Recognition And Role Of Virus Symptoms In Detection And Diagnosis

This presentation:

- Recognize the diversity of symptoms caused by viruses and be able to correctly describe symptoms caused by plant viruses

- Understand the relevance of symptoms for diagnosis of plant viruses

General Statements

- Many viruses cause no symptoms in some hosts, but may cause very severe symptoms in another host
- Each species of plants has a limited range of responses to changes to its normal physiology
- So very different viruses can cause very similar symptoms in the same host
- There are other (both biotic and abiotic) causes for symptoms that resemble those caused by viruses

There are two basic types of symptoms:

Local – symptoms appear only on the inoculated tissues

Systemic – symptoms appear on plant parts not were not inoculated

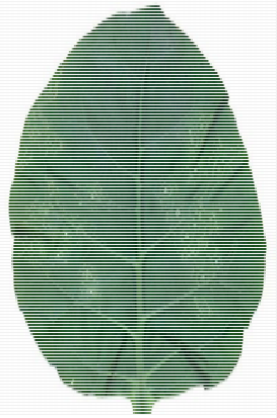
Local Symptoms –appear only on the inoculated tissue

The hypersensitive response on the inoculated leaf is a local symptom.

Local lesions that can result from inoculation vary in size, shape, color, and time to appearance depending upon host and virus

Chenopodium quinoa inoculated with *Carnation mottle virus*

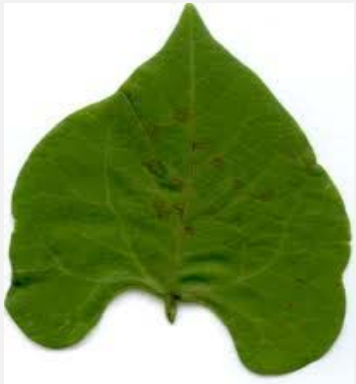
C. quinoa inoculated with Parsnip yellow fleck virus



Nicotiana tabacum inoculated with *Cherry leaf roll virus*

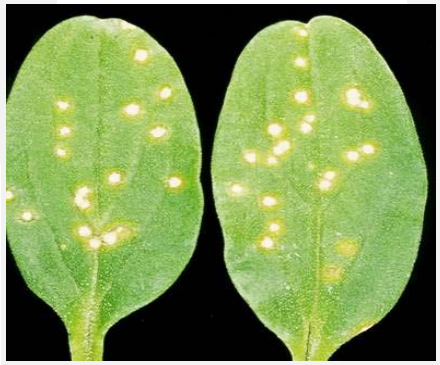
These “local” symptoms only appear on the inoculated leaves.

These “local” symptoms may be all the is produced, or the virus may more systemically and possibly cause the appearance of symptoms in other parts of the plant (“systemic symptoms”



Phaseolus vulgaris ‘Pinto 111’ inoculated with *Bean pod mottle virus (Comoviridae, Comovirus)*

P. vulgaris ‘Monroe’, 13 days after mechanical inoculation with *Bean common mosaic virus (Potyviridae, Potyvirus)*



Cucumis sativus inoculated with *Clover yellow vein virus (Potyviridae, Potyvirus)*

Naturally occurring local lesions:

Necrotic lesions in citrus leaves and fruit caused by *Citrus leprosis virus* (unassigned family, *Cilevirus*)

Each lesion is the site of feeding of the mite vector

SYSTEMIC SYMPTOMS

– Foliar Mosaics and Mottles

Mosaic: Due to breakdown of chlorophyll in yellow (chlorotic) areas.
Virus infection may also interfere with normal chloroplast development

Mosaic in *Abutilon stratum* caused *Abutilon mosaic virus (Geminiviridae, Begomovirus)*

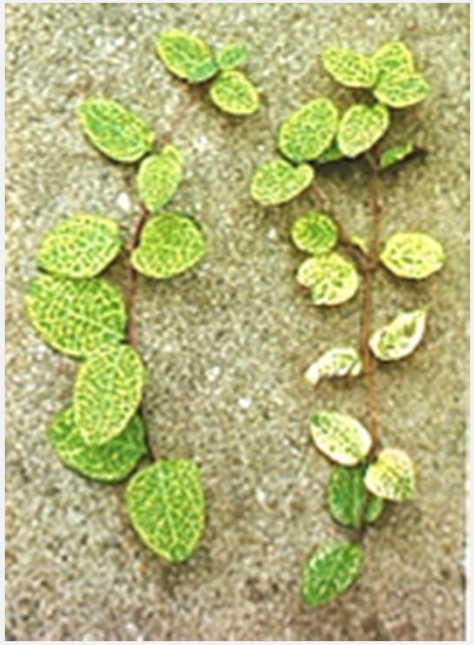
Stripe mosaic in Johnsongrass caused by *Sugarcane mosaic virus (Potyviridae, Potyvirus)*

MOSAIC VS MOTTLE

Mosaic – a disease symptom of leaves in which numerous small areas of discoloration stand out against a background of a different tint, tending to have a clearly defined boundary delineated by veins (Holliday, 1989).

Mottle - a disease symptom of leaves in which small but numerous areas of discoloration, commonly chlorotic, irregularly shaped and without sharply defined boundaries, stand out against a background of a different tint; the pattern is not related to the vein network (Holliday, 1989).

Mosaic



Tobacco leaf curl virus (Geminiviridae, Begomovirus) in *Lonicera japonica*

Mosaic

Papaya ringspot virus (Potyviridae, Potyvirus) in melon

Mottle, Chlorosis/Reddening

Red color due to the loss of chlorophyll and predominance of remaining plant pigments

Leaf chlorosis and reddening in carrots infected by *Carrot red leaf virus (Luteoviridae, Polerovirus)*

Color-breaking

Color-breaking of petals, flecks, streaks, or sectors of tissue with a color different from normal.
These are the result of anthocyanin pigment loss which reveals underlying coloration due to plastid pigments.

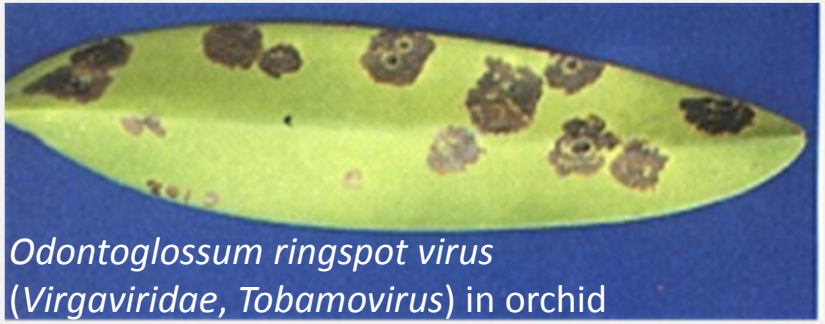
Tobacco mild green mosaic virus, (Virgaviridae, Tobamovirus) in *Nicotiana spp.*

Tulip on the left infected with *Tulip color breaking virus (Potyviridae, Potyvirus)*

NECROSIS

Viruses can cause necroses (programmed cell death) in plants. Seen as necrotic spots, ringspots, necrotic veins, and organ or plant death. Can occur in leaves, fruits, stems, etc…

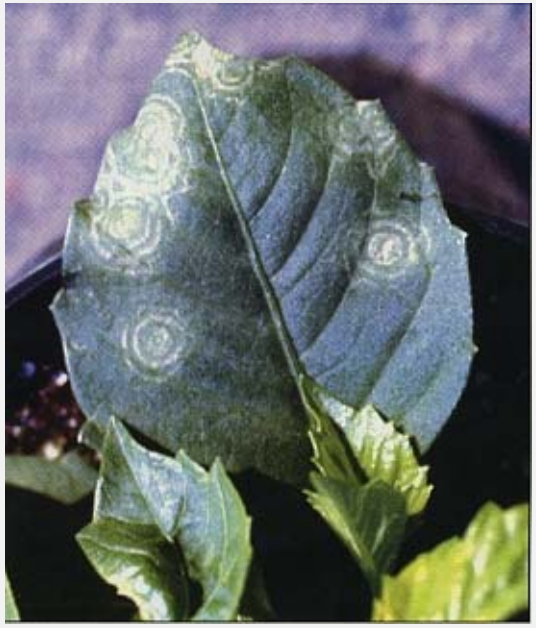
Necrotic Ringspots



Odontoglossum ringspot virus (*Virgaviridae*, *Tobamovirus*) in orchid

Plum pox virus (Potyviridae, Potyvirus) in peach

Impatiens necrotic spot virus (Bunyaviridae, Tospovirus) in impatiens



Systemic Necrosis

Necrotic symptoms - death of tissues, organs or whole plants.
Disruption of starch translocation.

Vein necrosis in tobacco infected with *Tomato spotted wilt virus (Bunyaviridae,Tospovirus)*

Necrotic spots and patches in pepper fruit caused by *Tobacco mosaic virus* (*Virgaviridae, Tobamovirus*)

Systemic Necrosis

Tobacco mild green mosaic virus (Virgaviridae, Tobamovirus) on tropical soda apple (*Solanum viarum*)

Localized necrotic flecks, 2 days after inoculation.

Same plants, showing a systemic necrosis and plant death, 2 weeks after inoculation.

Abnormalities of Growth And Developmental

Malformations - stunting, twisting of the growing tips, leaf curling, leaf distortions

Healthy pepper (*Capsicum annuum*)

Pepper infected with *Potato virus Y* (*Potyviridae, Potyvirus*)

Tomato infected with *Cucumber mosaic virus (Bromoviridae, Cucumovirus)*

Abnormalities of Growth And Developmental

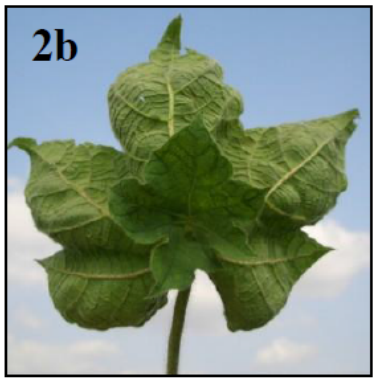
Leaf distortion in squash caused by *Zucchini yellow mosaic virus* (*Potyviridae, Potyvirus*)

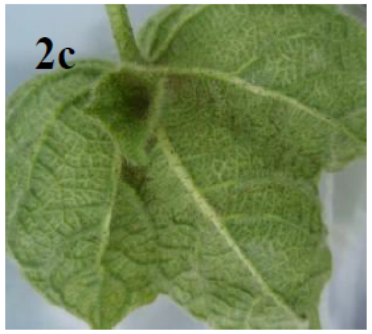
Abnormalities of Growth And Developmental

Enations (outgrowths from upper or lower surfaces of leaves)

Apple infected with *Cherry rasp leaf virus* (*Secoviridae, Cheravirus*)

Pea infected with Pea enation mosaic virus (Luteoviridae, Enamovirus)





Cotton leaf curl disease in cotton

Abnormalities of Growth And Developmental

Epinasty (unequal growth of two surfaces leading to curling of the whole leaf). Either downward or upward curling is possible

Downward leaf curling in cotton

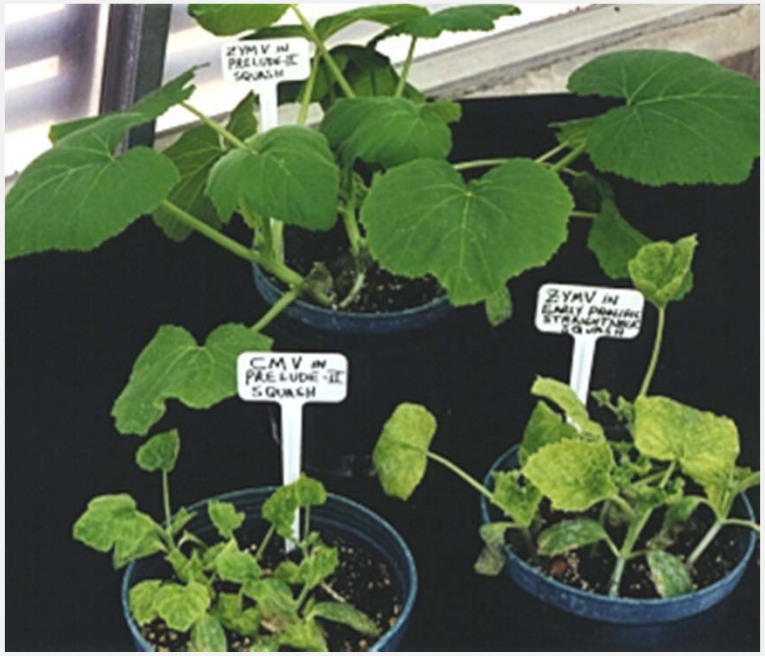
Upward leaf curling in cotton

Abnormalities of Growth And Developmental

Delayed senescence (plants remain vegetative)

Abnormalities of Growth And Developmental

Stunting and dwarfing



Foreground: *Squash plants infected with Cucumber mosaic virus* and *Zucchini yellow mosaic virus.* Background: Resistant plant

Left: tomato infected with *Tomato yellow leaf curl virus* (*Geminiviridae, Begomovirus*)
Right: Uninfected tomato

Abnormalities of Growth And Developmental in Fruit

Distortions, discoloration in fruit

Fruit distortion caused by *Zucchini yellow mosaic irus (Potyviridae, Potyvirus)* in zucchini (above) and in pumpkin (right)

Abnormalities of Growth And Developmental in Fruit

Flower abscission (leading to fewer fruit)

Left: Healthy tomato
Right: *Tomato infected with Tomato yellow leaf curl virus* (*Geminiviridae, Begomovirus*)

Left: Fruit from a healthy bean (*Phaseolus vulgaris*)
Right: Fruit from a bean plant infected with *Bean golden yellow mosaic virus* (*Geminiviridae, Begomovirus*)

Abnormalities of Growth And Developmental in Fruit

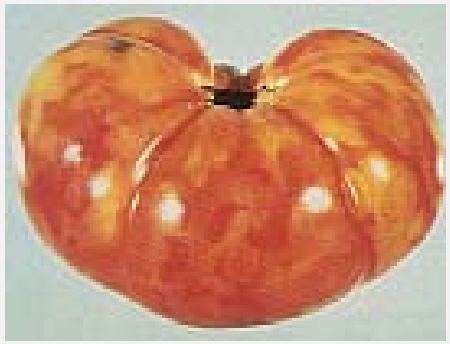
Distortions, reduced size

Left: Fruit from a healthy bean (*Phaseolus vulgaris*)
Right: Fruit from a bean plant infected with *Bean golden yellow mosaic virus* (*Geminiviridae, Begomovirus*)

Squash leaf curl virus (*Geminiviridae, Begomovirus*) in Mediterranean squash (healthy left, infected right)

Abnormalities of Growth And Developmental in Fruit

Mottling, Ringspots, Off-colored Sectors

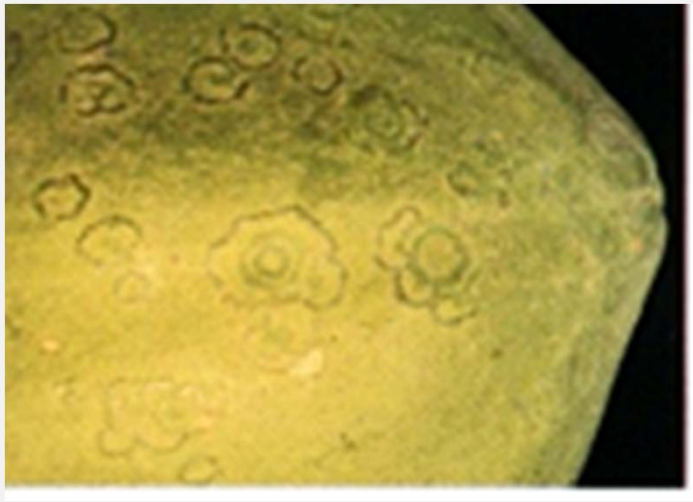


Tomato spotted wilt virus (*Bunyaviridae, Tospovirus*) in fruit of pepper (left) and tomato (right)

Fruit from a peach tree infected with *Plum pox virus* (*Potyviridae*, *Potyvirus*)

Abnormalities of Growth And Developmental in Fruit

Mottling, Ringspots, Off-colored Sectors



Papaya ringspot virus (Potyviridae, Potyvirus) in papaya

Abnormalities of Growth And Developmental in Fruit

Cracking, splitting

Fruit from various types of melon plants infected with *Tomato leaf curl New Dehli virus* (*Geminiviridae*, *Begomovirus*)

Abnormalities of Growth And Developmental in Fruit

Necrosis

Fruit from a tomato plant infected with *Tomato spotted wilt virus* (*Bunyaviridae, Tospovirus*) in tomato

Necrotic spots and patches in pepper fruit caused by *Tobacco mosaic virus* (*Virgaviridae, Tobamovirus*)

Abnormalities of Growth And Developmental in Seeds

Mottling of seeds

Seed from soybean plants infected with
Left: *Soybean mosaic virus (Potyviridae, Potyvirus)* and
Right: Bean pod mottle virus (Secoviridae, Comovirus)

Distortion

Seed from lentil plants infected with *Bean yellow mosaic virus (Potyviridae, Potyvirus)*

What happens to symptom expression when more than one virus infects a plant at the same time?

Symptoms May or May Not Be Modified By Mixed Infections Con't.

Possible Outcomes:

1. Co-infection may have no impact on the symptoms of either virus.

2. Co-infection may increase severity of symptoms due to enhanced replication, cell-to-cell movement, vector transmission of one or both viruses.

3. Plants systemically infected by a mild strain may mask the symptoms of a closely-related but more severe strain of the same virus. This phenomenon is known as cross-protection.

4. A cultivar with resistance to a virus may lose resistance, after infection with another virus and thus show symptoms.

Murphy and Kyle. 1995. Phytopathology 85:561-566.

2. Co-infection may increase severity of symptoms due to enhanced replication, cell-to-cell movement, vector transmission of one or both viruses.

Mixed infections are common

Symptoms of a squash plant infected with
Zucchini yellow mosaic virus
plus
Watermelon mosaic virus 2
Plus
Cucumber mosaic virus

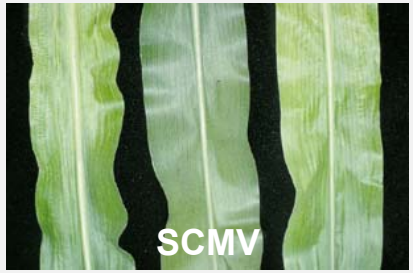
Some diseases (and their symptoms) are only caused by infection with multiple viruses

Ex. Maize lethal necrosis disease

Symptoms:

- Mosaic, necrotic areas
- chlorotic and dead leaves
- Stunting, early senescence
- dead heart, dieback, plant death

This disease is caused by co-infection with *Maize chlorotic mottle virus* (MCMV) (*Machlomovirus: Tombusviridae*) plus *Sugarcane mosaic virus* (SCMV) (*Potyvirus: Potyviridae*) or at least one of several cereal-infecting viruses of the genus *Potyvirus.*



Ex. Mealybug wilt of pineapple

Symptoms of mealybug wilt are caused by a complex of virus species in the genus *Ampelovirus*. Single infections of these viruses cause no symptoms

Virus-Like Symptoms Not Caused by Viruses

Virus-Like Disease Symptoms Caused By Other Agents

- Phytoplasmas, spiroplasmas, viroids, and rickettsia-like organisms cause yellowing, stunting, phyllody, and witches brooms.
- Direct and indirect damage produced by insect feeding.
- Genetic abnormalities
  (i.e. leaf variegations or mosaics in ornamental plants.)

Mosaics

Symptoms of Citrus greening, a bacterium in citrus leaves

Symptoms in grape caused by *Grapevine yellow speckle viroids 1 and 2*

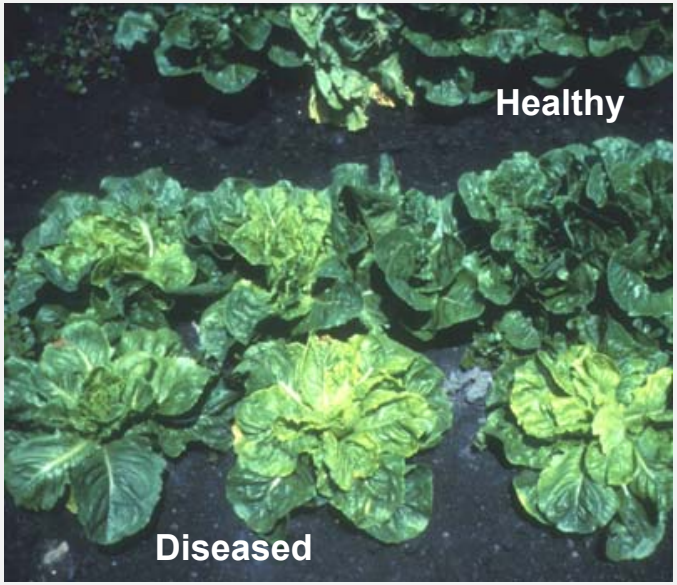
Chlorosis

Cucurbit Yellow Vine Disease (CYVD) caused by the bacteria, *Serratia marcescens*

Symptoms in grape caused by Grapevine yellow speckle viroids 1 and 2

Chlorosis, Distortion

Symptoms in citrus caused by
Citrus greening, a bacterium



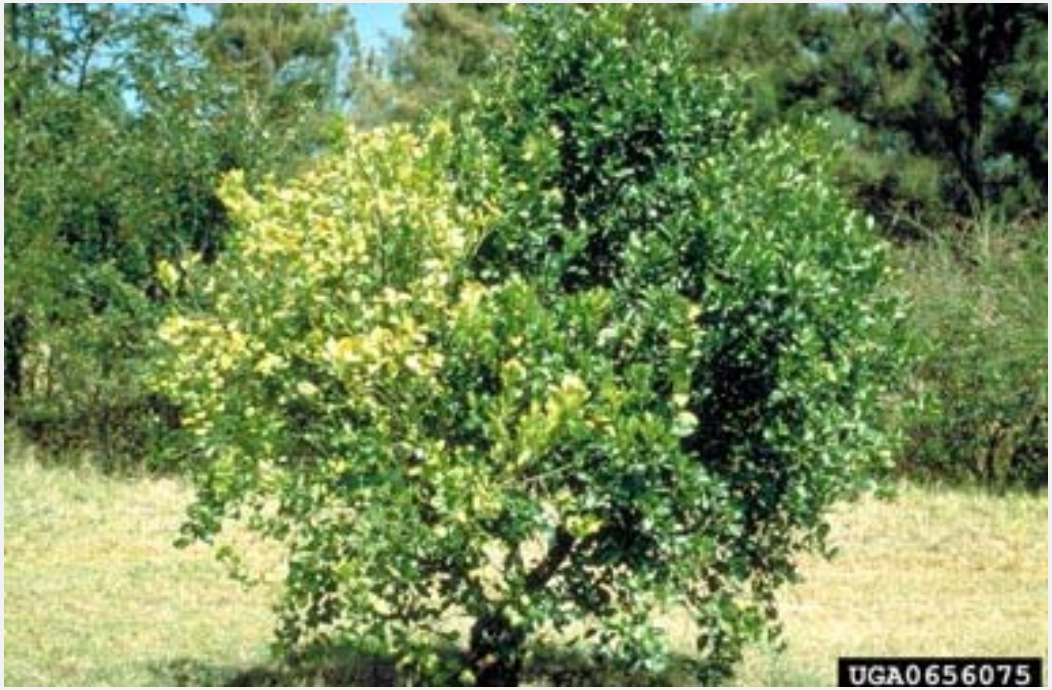
Symptoms in lettuce caused by
Aster yellows phytoplasma

Mottling, Distortion

Symptoms in peach caused by *Peach latent mosaic viroid*

Symptoms in chrysanthemum caused by *Chrysanthemum stunt viroid*

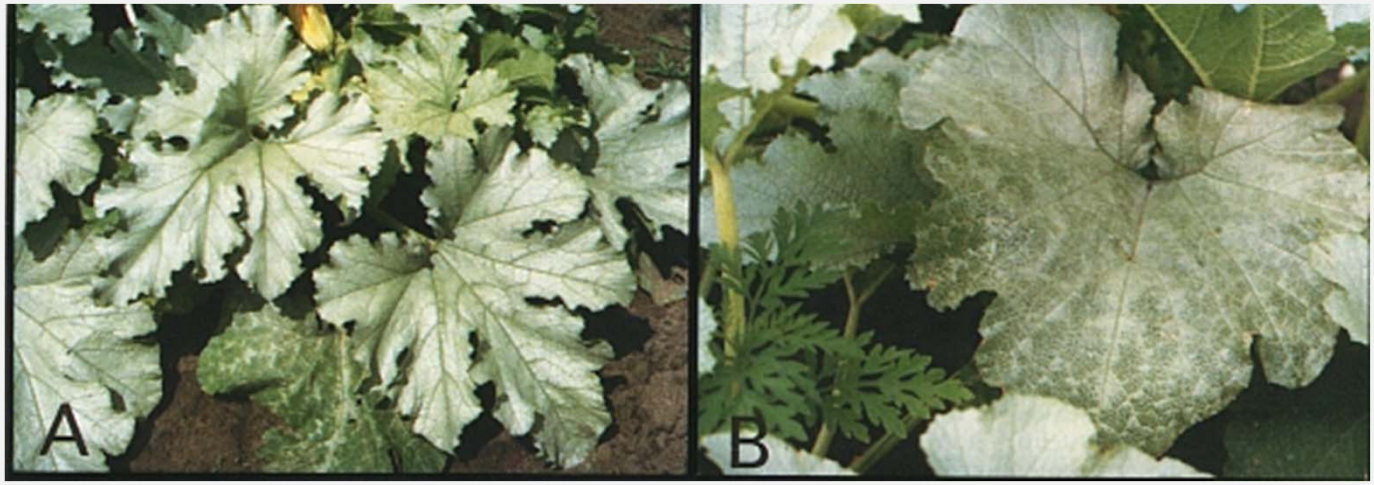
Uneven distribution of symptoms



Caused by Citrus greening, a bacterium

Virus-like Disease Symptoms:

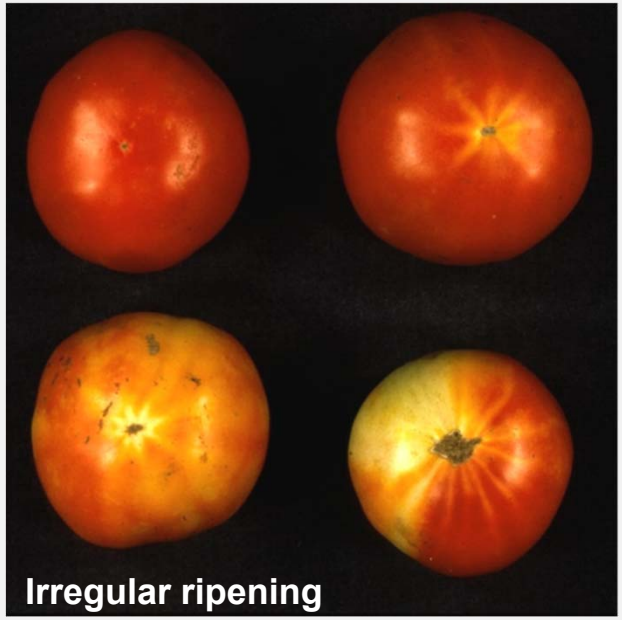
Silverleaf in cucurbits induced by whitefly feeding.

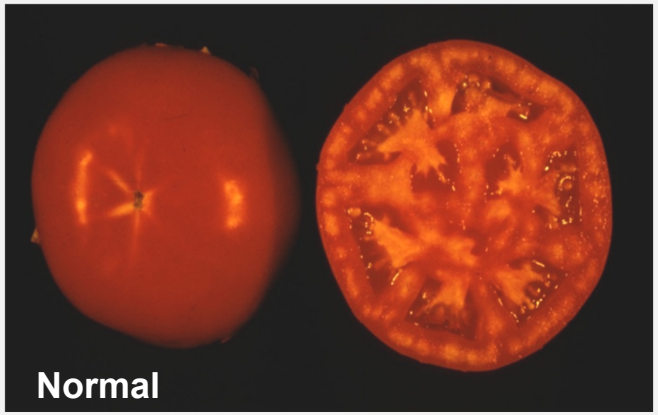


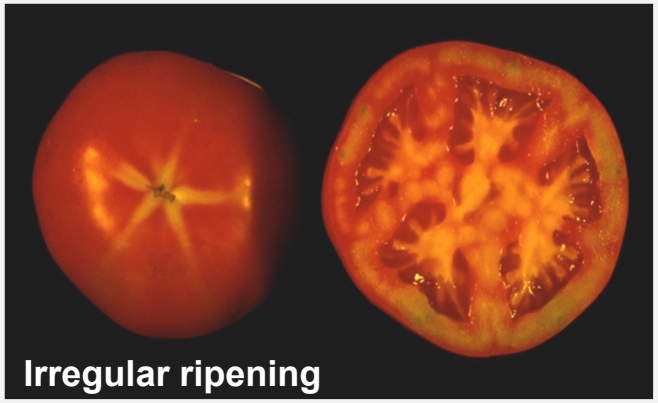
Whitefly Feeding Damage on Melons

Due to high populations of whiteflies (*Bemisia tabaci*)

Mottling of tomato fruit caused by feeding of a 5 or more immature whiteflies on plant leaves (saliva is phytotoxic)







Irregular ripening of tomato

Leaf distortion southern pea (*Vigna sinensis*)caused by Thrips feeding

Virus Like Disease Symptoms with Abiotic Causes

- Nutritional deficiencies, cause abnormal coloration, discoloration, or death of leaf tissue
- High temperatures
- Herbicide or insecticide damage
- Air pollutants

Mosaics and mottles due to nutritional deficiencies

Calcium deficiency in cucumber

Mottling in cabbage caused by high temperatures

Mottling in Dieffenbachia due to genetic abnormalities

Mosaics and mottles due to herbicide or insecticide damage

How useful are symptoms for diagnosis of plant viruses?

- Suggest that a virus might be the causal agent of the disease
- Suggest which virus might be present based on the published pictures of known virus/host combinations
- Suggest which tissue to choose for use in assays
- May give you a very rough estimate of how many plants in a field are infected
- May give you an idea of when the plant became infected