Principles of Plant Virus Disease Management

This lecture:

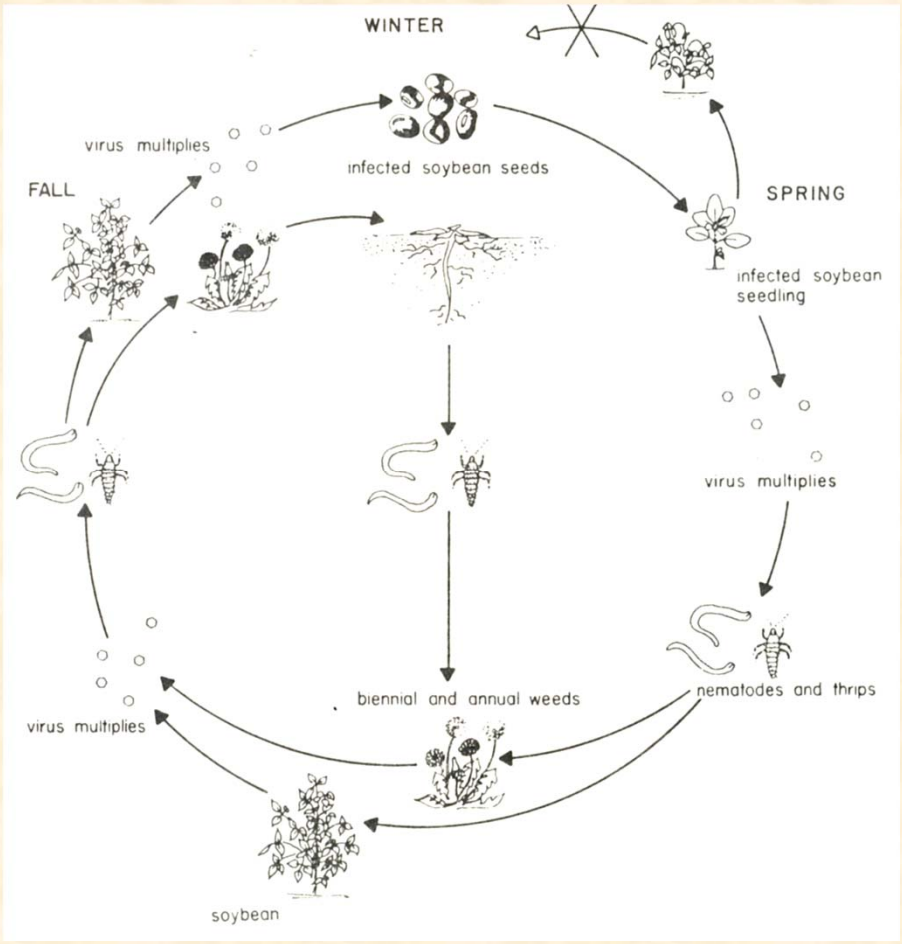
- Disease cycles and their role in developing management solutions
- Components of the disease cycles
- Approaches that can be used to manage viruses

Plant viruses need the interior of a plant cell to replicate. Only a few viruses survive outside a host cell or a vector for any period of time.

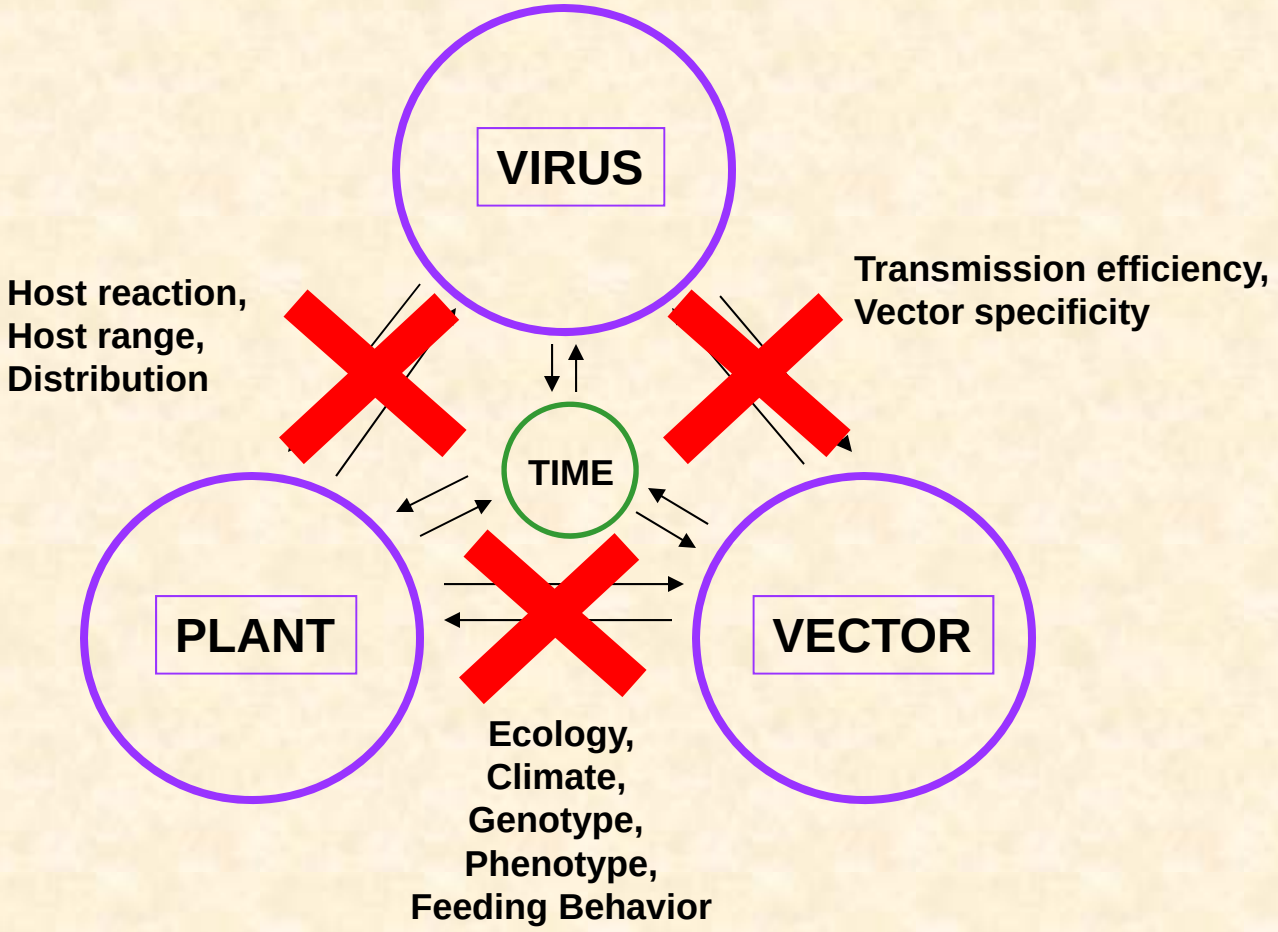
So plant viruses need to find new hosts to survive, in other words, they need to have one or more means to disperse

Each virus has its own combination of mechanisms for survival and dispersal. These combined are known as its disease cycle.

The key to effective management is dependent upon knowing the details of the disease cycle, and then findings ways to interrupt or break the cycle.



Basic Virus Disease Cycle:



Some biological components of the Disease Cycle

Properties of the virus

- **Physical stability of the virus**
  - this can affect the means of dispersal, very stable viruses have more means of survival and dispersal than other less stabile viruses
- **Concentration of the virus in a host**
  - this can affect efficiency with which a virus is acquired by its vector
- **Rate of movement and distribution within the host**
  - How quickly is the virus available to be transmitted?
- **Severity of the disease**
  - Are infected hosts killed?
  - Is the shape of the plant altered so much that vectors will not land on it or will not feed on it?

Some biological components of the Disease Cycle

Properties of the virus

- **Mutability and strain selection**
  - In a given location, some viruses have more sequence diversity than others so might overcome resistant hosts faster

- **Host range of the virus**
  - Wide or narrow?
  - How many are in the area of the epidemic?
  - How large are the populations of the hosts?

Some biological components of the Disease Cycle

Properties of the virus

- **Means of dispersal – these vary among viruses**
  - very stable viruses can be moved in water or soil debris
  - many viruses can be moved by mechanical transmission under the right circumstances:
    - cutting tools (pruning or grafting)
    - leaves rubbing against each other
    - many viruses disperse through movement of infected plant parts: transplants, seeds, pollen, tubers, grafting, cuttings, etc…
  - Many viruses can be transmitted to the next generation (via ovule or pollen)

Biological Components of the Disease Cycle

Properties of the virus

- **Means of dispersal – these vary among viruses**
  - most viruses (85%) have a vector and most of those can move on their own or with wind or water assist (insects, mites, nematodes)
  - the mode of transmission (non-persistent, semi-persistent, etc… plays an important role in how quickly and for what distance viruses can disperse
  - the distance a virus is able to move varies and depends upon many factors,
    - ability of the vector to fly (migrate)
    - is often determined by humans and agricultural trade and practices

Biological Components of the Disease Cycle

Properties of the virus

- **Host range of the virus**
  - What are the hosts? Is the host range wide or narrow?
  - How many are in the area of the epidemic?
  - Size of host populations
- **Means of survival**
  - Many viruses survive in the same host or in propagative material (live hosts: perennial hosts, tubers, runners, seed)
  - Stable viruses (like TMV, TBSV) can over-season in plant refuse
  - Ornamental trees, shrubs, biennial, and perennial wild plants may be important over-seasoning sources

Some biological components of the Disease Cycle

Properties of the virus

- **Means of survival**
  - Viruses that replicate in their vector can survive in eggs and nymphs of their vector without any plant hosts
  - Some viruses can survive in their vector (in the absense of plant hosts) even though they don't replicate in the vector

Biological factors that influence the Disease Cycle

Cultural Practices

Planting date
Crop rotation
Soil cultivation
Field size
Population density and plant size
Effects of glass or plastic houses
Pollination practices
Transport of crop plants or parts
Monocropping

*Production practices vary among locations for the same crop. So the disease cycle may not be identical among different locations, and therefore effective disease management practices for a virus may be different for different locations

Physical factors that influence the Disease Cycle

Rainfall
Wind
Air temperature
Soil
Seasonal variation in weather

These physical factors affect hosts, vectors and host (production practices and their timing)

Movement of viruses into and within fields by aerial vectors

Primary spread – source of virus is outside the field (other crops, weeds, infected transplants) may be close or distant

Secondary spread – virus source is within the field (other plants, weeds within the fields)

Insect transmission and number of plants infected per vector

Non-persistent transmission: one insect-one potentially infected plant

Semi- and persistent transmission: one insect-potentially many infected plants

Disease Cycles and Management:

- Determine the correct identity of the virus causing the disease

- Determine the specifics of the disease cycle: vectors, hosts, etc….
  - Some of this information can be obtained from literature
  - Some must be identified by research

- Use that information to design a disease cycle if one does not exist

- Develop means to disrupt or break the cycle
  - Some of this information can be obtained from literature
  - Some must be identified by trial

General Approaches to Management:

There are no chemicals that can be sprayed to kill viruses or to completely protect plants from infection, like there are for pathogens like fungi and bacteria. Usually once a plant is infected, it stays infected (except for ???)

In fact, once a field has infected plants there are only limited practices that can be employed that will be effective.

The most effective management practices are done **before** the crop is planted. So grower education regarding the viral pathogen's disease cycle is an important part of management.

- Prevention: remove or avoid sources of the pathogen
- Manage Vectors: control or avoidance
- Protect the plant from infection

Note: Epidemics are often the result of human activities

- Introduction of viruses into new areas through infected seed, or vegetative material
- Introduction of virus vectors into new areas
- Introduction of a new cultivar which is susceptible to viruses present in the area
- Production using monoculture: genetically-uniform plants in large areas, replacing traditional polyculture
- Use of irrigation to prolong the cropping seasons with overlapping plantings
- Repeated use of the same fields for the same crop

Note: Epidemics are often the result of human activities

Tomato field in Manatee Co. Florida –
100% of plants infected with TYLCV

Both virus and vector were introduced into Florida. They came from different locations at different times and on different plants, but both established and have caused millions of dollars in direct crop loss and in the expense of management.

General Approaches to Management:

- **Prevention: remove or avoid sources of the pathogen**
- Manage Vectors: control or avoidance
- Protect the plant from infection

Management: Prevention

- Produce or purchase virus-free plants.
- Remove all weeds.
- Destroy all crop debris from fields and greenhouses.
- Immediately set aside plants with viral symptoms and obtain a diagnosis from your Plant Disease Clinic.
- Discard virus-infected plants.
- Disinfest tools used for vegetative propagation frequently by placing them in a clorox solution (10%), hydrogen peroxide, or quartenary ammonium salt solution for at least 10 min. Rinse thoroughly with tap water.
- Propagate plants using certified virus-free seed rather than vegetatively when possible.

Management: Prevention

- **Removal or avoidance of sources of the pathogen**
  - Start with virus-free plants. Use certified virus-free seed, use tomato/tobacco/pepper seed treated to remove tobamoviruses.
  - Select transplants that have not been produced near production fields.
  - Select transplants/plants that are certified virus-free

Certified lettuce seed reduced losses due to *Lettuce mosaic virus* (*Potyviridae, Potyvirus*) (<0.003% infection was effective)

Seed certification of barley for *Barley stripe mosaic virus* (*Virgaviridae, Hordeivirus*) has saved millions US $$

Management: Prevention

- **Removal or avoidance of sources of the pathogen**
  - Growers should collect a symptomatic plant and get a good diagnosis from their local Plant Disease Clinic (so they can know which management approaches will work the best)
  - Living virus-infected or susceptible hosts – remove weeds, volunteer plants, abandoned fields (especially those upwind)
  - Remove crop debris promptly at the end of the crop
  - Rogueing: remove infected crop plants from the field.
    - Recommend only after much consideration.
    - Rogueing may not always be effective; May add unnecessary costs
    - Only effective when you remove plants infected by primary spread early in the season, and when you expect that there will be significant secondary spread. Rogueing:
    - Discard virus-infected plants – don't leave them in the field.

Management: Prevention

- **Modify cultivation procedures**
  - Make changes in planting/harvesting times that create breaks in the disease cycle (ex. Change planting date to avoid flights of vectors)
  - Separate plantings in time so that the virus cannot move from old plantings to new ones
  - Isolate plantings by distance – the greater the distance of a planting from a source of virus, the lower the chance of movement of the virus
  - Modify plant spacing (has helped in some virus/host combinations) (plant spacing affects the decision by an aphid to land on a plant)

Management: Prevention

- **Prevention of introduction or long distance movement by regulation**
  - Prevent movement of virus-infect plants by individuals
  - Prevent movement of virus-infect plants through experimental sources (new breeding lines, germplasm, etc.)
  - Commercial trade in plant propagules (seed, tubers, transplants, cuttings, plants, etc…)
  - Regulation of potential virus vectors upon entry
  - Foreign certification before entry
  - Quarantine after entry
  - Seed certification for the absence of specific viruses

Next Lecture:

General Approaches to Management:

- Prevention: remove or avoid sources of the pathogen
- **Manage Vectors: control or avoidance**
- **Protect the plant from infection**