UNDERSTANDING VIRUS POTENTIAL IN COMMERCIAL SOYBEAN FIELDS[4]

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Bean pod mottle virus (BPMV), *Soybean mosaic virus* (SMV), and A*lfalfa mosaic virus* (AMV) are frequently associated with soybean in Wisconsin (Table 1). The incidence of each virus has corresponded to activity of its primary insect vector. The bean leaf beetle, *Ceratoma trifurcata,* vector of BPMV, was most active between 2000 and 2002, with a noticeable decline since (Cullen et al., 2005). Although several aphid species transmit SMV and AMV, incidence of SMV and AMV relates strongly to the occurrence of the soybean aphid, *Aphis glycines*. Data and field observations suggest that BPMV is the virus most capable of causing yield loss in commercial soybean fields in Wisconsin. However, the threat of BPMV is greatly diminished because of sporadic occurrence of bean leaf beetle populations needed for epidemics to occur. In contrast to the bean leaf beetle, soybean aphid population densities required for transmission of SMV and AMV have occurred more frequently since the soybean aphid was first detected in Wisconsin in 2000.

Soybean aphid has emerged as an important pest of soybeans, and direct effects of feeding can result in significant yield reduction (Fujan, 2004). Insecticides are effective for soybean aphid control and are justified when aphid densities have reached economic threshold. The direct effects of the soybean aphid are documented (Fujan, 2004), but its economic impact as a virus transmitting agent is less clear. Transmission of SMV and AMV has been documented to increase proportionally to increasing soybean aphid population densities during the growing season. Although SMV is common in research plots, it has been difficult to detect SMV in commercial soybean fields.

Soybean viruses such as SMV and AMV are controlled most effectively by avoidance of insect vectors through planting of virus resistant soybean varieties. Although two public soybean varieties have been identified as resistant to SMV, this resistance trait is not common among commercial Roundup Ready varieties, and seldom is this trait mentioned in seed company information. Insecticides are an important tactic to control soybean aphids, but research to date suggests that insecticides do not consistently control transmission of SMV. Thus, foliar insecticide application is not a likely explanation for the low incidence of SMV in commercial soybean fields.

Research has been directed towards exploring traits among soybean varieties that could have an impact on SMV incidence. The primary source of SMV is SMV-infected seed. Seed transmission of 1 to 5% has been documented (Grau, 2005). Aphids acquire SMV from infected seedlings and transmission can occur throughout the growing season, with yield and seed quality being the most affected if transmission occurs prior to the R2 growth stage.

A research project was initiated in 2004 and continued in 2005 to determine why SMV has not become epidemic in commercial soybean fields despite high soybean aphid activity in recent years. Experiments were designed to answer the following questions: 1) Do commercial soybean varieties respond differently (yield and virus incidence) to insecticide applied for soybean aphid control? 2) Are commercial soybean varieties available that are resistant to soybean aphids and SMV? 3) Is seed transmission of SMV low among commercial soybean varieties? Answers to these questions can help identify factors that result in low occurrence of SMV, and provide guidance to the soybean seed industry for breeding varieties and producing seed.

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Table 1. Assessment of viruses detected in Wisconsin soybeans.

Virus	Risk level	Symptoms	Transmission
Bean pod mottle virus (BPMV)	High yield loss can be expected when high populations of bean leaf beetle are active during early vegetative growth stages	Young leaves in the upper canopy exhibit light green to yellow mottling; some puckering and distortion; stems remain green with mature pods; retain petioles after leaf drop. Seed discolored by pigments that bleed from hilum.	Bean leaf beetle is Common vector; seed transmission is less than 1%.
Soybean mosaic virus (SMV)	Low at present time for reasons unknown SMV is readily transmitted by the soybean aphid.	Leaves develop a mosaic of light and dark green areas; surface of leaves become raised or blistered; chlorosis may develop between dark green areas; wavy leaf margins or downward curling; maturity delayed and infected plants and remain green at harvest. Seed discolored by pigments that bleed from hilum.	32 aphid species transmit SMV; common seed transmission rates are 1-5%; Reaction of soybean varieties is not well documented.
Alfalfa mosaic virus (AMV)	Low at present time. Incidence is greater than SMV in commercial fields.	Bright yellow mosaic of leaves; leaf veins are yellow but leaf is a normal green color.	Transmitted by aphids; seed transmission 1-35%.

Experimental Protocol

The primary goal of the project is to investigate the potential role of soybean varieties in development and implementation of integrated pest management practices directed at the control of soybean aphids and associated viruses. The first step is to determine whether current commercial soybean varieties react differently to the soybean aphid, and whether soybean varieties modify the efficacy of insecticides to control the soybean aphid and associated viruses. The second step is to determine whether control of the soybean aphid can result in reduced virus transmission as well as improved yield and seed quality. Results from this project will increase our understanding of soybean aphid behavior and virus transmission patterns across a selected group of soybean varieties.

Twenty-eight soybean varieties were selected for this study. Nineteen commercial varieties were selected based on high yield performance in variety trials conducted by the Department of Agronomy in 2003 (Table 2). Five varieties (Vinton 81, IA 1008, IA 2017, IA 2065 and IA 2068) were selected for their identity preserved food grade status and/or suitability to USDA certified organic production systems, and four were selected as SMV susceptible varieties (Dwight, IA 2021) and SMV resistant check varieties (NE 3001, Colfax).

Soybean aphid population densities were monitored weekly for all 28 varieties in a completely randomized block split plot design (insecticide vs. no insecticide) replicated four times. The organophosphate insecticide Lorsban 4E was applied (1 pt./acre) to all 28 varieties in the insecticide plots at the R1 growth stage (July 8th, 2005) after soybean aphids had reached the economic threshold of 250 aphids per plant in several of the plots throughout the experiment. Lorsban 4E was applied due to the presence of twospotted spider mite in the experimental plots at the West Madison Agricultural

Research Station. Severity of virus symptoms and incidence of SMV infected plants were recorded for all plots. Plots were harvested for yield and incidence of seedcoat mottling recorded on a subsample of seeds from each plot following mechanical harvest.

Results

Soybean varieties differed in ability to support populations of the soybean aphid. DKB 25-51 had the fewest soybean aphids and IA 2017 supported the highest aphid populations. Yield improved 1.7 bu/a with one application of Lorsban insecticide when data were combined for all soybean varieties. Soybean aphid populations were reduced for all varieties after treatment with Lorsban, but the percentage of control was greater for some varieties. Statistically, all varieties responded equally to insecticide treatment for yield. However, differences of 8 to 11 bu/a were obtained for seven of the 28 varieties in the trial. Yield was improved by the Lorsban treatment for O'Soy 211RR and NE 3001, but reduced for AG2403, DKB 23-51, NK S24-K4, Colfax, and Vinton 81 (Table 3).

As expected, the incidence of SMV was low for NE3001 and Colfax, the resistant check varieties, and high for Dwight, a susceptible check variety. Five varieties, NK S20-F8, NK S24-K4, O'Soy 163RR, IA 2021, and IA 2065, expressed incidence of SMV similar to the resistant check varieties. Yield of the SMV resistant varieties was 8 to 9 bu/a higher than Dwight, the susceptible check variety. The incidence of SMV ranged from 0 to 50% in unsprayed plots and from 1 to 58% in treated plots. Soybean varieties differed in response to insecticide application and SMV incidence (Table 3). One application of Lorsban resulted in lowered SMV for DSR 234RR, H2627RR, RT2440, and Spansoy 253RR while increasing SMV for Dwight. Ten soybean varieties expressed 10% or less seedcoat mottling, a tolerance level acceptable for utilization by food grade markets (Table 2). Incidence of mottled seed was not affected by Lorsban.

Summary of Results for 2005

- Soybean aphid populations at R2 growth stage were correlated with SMV incidence and incidence of mottled seed, but not yield (Table 4).
- SMV reduced yield based on higher yield for SMV resistant check varieties compared to susceptible check varieties, and significant correlation between disease variables and yield (Table 4).
- Lorsban insecticide reduced the population density of the soybean aphid, however yield, averaged for 28 soybean varieties, was not increased by this treatment.
- Overall soybean aphid was controlled by Lorsban, but the percentage of control was greater for some varieties.
- Some soybean varieties supported lower populations of the soybean aphid in the untreated plots.
- Five commercial varieties were identified that expressed resistance to SMV comparable to the resistant check varieties.
- SMV incidence increased for three, and decreased for three varieties after treatment with Lorsban. This is the first observation of increased incidence of SMV following the application of an insecticide.
- Ten soybean varieties expressed 10% or less seedcoat mottling, generally acceptable for food grade markets.
- Experiments will be conducted during winter months to determine whether soybean varieties differ in seed transmission of SMV.

- Results in 2005 suggest that insecticides will remain the most effect control option for the soybean aphid until soybean aphid resistant varieties enter the market.
- BPMV and AMV were incidence levels were low for all soybean varieties.

Conclusion

Two variables were investigated in this study to explain the low incidence of SMV in commercial soybean fields, 1) potential SMV resistance among commercial soybean varieties and 2) insecticidal control of soybean aphid. Based on our results from 2005, neither of these variables identified the mechanism responsible for low SMV incidence in commercial soybean fields. Ten of the 19 commercial varieties screened in this experiment had an SMV incidence greater than 20%, indicating that many commercial varieties in fact do not currently provide acceptable SMV resistance. An application of Lorsban insecticide for soybean aphid suppression resulted in lower SMV incidence for only three of the 28 varieties in the experiment.

These results indicate that seed transmission of SMV may be higher in our experimental plots than is commonly the case in commercial soybean fields. Seed from the 2005 plots at West Madison are currently being assayed for SMV transmission. 2006 field experiments will be designed to further quantify the rate of seed transmitted SMV among soybean varieties and test the hypothesis that SMV transmission is significantly limited to seed borne inoculum.

References

Cullen, E., K. Lambrecht and A. Phibbs. 2005. Bean leaf beetle and bean pod mottle virus in Wisconsin – where do we stand? Proc. 2005 Wis. Fert., Aglime, and Pest Mgmt. Conf. 44:83-85.

Fujan, G. 2004. Soybean aphid research update. North Central Soybean Research Progr WWW document. URL http://www.planthealth.info/aphids_researchupdate.htm

Grau, C. 2005. Soybean viruses and soybean seed. WWW document. URL http://www.plantpath.wisc.edu/soyhealth/viruscomplex/virusseed.htm

Plant Health Initiative; North Central Soybean Research Program. http://www.planthealth.info/

Soybean Plant Health website, Univ. of Wisconsin-Madison. http://www.plantpath.wisc.edu/soyhealth/

Table 2. Evaluation of commercial cultivars for reaction to aphid virus complex at West Madison Agricultural Research Station, 2005.

Entry	Yield	Seed mottling	R6 24-Aug virus rating	R5 15-Aug SMV incidence	R3 15-Jul soybean aphid population
	bu/a	% incidence	% severity	%	per plant
Commercial cultivars					
A2247	66.2	4	35	31	87
AG2403	67.6	5	20	17	87
AG2703	58.2	43	53	13	71
AG2203	61.8	5	32	19	70
DSR218	65.2	7	30	18	84
DSR234RR	62.4	14	22	21	87
DKB 25-51	62.7	10	77	24	60
DKB 23-51	56.1	7	71	33	112
H2627RR	63.9	38	35	28	130
NKS20F8	70.5	13	13	11	99
NK S24-K4	69.3	31	32	11	107
O'SOY 163RR	65.5	2	27	8	94
O'SOY 211RR	63.4	16	35	21	118
PIONEER 92M72	55.7	53	29	19	83
PIONEER 92B38	67.5	38	12	26	71
RT 2092	62.2	22	37	28	65
RT 2440	63.8	24	42	26	83
SPANSOY 250	66.0	36	21	54	94
SPANSOY 253RR	64.6	19	37	18	69
Public cultivars					
Colfax	68.0	1	13	1	92
Dwight	60.2	40	16	28	160
IA1008	61.1	32	16	12	97
IA2017	57.1	50	32	23	171
IA2021	68.3	32	19	6	104
IA2065	72.9	4	30	8	68
IA2068	62.7	26	54	13	100
NE3001	69.3	2	9	6	95
Vinton 81	56.7	38	14	27	75
Mean	63.9	22	31	20	94
P-value (variety)	<0.1	<0.1	<0.1	<0.1	9.1
LSD(10%)	6	12.8	17	6.9	52
CV%	11	71	67	193	66

Table 3. Evaluation of commercial cultivars for reaction to insecticide treatment at West Madison Agricultural Research Station, 2005.

Entry	Yield		R5 8/15/2005 SMV incidence		R3 7/14/2005 Soybean aphid population	
	NT[1]	Lorsban	NT	Lorsban	NT	Lorsban
	bu/a		%		per plant	
Commercial cultivars						
A2247	67.9	64.5	28	34	132	42
AG2403	72.3	62.9	13	21	152	22
AG2703	56.6	59.7	16	9	111	31
AG2203	60.9	62.8	14	24	108	32
DSR218	66.1	64.4	13	24	128	40
DSR234RR	62.8	62.1	29	14	143	30
DKB 25-51	63.9	61.6	26	21	89	30
DKB 23-51	60.5	51.6	29	38	158	65
H2627RR	66.6	61.3	25	31	234	27
NKS20F8	71.5	69.5	16	5	150	48
NK S24-K4	73.8	64.8	15	8	197	17
O'SOY 163RR	66.1	64.9	6	9	136	51
O'SOY 211RR	59.5	67.3	19	24	201	36
PIONEER 92M72	56.7	54.7	16	21	146	20
PIONEER 92B38	67.4	67.6	24	28	116	27
RT 2092	59.4	65.0	26	29	104	26
RT 2440	66.7	61.0	35	16	136	31
SPANSOY 250	68.6	63.3	50	58	148	40
SPANSOY 253RR	63.4	65.8	33	6	112	27
Public cultivars						
Colfax	73.5	62.6	0	1	146	38
Dwight	57.8	62.7	15	41	283	37
IA1008	60.9	61.2	13	12	144	49
IA2017	56.5	57.6	28	18	310	31
IA2021	67.0	69.7	8	3	178	29
IA2065	75.1	70.6	3	14	110	26
IA2068	64.6	60.9	15	11	144	56
NE3001	64.1	74.5	0	11	159	32
Vinton 81	62.4	51.0	31	23	117	33
Mean	64.7	63.1	19	20	153	35
P-value (Variety x Lorsban)	27.8		<0.1		8.2	
LSD (10%)	NS		11.5		20	
CV%	11		193		66	

[1]- NT=No insecticide treatment

Table 4. Correlation coefficients among variables for yield, seed mottling, virus incidence and severity, aphid populations and plant stand at West Madison Agricultural Research Station, 2005.

		Yield	Seed mottling	Virus rating	Aphid population 1-Jul	Aphid population 14-Jul	Plant stand	SMV incidence	
Yield	R	1.00	-0.29	-0.18	-0.09	-0.08	0.25	-0.22	R
	p-value		<.0001	0.01	0.18	0.24	0.00	0.00	p-value
Seed Mottling		R	1.00	0.13	-0.11	0.18	-0.10	0.29	R
		p-value		0.05	0.11	0.01	0.12	<.0001	p-value
Virus rating			R	1.00	-0.13	0.09	-0.02	0.20	R
			p-value		0.05	0.16	0.82	0.00	p-value
Aphid population 1-Jul				R	1.00	-0.10	0.10	0.07	R
				p-value		0.13	0.15	0.30	p-value
Aphid population 14-Jul					R	1.00	-0.16	0.12	R
					p-value		0.02	0.07	p-value
Plant stand						R	1.00	-0.03	R
						p-value		0.63	p-value
SMV Incidence								1.00	