LESSON 4: PLANT DISEASES CAUSED BY VIRUSES

4.1. Introduction

Plant viruses have a huge impact on crop production throughout the world. Consequently, there has been a considerable effort and resources directed towards managing virus diseases. Crop failure due to debilitating viruses creates significant financial hardship and food insecurity in developing countries. Insect-transmitted viruses cross national boundaries into new geographic areas, resulting in negative social and economic impacts on subsistence agriculture. To be successful, virus management strategies must have the capacity to deal with these challenges. Furthermore, such strategies require a good understanding of how viruses spread between crops and across seasons. In addition, accurate diagnosis backed up by reliable detection techniques is the critical first step in virus disease management. Generally, virus management is guided by a number of principles that

4.2.Lecture objectives

At the end of this lecture of this lecture the student should be able to

5. Distinguish virus from other types of plant pathogens.
6. Explain the basic procedures of diagnosing viral crop pathogens.
7. Explain the various measures of managing plant viral diseases.

4.3 VIRUSES

A virus is a nucleoprotein that multiplies only in living cells and has ability to cause disease. All viruses parasitize cells and cause a multitude of diseases in all forms of living organisms. Plant viruses differ greatly from all other plant pathogens not only in size and shape, but also in the simplicity of their chemical constitution and physical structure, methods of infection, multiplication, translocation within the host, dissemination, and the symptoms they produce on the host. Because of their small size and the fact that they are transparent, viruses generally cannot be viewed and detected by the methods used for other pathogens. Cell inclusions consisting of virus particles, however, are visible by light microscopy. Viruses are not cells nor do they consist of cells.

4.4 Morphology of plant viruses

- Plant viruses come in different shapes and sizes. Nearly half of them are elongate (rigid rods or flexuous threads), and almost as many are spherical (isometricor polyhedral), with the remaining being cylindrical bacillus-like rods Some elongated viruses are rigid rods about 15 by 300 nanometers, but most appear as long, thin, flexible threads that are usually 10 to 13 nanometers wide and range in length from 480 to 2,000 nanometers.

4.5 TRANSLOCATION AND DISTRIBUTIONOF VIRUSES IN PLANTS

- When a virus infects a plant, it moves from one cell to another and multiplies in most, if not all, such cells. Viruses move from cell to cell through the plasmodesmata connecting adjacent cells. Viruses multiply in each parenchyma cell they infect. In leaf parenchyma cells the virus moves approximately 1 millimeter, or 8 to 10 cells, per day. In all economically important viral infections, viruses reach the phloem and through it are transported rapidly over long distances within the plant. Most viruses, however, require 2 to 5 days or more to move out of an inoculated leaf. Once the virus has entered the phloem, it moves rapidly in it toward growing regions (apical meristems) or other food-utilizing parts of the plant, such as tubers and rhizomes. In the phloem, the virus spreads systemically throughout the plant and re-enters the parenchyma cells adjacent to the phloem through plasmodesmata.

- The development of local lesion symptoms is an indication of the localization of the virus within the lesion area. In several diseases, however, the lesions continue to enlarge and, sometimes, the development of systemic symptoms follows, indicating that the virus continued to spread beyond the borders of the lesions. In systemic virus infections, some viruses are limited to the phloem and to a few adjacent parenchyma cells. Viruses causing mosaic-type diseases are not generally tissue restricted, although there may be different patterns of localization. Mosaic virus-infected plant cells have been estimated to contain between 100,000 and10,000,000 virus particles per cell. The systemic distribution of some viruses is quite thorough and may involve all living cells of a plant. Many viruses, however, seem to leave segments of plant tissues that are virus free. Also, a few viruses invade all new meristem tip tissues, whereas most others leave the growing points of stems or roots of affected plants apparently free of virus.

4.6 SYMPTOMS CAUSED BY PLANT VIRUSES

Almost all viral diseases seem to cause some degree of dwarfing or stunting of the entire plant and reduction in total yield.

- In many plants inoculated artificially with certain viruses, the virus causes the formation of small, chlorotic or necrotic lesions only at the points of entry (local infections), and the symptoms are called **local lesions.**
- Many viruses infect certain hosts without causing development of visible symptoms on them. Such viruses are usually called **latent viruses**, and the hosts are called **symptomless carriers**.
- In other cases, however, plants that usually develop symptoms on infection with a certain virus may remain temporarily symptomless under certain environmental conditions (e.g., high or low temperature), and such symptoms are called **masked**.
- Finally, plants may show acute severe symptoms soon after inoculation that may lead to death of young shoots or of the entire host plant if the host survives the initial shock phase, the symptoms tend to become milder (chronic symptoms) in the subsequently developing parts of the plant, leading to partial or even total recovery. In some diseases, however, symptoms may increase progressively in severity and may result in gradual (slow) or quick decline of the plant.
- The most common types of plant symptoms produced by systemic virus infections are **mosaics** and **ring spots**. Mosaics are characterized by light-green, yellow, or white areas intermingled with the normal green of the leaves or fruit or of lighter–colored areas intermingled with areas of the normal color of flowers or fruit. Depending on the intensisty or pattern of discolorations, mosaic-type symptoms may be described as mottling, streak, ring pattern, line pattern, vein clearing, vein banding, or chlorotic spotting. Ring spots are characterized by the appearance of chlorotic or necrotic rings on the leaves and sometimes also on the fruit and stem. In many ring spot diseases the symptoms, but not the virus, tend to disappear later on.
- A large number of other, less common virus symptoms have been described and include stunt (e.g., tomato bushy stunt), dwarf (barley yellow dwarf), leaf roll (potato leafroll), yellows (beet yellows), streak(tobacco streak), pox (plum pox), enation (pea enation

mosaic), tumors (wound tumor), pitting of stem (apple stem pitting), pitting of fruit (pear stony pit), and flattening and distortion of stem (apple flat limb). These symptoms may be accompanied by other symptoms on other parts of the same plant.

Figure 4. Symptoms caused by Maize streak virus and tobacco mosaic virus.

4.7 Transmission of plant viruses

I. Vegetative Propagation
II. Mechanical transmission through sap
III. Seed transmission
IV. Pollen transmission
V. Insect transmission
VI. Mite transmission
VII. Nematode transmission
VIII. Fungus transmission
IX. Dodder transmission

4.8 *Key guiding principles in virus management*

- Unlike other plant pathogens, there are no direct methods available yet to control viruses and, consequently, the current measures rely on indirect tactics to manage the viral diseases.

- Traditionally, standard approaches such as quarantine, eradication, crop rotation, and certified virus-free stock have been important tools to control virus diseases although each has demerits such as cost, questionable effectiveness, and lack of reliability.
- There is no one management approach that applies to all virus diseases, since different diseases have distinct ecological and epidemiological characteristics. This requires a good understanding of a virus disease in a given crop and agro ecosystem in order to develop targeted solutions.
- Chemical control of insect vectors has for a long time been the preferred approach. However, due to the increasing awareness on the disadvantages of pesticides including harmful effects on human health and the environment, their use for the management of viruses is declining.
- Host plant resistance developed through conventional plant breeding has been successfully applied to manage economically important viruses in economically important crops. Currently, host plant resistance is developed through genetic engineering in addition to convention plant breeding.
- Since there are no economically feasible chemical agents similar to fungicides and bactericides that are effective against plant viruses, the strategies aimed at plant virus disease control are largely directed at preventing virus infection through;

  i. Eradicating the source of infection to prevent the virus from reaching the crop
  ii. Minimizing the spread of the disease by controlling the virus vector
  iii. Utilizing virus-free planting material
  iv. Incorporating host-plant resistance to the virus

4.9 Management of Plant Virus Diseases

Although there are virtually no antiviral compounds available to cure plants infected with viral diseases, efficient control measures can to a large extent mitigate or prevent disease from occurring. As indicated before, virus identification is a mandatory first step in the management of a disease caused by a virus. The subsequent strategy for management will depend on the means by which a particular virus enters a crop, how the virus is transmitted between plants within a crop, and how the virus survives in the absence of the crop (Hadidi *et al.*, 1998). A number of approaches are applied in the management of virus diseases in plants as discussed below;

4.9.1 Cultural Practices

There are several cultural practices that can be used to reduce plant losses due to virus infections. These include;

- Scouting and removal of symptomatic plants (*rouging*) or known alternative weed or volunteer plants that may serve as a reservoir for a virus.
- The use of clean or disinfected tools and equipment as well as hand washing
- Rotations with non-host crops.
- Geographic isolation of production facilities may also help avoid losses caused by plant viruses.
- The isolation of newly received plant material prior to its introduction into the rest of a production system can also minimize the unintentional introduction of pathogens.
- Use virus-free soil or potting mixture.
- Avoiding smoking of cigarettes near a garden, especially if the crop is tomato; this may spread tobacco mosaic virus.
- Preventative measures may include use of pathogen-free seed and pathogen-free transplants.
- If the virus is known to be transmitted by a particular vector, control or avoidance of this vector is of paramount importance. For instance insect, nematode or fungal vectors can be controlled by insecticides, nematicides, or fungicides, respectively.

4.9.2 Elimination/heat therapy

Some viruses are permanently inactivated by prolonged exposure of infected tissue to relatively high temperatures—for example, 20 to 30 days at 38^{o} C frees individual plants or cuttings of the virus. The principle behind this is that the temperature is high enough to inactivate the virus but not as high as to kill the plant.

4.9.3 Cross Protection

The prospects for pathogen-mediated intervention in virus disease development were first realized in 1929 when H.H. McKinney demonstrated that tobacco could be protected from infection by a severe strain of TMV by prior inoculation with a milder strain of TMV (Gadani *et al*., 1990). This type of protective measure, known as cross-protection, has since been employed throughout the world on several important crops, including tomato, papaya, and citrus (Beachy *et al*., 1990; Hull and Davies, 1992; Fulton, 1986). However, this labor-intensive type of protection is not only expensive but it also necessitates the use of an infectious virus as a control measure. The challenge is that strains of viruses vary in their virulence on different crops and even within varieties of the same crop. A virus used to protect one crop could potentially cause serious diseases on alternate crops or varieties growing nearby. This approach is therefore not widely used for the management of virus diseases.

4.9.4 Host resistance

An alternative strategy for virus control is utilization of conventional or engineered resistance to virus infection. If available, natural virus resistance genes can be introduced into crop cultivars by conventional breeding. These natural resistance genes are often found among the many cultivars that are available for a particular crop, or the resistance genes are found in related plants that have been identified near the center of origin for that crop. Genetic engineering, the transfer of genes between organisms using laboratory techniques rather than biological hybridization, allows cross-species introduction of such genes.

4.9.5 Management of virus vectors (through use of chemical and biological control)

Insecticides and biocontrol products are used to control insect vectors as a means to control vector-transmitted viruses. This has been done by spraying insecticides to reduce the vector populations. However, the effectiveness of chemical treatments in controlling the virus depends on virus/vector relationships. For instance, insecticide treatments may be ineffective in controlling non-persistently-transmitted because their acquisition, latent, and inoculation periods are so short that the virus is acquired and transmitted before the vector can be affected by most insecticides. A small proportion of insects that usually survive the insecticide application are enough to cause important infections if virus sources are present.

4.9.6 Government Regulatory Measures

Quarantine (domestic or international) is one of the measures of managing virus diseases. However, management of insect vector populations in the field can be difficult or impossible unless coordinated at government of intergovernmental level (on a regional basis).

4.9.7 Production of virus-free clones

It is not possible to cure a plant of viruses, but there are techniques useful in the production of "virus free" clones. One such technique is meristem tip culture coupled with chemotherapy and/or thermotherapy. Recently, a technique was developed known as cryotherapy for the elimination of viruses from already infected plant tissue. Once a clean plant is obtained, it can be used to produce several other clean plants.

4.9.8 Integrated Plant Virus Management

This is any approach that combines selected multiple management strategies (e.g., biological, cultural, genetic and chemical) based on knowledge of the biology of a target virus. The goal is to efficiently and economically manage the virus while minimizing pesticide application to an environmentally friendly level. This relies on the correct identification of the virus and a good understanding of the virus biology and the virus disease epidemiology.

Summary

Understanding biology of plant viruses is important so as to know at what stage the pathogen is expected to attack the crop and also help in timely management of the pathogen.

Correct diagnosis of plant pathogenic viruses is encouraged as wrong diagnosis can lead to easy spread of the pathogen and management become costly.

NOTE

ACTIVITIES

> Visit a market place or a vegetable farm and identify symptoms characteristic of plant viruses in different crops .