Soybean Viruses and the Organic Farmer

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Something strange is going on in your soybean field! By midsummer, the leaves look thickened, wrinkled, darker green, almost like Savoy cabbage or crinkly spinach. The plants may be shorter than usual, perhaps with a bronze cast to the field. Then, at harvest, instead of dying down and losing their leaves normally, the plant stems remain green and the seeds do not mature properly. Beans are frequently small, lighter weight, they appear mottled brown, often with a brown or purplish stain leaking out from the hilum area. Then, your buyer takes one look at your organic soybeans and tells you that they are unacceptable for tofu production. What is going on around here?

This condition is sweeping the country wherever soybeans are grown. It is now clear that two viruses, acting synergistically, produce these symptoms. Soybean mosaic virus (SMV) has been around for a long time, while bean pod mottle virus (BPMV) was first described in the 1940's. Typically, soybean mosaic virus alone can produce a 8-25% reduction in yield. However, when plants become infected with both soybean mosaic virus and bean pod mottle virus, symptoms are much more severe and yields can be reduced by as much as 66-80%.

While soybean mosaic virus alone may cause mild brown stains on the hull of the beans, it appears that the combination of the two viruses causes a much deeper and more severe discoloration, even deforming some of the beans. Clear hilum varieties show this discoloration more intensely than black hilum varieties. In severe cases, the beans are just plain ugly, usable only for animal feed.

Temperature plays a key role in the expression of viral infections in soybeans. When the temperature is above 86 F, the severity of foliar symptoms is suppressed, sometimes making it difficult to determine which plants are infected. Badly discolored seeds can still be produced, even though the plants do not appear infected. The crinkled leaves are most apparent when plants are growing around 65 F. In a cool season, severely infected plants may never mature, remaining green late into the fall with immature seeds. Viral infection also reduces the ability of soybean roots to fix nitrogen. Infected plants produce fewer and smaller nodules with Rhizobium bacteria.

What can an organic soybean grower do to prevent major crop loss, both in yield and in quality, from these virus diseases? The best defense that an organic farmer has against the development of any plant disease is to provide correctly balanced soil fertility and excellent weed control. A healthy vigorous plant is always much less likely to develop severe disease symptoms than a plant under stress.

Viral diseases, even with the option of chemicals, because viral infections behave quite differently than fungal or bacterial infections. Virus particles are very simple, consisting only of a small chunk of DNA or RNA, surrounded by a protein coat. When the virus enters a plant, usually introduced by an insect vector feeding on leaf or root tissue, the viral DNA is injected into a living plant cell where it forces the cell to produce more

viral particles and often other toxic materials. These new viruses then are spread rapidly throughout the plant in sap and can be picked up by new insects feeding, thereby carrying the virus to uninfected plants. Viruses can move from plant tissue into the developing seed, forming a source of infection once the seed germinates.

There are additional standard control approaches to combat plant viruses - (1) control the vectors, usually insects, (2) control the co-hosts, usually weeds or other plants of the same crop, (3) use only virus-free seed, and (4) use varieties that have genetic resistance to the virus.

Soybean mosaic virus is vectored, or transmitted, by aphids, while bean pod mottle virus appears to be vectored by the bean leaf beetle (Ceratoma trifurcata). Indeed, Dr. Denis McGee of Iowa State University attributes the rapid rise bean pod mosaic virus to the logarithmic rise in the bean leaf beetle population size over the past few years due to mild winters in the Midwest. Both diseases can be spread in infected seed.

There are chemical insecticides that reduce disease incidence by controlling the insect vectors. However, researchers at Iowa State found in 2000 that even with a powerful seed insecticide and 10 applications of insecticide during the growing season, they had reduced but still significant bean pod mosaic virus in their test plots where there was high pressure from bean beetles.

While obviously organic farmers can't use most of the chemical products out there to control the insect vectors, there are creative approaches that may control viral spread in a field. Garlic oil can repel many insects, and while it doesn't kill the them, it certainly makes the plants much less inviting. There is anecdotal evidence that spraying plants with sugar water or diluted molasses either can kill insects or make the leaf surface less appealing to insects. Perhaps dusting plants with an abrasive, like DE or ground lava, or with a clay material, like soft rock phosphate or kaolinite, would repel vectoring insects, though the value of these treatments has not been proven on soybeans. Kelp and fish sprays, or other organic foliar fertilizer materials, may be effective in raising the Brix levels of the leaves and the overall vigor of the plants.

The stringent control of co-host weeds and planting soybeans later than usual can help reduce spread of viral contamination in a soybean field. Common weeds, such as lambsquarters and pigweed, are asymptomatic co-hosts of soybean mosaic virus, while bean pod mottle virus can infect many other legume species, like alfalfa, clover, and dry beans. Growing virus-free soybean seed in a weedy field might still result in virus-contaminated soybean plants, because of the spread of the viruses from infected weeds. In 1999, we planted Vinton soybeans in a field that had produced virus infected soybeans in 1995. Where weed control was incomplete, soybean yield was reduced and the beans badly stained. However, in areas of the field where weed control was excellent, good quality beans were produced.

The presence of the virus in co-host weeds or crops can provide viral inoculum for years after the initially infected soybean crop. Organic farmers should carefully identify which fields that have grown infected soybeans and avoid planting highly susceptible varieties in

those fields for several years, especially if weeds are not thoroughly controlled.

Obtaining virus free-seed is proving difficult for many organic farmers, in fact, Dr. John Hill of Iowa State says that there is no known virus-free Vinton 81 seed for 2001 planting. Both organic and conventional farmers are in the same boat with contaminated seed, since chemical seed treatments are not effective to eliminate the viruses from infected seeds. This is partly because the viruses are inside, not on the surface of the seed. However, if an effective chemical seed treatment was identified, use of this material would be most valuable in seed production fields to produce virus-free seed.

Seed mottling alone is not a definitive diagnosis of infected seed. The variability in symptom expression in parental plants, depending on environmental conditions, makes rouging seed production fields and visually assessing seed lots difficult. Seed should be tested professionally for the presence of virus before planting, especially for seed to be planted on fields not yet infected by the virus. Any seed that tests positive for viral infection should not be planted, though a positive test result should be interpreted with some caution. The virus will be transmitted through the seed only if the embryo is infected, not if only the seed coat is infected. A seed test grinds up the whole seed, so the test results may not always accurately estimate the number of seeds that will produce infected seedlings.

To be safe, a farmer probably should avoid planting soybean seed that shows brown mottling or staining, and they should not plant back their own seed if the parent plants exhibited significant viral symptoms. Virus-free planting stock of other species, such as raspberries, can be obtained by producing plantlets from shoot tip fragments in tissue culture. That would not be practical with soybeans on a farm scale but could produce virus-free plants which then could be planted for breeder seed production, grown in isolated areas not yet affected by the viruses.

Favorite varieties of organic farmers, Vinton 81 and Vinton-type soybeans, seem particularly susceptible to these soybean viruses. Perhaps other varieties are equally susceptible, but they do not show the bean staining symptoms as severely as Vinton. It would be useful to screen food grade soybean varieties with similar quality and agronomic characteristics for their ability to either resist the virus or not exhibit severe bean staining. This could actually form a valuable niche for some organic farmers to fill, growing organic soybean seed of other varieties that are asymptomatic for the virus.

Organic farmers should encourage soybean breeders to screen breeding lines for genetic resistance and incorporate this resistance into superior food grade soybean varieties. Resistance to soybean mosaic virus has been identified in some soybean cultivars and could be transferred by traditional breeding techniques into high quality food-grade varieties adapted to northern US growing conditions. Dr. John Hill reports that several breeding lines with very good resistance to soybean mosaic virus have been developed through an interesting technique called pathogen derived resistance. A very small piece of the viral DNA that codes for the viral protein coat is inserted into the plant cell, allowing the plant to launch an effective immune response when

challenged by the virus. Because the approach uses genetic engineering techniques, it would not be allowed for certified organic production, but it has been effective in controlling virus infection in papaya and other species.

Perhaps variety selection could focus on other plant characteristics. Joe Roberts, a soybean grower in Nebraska, reports that he has heard observational evidence that the bean beetles prefer plants of a certain shade of green, and that varieties with lighter or darker color seem to have less insect damage. This characteristic might be well worth screening for to see if there is indeed a consistent connection between virus infection and leaf color.

For additional information about soybean viruses and other soybean diseases, the Fourth Edition of the Compendium of Soybean Diseases, published by the American Phytopathological Society Press in St. Paul, MN (800-328-7560), is a valuable source of information and excellent pictures for positive symptom identification.