Soybean Viruses: Curiosity or Production Problem

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Prior to the discovery of the soybean aphid, researchers at the University of Wisconsin-Madison have been researching the cause of several abnormal symptoms of unknown cause common to soybean in most regions of Wisconsin. Major symptoms are changes in leaf and pod appearance that frequently are confused with symptoms caused by post-emergence herbicides. Plants with abnormal leaf phenotypes are commonly stunted, produce fewer pods, and have stems that remain green while other plants in the field mature normally. Frequently, seed from symptomatic plants have mottled seed coats resulting from hilum pigments "bleeding" into the seed coat. Viruses were suspected as a cause of these symptoms, but research was needed to prove this theory.

Soybean viruses identified in Wisconsin

Bean pod mottle virus (BPMV), soybean mosaic virus (SMV), alfalfa mosaic virus (AMV), bean yellow mosaic virus (BYMV) and tobacco streak virus (TSV) are viruses frequently "associated" with symptomatic leaf tissues (Table 1). AMV and SMV are the most common viruses and are transmitted by aphids including the newly detected soybean aphid. Several viruses commonly occur together and also form a complex within the virus component of the aphid-virus complex. Further research is needed to determine specific symptoms caused by each virus, and the extent of yield and seed quality loss caused by each virus.

Table 1. Incidence of viruses in Wisconsin soybean in 1999

		% Samples positive for virus					
Wisconsin	No. samples	TRSV	BPMV	SMV	AMV	BYMV	TSV
Southern	42	0	0	47	36	11	27
Central	63	13	4	25	38	3	14
Northern	48	3	3	23	3	10	10
Total/Mean	153	5	2	32	26	8	17

TRSV = tobacco ringspot virus, BPMV = bean pod mottle virus, SMV = soybean mosaic virus, AMV = alfalfa mosaic virus, BYMV = bean yellow mosaic virus, TSV = tobacco streak virus.

Symptoms caused by viruses

Symptoms in question are distorted leaves with rolled (downward) leaf margins, rough and puckered leaf surface (rugosity), yellow blotches (mosaic) among green tissues, mottled yellow areas, dark leaf veins and smaller leaves. Plants with distorted leaves are commonly stunted, produce fewer pods, and remain green while other plants in the field mature normally. Frequently, seed coats are stained with pigments that originate from the seed hilum. It should be noted that "bleeding hilum" is associated with virus infection, but is not the sole cause of this disorder that results in bicolored seed. Leaf symptoms are similar to those associated with injury from several herbicides. Similar is the key term because some aspects of the symptoms are atypical for herbicide injury. Also, the pattern of symptomatic plants in fields frequently does not relate to drift, spray or tank contamination patterns commonly associated with

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herbicide injury. Although it is tempting to assign blame to herbicides or weather conditions, the fact of the matter is that viruses should be considered as another potential cause of these symptoms.

Several viruses are associated with the incidence of green stem plants at harvest. Green stem plants are generally lower in yield, produce more discolored seed and are more difficult to harvest compared to plants that have matured normally. Soybean variety will influence symptom severity caused by viruses and severity will be increased by later planting date. Although possibly only coincidental, the incidence of viruses, green stem incidence and discolored seed is increasing during a time of increased insect activity in soybeans. Thus, a multidisciplinary research group has been assembled to investigate this situation.

Soybean insects and viruses

Soybean growers are not accustomed to managing insect pests of soybean in Wisconsin. Besides the soybean aphid, the bean leaf beetle has become more common in Wisconsin and the increasing activity of these insects may explain in part the increased incidence of viral-like symptoms in soybeans. The soybean aphid and the bean leaf beetle have reached unprecedented populations in Wisconsin during the 2000- growing season. The soybean aphid reached high populations in the southern half of Wisconsin and the bean leaf beetle was confined primarily to the southern tier of counties. Each insect is capable of transmitting soybean viruses (Table 1). It is a challenge to separate yield loss caused directly by insects, by viruses and by the combination of insects and viruses. Together the soybean aphid and the bean leaf beetle may have a profound affect on the overall management of soybeans in Wisconsin.

Characteristics of soybean viruses

Management of losses caused by soybean viruses starts with an understanding where viruses survive and how they are transmitted (Table 1).

Soybean mosaic virus (SMV) is able to infect soybeans, snap beans, and many other legumes. Symptoms caused by SMV include a mosaic of light and dark green areas, chlorosis, and leaf curl. Long term effects on plants are reduced yield, stunting, delayed maturity, and bleeding hilums on seed. SMV is vectored by at least 32 different aphid species are known to vector the virus, and transmission on seed has been reported between 5 and 75% depending on the soybean variety.

Bean pod mottle virus (BPMV) infects soybean, snap bean, and many other legumes. The young leaves of infected plants will turn light green to yellow, and puckering of leaves. BPMV is a cause of the green-stem syndrome. BPMV is transmitted by several beetles including the bean leaf beetle, which has been found in the southern part of Wisconsin.

Tobacco ring spot virus (TRSV) has a broad host range including soybean, tobacco, snap bean, velvet leaf, and pigweed. A characteristic symptom of this disease is the hooking down and death of the apical meristem. Lateral buds will proliferate excessively, producing many small leaves. Typically infected plants are delayed in maturing and have under developed pods. Thrips and the dagger nematode are vectors for TRSV, but neither plays a major role in the spread of the disease. TRSV is known to be seed transmitted.

Table 2. Characteristics of major viruses detected in Wisconsin soybeans

Virus	Host Range	Symptoms	Transmission
Soybean mosaic Virus (SMV)	Soybean Red clover Dandelion	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 curl downward; maturity delayed and infected plants and remain green. Seed may be discolored by pigments that bleed from hilum.	32 aphid species transmit SMV; seed transmission varies from 5-75% and transmission rate varies with soybean variety.
Bean pod mottle Virus (BPMV)	Soybean Snap bean	Young leaves in the upper canopy exhibit light green to yellow mottlir some puckering and distortion; stems remain green with mature pods; retain petioles after leaf blades drop. Discolored seed from pigments that bleed from hilum.	Bean leaf beetle is Common vector; seed transmission is less than 1%.
Tobacco streak Virus (TSV)	Soybean Alfalfa Clovers Tobacco Snap bean	Symptoms are mild mosaic of yellow and green; leaf and floral buds may proliferate excessively; pods mature but stems remain green.	Pollen transmitted; Thrips are reported as vector. Seed transmission as high as 50%.
Bean yellow Mosaic virus (BYMV)	Soybean Snap bean Pea Clovers	Bright yellow mottling of leaves; crinkled leaves; yellow areas are either scattered or produced in indefinite bands; rusty, necrotic spots appear in yellow areas as leaves mature; leaf veins may turn dark; BYMV will cause delayed maturity.	20 species of aphids reported to transmit BYMV; seed transmission is not reported.
Alfalfa mosaic Virus (AMV)	Soybean Alfalfa Clovers Snap bean Pea	Bright yellow mosaic of leaves; or leaf veins are yellow but remainder of leaf is a normal green color.	Transmitted by Aphids; seed transmission is low, 1-5%.

Bean yellow mosaic virus (BYMV) infects snap beans, soybean, pea, and clover. BYMV usually causes a bright yellow mottling of the leaves. As leaves mature yellow areas develop necrotic spots and leaf veins darken. BYMV will reduce pod number and size. Aphids transmit BYMV, and seed transmission is not reported.

Tobacco streak virus (TSV) is able to infect most legumes like soybeans and snap beans. TSV displays similar symptoms to TRSV with a hooked top, but does not usually show symptoms on young plants. Lateral buds may proliferate causing small leaves. Other symptoms include the development of mosaic symptoms and necrotic streaks at the nodes accompanied by

reduced pod number and delayed seed maturation. Thrips are suspected of transmitting TSV but this has not been proven. TSV is seed transmitted.

Alfalfa mosaic virus (AMV) has a broad host range including soybean, alfalfa, clover, snap bean, and pea. Bright yellow mosaic leaves and vein yellowing are common symptoms of AMV on soybeans. Several species of Aphid transmit AMV. Seed transmission has not been reported in soybeans, but AMV is both seed and pollen transmitted in alfalfa.

Evidence of yield loss caused by viruses

The effect of viruses on soybean yield is not known. Thus, research is needed to determine the agronomic importance of viruses because of the dramatic increase in incidence of infected and symptomatic soybean plants. Data to determine the importance of viruses is complicated by their insect vectors. It is difficult to determine how much yield is lost to feeding injury by the vector and how much is due to the viruses the insect vector has transmitted. Two experiments conducted in 2000 provide evidence that viruses are capable of reducing soybean yield in Wisconsin.

Pioneer Brand 92B21 soybeans were planted in 10 x 20 foot plots consisting of four rows spaced 30 inches apart. Symptom severity and yield data were recorded in 48 individual plots. Yield of 92B21 declined as symptom severity exceeded 25% of the canopy foliage expressed various types of symptoms associated with soybean viruses (Figure 1). Yield and symptom severity ranged from 37.0 bu/a (18% severity) to 26.4 bu/a (90% severity). Yield declined as symptom severity increased.

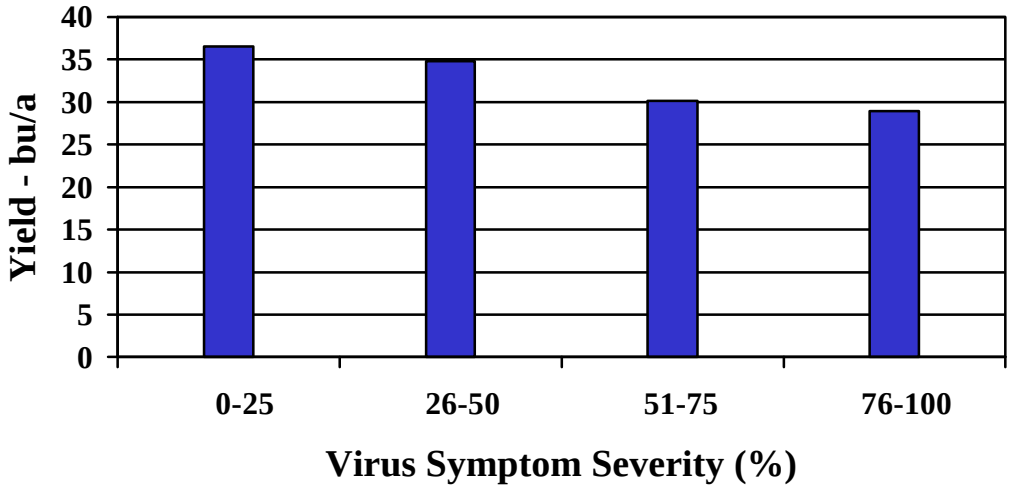

Figure 1. Relationship between symptom severity caused by viruses and soybean yield at the Arlington Agricultural Research Station in 2000.

A second experiment was conducted at the Arlington Agricultural Research Station and a private farm near Whitewater, Wisconsin. Eleven soybean varieties were compared for yield and symptom severity caused by viruses. The population density also was determined by counting the number of aphids on one sampled leaf. Performance data of varieties was group

by high yield and low yield varieties. Varieties within each group were not statistically different, but the high and low yield groups were statistically different from each other.

Varieties in the high yield group expressed lower virus symptom severity compared to the low yield group of varieties at both locations (Table 3). Although not statistically significant, there was a trend for fewer soybean aphids feeding on varieties in the high yield, compared to the low yield group. Greater symptom severity due to viruses was observed at the Whitewater location which also had the highest aphid population. This data provides further evidence that soybean viruses and the soybean aphid form a complex that must be managed together.

Table 3. Eleven soybean varieties group by high or low yield in the presence of viruses and soybean aphids at two locations in 2000.

		Arlington			Whitewater		
Variety group	No. Varieties	Yield bu/a	% virus severity	No. aphids	Yield bu/a	% virus severity	No. aphids
High	7	44.6	8	19	50.3	30	35
Low	4	37.2	30	27	42.9	75	61
LSD 0.10		5.1	4	12	7.6	6	30

Virus Management. There are no definitive recommendations at this time on how to manage viruses in soybean. In principle, viruses are controlled by eliminating sources of virus inoculum, control of insects that transmit viruses and resistant varieties (Table 4). Soybeans planted adjacent to forage legumes are likely at high risk to virus infection. Research is underway to determine the reaction of soybean varieties to viruses, but highly resistant varieties are not likely available. Thus, management of insect vectors is likely the best virus management option at this time. There is evidence that maintaining a full soybean canopy lessens aphid activity, which in turn could reduce the incidence of AMV and SMV infected plants. Thus, planting early and in narrow- row spacings, and avoiding herbicide injury should provide fast canopy development and possibly reduce aphid activity and virus transmission. Iowa data indicates that planting should be delayed to avoid bean leaf beetle feeding early in the growing season. Although the bean leaf beetle causes no direct economic loss at this time, this is the critical time in transmission of bean pod mottle virus. Thus, management of early season populations of bean leaf beetles is critical to the control of bean pod mottle virus. Thus, planting date recommendations is in conflict for bean leaf beetle and soybean aphid.

Table 4. Management of major viruses in Wisconsin soybeans

Virus	Inoculum source	Management options
Soybean mosaic Virus	Seed, forage Legumes and Dandelions	Plant virus-free seed; Maintain dense crop canopy to avoid high aphid activity. Varieties appear to differ in susceptibility.
Bean pod mottle Virus	Forage legumes; low transmission in seed.	Delay planting to mid-May to avoid over wintered bean leaf beetles. Insecticides to control beetles. No resistant varieties are available.