MICHIGAN SOYBEAN ON-FARM RESEARCH

2019

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MICHIGAN SOYBEAN ON-FARM RESEARCH

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THANK YOU to the farmer cooperators for contributing their land, equipment and time during the busy planting and harvest seasons to help improve Michigan soybean production.

For more information on participating in a 2020 on-farm research project, contact Mike Staton at (269)673-0370 extension 2562 or staton@msu.edu.

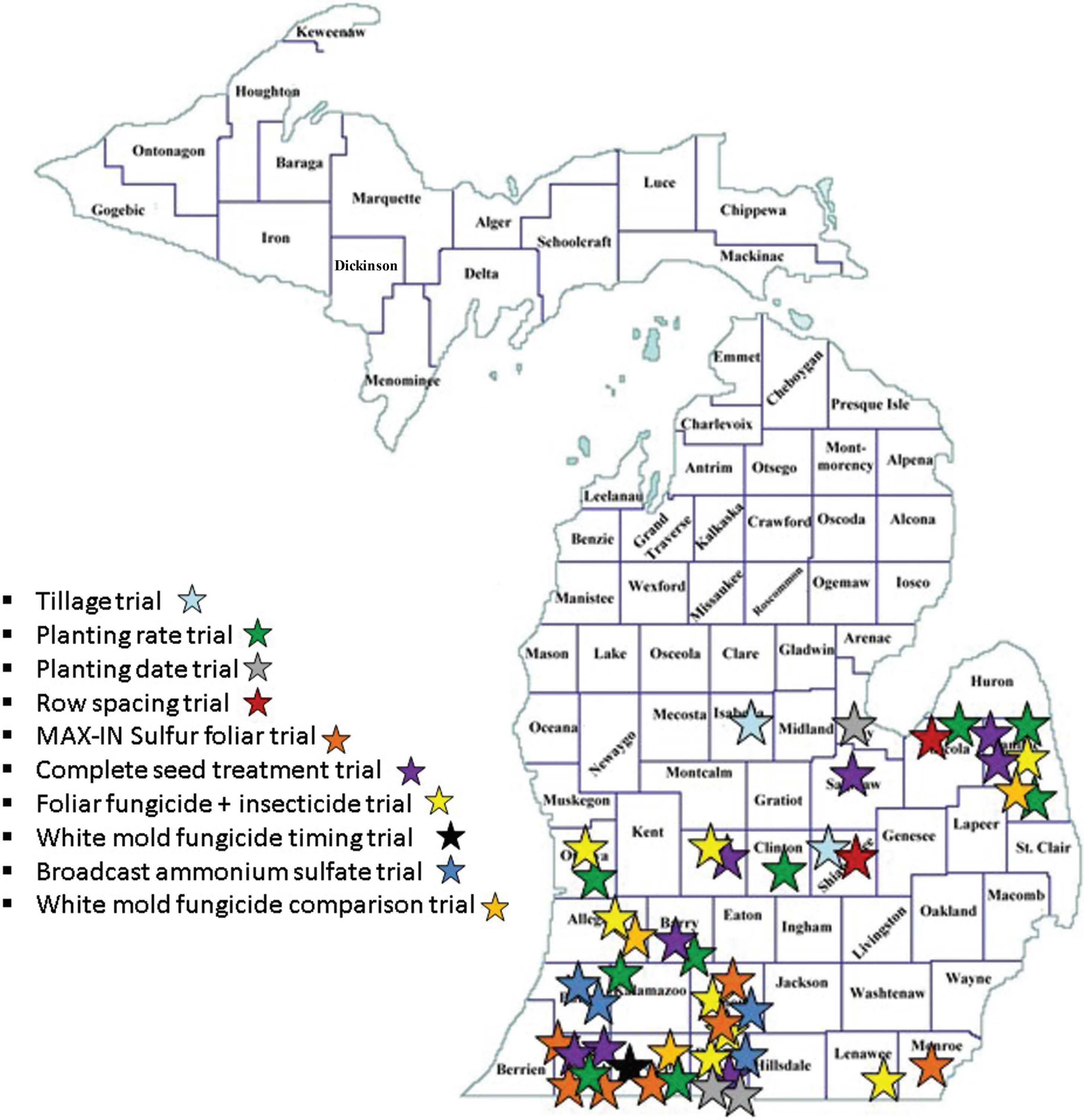
2019 marks the ninth season of the on-farm research program, made possible by the checkoff investment of Michigan soybean producers. This year, 36 producers around the state conducted on-farm research trials within ten projects. Contained in this publication you'll find the results from 47 individual trial locations. The research projects were developed with producer input and represent some of the most challenging production issues confronting producers. Most of the projects were conducted at multiple locations and, in some cases, across several years, improving the reliability of the results presented.

Agronomic and economic data is presented for each treatment. Partial budgets and breakeven yields utilized the projected USDA 2019-20 average soybean price of $9.00 per bushel, the manufacturers' suggested retail prices for all product(s) and application costs associated with the treatments.

Conducting these trials would not be possible without strong partnerships. One example is the unique collaboration between Michigan State University Extension (MSUE) and the Michigan Soybean Promotion Committee (MSPC) to jointly fund Mike Staton, MSUE statewide soybean educator and on-farm project coordinator. This program would also not be possible without the efforts of Ned Birkey and Dan Rajzer with whom MSPC contracts to implement on-farm trials and who are essential to this project's success. MSPC soybean production specialist Ty Bodeis took final plant stand counts, rated the white mold trials for white mold incidence, collected soil samples for nutrient analysis and compiled other valuable information. We also want to thank MSU Extension educators Roger Betz, Paul Gross and Bob Battel for their efforts in making this research possible.

Only the statistically significant yield increases are mentioned in the text in this report. All other yield differences (no matter how large) are not due to the applied treatment and should be ignored.

2019 On-farm Trial Locations



2019 Planting Rate Trial

Purpose: Soybean planting rates was the highest ranked topic identified by soybean producers for evaluation in the on-farm trials. The producers were interested in evaluating the effect of reduced planting rates on soybean yields and income. There are two main factors driving the increased interest in reducing soybean planting rates – seed cost and white mold. The purpose of this trial was to continue to evaluate how reducing planting rates will affect soybean yield and income.

Procedure: There were nine planting rate trials conducted in 2019. Four target planting rates (80,000, 100,000, 130,000 and 160,000 seeds per acre) were compared. Stand counts were taken to determine actual final plant stands at each location. Projected market prices and conservative seed costs were used to determine the income (gross income minus seed cost) produced by the four planting rates.

Results: In 2019, the 160,000 planting rate out-yielded the 130,000 rate at two of the nine sites, the 100,000 rate at two locations and the 80,000 rate at four of the locations (Table 3). When all the locations were combined and analyzed, the 160,000 rate yielded more than the 130,000 and 100,000 rates by less than two bushels per acre and beat the 80,000 rate by only four bushels per acre. In 2019, the 100,000 planting rate produced the most income, followed by the 130,000 rate, and the 80,000 and 160,000 rates were tied as the least profitable (Table 3). 2019 is the fifth year of the planting rate trial in Michigan. This fifth year data builds on the confidence of the previous four years (Figure 1).

The 2015 to 2017 planting rate trials were summarized in detail in the 2017 SMaRT On-Farm Research Report, which is available online at michigansoybean.org. An article summarizing all five years (2015-2019) of the on-farm planting rate trials is included in this report on pages 6 and 7.

Figure 1. Planting rate effects on soybean yield and income in 2019 compared to the 5-year average (2015 to 2019)

Table 1. Tillage, planting equipment, row spacing, CEC, planting date, planting depth and seed treatment in 2019

Location	Tillage operations (fall/spring)	Planter/drill	Row spacing	CEC	Planting date	Planting depth	Seed treatment
Sanilac 1	NT/VT	JD DB44	22	8.3	May 25	1.5	Seed Shield First Up
Kalamazoo	CP/FC	JD 1795	15	6.7	May 16	1.5	Pioneer FST/IST
Barry	NT	JD 1780	30	6.0	May 17	1.25	None
Clinton	NT	Kinze 3500	15	9.9	June 4	1.5	Acceleron Standard
St. Joseph	D/NT	JD 2290	20	3.3	June 7	1.0	Acceleron
Ottawa	VT/VT	JD 7000	30	5.4	May 15	1.5	Escalate
Sanilac 2	DR/VT	White 8500	22	17.0	May 22	1.5	Stine XP-F&I
Cass	D	Case IH 1200	30	15.7	June 7	1.5	Agrishield Max
Sanilac 3	NT	JD 1790	15	9.8	May 31	1.25	DFender

FC = field cultivator, NT = no-till, VT = vertical tillage, D = disc, CP = chisel plow, and DR = disc ripper

Table 2. Target planting rates and actual plant stands in 2019

	------------------- Target planting rate (seeds/ac) ------------------			
Location	**80,000**	**100,000**	**130,000**	**160,000**
	------------------- Actual plant stands (plants/ac) ------------------			
Sanilac 1	54,400	71,500	91,000	110,800
Kalamazoo	62,200	77,300	98,300	118,200
Barry	63,800	81,000	104,300	120,800
Clinton	64,200	78,300	98,500	126,000
St. Joseph	66,000	84,500	101,500	121,000
Ottawa	50,100	65,500	69,700	87,300
Sanilac 2	88,600	100,000	128,600	144,100
Cass	58,900	74,600	98,400	120,400
Sanilac 3	70,300	84,300	112,500	131,000
Average (all locations)	**64,300**	**79,700**	**100,300**	**120,000**
	---------------------- Average stand loss (%) ----------------------			
	20	20	23	25

Table 3. Effect of four planting rates on soybean yield and income in 2019

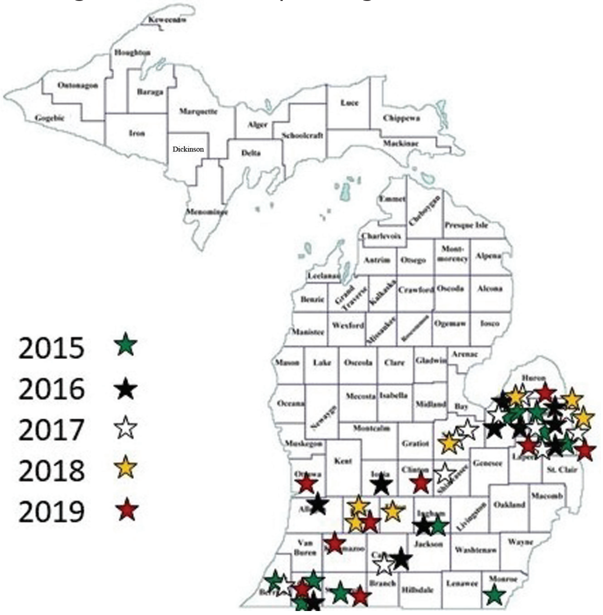
	------------------- Target planting rate (seeds/ac) ------------------				
Location	**80,000**	**100,000**	**130,000**	**160,000**	**$LSD_{0.10}$**
	-------------------- Yield (bushels/ac) --------------------				
Sanilac 1	58.4 b	58.0 b	62.5 a	63.6 a	2.7
Kalamazoo	64.9 b	65.0 b	67.4 a	66.1 ab	1.6
Barry	50.4	49.5	48.6	50.6	4.5
Clinton	50.9 c	58.1 b	58.9 b	62.6 a	3.6
St. Joseph	71.0	71.6	72.8	72.3	1.5
Ottawa	59.4 c	63.4 a	61.8 b	63.6 a	1.6
Sanilac 2	46.0 b	48.7 a	46.5 b	47.0 b	1.3
Cass	60.2	62.9	65.0	65.9	4.4
Sanilac 3	62.3 c	63.2 bc	65.1 ab	65.9 a	2.1
Average yield	**58.1 c**	**60.1 b**	**60.9 b**	**62.0 a**	**1.0**
	-------------------- Income ($/ac) --------------------				
Average income	**$489**	**$498**	**$492**	**$489**	

Seed cost = $60 per 140,000 seed unit

Reducing Soybean Planting Rates (5-year summary)

Michigan soybean producers have consistently identified planting rates as the highest priority topic to evaluate in on-farm replicated trials. Furthermore, producers prioritized evaluating the effect of low planting rates on soybean yield and income. The two factors driving the increased interest in reducing soybean planting rates are seed cost and white mold. To help Michigan soybean producers make planting rate decisions, the on-farm research program conducted a total of 49 on-farm replicated trials from 2015 to 2019. Please see Figure 1 for the trial locations.

Figure 1. On-farm planting rate trial locations



Eleven planting rate trials were conducted each year from 2015 to 2017, seven trials were conducted in 2018 and nine in 2019. Four target planting rates (80,000, 100,000, 130,000 and 160,000 seeds per acre) were compared at all but one location where the lowest rate was not included. Stand counts were taken to determine actual final plant stands at each location in all years. To calculate the income (gross income minus seed cost) generated by each planting rate, we used the USDA projected prices and average seed costs for treated seed for each year. None of the varieties planted in the trials were straight line or thin line plant types and a complete seed treatment was used at 41 of the locations.

Because we conducted the trials over five years, we learned how the planting rates performed over a range of growing conditions. Planting conditions were nearly ideal in 2015 but were much more challenging in 2016 to 2019, as evidenced by the average stand loss shown in Table 1. Statewide record yields were achieved in 2015 and again in 2016. However, yields declined significantly in 2017 due to excessive early rains and a lack of rain in August and September. Yields rebounded in 2018 but fell again in 2019 due to planting delays and dry weather in August.

Table 1. Average stand loss in the planting rate trials

Year	Average stand loss for all planting rates (percent)
2015	12
2016	18
2017	22
2018	26
2019	22

Table 2 shows the average yield and income for all 49 locations. When all 49 sites were combined, the yields from the highest two planting rates were identical and beat the 100,000 seeds per acre planting rate by less than one bushel per acre and the 80,000 rate by only 2.2 bushels per acre. The 100,000 seeds per acre planting rate generated the most income while the 160,000 rate produced the least income.

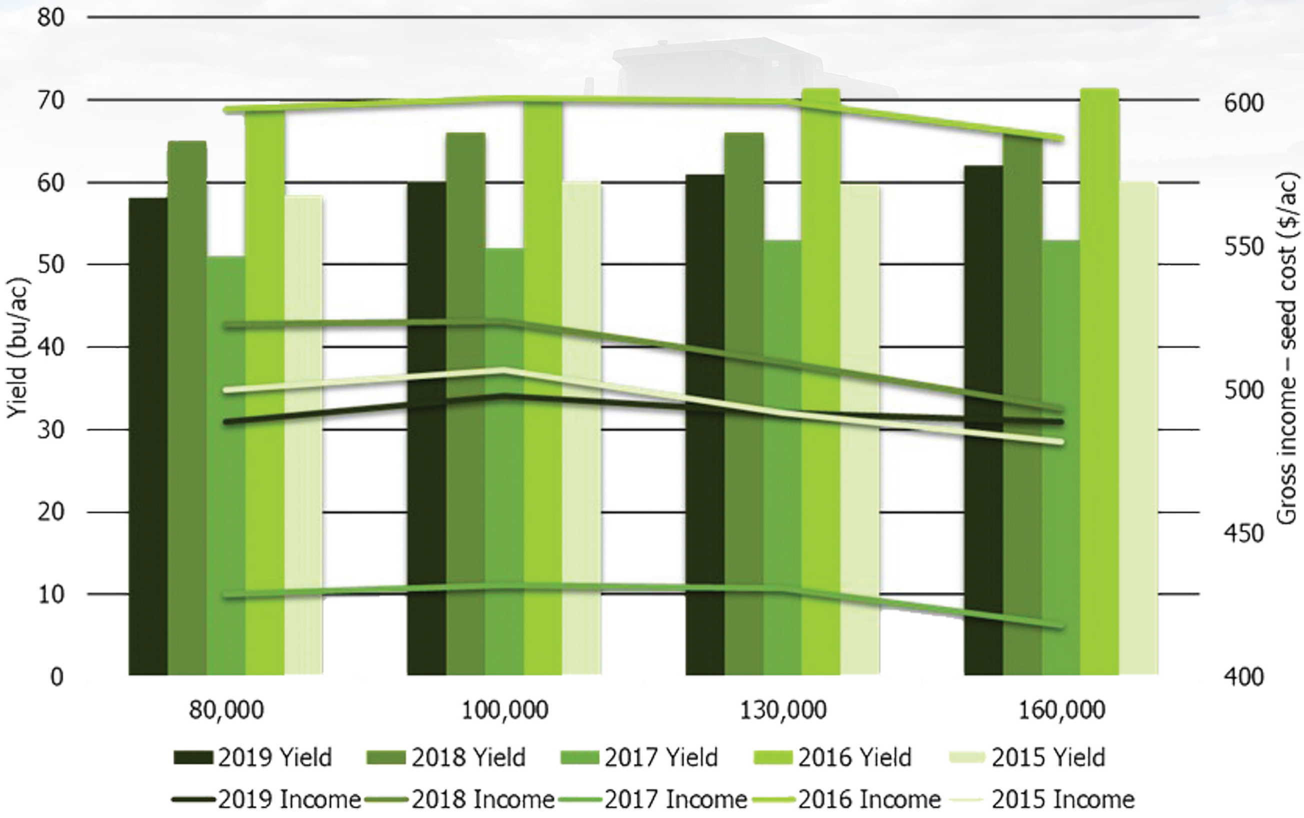
Table 2. Planting rate effects on average yield and income from 2015 to 2019 (all 49 locations)

Planting rate	Average yield (bu/ac)	*Gross income – seed cost ($/ac)
80,000	59.9 c	$505
100,000	61.4 b	$510
130,000	62.1 a	$503
160,000	62.3 a	$492

*Using 2019 figures for seed cost ($60/140,000 seed unit and market price ($9.00) per bushel)

The effects of soybean planting rates on yield and income by year are shown in Figure 2. The bars represent yield and the lines represent income. The figure clearly shows the year-to-year variability in yield and income. It also shows that the lowest two planting rates were the most profitable in 2015 and 2018 and the highest planting rate was the least profitable each year.

Figure 2. Planting rate effects on soybean yield and income from 2015 to 2019



Two of the trials were infested with white mold, which shows that reducing soybean planting rates can also be an effective management practice for reducing yield and income losses from white mold (Table 3). At both sites, the lowest planting rate produced $80.00 per acre more income than the highest planting rate. Figure 3 shows how planting rates affected white mold in the 2018 Saginaw location. This site was planted in 30-inch rows.

Table 3. Soybean planting rate effects on yield and income at two locations infested with white mold

Planting rate	------- Yield (bu/ac) --------		------- Income ($/ac) -------	
	2015 Sanilac 2	2018 Saginaw	2015 Sanilac 2	2018 Saginaw
80,000	63.2 a	66.2 a	$534	$561
100,000	61.1 b	66.5 a	$507	$556
130,000	61.5 b	64.3 a	$497	$523
160,000	57.9 c	61.2 b	$452	$482
LSD $_{0.10}$	1.7	2.4		

*Using 2019 figures for seed cost ($60/140,000 seed unit and market price ($9.00) per bushel)

Figure 3. Drone image showing planting rate effects on white mold incidence at the 2018 Saginaw trial

Nearly half of the planting rate trials were conducted in Tuscola and Sanilac Counties, so the Thumb area has been well represented. However, we are looking for sites in mid-Michigan, southwest Michigan and southeast Michigan for 2020 as we want producers in these areas to have local research results. We also want to collect enough data to be able to make specific planting rate recommendations based on management practices such as tillage intensity, seed treatments, planting date, row spacing, etc. This trial is very easy to conduct when the planter is equipped with electric or hydraulic variable rate drives. Please contact me (Mike Staton) by phone at 269.673.0370 ext. 2562 or by email at staton@msu.edu if you are interested in conducting a soybean planting rate trial on your farm in 2020.

2019 Planting Date Trial

Purpose: Early planting is an important management practice for producing high-yielding soybeans. However, many Michigan soybean producers believe that planting early is risky and have not fully adopted the practice. The question is, do the benefits of early planting outweigh the risks? The purpose of this trial was to evaluate the yield and income benefits of early-planted soybeans in 2019.

Procedure: This trial compared soybeans planted at an early date for the area vs. soybeans planted at a normal planting date for the area at three locations in 2019. The early planting dates at the Branch County sites are considered very early whereas the early planting date in Bay County is consistent with the current MSU recommendations for planting soybeans during the last week of April if soil conditions are conducive (Table 1). All other factors were kept the same to isolate the effect of planting date in these trials.

Results: Early planting increased soybean yield by 6.5 bushels per acre at an irrigated location (Branch 1). However, planting date did not affect soybean yield at the other two sites. The results from all three trials support the recommendation for planting soybeans early. The Branch 1 location showed there is potential for early planting to increase soybean yields and the other two sites demonstrated that early planting did not reduce yields. Because soybean yield was not adversely affected by planting date, producers may be able to plant earlier than they previously thought was possible. This information will help producers manage weather risk in the spring by extending their soybean planting window.

The 2019 results support the recommendation for planting soybeans early.

Figure 1. Effect of planting date on soybean yield at three locations in 2019

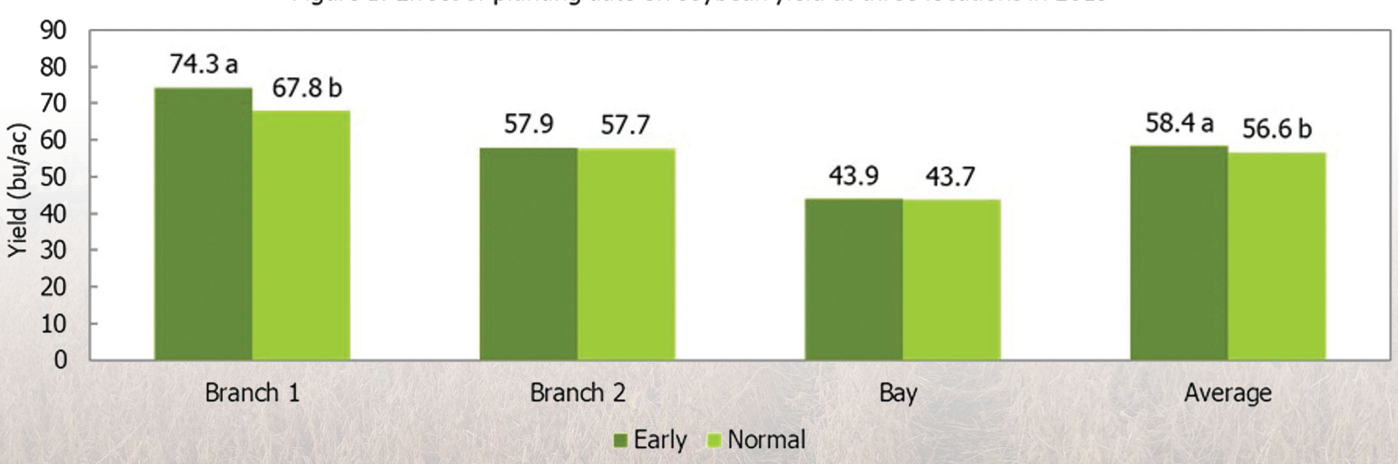


Table 1. Background information for the planting date trials conducted in 2019

Location	Early planting date	Normal planting date	Tillage	CEC (meq/100g)	Planter	Previous crop	Seed treatment	Row width
Branch 1*	April 4	May 5	VT/NT	4	JD 1790	Corn	Pioneer FST/IST, ILeVO	15"
Branch 2	March 29	May 5	NT	5	JD 1790	Corn	Pioneer FST/IST, ILeVO	15"
Bay	April 25	May 15	DR/FC,R	14	JD 1790	Corn	Agrishield	20"

CP = chisel plow, FC = field cultivator, NT = no-till, VT = vertical tillage, SF = soil finisher, DR = disc ripper and R = roller
* This is an irrigated site

Table 2. The effect of planting date on soybean yield and income in 2019

Location	Early planting date	Normal planting date	LSD $_{0.10}$	Yield difference
	------------------- Yield (bu/ac)	------------------		Yield (bu/ac)
Branch 1	74.3 a	67.8 b	1.7	6.5
Branch 2	57.9	57.7	3.1	0.2
Bay	43.9	43.7	1.7	0.2
Average	**58.4 a**	**56.6 b**	**1.7**	**1.8**
	------------------- Income ($/ac)	-----------------		
Average income	**$526**	**$509**		

Early planted soybeans (on left) emerging before the ones planted 3 weeks later

2017 to 2019 Complete Seed Treatment Trial

Purpose: Seed treatments have repeatedly been identified as a high priority for evaluation in on-farm research trials. The purpose of this trial was to provide an opportunity for cooperators to evaluate the performance of the complete seed treatment (multiple fungicides plus an insecticide) of their choosing on their farms in 2017 to 2019.

Procedure: This trial compared two treatments (a complete seed treatment including multiple fungicides plus an insecticide vs. untreated seed). Eight trials were conducted in 2017, 13 in 2018 and eight in 2019. The cooperators worked closely with their seed dealers to ensure that all seed planted in each trial was the same variety and came from the same seed lot. We also took final stand counts to determine the effect that seed treatments had on soybean stands.

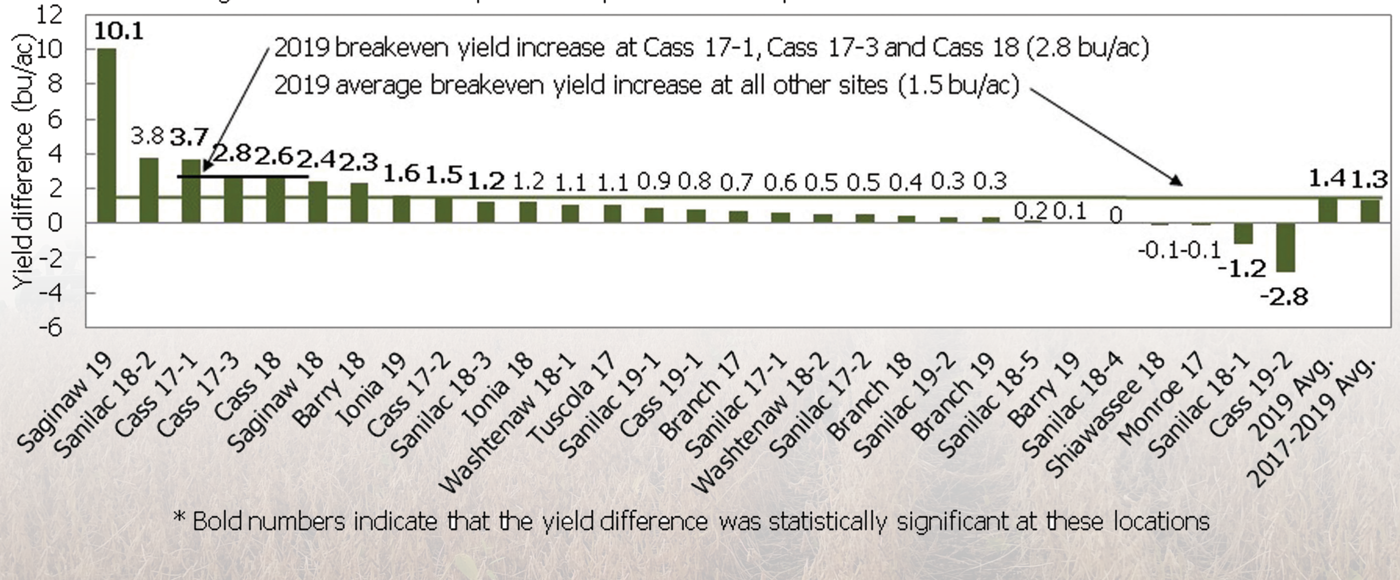
Results: Complete seed treatments increased soybean yield at two locations in 2017, five in 2018 and two in 2019. The Saginaw 19 site showed a yield increase of 10.1 bushels per acre (Table 2) which is an outlier compared to the other 28 sites. The very high clay content (CEC of 18 meq/100g) combined with heavy rainfall events following planting may have contributed to the large yield increase. The site was also injured by a pre-emergence herbicide application. At the Cass 19-2 site, the seed treatment reduced yield by 2.8 bushels per acre.

When all 29 sites were combined and analyzed, the complete seed treatments increased soybean yields by 1.4 bushels per acre. This is slightly less than the 1.5 bushels per acre required to recoup the cost of a basic fungicide plus insecticide seed treatment costing $14.00 per acre.

The seed treatments led to significantly higher final plant stands at seven of the 29 locations (two in 2017, three in 2018 and two in 2019). However, treated seed stand at the Cass 19-2 location was significantly lower because the treated seed did not plant at the same rate as the untreated seed. When all the sites were combined and analyzed, the complete seed treatments increased plant stands by 4,500 plants per acre.

We appreciate the help provided by local seed dealers.

Figure 1. Yield difference produced by the use of complete seed treatments in 2017 to 2019



* Bold numbers indicate that the yield difference was statistically significant at these locations

Table 1. 2019 Seed treatments, varieties, phytophthora genes/tolerance rating, tillage practices and planting dates

Location	Seed treatment	Variety	Phytophthora gene/tolerance	Tillage fall/spring	Planting date
Saginaw 19	Pioneer FST/IST	Pioneer P22T69	1k/4 (9=excellent, 1=poor)	NT	May 17
Ionia 19	Vibrance Trio	GH2230X	1c/4 (1=best, 5=worst)	VT/VT	June 6
Sanilac 19-1	Dfender	DF Seeds DF227	1a/1.8 (1=best, 5=worst)	NT	May 17
Cass 19-1	Pioneer FST/IST	Pioneer P21A28X	1k/5 (9=excellent, 1=poor)	VT	April 22
Branch 19	Pioneer FST/IST	Pioneer P31A06L	1k/5 (9=excellent, 1=poor)	NT	June 4
Sanilac 19-2	Dfender	DF Seeds DF227	1a/1.8 (1=best, 5=worst)	NT	May 18
Barry 19	Pioneer FST/IST	Pioneer P26A61X	1k/5 (9=excellent, 1=poor)	NT	May 17
Cass 19-2	Pioneer FST/IST	Pioneer P31A22X	1k/6 (9=excellent, 1=poor)	VT	June 2

CP = chisel plow, FC = field cultivator, NT = no-till, VT = vertical tillage, SF = soil finisher and DR = disc ripper

Table 2. The effect of complete seed treatments on soybean yield and income in 2019

Location	Untreated control	Treated seed	LSD $_{0.10}$	Yield difference
	------------------- Yield (bu/ac)	------------------		Yield (bu/ac)
Saginaw 19	49.3 b	59.4 a	2.2	10.1
Ionia 19	58.2 b	59.8 a	0.6	1.6
Sanilac 19-1	72.7	73.6	1.2	0.9
Cass 19-1	37.6	38.4	3.8	0.8
Branch 19	73.8	74.1	3.9	0.3
Sanilac 19-2	60.4	60.7	1.6	0.3
Barry 19	46.5	46.6	0.9	0.1
Cass 19-2	59.6 a	56.8 b	2.0	-2.8
Average (2019)	**57.2 b**	**58.6 a**	**1.0**	**1.4**
	------------------- Income ($/ac)	-----------------		
***Average income**	**$515**	**$513**		

*Using an average cost for complete seed treatments (fungicide mix + insecticide) of $14.00 per acre

Table 3. The effect of complete seed treatments on final plant stands in 2019

Location	Untreated control	Treated seed	LSD $_{0.10}$	Stand difference
	----------- Plant stand (plants/ac)	-----------		Plant stand (plants/ac)
Saginaw 19	52,200 b	66,000 a	7,070	13,800
Ionia 19	131,600	133,100	3,632	1,500
Sanilac 19-1	78,600	76,300	10,553	-2,300
Cass 19-1	109,700	111,700	8,327	2,000
Branch 19	73,100	74,900	10,702	1,800
Sanilac 19-2	81,100	78,600	4,563	-2,500
Barry 19	80,400 b	86,000 a	3,223	5,600
Cass 19-2	168,000 a	140,100 b	12,026	-27,900
Average (2019)	**97,000**	**95,700**	**3,460**	**-1,300**
Average (2017-2019)	**100,400 b**	**104,900 a**	**1,822**	**4,500**

2018 and 2019 Pre-plant, Broadcast Ammonium Sulfate Trial

Purpose: There is growing interest in applying sulfur fertilizers to soybeans. Much of this is due to recent research conducted by Dr. Shaun Casteel at Purdue University. Dr. Casteel has shown some profitable yield increases when ammonium sulfate is broadcast prior to planting soybeans. The purpose of this trial was to evaluate how a pre-plant, broadcast application of ammonium sulfate will affect soybean yield and income in Michigan in 2018 and 2019.

Procedure: A pre-plant, broadcast application of ammonium sulfate (21-0-0-24) was compared to an unfertilized control at four locations in 2018 and four more locations in 2019. The ammonium sulfate was applied at 100 pounds per acre. Soil tests were collected from each site to determine the baseline sulfur levels in the soil.

Results: The ammonium sulfate did not increase soybean yields at any of the 2018 trials or when all the 2018 locations were combined and analyzed. However, in 2019 the ammonium sulfate application increased yield by 3.8 bushels per acre and income by $14.40 per acre at one site (Calhoun 19). Due to the lack of a consistent positive yield response and the associated fertilizer and application costs with this treatment, the ammonium sulfate treatment reduced income by $13.50 per acre when all eight locations were combined and analyzed.

Ammonium sulfate significantly increased yield at only one of eight sites.

As-applied map from one of the AMS trial sites. At this site, the AMS was applied in 80 foot wide strips and a calibrated yield map was provided, eliminating the need for weigh wagons or individual yield monitor loads.

Table 1. Soil test levels at the 2018 and 2019 pre-plant ammonium sulfate trial locations

Location	Organic matter	Phosphorus	Potassium	Magnesium	Calcium	Sulfur	CEC	Soil pH
	Percent	Parts per million					meq/100g	1:1
Calhoun 19	2.0	83	145	95	950	8	7.1	6.5
Branch 19	2.0	16	**81**	170	500	**4**	5.1	6.7
Van Buren 18	1.7	34	115	75	700	**7**	5.6	6.4
Branch 18	1.5	45	91	100	600	8	4.1	6.9
Tuscola 18	2.9	**14**	125	145	1250	9	7.8	7.0
Van Buren 19-1	1.9	40	108	90	500	9	4.7	6.3
Van Buren 19-2	1.9	33	137	70	550	10	4.9	6.4
Lenawee 18	3.9	31	154	495	2500	**7**	17	7.0

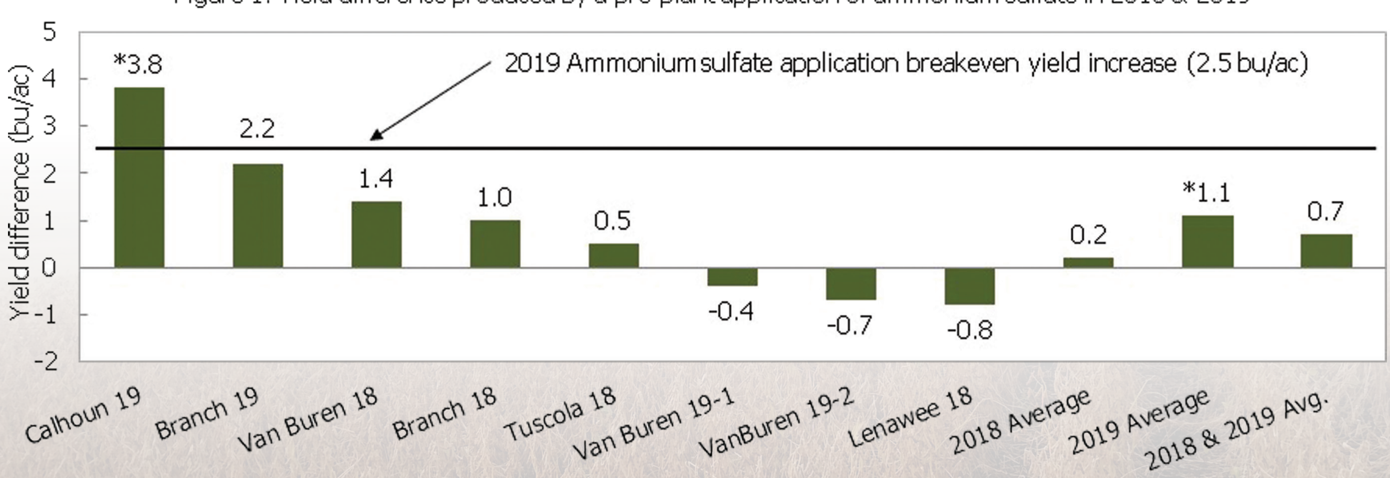
Bold figures indicate low or very low soil test levels

Table 2. The effect of a pre-plant broadcast application of ammonium sulfate on soybean yield and income in 2018 & 2019

Location	Untreated control	Ammonium sulfate	LSD $_{0.10}$	Yield difference
	Yield (bu/ac)			Yield (bu/ac)
Calhoun 19	47.9 b	51.7 a	2.1	3.8
Branch 19	45.2	47.4	3.3	2.2
Van Buren 18	56.6	58.0	1.5	1.4
Branch 18	51.5	52.5	10.1	1.0
Tuscola 18	54.6	55.1	3.6	0.5
Van Buren 19-1	38.3	37.9	1.6	-0.4
Van Buren 19-2	49.1	48.4	1.7	-0.7
Lenawee 18	53.9	53.1	2.6	-0.8
Average 2018 & 2019	**49.7**	**50.4**	**0.8**	**0.7**
	Income ($/ac)			
Average income	**$447**	**$431**		

Ammonium sulfate cost = $16.90 per acre
Dry fertilizer spreading cost = $5.22 per acre

Figure 1. Yield difference produced by a pre-plant application of ammonium sulfate in 2018 & 2019



*The yield difference was statistically significant at these locations

2019 Row Spacing Comparison Trial

Purpose: The most common row spacing for soybean production in Michigan is 15 inches and many of these acres are planted with planters equipped with interplant units. These planters are significantly more expensive than planters of comparable width set up for 30-inch rows and producers want to know if the extra expense is justified. The purpose of this trial was to evaluate how two common row spacings affected soybean yield and income in Michigan in 2019.

Procedure: Two row spacings (15 inches and 30 inches) were compared at two locations in 2019. Both trials were planted with planters equipped with interplant units and planting rates were kept the same regardless of row spacing. The planting rate was 130,000 seeds per acre at the Tuscola site and 140,000 seeds per acre at the Shiawassee site. Stand counts were taken to determine the effect row spacing would have on final plant stands.

Results: The 15-inch rows yielded 2.7 bushels per acre higher than the 30-inch rows at the Tuscola site. The same trend occurred at the Shiawassee site, but the yield increase was not statistically significant. When both locations were combined, the 15-inch rows produced 2.6 bushels per acre more than the 30-inch rows in 2019. Row spacing did not affect final plant stands at the Tuscola location. However, final plant stands were almost 10,000 plants per acre higher in the 15-inch rows at the Shiawassee site. The 30-inch rows may perform better in fields with a history of white mold or in fields prone to crusting.

Roger Betz, MSU farm management educator, generated a partial budget comparing the economics of purchasing a 12/24 interplant planter vs. a 12-row 30-inch planter. This analysis showed that the 15-inch rows increased income by $3,011 per year over the life of the planter. The assumptions used in the analysis are listed below:

- 15% rate of return on investment
- 2.6 bushels per acre yield increase
- Soybean market price of $9.00 per bushel
- 500 acres of soybeans per year
- Planter life of 10 years
- $50,000 additional cost for the interplant planter
- $7,500 salvage value

Row closure at the Tuscola site

Harvesting the Tuscola row spacing trial

Row spacing trial in Shiawassee County

Table 1. Background information for the row spacing trials conducted in 2019

Location	Tillage fall/spring	Planter/drill	Previous crop	Planting date	Variety	Plant type
Tuscola	CP/FC, R	JD 1790 12/23	Corn	May 11	Pioneer P24A80	5 (9=extremely bushy, 1=very narrow)
Shiawassee	CP/FC	JD 1790 12/24	Corn	May 15	LG 2942	MB (TL; M; MB; B)

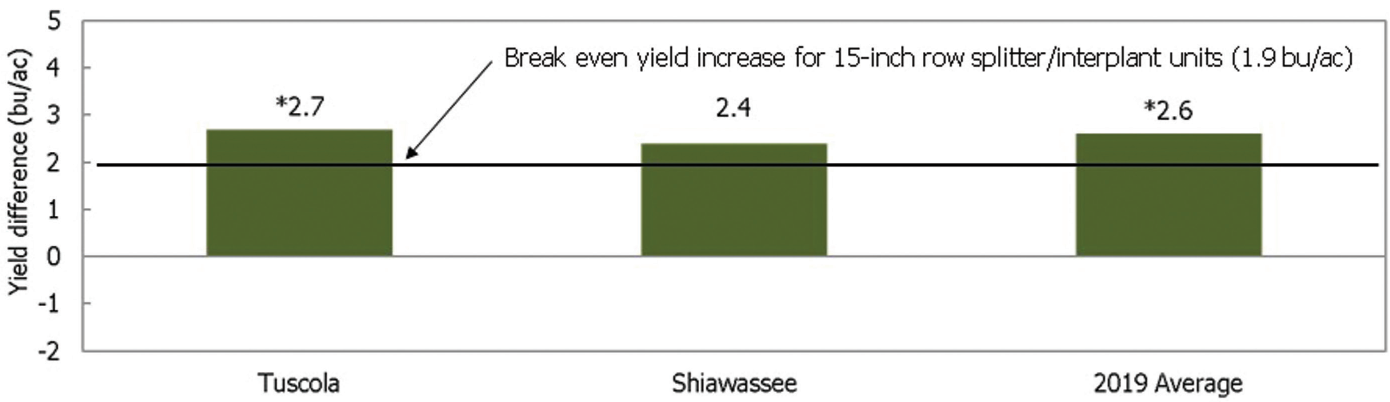
CP = chisel plow, FC = field cultivator, NT = no-till, VT = vertical tillage, SF = soil finisher, DR = disc ripper and R = roller

Table 2. The effect of row width on soybean yield and income in 2019

Location	15-inch rows	30-inch rows	LSD $_{0.10}$	Yield difference
	------------------- Yield (bu/ac) ------------------			Yield (bu/ac)
Tuscola	59.2 a	56.5 b	1.3	2.7
Shiawassee	32.8	30.4	3.6	2.4
Average	**46.0 a**	**43.4 b**	**1.4**	**2.6**
	------------------- Income ($/ac) -----------------			
Average income	**$397**	**$391**		

Increased cost per acre to own and operate a 12/24 15-inch row planter given 500 acres of soybeans per year for 10 years = $17.40 per acre.

Figure 1. Yield difference produced by narrowing row width from 30-inches to 15-inches in 2019



*The yield difference was statistically significant at these locations

Table 3. The effect of row spacing on final plant stands in 2019

Location	15-inch rows	30-inch rows	LSD $_{0.10}$	Stand difference
	-----------Plant stand (plants/ac) -----------			Plant stand (plants/ac)
Tuscola	114,200	111,500	2,912	2,700
Shiawassee	95,100 a	85,300 b	6,904	9,800
Average (2019)	**105,500 a**	**98,600 b**	**3,522**	**6,900**

The Tuscola site was planted at 130,000 seeds per acre and the Shiawassee site was planted at 140,000 seeds per acre

2019 Tillage Trial

Purpose: During our winter meetings, soybean growers have identified tillage and residue management as a high priority project to be evaluated by the on-farm program. The purpose of this trial was to evaluate how a single pass of any tillage implement selected by the trial cooperators will affect soybean yield and income in 2019.

Procedure: A single tillage pass was compared to an untilled control at two locations in 2019. A Degelman Pro-Till® was used at the Shiawassee location and a John Deere 230 disc was used at the Isabella site. Both implements were run in the spring. We took stand counts to determine the effect that the tillage operations would have on final plant stands.

Results: The one-pass tillage operations did not increase soybean yields or final plant stands compared to the untilled control at either location. Because yields were not improved by tillage, the tillage operations were less profitable than the untilled control in 2019. When both sites were combined, the net loss due to tillage was $8.00 per acre. This is consistent with tillage research results from the northern U.S., Canada and Michigan. The soybean yield increase produced by tillage operations is typically not enough to outweigh the lower costs and the conservation benefits of no-till.

Despite the lack of consistent economic returns to tillage, many producers feel that tilling the soil prior to planting soybeans offers other benefits including: improved marestail control, improved planter/drill performance and the ability to dry out the soil surface and allow earlier planting under wet soil conditions. There are conflicting reports about how spring tillage affected planting progress this spring. Some producers felt that operating a high-speed disc like the Pro-Till at very shallow depths allowed them to plant sooner, while others felt that a stale seedbed or untilled soil facilitated earlier planting.

Soybean yield was not increased by tillage in 2019.

Pro-Till at work before soybean planting
Photo credit: Degelman Industries Ltd.

Table 1. Background information for the tillage trials conducted in 2019

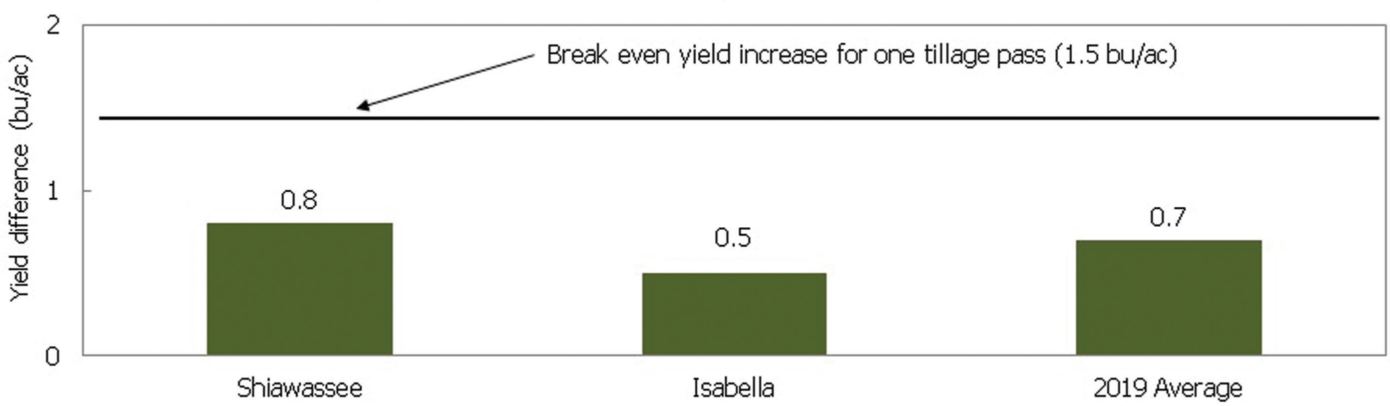
Location	Tillage tool	Planter/drill	Previous crop	Planting date	Seed treatment	Row width
Shiawassee	Degelman Pro-Till	JD 1990	Corn	June 18	Pioneer FST/IST	15”
Isabella	JD 230 disc	JD 750	Corn	June 8	Eclipse Quad IM	15”

Table 2. The effect of a single spring tillage pass on soybean yield and income in 2019

Location	Untilled control	Single tillage pass	$LSD_{0.10}$	Yield difference
	------------------ Yield (bu/ac)	------------------		Yield (bu/ac)
Shiawassee	55.8	56.6	1.6	0.8
Isabella	55.3	55.8	0.8	0.5
Average	**55.5**	**56.2**	**0.7**	**0.7**
	------------------ Income ($/ac)	----------------		
Average income	**$500**	**$492**		

Tillage cost is $14.00 per acre.

Figure 1. Yield difference produced by a single tillage pass in the spring 2019



The yield difference was not statistically significant at any of the locations

Table 3. The effect of a single spring tillage pass on soybean plant stand in 2019

Location	Seeding rate	Untilled control	Single tillage pass	$LSD_{0.10}$	Stand difference
	Seeds/acre	--- Final plant stand	(plants per acre) ---		Plants per acre
Shiawassee	165,000	118,700	119,300	19,205	600
Isabella	154,000	72,800	77,300	11,606	4,500
Average		**95,500**	**98,300**	**7,944**	**2,800**

2018 and 2019 MAX-IN® Sulfur Trial

Purpose: There is growing interest in applying nutrients directly to soybeans through foliar applications. Many questions are included in this interest such as which nutrient is needed, what is the best formulation or product, when should it be applied and at which rate. The purpose of this trial was to evaluate how a foliar application of MAX-IN Sulfur, a liquid fertilizer containing potassium and sulfur sold by WinField® United, affected soybean yield and income in 2018 and 2019.

Procedure: A foliar application of MAX-IN Sulfur (0-0-19-13) plus MasterLock® adjuvant was compared to an unfertilized control at nine locations in 2018. The MAX-IN Sulfur was applied at 1 quart per acre and the MasterLock was applied at 6.4 ounces per acre at the R1 growth stage in 2018.

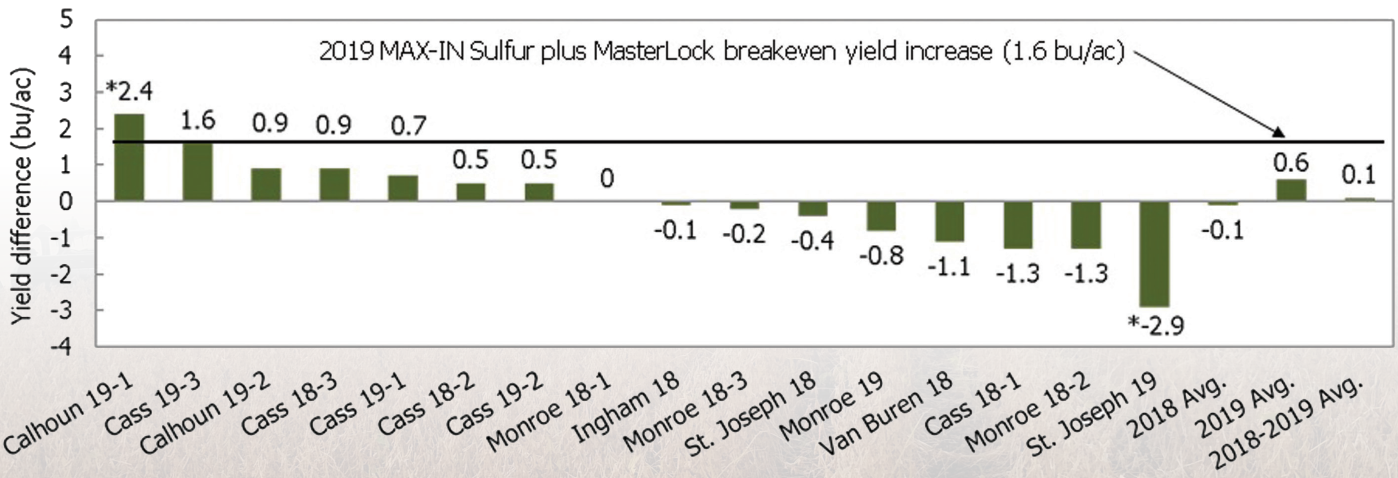
There were seven locations in 2019. For the 2019 trials, the MAX-IN Sulfur rate was increased to 2 quarts per acre and the application timing was changed to R3.

Results: In 2018, the foliar application of MAX-IN Sulfur plus MasterLock did not increase soybean yields in any of the individual trial locations or when all the locations were combined and analyzed. However, in 2019, the MAX-IN Sulfur application increased yield by 2.4 bushels per acre at one location and reduced yield by 2.9 bushels per acre at another. The lack of a consistently positive yield response is probably due to the fact that the soil was able to supply enough potassium and sulfur to meet crop demand.

These results show that prophylactic foliar applications of sulfur are not consistently profitable even when sulfur soil test levels are low or very low. Foliar nutrition applications may have more value when tissue tests indicate deficiencies, especially with micronutrients rather than macronutrients like sulfur. We hope to be able to evaluate the yield and income benefits of applying prescription foliar fertilizer mixtures based on in-season plant tissue testing in future on-farm trials.

We want to thank WinField United for donating the products for these trials.

Figure 1. Yield difference from a foliar application of MAX-IN Sulfur plus MasterLock in 2018 and 2019



*The yield difference was statistically significant at these locations

Table 1. Soil test levels at the 2018 and 2019 MAX-IN Sulfur trial locations

Location	Organic matter	Phosphorus	Potassium	Sulfur	CEC	Soil pH
	Percent	------------------- Parts per million		--------------------	meq/100g	1:1
Calhoun 19-1	2.2	113	151	8	8.4	6.6
Cass 19-3	1.2	36	105	**6**	3.4	6.6
Calhoun 19-2	2.0	36	125	**7**	4.8	6.2
Cass 18-3	2.4	17	**86**	**7**	7.5	6.5
Cass 19-1	1.4	39	118	**5**	3.9	6.6
Cass 18-2	1.7	36	98	**4**	3.9	6.9
Cass 19-2	1.6	22	99	**4**	4.2	6.4
Monroe 18-1	2.7	42	**58**	**7**	5.0	6.0
Ingham 18	1.3	75	123	**7**	4.2	6.6
Monroe 18-3	2.7	72	113	8	5.4	5.8
St. Joseph 18	1.3	36	97	**3**	3.6	6.9
Monroe 19	2.7	39	**57**	**5**	5.9	6.9
Van Buren 18	1.6	50	109	9	4.4	5.9
Cass 18-1	1.9	74	106	**6**	4.9	6.5
Monroe 18-2	3.5	32	167	9	11.2	6.8
St. Joseph 19	1.4	22	**46**	**3**	2.0	6.7

Bold figures indicate low or very low soil test levels.

Table 2. The effect of a foliar application of MAX-IN Sulfur plus MasterLock on soybean yield and income in 2018 and 2019

Location	Untreated control	MAX-IN Sulfur plus MasterLock	LSD 0.10	Yield difference
	------------------- Yield (bu/ac)	----------------		Yield (bu/ac)
Calhoun 19-1	43.4 b	45.8 a	2.1	2.4
Cass 19-3	20.9	22.5	1.8	1.6
Calhoun 19-2	36.3	37.2	1.2	0.9
Cass 18-3	71.0	71.9	2.0	0.9
Cass 19-1	49.8	50.5	1.0	0.7
Cass 18-2	66.0	66.5	2.8	0.5
Cass 19-2	54.6	55.1	3.8	0.5
Monroe 18-1	32.5	32.5	2.9	0.0
Ingham 18	56.0	55.9	2.6	-0.1
Monroe 18-3	45.9	45.7	4.5	-0.2
St. Joseph 18	64.7	64.3	0.6	-0.4
Monroe 19	38.4	37.6	2.3	-0.8
Van Buren 18	55.1	54.0	3.7	-1.1
Cass 18-1	63.6	62.3	4.1	-1.3
Monroe 18-2	51.0	49.7	5.9	-1.3
St. Joseph 19	76.1 a	73.2 b	1.9	-2.9
Average 2018 & 2019	**51.5**	**51.6**	**0.5**	**0.1**
	------------------ Income ($/ac)	----------------		
Average income	**$464**	**$450**		

MAX-IN Sulfur cost = $11.25 per acre
MasterLock cost = $3.00 per acre

2017 to 2019 Foliar Fungicide and Insecticide Tank Mixture Trial

Purpose: Soybean producers are trying to improve soybean yields and many are willing to manage the crop more intensively to achieve this goal. There is interest in applying foliar tank mixtures which include a fungicide and an insecticide. The purpose of this trial was to provide an opportunity for interested producers to evaluate the yield and income performance of the fungicide and insecticide tank mixture of their choosing on their farm in 2017, 2018 and 2019.

Procedure: Cooperating producers were given the opportunity to select the foliar fungicides and insecticides they wanted to evaluate on their farms. The products, application rates and rainfall information for each location are listed in Table 1. The foliar applications were made at R3 and the sprayers were driven through the untreated control treatments to prevent tire tracks from being a factor.

Results: The foliar fungicide-insecticide application increased soybean yields at five of the 15 locations (Table 2). However, it was profitable at only two locations. When all 15 locations were combined and analyzed, the foliar fungicide and insecticide tank mixture produced an average yield increase of 1.6 bushels per acre which is just over half the yield increase required to break even. The plant and yield responses to foliar pesticides are sometimes difficult to determine but weather is one likely factor. Rainfall and hours of rainfall during the critical growth stages that normally occur in July and August are included for each trial site (Table 1).

It is interesting to note that the cooperator in Sanilac County has produced the three highest yield increases from applying the tank mixture. We have discussed this extensively and he feels that he is applying the products at the optimum growth stage and providing excellent coverage by using a spray volume of 20 gallons per acre. We have not identified anything else that could be responsible for the yield increases.

Table 1. Products, application rates and rainfall information for the trial locations in 2017 to 2019

			*Rainfall totals and hours of rain for July & August			
Location	Fungicide – rate (oz/ac)	Insecticide - rate (oz/ac)	Trial Year (inches)	2016-2019 avg. (inches)	Trial year (hrs)	2016-2019 avg. (hrs)
Sanilac 19	Priaxor® - 4	Fastac™ - 3.8	4.0	6.1	47.0	65.0
Sanilac 17	Priaxor® - 4	Fastac™ - 3.8	4.5	6.1	68.0	65.0
Sanilac 18	Priaxor® - 4	Fastac™ - 3.8	5.3	6.1	72.0	65.0
Lenawee 17	Priaxor® - 4	Fastac™ - 3.8	3.9	6.0	52.0	59.5
Lenawee 19	Priaxor® - 6	Fastac™ - 3.8	7.4	6.0	69.0	59.5
Allegan 19	Delaro™ – 8	Leverage® – 2.8	5.5	7.8	58.0	70.0
Ottawa 19	Quadris® - 6	Baythroid XL® - 1.5	5.5	6.1	60.0	64.3
Monroe 17-2	Priaxor® - 4	Fastac™ - 3.8	3.9	6.0	52.0	59.5
Ionia 18	Stratego® YLD - 6	Mustang® Maxx - 3	7.7	7.7	82.0	82.5
Monroe 17-1	Priaxor® - 4	Fastac™ - 3.8	3.9	6.0	52.0	59.5
Ionia 19	Lucento™ – 5	Mustang® Maxx - 3	5.6	7.7	64.0	82.5
Calhoun 19	Miravis Neo® -14	Endigo® – 4	6.3	6.8	63.0	64.8
Ionia 17	Stratego® YLD – 6	Mustang® Maxx – 3	5.3	7.7	54.0	82.5
Branch 17	Priaxor® - 4	Fastac™ - 3.8	5.1	6.8	64.0	64.8
Branch 19	Priaxor® - 4	Fastac™ - 3.8	6.3	6.8	63.0	64.8

*Rainfall data was obtained from the nearest MSU Enviroweather station

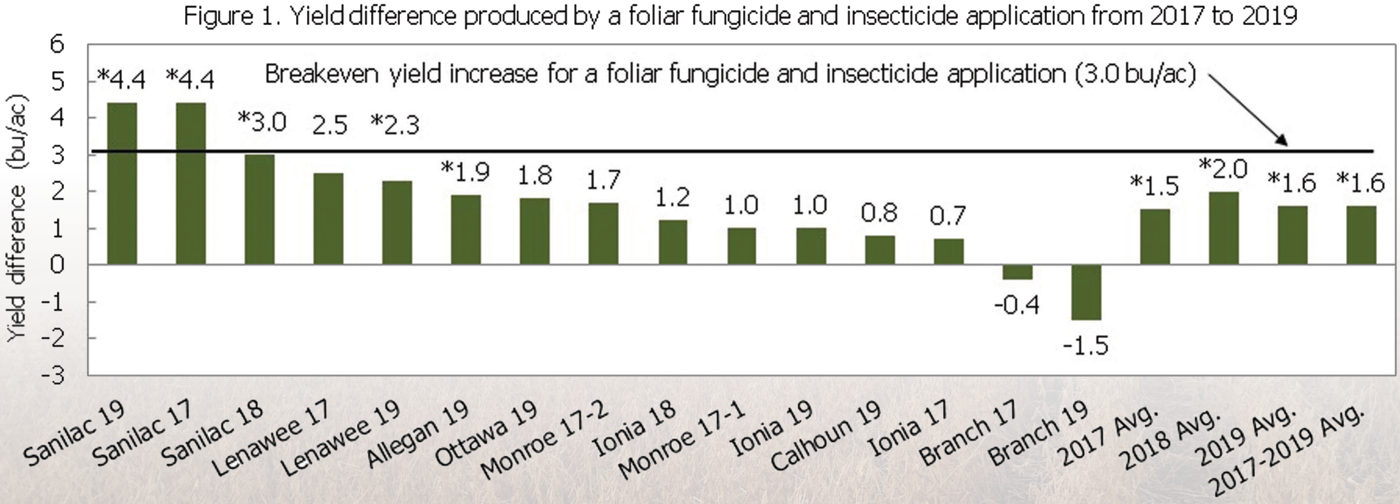
Table 2. The effect of a foliar fungicide and insecticide application on soybean yield and income in 2017 to 2019

Location	Untreated control	Foliar fungicide and insecticide	LSD 0.10	Yield difference
	------------------- Yield (bu/ac)	------------------		Yield (bu/ac)
Sanilac 19	55.2 b	59.6 a	2.2	4.4
Sanilac 17	39.3 b	43.7 a	2.6	4.4
Sanilac 18	56.8 b	59.8 a	1.9	3.0
Lenawee 17	59.8	62.3	3.7	2.5
Lenawee 19	60.6 b	62.9 a	1.3	2.3
Allegan 19	62.4 b	64.3 a	1.0	1.9
Ottawa 19	80.1	81.9	5.7	1.8
Monroe 17-2	46.1	47.8	5.1	1.7
Ionia 18	59.6	60.8	1.4	1.2
Monroe 17-1	60.3	61.3	2.9	1.0
Ionia 19	54.3	55.3	1.2	1.0
Calhoun 19	42.0	42.8	3.1	0.8
Ionia 17	46.6	47.3	0.8	0.7
Branch 17	54.5	54.1	7.7	-0.4
Branch 19	52.8	51.3	3.0	-1.5
Average 2017-2019	**54.9 b**	**56.5 a**	**0.6**	**1.6**
	------------------- Income ($/ac)	-----------------		
***Average income**	**$494**	**$481**		

*Using the cost for a foliar application of Priaxor and Fastac
Priaxor fungicide cost = $15.26 per acre
Fastac insecticide cost = $3.81 per acre
Application cost = $8.00 per acre

Foliar fungicide and insecticide application in R3 soybeans

Figure 1. Yield difference produced by a foliar fungicide and insecticide application from 2017 to 2019



* The yield difference was statistically significant at these locations

2019 White Mold Foliar Fungicide Comparison Trial

Purpose: *Sclerotinia Stem Rot* or white mold can cause significant yield reductions in soybeans grown in Michigan and fungicides can be an important management tool for managing the disease. This trial evaluated the effect of two foliar fungicide programs on soybean yields and income in 2019.

Procedure: This trial consisted of three treatments: 1) sequential applications of Cobra® followed by Aproach®; 2) a single application of Propulse®; and 3) an untreated control. The trial was conducted at three locations in 2019. All products were applied at labeled rates (6 ounces per acre for Cobra, 9 ounces per acre for Aproach and 8 ounces per acre for Propulse). The Cobra was applied at the appearance of the first blossoms and the Aproach and Propulse were applied 10 to 14 days later. Sprayer tracks were eliminated from being a factor by driving the sprayer through the untreated strips or using a spray boom wide enough that none of the harvested strips contained tire tracks. White mold incidence was determined at all locations by counting 100 consecutive plants and recording the number of diseased plants.

Results: All three sites had a history of white mold. However, environmental conditions favoring disease development did not occur at any of the locations, resulting in very low incidence of white mold. These sites demonstrate how the foliar fungicide programs affected soybean yield and income in the absence of white mold pressure. Propulse increased soybean yields over the untreated control at two of the three locations (Sanilac and Allegan) and when all three sites were combined (Table 2). However, the Cobra followed by Aproach program did not perform better than the untreated control at any of the sites. This is consistent with previous research conducted in Michigan which concluded that Cobra improved yield when white mold occurred, but reduced yield when the disease did not develop. The Propulse treatment was profitable at the Sanilac and Allegan locations and when all three sites were combined and analyzed.

We want to thank Valent®, Bayer Crop Science and Corteva Agriscience™ for donating products.

Cobra followed by Aproach staying green

Mature bird's nest apothecia.
Photo from Dr. Martin Chilvers

White mold apothecia

Table 1. Varieties, planting dates, planting rates, row spacing and fungicide application dates at the trial locations

Location	Soybean variety	White mold resistance/tolerance of soybean variety	Planting date	Planting rate	Row spacing	*Application dates
Sanilac	AG23X8	4 (1 = excellent, 9 = poor)	May 24	140,000	20”	7/22 & 8/6
St. Joseph	AG30X6	6 (1 = excellent, 9 = poor)	June 2	139,000	20”	7/30 & 8/8
Allegan	DF 278	1.5 (1 = best, 5 = worst)	May 15	130,000	Twin 7”	7/11 & 7/22

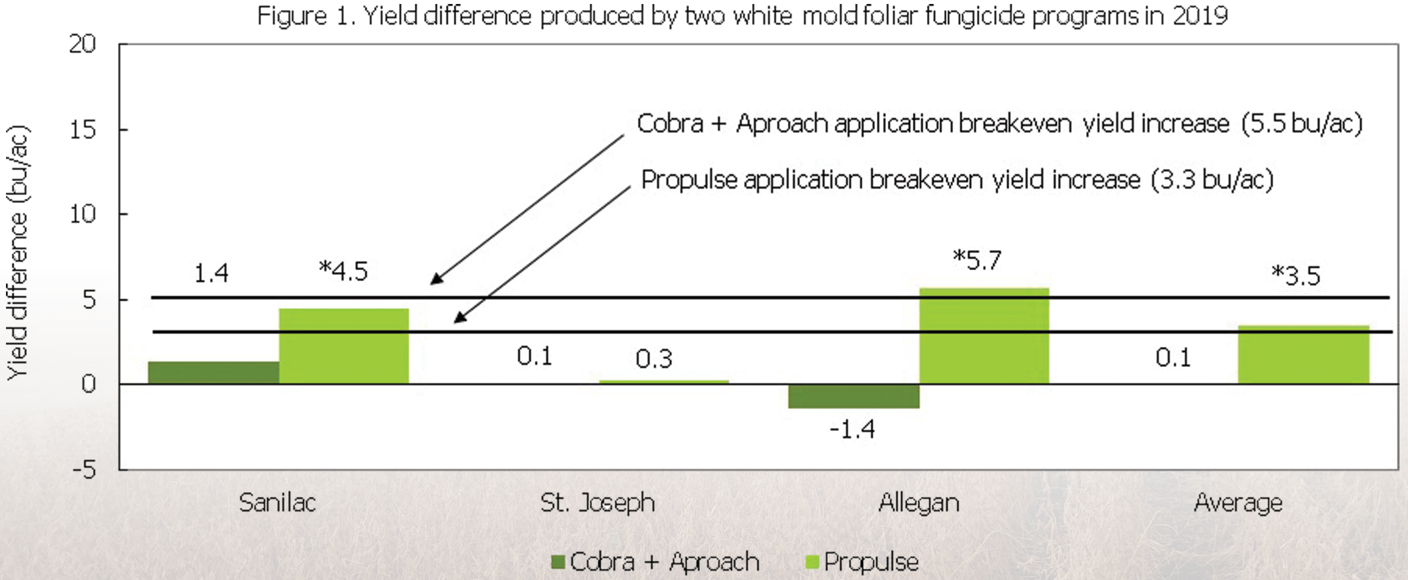
* The first application date is for Cobra and the second date is for Aproach and Propulse

Table 2. White mold foliar fungicide program effect on soybean yield and income in 2019

	Untreated control	Cobra + Aproach	Propulse	LSD $_{0.10}$
	------------------ Yield (bu/ac) ------------------			
Sanilac	53.8 b	55.2 b	58.3 a	2.9
St. Joseph	66.5	66.6	66.8	2.9
Allegan	67.9 b	66.5 b	73.6 a	1.6
Average	**62.7 b**	**62.8 b**	**66.2 a**	**1.6**
	----------------- Income ($/ac) -----------------			
Average income	**$564**	**$516**	**$566**	

Cobra + Aproach cost = $31.50 per acre, Propulse cost = $21.90 per acre, application cost = $8.00 per acre

Figure 1. Yield difference produced by two white mold foliar fungicide programs in 2019



*The yield difference between the fungicide programs and the control was statistically significant at these locations. The yield difference between the fungicide programs was statistically different at only the Sanilac and Allegan locations.

2018 and 2019 White Mold Foliar Fungicide Application Timing Trial

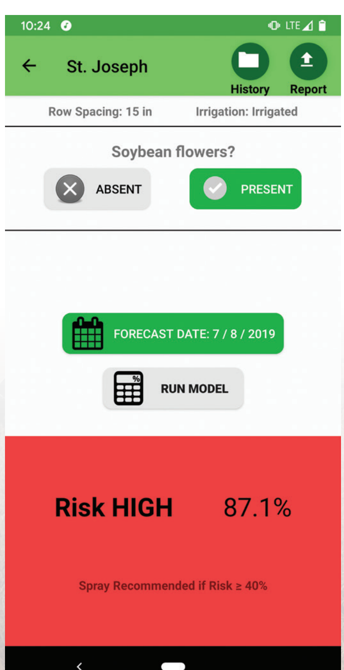
Purpose: Foliar fungicides can be an important tactic for reducing yield loss from white mold, especially when combined with other effective management practices such as resistant/tolerant varieties, wide rows, reduced planting rates, tillage decisions and irrigation water management. Properly timing fungicide applications is essential for success but challenging for producers. The purpose of this trial was to determine the effect that fungicide application timing had on soybean yield and income in 2018 and 2019. Another goal was to use the yield data from this trial to validate Sporecaster, a new white mold apothecia prediction application for smart phones.

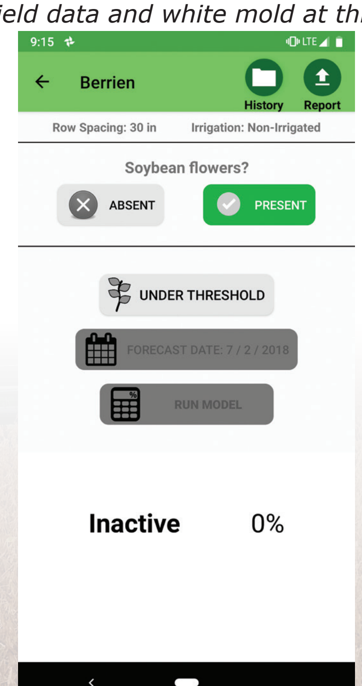
Procedure: The trial compared three fungicide application timings to an untreated control at three locations previously infested with white mold. The application timings were: R1 (one open flower on 50% of the plants); R3 (one pod >3/16" long on any of the upper four nodes on the main stem); and R1 followed by R3. Aproach® fungicide was applied at a rate of 9 ounces per acre for all application timings. We entered the dates for the R1 and R3 applications into the Sporecaster app to determine the apothecia risk level for the dates and locations. White mold incidence was also determined at all locations.

Results: White mold did not occur at the Sanilac 18 and St. Joseph 19 sites but was present at Berrien 18. The sequential application of Aproach produced a higher yield than the R3 timing, the R1 timing and the untreated control at the Berrien 18 site. The R3 timing also produced a higher yield than the R1 timing and the control at this site. Despite the absence of white mold at the Sanilac 18 site, the sequential application produced a higher yield than the R1 timing and the control. When the product and application costs were subtracted from the gross income for each treatment, the income ranking for the treatments was: control > R3 > R1+R3 > R1.

We want to thank Corteva Agriscience™ for providing the Aproach fungicide and Dr. Martin Chilvers for his input.

The Sporecaster app recommended spraying at R1 at the Sanilac 18 and the St. Joseph 19 sites but not at the Berrien 18 site. However, the hot dry weather occurring in July prevented white mold from developing at these locations. At R3, Sporecaster recommended spraying only at the Berrien 18 site which is consistent with the yield data and white mold at this site.





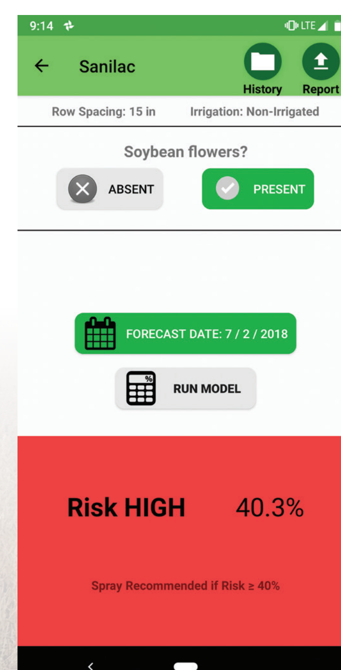


Table 1. Planting dates, planting rates, row spacing and fungicide application dates at the trial locations

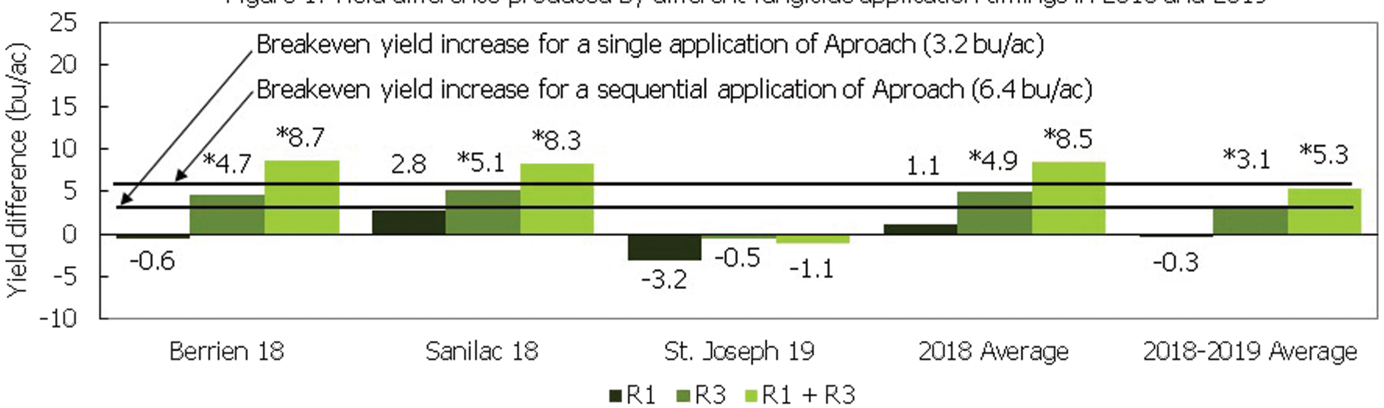
Location	Soybean variety	White mold resistance/tolerance of soybean variety	Planting date	Planting rate (seeds/ac)	Row spacing	Application dates
Berrien 18	NuTech 7240-DA26	6 (1=excellent and 9=poor)	May 26	130,000	30"	July 2 and August 11
Sanilac 18	Asgrow AG19X8	4 (1=excellent and 9=poor)	May 13	130,000	20"	July 2 and July 14
St. Joseph 19	Pioneer P25A82L	5 (9=excellent and 1=poor)	May 16	130,000	Twin 8"	July 8 and July 24

Table 2. White mold foliar fungicide application timing effect on soybean yield and income in 2018 and 2019

Location	Untreated control	R1	R3	R1 + R3	$LSD_{0.10}$
	------------------- Yield (bu/ac) -------------------				
Berrien 18	74.5 c	73.9 c	79.3 b	83.2 a	3.8
Sanilac 18	63.9 c	66.8 bc	69.0 ab	72.2 a	4.4
St. Joseph 19	71.8	68.6	71.3	70.7	2.3
Average	**70.1 b**	**69.8 b**	**73.2 a**	**75.4 a**	**2.3**
	------------------- Income ($/ac) -------------------				
Average income	**$631**	**$599**	**$629**	**$620**	

Aproach fungicide cost for a single application = $21.00 per acre, application cost = $8.00 per acre

Figure 1. Yield difference produced by different fungicide application timings in 2018 and 2019



*The yield difference between the fungicide application timings and the control were statistically significant at these locations. The yield difference between the R3 and the R1 + R3 application timings was statistically significant at the Berrien County site and when both locations were combined in 2018. However, these two treatments were not different at the Sanilac 18 and St. Joseph 19 sites or when all three sites were combined.

Table 3. Foliar fungicide application timing effect on white mold incidence in 2018

Location	Control	R1	R3	R1+R3	$LSD_{0.10}$
	-------------- White mold disease incidence (% infected) --------------				
Berrien 18	0.5	0.3	0	0.3	0.5
Sanilac 18	0.8	0.1	0.5	0.4	0.7
Average	**0.6**	**0.2**	**0.3**	**0.3**	**0.4**

Due to a soil type change, the incidence of white mold increased significantly in the last 200 feet of row at the Berrien 18 site (approximately 25% incidence in the control strips). This is not represented in the incidence levels listed above. White mold did not occur in the St. Joseph 19 location.

Herbicide-resistant Horseweed (Marestail) in Michigan

Keys to management in no-till soybean

Christy Sprague, Extension Weed Science

www.MSUweeds.com
November 2019

MICHIGAN STATE UNIVERSITY WEED SCIENCE

MSUWS08-2019

Horseweed (*Conyza canadensis*), also known as marestail, is an annual weed that can follow a winter or summer annual life cycle. While horseweed can emerge in the fall, we have recently been observing more horseweed emergence from early spring through summer (March through August) in Michigan. Unlike other winter annuals, horseweed does not mature until late summer, allowing for greater competition with crops compared with other winter annual weeds. Horseweed plants generally start out as a rosette, bolt in April/May, flower in July, and set and disperse seed from August through October. These plants not only reduce soybean yield, but large mature plants may interfere with soybean harvest. Each plant can produce up to 200,000 seeds that travel long distances in the wind. Up to 86% of seeds produced can germinate right off the plant and 59 to 91% of fall emerging seedlings can survive the winter, causing problems in the next spring's crop.

Michigan no-till soybean field infested with horseweed

Herbicide resistance in horseweed:

Horseweed resistance to the ALS-inhibitors (Group 2), triazines (Group 5), and glyphosate (Group 9) have been identified in Michigan. However, horseweed **resistance to multiple herbicides** including, **glyphosate** and **ALS-inhibitors**, are common in Michigan. These multiple resistance profiles make it difficult to manage horseweed, since glyphosate will not control horseweed in the burndown application or postemergence in Roundup Ready soybean. If ALS-resistance is present the use of PRE or POST applications of Classic (*chlorimuron*), FirstRate (*cloransulam*), or other ALS-inhibitors will not effectively control horseweed. Horseweed management strategies need to rely heavily on effective burndown treatments that include 6 to 8 weeks of residual control from PRE herbicides, as well as, the use of soybeans with other herbicide-resistant traits for postemergence herbicide options.

Fall emerging horseweed

Spring/summer (June) emerging horseweed

Horseweed bolting in spring

Seedhead prior to seed dispersal

Consider planting LibertyLink, LibertyLink GT27, or Enlist E3 soybean

Glufosinate (Liberty, Interline, Scout, others) is one of the most effective postemergence herbicide options for control of multiple-resistant horseweed. Soybean that are LibertyLink, LibertyLink GT27 or Enlist E3 can be treated with glufosinate postemergence. To effectively control horseweed in soybeans with these traits the following recommendations need to be followed.

- Effective burndown and residual herbicides outlined on the following page are needed prior to planting.
- Apply Liberty (32-43 oz/A) POST prior to horseweed exceeding 6-inches in height. Ammonium sulfate (AMS) should always be included. Use the higher glufosinate rate to control taller plants or plants that have escaped initial control. Follow with a second POST application of Liberty as needed.

Remember glufosinate products can only be applied over-the-top of soybean that are glufosinate-resistant.

Enlist E3 soybean:

In addition to glufosinate resistance, Enlist E3 soybean are also resistant to the choline salt of 2,4-D and glyphosate. The use of Enlist One (2,4-D choline) or Enlist Duo (2,4-D choline + glyphosate) in Enlist E3 soybean provides additional options for horseweed control. From MSU research we have observed effective horseweed control when these recommendations are followed.

- Tank-mix and apply Enlist One (32 oz/A) or Enlist Duo (4.75 pt/A) with an effective residual (PRE) herbicide prior to planting or emergence of Enlist E3 soybean. Other burndown herbicides can also be used.
- Apply Enlist One (32 oz/A), Enlist Duo (4.75 pt/A), Liberty (32-43 oz/A) or combinations of Enlist One + Liberty POST prior to horseweed exceeding 6-inches in height. Follow with a second POST application of any of these products if needed.

Guidelines and ***additional precautions*** for use of Enlist One and Enlist Duo in Enlist E3 soybean are outlined in Table 2H of the MSU Weed Control Guide (E0434).

What about Roundup Ready 2 Xtend soybean?

Roundup Ready 2 Xtend (dicamba-resistant) soybean provides growers another option for multiple-resistant horseweed control. Emerged horseweed is effectively controlled by registered dicamba products used prior to or after planting Roundup Ready 2 Xtend soybean. However, concerns with off-target dicamba movement to sensitive crops and species force us to limit our recommendations to using dicamba for horseweed control in the burndown application (preplant or preemergence). Postemergence applications of dicamba may be used, but there are greater chances for off-target movement. There are several restrictions that need to be followed if applying dicamba in this system. From MSU research we have observed effective multiple-resistant horseweed control when these recommendations are followed.

- Tank-mix and apply XtendiMax, FeXapan (22 or 44 oz), or Engenia (12.8 oz) with an effective residual (PRE) herbicide prior to planting or emergence of Roundup Ready 2 Xtend soybean only. Mixtures of *two effective residual* active ingredients provide the most consistent horseweed control. Effective residual herbicides are outlined on the following page.

Restrictions and ***additional precautions*** for use of dicamba in Roundup Ready 2 Xtend soybean are outlined in Table 2I of the MSU Weed Control Guide (E0434) and remember the label must be followed.

Steps for successful horseweed management in soybean

Step 1: Control emerged horseweed prior to planting!!

Tillage or effective burndown herbicide applications are the only two methods available to control emerged horseweed prior to planting soybean. For tillage to be effective it needs to be close to the time of planting, thoroughly mixing the top few inches of soil to uproot any existing horseweed plants. Vertical tillage tools are not effective. However, due to horseweed being mostly a problem in no-till or reduced till fields most growers will need to use effective burndown treatments for horseweed control. In some cases, in fields with historical horseweed problems two applications may be needed (fall followed by spring applications).

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Step 1: Control emerged horseweed prior to planting *(continued)*

Effective burndown treatments (Fall):

- Best applied when horseweed is in the rosette stage, prior to 4-inches tall.
- Fall treatments should be used to control emerged horseweed, but a spring burndown treatment will still be needed. These treatments reduce variability from spring only treatments.
  - Use 2,4-D, dicamba, or Sharpen as the base herbicides in fall treatments. Tank-mixtures with other herbicides (i.e., glyphosate) will be needed to control other winter annual and perennial weeds.

Effective burndown treatments (Spring prior to soybean planting):

- Horseweed needs to be managed prior to planting.
- Preplant herbicide treatments should be applied when horseweed plants are less than 4-inches tall.
- The most consistent options for horseweed control have more than one effective herbicide site of action.

Options with one effective herbicide:

- 2,4-D ester (1 pt) + glyphosate + AMS (7 days or more prior to planting)
- Sharpen (1 oz) or *saflufenacil* products (OpTill, Optill PRO, Zidua PRO or Verdict) + glyphosate + MSO + AMS
- Liberty (36 to 43 oz) + AMS
- Enlist One (32 oz) + glyphosate + AMS or Enlist Duo (4.75 pt) + AMS in ***Enlist soybean.*** See guidelines.
- XtendiMax, FeXapan (22 or 44 oz), or Engenia (12.8 oz) + glyphosate in ***Roundup Ready 2 Xtend (dicamba-resistant) soybean only***. See restrictions.

Options with more than one effective herbicide:

- 2,4-D ester (1 pt) + Sharpen (1 oz) + glyphosate + MSO + AMS (7 days or more prior to planting)
- 2,4-D ester + Gramoxone + *metribuzin* + COC (7 days or more prior to planting)
- Sharpen (1 oz) or *saflufenacil* products + Liberty + MSO + AMS
- Liberty (32 to 43 oz) + *metribuzin* + AMS
- Gramoxone + *metribuzin* (at least 8 oz) + COC

Step 2: Include effective residual (PRE) herbicides with burndown treatment

- The use of effective residual herbicides is essential for horseweed control until the soybean canopy develops. Options with only one effective active ingredient provide more variability in residual control. Utilizing more than one effective active ingredient is more consistent.

Options with one effective herbicide:

- Group 5 herbicides: *metribuzin* (at least 8 oz) and *metribuzin* premixes (i.e., Boundary, Canopy, Moccasin MTZ, Tripzin ZC) can be applied with any of the burndown treatments. Additional *metribuzin* may need to be added to premixes to increase the *metribuzin* rate to at least 8 oz/A. DO NOT exceed the recommended *metribuzin* rate for the soil type.
- Group 14 herbicides can be applied with any of the burndown treatments, except Sharpen (*saflufenacil)* products unless applied 14 days prior to planting soybean. Group 14 herbicides include:
  - Valor or *flumioxazin* products: Afforia, Envive, Fierce, Fierce XLT, Surveil, or Valor XLT
  - *Sulfentrazone* products: Authority Assist/Elite/First/MAXX/Supreme/XL, BroadAxe XC, or Sonic
  - Sharpen (1.5 oz) can be applied, but only if applied 14 d prior to planting and soil O.M. >2%, see label.

Options with more than one effective herbicide:

- Best residual control of multiple-resistant horseweed will be from tank-mixtures or premixtures that contain two effective herbicides.
  - *Metribuzin* + Valor (*flumioxazin*)
    - Premixtures containing *metribuzin* + *flumioxazin*: Dimetric Charged, Fierce MTZ, Trivence
  - *Metribuzin + sulfentrazone*
    - Premixtures containing *metribuzin* + *sulfentrazone*: Authority MTZ

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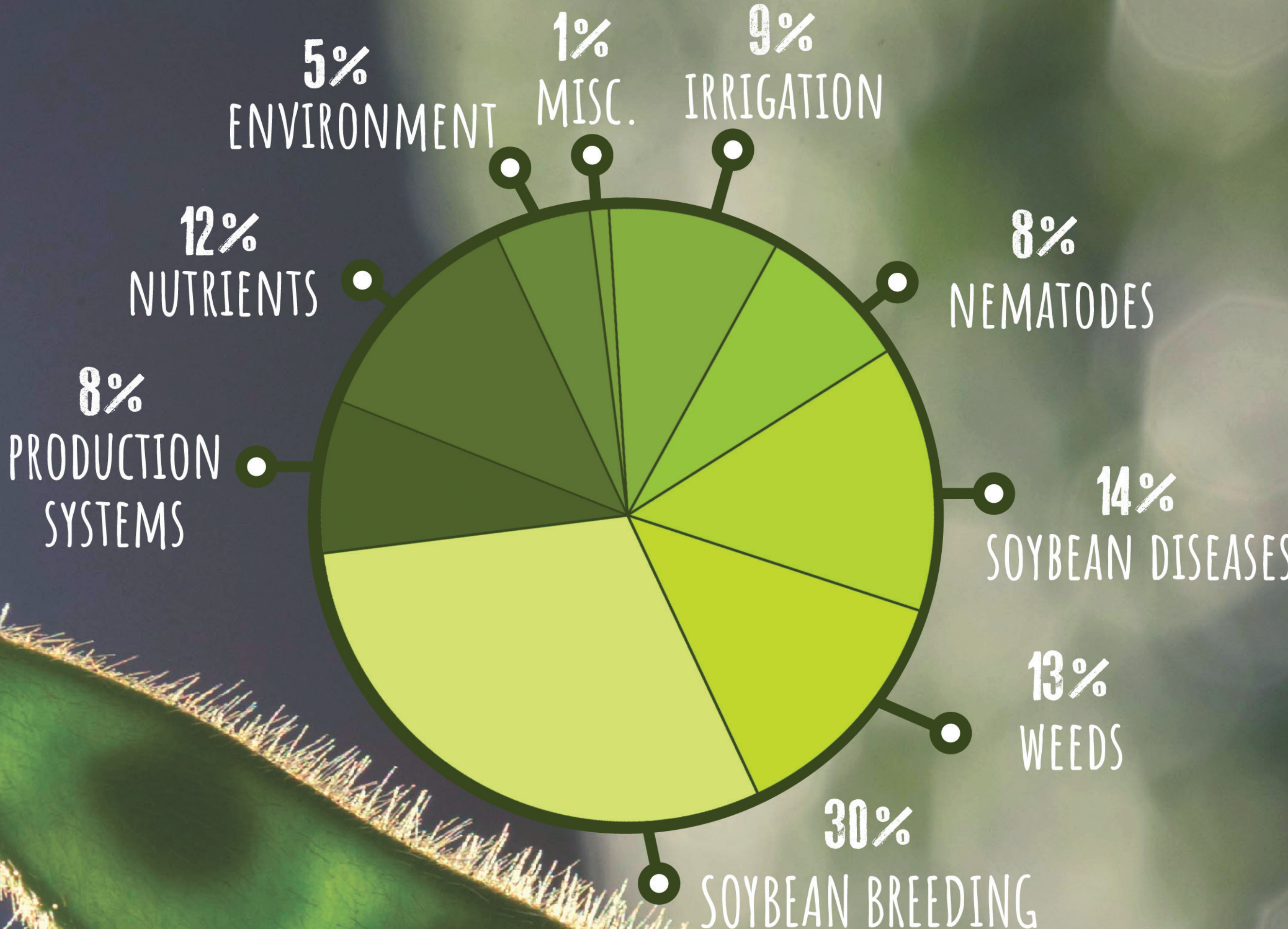
MSPC FUNDED RESEARCH



MSPC funds more than $600,000 in soybean production research each year using soybean checkoff dollars. Funding is divided among the categories listed above to provide well-rounded research results for Michigan soybean farmers.

Introduction to Experimental Design, Statistical Analysis and Interpretation

The on-farm research program designs and analyzes field research trials enabling Michigan soybean producers to reliably evaluate the performance and profitability of new products, equipment and practices on their farms. Developing and implementing trials requires sound experimental design which is the first step to generating meaningful and reliable results from on-farm research trials. One of the most common and effective designs is called the randomized complete block design (RCBD). The RCBD is also one of the easiest for cooperators to implement. The RCBD reduces experimental error by grouping or blocking all of the treatments to be compared within replications. Increasing the number of replications generally increases the sensitivity of the statistical analysis by reducing the experimental error. The on-farm research program encourages cooperators to use at least four replications. Six replications is preferred for trials comparing only two treatments.

Another important aspect of a good experimental design is the concept of randomization. Randomly assigning the order of the treatments within each block removes bias from treatment averages or means and reduces experimental error. Figure 1 shows the actual RCBD design that was used in the 2019 planting rate trials and demonstrates the principles outlined above. Note how each planting rate is included and randomized within the replications. All of the 2019 trials comparing three or more treatments utilized the RCBD with four replications of each treatment, unless stated otherwise. The treatments in all the trials comparing two treatments were alternated (not randomized within each block) and replicated at least four times.

Figure 1. The randomized complete block design used in the 2019 on-farm planting rate trials.

80K	**100K**	**130K**	**160K**	**100K**	**160K**	**80K**	**130K**	**100K**	**80K**	**160K**	**130K**	**160K**	**100K**	**130K**	**80K**
Replication 1				**Replication 2**				**Replication 3**				**Replication 4**			

After the trials were harvested, the GLIMMIX procedure within SAS was used to determine if the differences in measurable variables such as yield were due to the treatments or other outside factors. We set our confidence level at 90 percent for all statistical analysis as designated by $LSD_{0.10}$ (Least Significant Difference). Whenever the difference between two or more yields or other measurable variables is greater than the $LSD_{0.10}$, we can say that the difference is due to the treatment. This is always true in trials comparing only two treatments. However, the $LSD_{0.10}$ can falsely indicate statistical significance whenever more than two treatments are compared. The risk of this occurring increases with the number of treatments compared. There are three examples of this situation in this publication (the St. Joseph and the Cass sites in Table 3 on page 5 and the St. Joseph 19 site in Table 2 on page 25). If the yield of two treatments differs by less than the $LSD_{0.10}$ listed, we cannot say with a reliable degree of confidence that it is due to the treatment.

Letters are used in the tables and an asterisk (*) is used in the figures in this publication to identify yields or other measurements that are statistically different. When no letters are listed or the same letter appears next to the yield or other measurable condition, the difference between the treatments is not statistically significant. Only the statistically significant yield increases are mentioned in the text in this report. All other yield differences (no matter how large) are not due to the applied treatment and should be ignored.

In many cases, a given trial like the planting rate trial will be conducted at multiple locations and over multiple years. This greatly improves the reliability of the information produced.

2020 Michigan Soybean On-farm Research Cooperator Form

The on-farm program provides Michigan soybean producers with a statistically sound method for evaluating the yield and income benefits of new products, management practices and equipment. Producers across Michigan help identify new products, management practices or equipment of interest to them and conduct field scale research trials using a common protocol. The data is collected, subjected to statistical scrutiny, summarized across locations and years and shared with soybean producers. The cooperating producers are never identified to maintain confidentiality.

Please provide the following information if you are interested in conducting an on-farm research project in 2020.

Name:____

Address:____

____

Phone:______________________ Cell phone:___________________

Email:____

Please use the space below to list the soybean topic(s) that you would like to see evaluated in on-farm trials and return this form by U.S. mail, email or fax before February 1, 2020. Please complete this section even if you do not plan to conduct a trial on your farm in 2020. We will use your input when we identify the 2020 on-farm research projects.

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