	4.5	5/16/17	11/1/17	Accelaron
4	2017	SL	Stine 43RE02	4.3	6/7/17	10/13/17	Accelaron
5	2017	SL	Channel 4009R2	4.0	5/18/17	9/30/17	Accelaron
6	2017	SC	Garst S34-N3	3.4	5/10/17	10/2/17	CruiserMaxx
7	2017	SL	Beck's 424L4	4.2	4/25/17	9/26/17	Poncho 1250
8	2017	SL	DynaGRO S40LL35	4.0	5/8/17	11/1/17	Fungicide
9	2017	SL	Merschman Truman 1438LL	3.8	6/1/17	10/2/17	Merschman proprietary
10	2017	SL	Stine 43RE02	4.3	6/6/17	10/12/17	Accelaron
11	2017	SL	Beck's 394L4	3.9	4/24/17	9/25/17	Escalate
12	2017	SL	Beck's 394L4	3.9	4/25/17	9/21/17	Escalate
13	2017	SL	Pioneer 48T53R	4.8	6/8/17	10/17/17	Accelaron
14	2017	SL	Beck's 394L4	3.9	5/30/17	10/21/17	Escalate
15	2017	C	Pioneer 38T42R	3.8	5/11/17	11/3/17	Allegiance, Gaucho, Evergol, PPST 2030
16	2018	SL	Stine 41LF32 LL	4.1	4/26/18	10/22/18	TRX custom
17	2018	SL	Pioneer P44T63R	4.4	6/1/18	10/22/18	Fortix
18	2018	SL	Channel 4116R2X	4.1	5/1/18	10/9/18	Yes, not specified
19	2018	SL	Beck's 424L4	4.2	4/30/18	10/3/18	Not specified
20	2018	SL	Pioneer P37T09L	3.7	5/29/18	11/16/18	Yes, not specified

¹Soil types: SL=Silt Loam, SC=Silty Clay, C=Clay.

Appendix 2.

Summary of location yields for the 20 Missouri strip trials. A positive difference implies ILeVO increased yield. Note that differences are calculated on detrended yields that account for spatial trends in the field and may have reduced reported yield variability (standard deviations) in this table.

ID	Year	County	SDS ¹ history	SDS present	Initial SCN ² (STD ³)	Location Mean Yield (STD)		
						No ILeVO	ILeVO	Difference ⁵
					<i>eggs per cup</i>	<i>- - - bushels per acre - - -</i>		
1	2017	Lincoln	N	N	230 (414)	49.9 (1.1)	50.9 (1.0)	0.9
2	2017	Ralls	N	N	- ⁴	67.0 (1.8)	69.0 (3.2)	1.5
3	2017	Lafayette	N	Y	20,953 (17,668)	51.7 (6.7)	58.8 (5.7)	8.6
4	2017	Barton	Y	N	5,438 (4,820)	72.4 (2.1)	73.2 (3.1)	1.2
5	2017	Lincoln	Y	N	14 (44)	56.0 (2.5)	57.0 (1.5)	1.1
6	2017	Holt	Y	N	1,875 (3,011)	60.2 (13.1)	52.2 (22)	-2.8
7	2017	Warren	N	N	17,700 (10,462)	67.0 (1.6)	66.4 (1.0)	-0.4
8	2017	Adair	N	N	3,514 (1,835)	68.0 (0.8)	73.1 (0.5)	5.0
9	2017	Lincoln	Y	N	3,688 (4,638)	52.2 (2.5)	53.8 (4.0)	1.8
10	2017	Barton	Y	Y	9,600 (5,5316)	64.8 (2.3)	69.2 (1.5)	3.9
11	2017	Audrain	N	N	19,275 (9,123)	64.9 (1.7)	68.0 (2.7)	3.8
12	2017	Audrain	Y	N	5,354 (6,871)	72.6 (2.3)	74.8 (2.8)	1.5
13	2017	Barton	Y	Y	-	61.5 (4.1)	71.4 (1.9)	8.9
14	2017	Ralls	Y	N	293 (323)	60.9 (1.9)	63.6 (0.9)	2.8
15	2017	Holt	Y	N	94 (152)	69.0 (0.5)	69.9 (1.0)	1.1
16	2018	Ralls	Y	N	985 (663)	61.7 (1.9)	64.4 (1.6)	2.5
17	2018	Barton	Y	Y	394 (176)	72.3 (8.0)	75.4 (5.2)	1.4
18	2018	Lincoln	Y	N	47 (49)	58.6 (1.3)	58.7 (1.4)	0.1
19	2018	Warren	Y	N	1,461 (1,247)	59.9 (1.7)	61.2 (1.0)	1.4
20	2018	Knox	Y	N	3,075 (985)	44.1 (1.9)	47.6 (2.8)	3.4

¹SDS=Sudden Death Syndrome.

²SCN=Soybean Cyst Nematode egg count per cup.

³STD=standard deviation.

⁴- “=no data;

⁵The detrended difference may not equal the difference between mean yield with and without ILeVO.

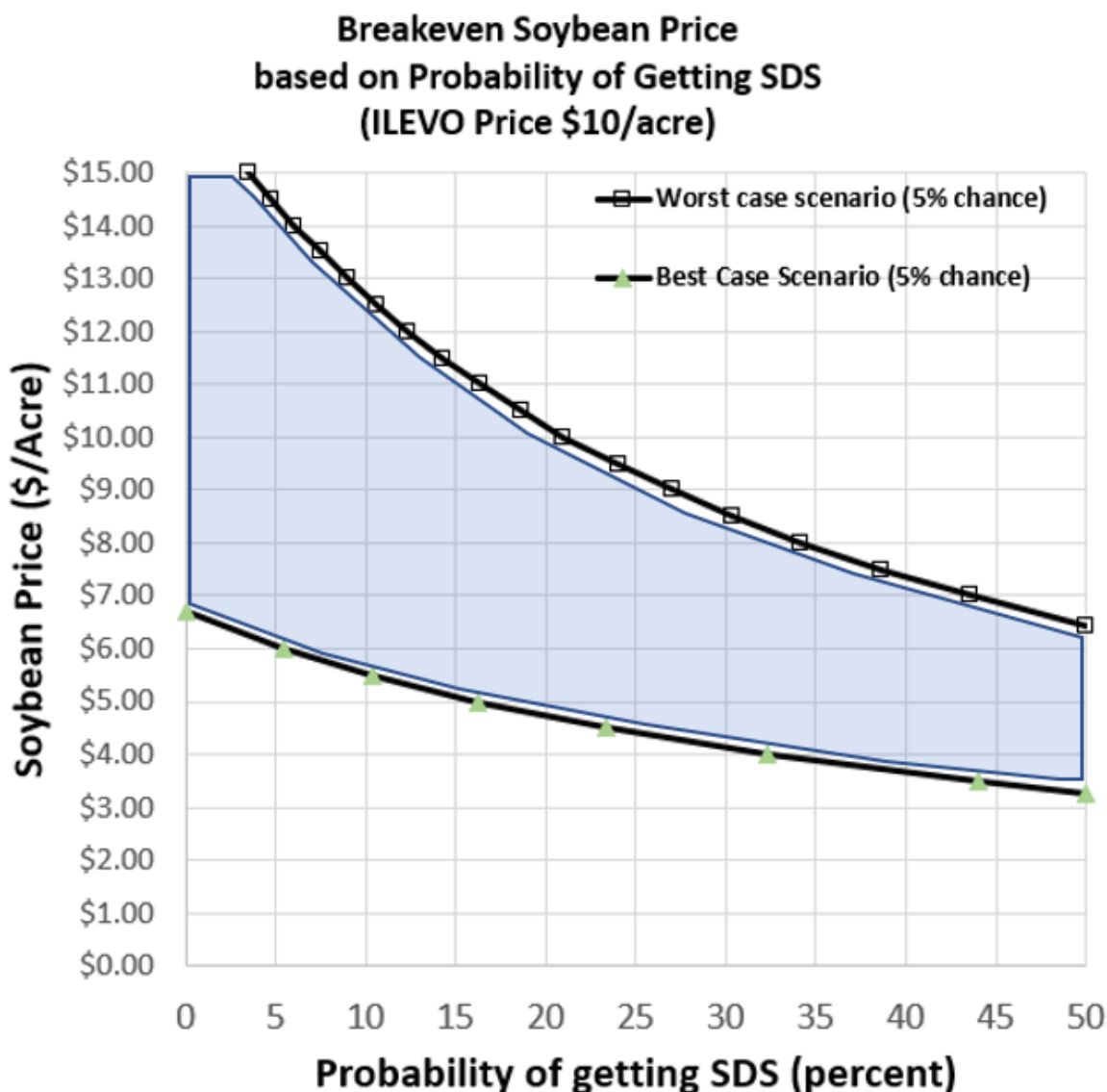
Appendix 3.

Iowa site information. Iowa Soybean Association shared strip yield data from 23 trials comparing the high rate of ILeVO with a no-ILeVO control treatment. The table summarizes the site information from these 23 locations.

ID	Year	County	SDS¹ present	Strips	Mean Yield (Bushels/Acre)
1	2015	Greene	N	10	62.3
2	2015	Greene	N	8	69.2
3	2015	Boone	N	18	74.4
4	2015	Boone	N	22	58.8
5	2015	Jasper	Y	18	72.7
6	2015	Chickasaw	Y	20	64.7
7	2015	Clay	N	8	67.8
8	2015	Shelby	N	14	61.4
9	2015	Chickasaw	N	12	54.9
10	2015	Bremer	N	10	75.0
11	2015	Greene	N	18	66.3
12	2015	Greene	N	10	68.2
13	2015	Greene	N	16	60.9
14	2016	Jasper	Y	8	68.4
15	2016	Warren	N	8	55.8
16	2016	Johnson	Y	16	41.7
17	2016	Bremer	N	24	80.4
18	2016	Jones	N	36	84.6
19	2016	Humboldt	Y	10	58.8
20	2016	Boone	N	26	70.3
21	2016	Clay	N	8	78.6
22	2016	Hardin	N	12	71.9
23	2016	Hardin	N	28	73.1

¹SDS=Sudden Death Syndrome.

Appendix 4: Economics of ILeVO on Missouri farms with ILeVO price = \$10/acre



Interpretation:

- Select the probability that you will get SDS on your farm. If you expect SDS once every five years, select 20%.
- The y-axis represents the break-even price of soybean for ILeVO assuming ILeVO costs \$10 per acre.
- If you expect SDS 20% of the years and the worst-case scenario, the break-even price of soybean is about \$10.00 per bushel.

Key points:

When the price of ILeVO decreases to \$10 per acre:

- When expectation of benefits are on the upper limits of Missouri response, ILeVO always pays.
- If there is no expectation of a big yield benefit from ILeVO, then ILeVO only pays on fields with a significant expectation of SDS.

Appendix 5

MU Extension SCN and SDS Resources

Dr. Kaitlyn Bissonnette, MU Extension Field Crop Plant Pathologist:

<https://extension2.missouri.edu/people/kaitlyn-bissonnette-108661>

SCN Diagnostics Plant and Nematode Screening Services: <https://scndiagnostics.com/>

MU Guide G4450: Soybean Cyst Nematode: Diagnosis and Management:

<https://extension2.missouri.edu/g4450>

Dr. Bissonnette IPM articles on SDS and SCN, April 27, 2018:

https://ipm.missouri.edu/IPCM/2018/4/Early_season_soybean_diseases/

Appendix 6

ILeVO Strip Trial Project Leadership Team:

Dr. John Lory, MU Extension, Nutrient Management

Dr. Kaitlyn Bissonnette, MU Extension, Field Crop Pathologist

Greg Luce, MU Extension, Missouri Soybean Association, Agronomist

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