Overview
Viruses are submicroscopic particles of DNA or RNA that can cause disease in plants. They can grow and reproduce only inside a living plant cell.

Virus-like symptoms have been increasing in midwestern soybean fields in recent years. Mottled, crinkled leaves during periods of rapid growth, mottled seed, and lower than expected yields can be possible signs of virus infection.

The impact and management of soybean viruses in the midwest is currently an active area of research.

**Insection-virus complex**

Unlike other soybean pathogens, which are spread by wind, water, soil or plant debris, most plant viruses are spread from plant to plant by specific insect vectors.

The insects that most commonly transmit viruses in soybean are bean leaf beetle (*Cerotoma trifurcata*), the soybean aphid (*Aphis glycines*) and other migratory aphid species, and thrips. Recognizing the virus as part of a unique plant-insect-virus relationship is the key to effective management.

Bean Pod Mottle Virus (BPMV) and Soybean Mosaic Virus (SMV) have historically been the most important viruses in the north-central region. However, recent surveys have identified the presence of several other viruses, including Alfalfa Mosaic Virus (AMV), Soybean Dwarf Virus (SbDV), Soybean Vein Necrotic Virus (SVNV), Tobacco Ringspot Virus (TRV), and Tobacco Streak Virus (TSV) in midwestern soybean fields.

Viruses have been identified in symptomatic and non symptomatic plants, often in dual or multiple infections. Multiple infections pose the greatest risk of reduced quality and yield.

**Major soybean viruses**

**Alfalfa Mosaic Virus** (AMV)
Alfalfa mosaic virus is transmitted by several aphids species, including the soybean aphid, and also through seed. Alfalfa and clover plants in the region are commonly infected with AMV. Symptoms of AMV tend to decrease as the soybean plant matures.

**Bean Pod Mottle Virus** (BPMV)
BPMV is the most common and widespread viral pathogen of soybean in the region. BPMV is transmitted by leaf-feeding beetles, primarily the bean leaf beetle *Cerotoma trifurcata*. The incidence of BPMV infection in soybean fields can be very high in years when overwintering bean leaf beetle populations are high. Milder winters are thought to be contributing to regular high overwintering populations of the beetle.
**Soybean Mosaic Virus** (SMV)
Soybean mosaic virus is transmitted through seed at rates ranging from 0 to 5% in most commercial varieties, and by several species of aphids, including soybean aphid, *Aphis glycines*.

The incidence of SMV infection in soybean fields has been much lower than that reported for BPMV. However, yield losses from SMV infection in the region have been as high as 94%. When soybean plants are infected with both BPMV and SMV, symptoms can be more severe than infection by either virus alone.

**Soybean Dwarf Virus** (SbDV)
SbDV causes severe yield losses in soybean in Japan. SbDV has been detected in more than 40% of red clover plants sampled in Illinois, and has been consistently detected in commercial soybean fields in both Illinois and Wisconsin. Although SbDV has been shown to be transmitted by soybean aphids, the SbDV incidence in Illinois and Wisconsin have not been correlated with annual aphid abundance as determined by the North Central Regional Soybean Aphid Suction Trap Network.

**Soybean Vein Necrosis Virus** (SVNV)
Soybean farmers should be aware of a new disease caused by soybean vein necrosis virus (SVNV). The virus has likely been in soybeans for some time, but was probably overlooked or misdiagnosed before recent detections. The disease has been detected across the United States (including many states in the North Central region) and in Ontario, Canada.

**Tobacco Ringspot Virus** (TRSV)
Of the many diseases caused by TRSV, budblight of soybeans is one of the the most severe. In general, most significant yield loss occurs when plants become infected before flowering.

The primary source of TRSV in soybeans is not clear. Seed transmission occurs, but at a very low rate. The dagger nematode can spread TRSV to some host species as it feeds, but transmission efficiency to soybean is low.

Several insect vectors have been reported, including aphids *Myzus persicae* and *Aphis gossypii*, grasshoppers, the tobacco flea beetle, and thrips.

**Tobacco Streak Virus** (TSV)
Tobacco streak virus is transmitted by thrips, and through infected soybean seed. It is capable of reducing yield. TSV infection can be difficult to detect because the concentration of TSV particles decline significantly as soybean plants mature.
Scouting

To determine if a virus problem exists in your field, look for the following signs. Foliar symptoms of virus infection will be most apparent during times of rapid growth and cooler weather.

- Moderate to high insect activity
- Presence of leaf symptoms: mottled, crinkled leaf symptoms typical of virus infection.
- Lower than expected yields
- Mottled seed

Be aware that leaf symptoms are not a consistent indicator of virus infection — weather conditions and growth stage can mask leaf symptoms, and soybean varieties will differ in the amount of leaf symptoms that develop. Mottled and crinkled leaves can have other causes, such as herbicide injury or nutrient deficiencies.

Symptoms

Most virus-infected plants have fewer pods, lower-than-expected yields and are stunted to some degree. Pods may be flatter and smaller.

Different viruses can cause similar symptoms, and infection by more than one virus is common.

Mottling and mosaic leaf symptoms

Virus-infected leaves may show a mosaic of light and dark areas. Leaf margins may curl downward. Foliar symptoms of virus infection will be most apparent during times of rapid growth and cooler weather. Sometimes foliar symptoms resemble injury from herbicide drift.

Viruses associated with mosaic symptoms:

Soybean mosaic virus (SMV)
Bean pod mottle virus (BPMV)
Alfalfa mosaic virus (AMV)
Tobacco streak virus (TSV)
Tobacco ringspot virus (TRV)
**Bumpy, rugose (rough) leaves**

Viruses associated with rugose leaves:

- Soybean mosaic virus (SMV)
- Bean pod mottle virus (BPMV)
- Tobacco streak virus (TSV)
- Tobacco ringspot virus (TRV)

**Seed coat mottling, bleeding hilum, discoloration of soybean seed**

Viruses associated with discolored seed:

- Soybean mosaic virus (SMV)
- Bean pod mottle virus (BPMV)
- Tobacco streak virus (TSV)

**Vein clearing and leaf necrosis**

Soybean vein necrosis virus (SVNV)

**“Shepherd’s crook”**

A curving of the terminal bud on the main stem, forming a “shepherd’s crook”, can be a symptom of Tobacco ringspot virus infection.

**Risk Assessment**

Fields with these signs are at most risk from virus infection:

- Moderate to high insect activity
- Late planting – coincides with higher populations of the soybean aphid and increases the probability of virus transmission to young seedlings.
- Virus-infected soybean seed
- Virus-susceptible soybean varieties
- Presence of dagger nematodes (*Xiphinema americanum*, a vector of Tobacco ringspot virus)
- Presence of leaf symptom such as mottled, crinkled leaves on the newest growth.
Management

There are no specific recommendations available yet for consistent, effective management of soybean virus diseases.

However, there are several integrated management strategies that can have some impact on limiting losses from virus infection, depending on the virus or viruses involved:

- Select resistant or tolerant soybean varieties
- Plant virus-free, certified seed
- Time soybean planting to avoid the highest populations of the bean leaf beetle. This can be done using a degree day model (see: Bean leaf beetle management)
- Consider early-season insecticide treatments if BPMV has been confirmed in your fields in previous years and bean leaf beetles are present
- Time soybean planting to avoid the highest populations of the soybean aphid
- Avoid planting in fields that are known to be infested with the dagger nematode (*Xiphinema americanum*)

Soybean variety selection

The most effective strategy to limit losses from virus diseases is to select soybean varieties that are resistant to or tolerant of virus infection. It is known that soybean lines and varieties currently grown in the north differ in their response to SMV and other viruses, and that some varieties have significant tolerance to certain viruses.

Although progress has been made in quantifying field tolerance to soybean viruses, information on specific varieties is not always available. The development of new virus-resistant or tolerant varieties is an active area of soybean research and plant breeding.

Resistance genes for BPMV are not known to exist in cultivated soybean, but have been found in closely-related species. Some currently available commercial cultivars have been shown to have tolerance to BPMV infection, in that they consistently yield better in the presence of BPMV than other varieties. Some resistance has also been found in germplasm and breeding lines.

Genes for resistance to infection by AMV and TSV have been identified in soybean. Resistance to TRSV has been identified in *Glycine soja* but is not known in the cultivated soybean, *Glycine max*. 
Vector (insect) control
Many studies have shown that insecticidal control of vector insects reduces the amount of feeding by insect vectors, but it does not provide consistent reduction in the incidence of virus infections.

In the case of the soybean aphid transmitting SMV, foliar applications of a pyrethroid or organophosphate timed to suppress soybean aphid populations still does not eliminate the potential impact of the numerous aphid species immigrating into the soybean field, including spring migrants of the soybean aphid, from transmitting the virus.

In the case of BPMV prevention, current recommendations are to consider early-season insecticide treatments only if BPMV has been confirmed in your fields in previous years and bean leaf beetles are present.

Accurate diagnosis is important
Symptoms of virus diseases look similar. But because of the specific plant-insect-virus relationships involved, effective management requires accurate knowledge of which virus (or viruses) are causing the most prevalent virus problem. Most diagnostic clinics in the north central region can perform serological diagnostic tests if a virus infection is suspected. Send in green, symptomatic leaves.

Resources

Incidence of Alfalfa mosaic virus, Bean pod mottle virus, and Soybean mosaic virus in Nebraska Soybean Fields
Loren J. Giesler and Amy D. Ziems, University of Nebraska-Lincoln, Plant Management Network, 2006

Bean leaf beetle management for reduction of bean pod mottle virus
Journal of Economic Entomology

Identification of field tolerance to Bean pod mottle and Soybean mosaic viruses in soybean
Crop Science, 2007

Seasonal progression, symptom development, and yield effects of Alfalfa mosaic virus epidemics on soybean in Wisconsin
Plant Disease, 2007
https://apsjournals.apsnet.org/doi/abs/10.1094/PDIS-91-3-0266
Response of soybean cultivars to Bean pod mottle virus infection
*Plant Disease*, 2007

Incidence of Soybean dwarf virus and identification of potential vectors in Illinois
*Plant Disease*

*Soybean Mosaic Virus*
*University of Nebraska*
https://cropwatch.unl.edu/plantdisease/soybean/mosaic-virus

Quantifying the Within-Field Temporal and Spatial Dynamics of Bean pod mottle virus in Soybean
*Plant Disease*, 2011