MANAGEMENT OF INSECT-VECTORED PATHOGENS OF PLANTS

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Epidemiology of vectored plant pathogens involves the plant, the pathogens, the vectors, and the environment, all interacting in various ways. Often, an understanding is needed of seasonal cycles of host plants, pathogens, and vectors. For example, pathogens and vectors important to an annual crop may have non-crop reservoirs between harvest and re-planting. Vectors may overwinter in the crop, or on alternate host plants. The host range of the pathogen may determine whether inoculum control is feasible or not. Some pathogens are transmitted via plant propagation, and others are not. The epidemiology of vectored plant pathogens often is complex and an integrated approach to management is needed. Often, no single approach will achieve adequate control. This section is organized according to the concept of integrated pest management, including chemical control, biological control, host plant resistance, cultural control, and regulatory measures. Each of these categories will be considered in terms of the vectors and the pathogens.

Chemical control

Chemical control of vectors will limit spread of vectored plant pathogens if two conditions are met. First, the vector being controlled must be a colonizer of the crop being treated. Some plant viruses are transmitted by transient flying insects. In these cases, chemical control has a poor record. Second, most of the spread must come from within the treated area (secondary spread). For the most part, insecticides simply prevent the buildup of populations of insects within a treated area. Most pesticides will not kill an immigrant insect before it has a chance to transmit a pathogen. Thus, if there is an infected field nearby with a high population of vectors, pesticide treatment may not be very effective in preventing infection from primary spread. Pesticide treatment has a good track record for control of certain luteovirus diseases such as potato leafroll and barley yellow dwarf, spread by colonizing aphids. Even if the above conditions are met, dependence on chemical control of vectored pathogens in perennial crops may be risky, because a single missed spray application or insecticide failure could result in infection and demise of the crop.

Another variation on chemical control is the use of stylet oil. Certain horticultural oils can reduce transmission of viruses by aphids. This methodology can reduce transmission of pathogens carried by transient insects, something that is not usually possible with standard insecticides. There is also potential for use of insect repellents for vector management. Some work has been done with visual repellents (mulches, paints, colored netting), but little has been done with chemical repellents.

There is no known chemical control of plant viruses, but some fastidious bacteria in perennial tree crops can be controlled with injected antibiotics. Remission of symptoms usually is temporary.

Biological control

The use of biological control for management of vectored pathogens has a mixed review. Obviously, fewer vectors is better; however, sometimes the economic threshold for vectors is so low that it is not achievable through biological control. Sometimes, the presence of natural enemies evokes scatter responses in vector prey. This can actually cause an increase in pathogen transmission.

Total dependence on biological control for a vectored pathogen in a perennial crop is risky. Biological control inherently fluctuates between high populations of pests and high populations of natural enemies. If pests are not vectors, the crop often can stand temporary high pest populations, but if the main concern is pathogen transmission, the entire crop can be lost if populations fluctuate in favor of the pest. Similarly, often a grower will have to spray for another pest. The pesticide may kill the natural enemies of the vector, resulting in an increase in transmission of the pathogen and destruction of the crop.

Biological control in simpler island ecosystems may have a better chance to work than in more complex settings. For example, the introduction of psyllid parasitoids into Réunion Island dramatically reduced the transmission of the bacteria that cause citrus greening disease. However, the same parasitoids are present in Viet Nam, and citrus greening disease is a major limiting factor in citrus production there.

Sometimes disruption of existing biological control can result in an increase in transmission of a plant pathogen. Increased spraying for late blight (caused by a fungus) in potatoes was linked to a major increase in numbers of green peach aphids. Evidently, populations had been controlled by an aphid pathogenic fungus that was killed by the fungicide applications for late blight. The result was a big increase in incidence of potato leafroll virus (PLRV), transmitted by the aphids.

Biological control of the pathogen is another option. Usually this is done by means of cross protection - infecting a crop with a mild strain of a pathogen that prevents symptom expression of a more severe strain that may be transmitted by an insect later on. Cross protection has worked very well for control of citrus tristeza virus, an aphid transmitted closterovirus, in several parts of the world.

Host plant resistance

The efficacy of plant resistance to vector depends on the means of resistance and the mode of transmission. Resistance that prevents feeding or repels the insects can prevent transmission of pathogens spread by feeding. If the resistance merely prevents or slows population growth, it cannot prevent primary spread. It can, however, have some effect on secondary spread.

Resistance to the pathogen probably is the most effective means of controlling vectored plant pathogens. If plant resistance to the pathogen is available, it should be the first line of defense. Complications with host plant resistance can occur if the pathogen evolves strains that can break down the resistance. Also, some crops are notoriously difficult to breed due to difficult genetics or longevity.

Resistance to the pathogen may be the only means of management in some cases. An example is sugarcane mosaic virus. Sugar cane is propagated vegetatively, so the virus is propagated with the crop. Once planted, a crop remains in the same field for several years of production, and planting is staggered throughout the production area. Thus, even if clean planting stock could be found, there is no possibility for an area-wide crop-free (and virus-free) period. The virus is transmitted by transient winged aphids, including species that do not necessarily colonize the sugar cane crop, so pesticide application is not effective. Fortunately, there has been success with mosaic resistant cultivars.

Cultural control

Many of the effective management practices for diseases caused by vectored plant pathogens involve some sort of cultural control such as adjusted planting date, pruning, roguing, and removal of volunteer crop plants and other non-crop reservoir hosts of vectors or pathogens.

Adjusting planting dates can minimize crop exposure to vectored pathogens. In the Pacific Northwest, several vectored pathogens, transmitted by eriophyid mites and aphids, can damage early-planted fall cereals. The mite transmitted viruses are particularly serious because they cause severe yield loss, resulting in total crop failure in some cases. These viruses infect newly seeded winter wheat that is planted near a maturing crop from the previous season, or near infected volunteer grain. These viruses are most troublesome in years when the old crop is slow to mature, and there is overlap between late-maturing cereal crops from the previous season and emergence of newly sown winter wheat. The infective mites are blown from the old crop to the new one. After landing on the new crop, they apparently stay put, because there is little secondary spread in the fall. The mites cannot survive very long off a host plant, so any break in the “green bridge” between old and new crops will prevent infection. As little as 10 days delay in planting can make the difference between crop failure and negligible incidence. Similarly, the aphid-transmitted barley yellow dwarf virus complex largely can be prevented by delay in planting. Other viruses are managed on an area-wide basis by maintaining a crop-free period at some time during the year. For such a policy to work, all growers in the area must cooperate in field clean-up and coordination of planting dates.

Pruning and roguing often are used as a means of management of vectored plant pathogens, especially in perennial crops. The efficacy depends on whether latent infections remain, and if so, whether plants with latent infections are suitable source plants for vectors. In the early stages of an epidemic, there usually will be more plants with latent infections than with visible symptoms. If plants with latent infections can serve as source plants for vectors to acquire the pathogens, and vectors are present, pruning and roguing will not be very effective.

In some cases, pruning actually can eliminate disease. Pierce’s disease of grape vines is caused by a xylem limited bacteria called *Xylella fastidiosa*. It moves slowly in the plants. If Pierce’s disease is transmitted by small leafhoppers that feed on twigs, winter pruning can eliminate most of the infection. However, if the disease is transmitted by the much larger glassy-winged sharpshooter (*Homalodisca coagulata*), which feeds on larger branches and trunks, pruning is much less effective.

Control of volunteer crop plants may limit or eliminate primary inoculum for newly planted crops. Volunteer potatoes are important sources of virus inoculum in Idaho potato seed production areas. Similarly, volunteer grain can be an important reservoir for aphids and barley yellow dwarf at planting time for winter wheat. The volunteer wheat provides a "green bridge" for the viruses and their vectors between harvest of one crop and emergence of the next one.

Other cultural control measures include elimination of weed hosts of vectors or pathogens, use of reflective mulches and paints to repel vectors, and various protective row covers. Quite a bit of work also has been done on the use of windbreaks and barrier crops to protect susceptible plantings.

Regulatory measures

Regulatory measures for control of vectored plant pathogens are a very important aspect of management, especially for those pathogens that are transmitted through propagation. Strict sanitation measures for propagative material are common. Other kinds of regulatory measures include crop-free periods, quarantines, and required virus testing.

One of the best ways to prevent vector-borne disease in plants is to keep the disease and the vector out. Many plant diseases and vectors that occur elsewhere in the world do not occur in the United States. Some of these are listed as quarantine or actionable pests/ diseases. If they are found at U.S. ports of entry, the shipment is rejected. If a pest or disease has a limited distribution in the U.S., there may be a state quarantine for certain items. For example, if a pest is found in Florida but not in California, California may reject shipments from Florida that contain the pest.

Production of healthy propagation materials involves regulatory agreements. Potato tubers grown for seed are subject to winter testing for a variety of vector-borne viruses. Standards are much stricter for early generation seed. Citrus trees are propagated vegetatively by grafting, in order to ensure varietal uniformity. Citrus trees used for budwood in Florida are required to be tested for citrus tristeza virus every year. Those found to contain severe strains are no longer allowed to be used for propagation purposes. Lettuce mosaic virus and bean common mosaic virus are transmitted by seed as well as by aphid vectors. Some states have regulations in place requiring that seed used commercially in the state be tested and meet standards for virus incidence.

In warm climates where crops are grown year around, control of diseases caused by vectored pathogens can be particularly challenging. Sometimes an agreement is made to adhere to a crop-free period to break the disease cycle. State regulatory agencies may be involved to ensure that there are consequences for any growers that do not comply.

Other regulations are tailor-made for a given situation. Green peach aphids (*Myzus persicae* (Sulzer)) transmit potato leafroll virus (PLRV), which causes an important disease in potatoes. The aphids overwinter in peach and apricot trees. In the spring, they leave the trees and infest potatoes and other plants. In parts of Idaho where seed potatoes are grown, it is illegal to grow peach and apricot trees. If the trees are found, the state can require their removal. Guy Bishop, University of Idaho, discovered that another source of green peach aphids was greenhouse grown bedding plants. These infested seedlings were purchased by home gardeners, who often also grew potatoes. Frequently, the home grown potatoes either were grown from seed saved from previous years, or from unregistered seed. Thus, the PLRV infection rate in home gardens was high. Bishop found that the closer a seed potato field was to a town with home gardens, the more likely it was that the seed farmer had unacceptably high levels of PLRV. Regulations were made to prevent sale of infested bedding plants. Additionally, the local growers provided home gardeners with clean potato seed tubers. Incidence of PLRV in seed potatoes decreased dramatically in the region after the regulations were implemented.

Integrated management

Most often control of vectored pathogens of plants will involve an integrated approach. A good example is potato production. Some popular varieties of potatoes develop internal discoloration as a result of infection with PLRV that results in rejection by potato processors. In order to prevent PLRV infection there are regulatory measures to ensure clean propagation material. Additionally, commercial ware potato growers employ scouts to survey for green peach aphids. If numbers reach an economic threshold the crop is treated with insecticide to prevent secondary spread of PLRV. Cultural controls include removal of volunteer potatoes, and in some cases, removal of peach and apricot trees that are overwintering sites for vectors. Department of Agriculture inspectors make the rounds of retail vendors of bedding plants, preventing sale of infested ones. Finally, there is work at the federal and state levels to breed potato varieties that are more tolerant to PLRV infection, but that also retain the taste, baking and processing qualities of the popular susceptible cultivars.

Epidemiology of vectored pathogens affecting crops is a complex and very interesting field of study. Many more puzzles remain to be solved that will make even more effective management a possibility.

References

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