

# Pathogenesis

Chain of more or less distinct event occurring in succession and leading to development and perpetuation of a disease and pathogen is called pathogenesis or disease cycle.

The disease cycle is close to the life cycle of pathogen, but it refers primarily to the appearance, development and perpetuation of diseases as a function of pathogen rather than to the pathogen itself.

The disease cycle involves changes and its symptom in the plant as well as changes in the pathogen and spans within a growing season and from one growing season to another.

The disease cycle or infection chain can be of two types:

- i) *Continuous infection chain*: In this type of disease cycle, the pathogen remains continuously active form from one host to another. Most viral and some fungal diseases come under this category.
- ii) *Intermittent infection chain*: In this type disease cycle, pathogen survives in dormant state or as active saprophyte to maintain the continuity of chain after the harvest of crop. Most of fungal, bacterial and nematodes diseases fall under this category

Diseases with intermittent infection chain are further of two types:

- a) *Monocyclic diseases*: In such diseases only one cycle of disease is completed in one season and there is no repetition of disease cycle within a season. Such diseases are also called simple interest diseases. Eg. Loose smut of wheat and covered smut of barley etc.
- b) *Polycyclic diseases*: In such diseases many cycle of a disease are repeated within the same crop season on host through spore-infection-spore chain. Such pathogens are responsible for epidemics if the environmental condition favors the disease. Such disease are called compound interests disease. Eg. Rust, powdery mildew, late blight of potato, apple scab etc.

Depending upon the host plants involved, infection chains can be:

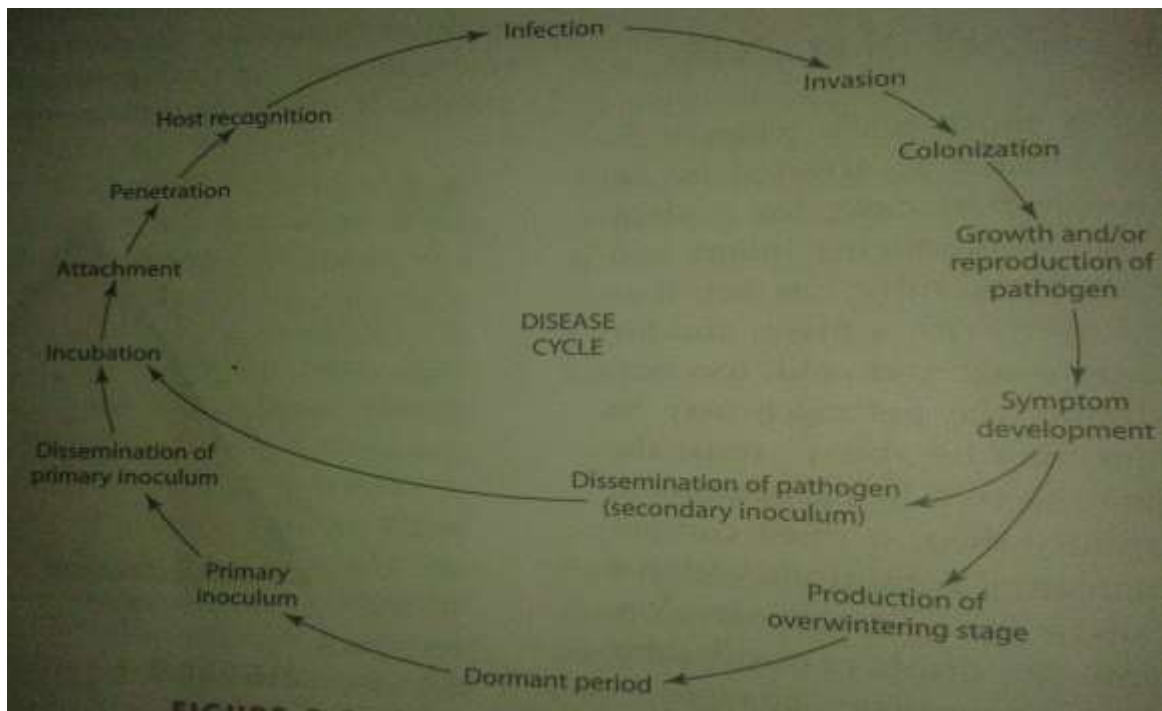
- a) *Homogenous*: when the pathogen survive only one genus of plants.
- b) *Heterogeneous*: when many plant species are involved in disease cycle

Disease developments in plants

For successful development of disease in plants it requires three components i.e. virulent pathogen, susceptible host and favorable environment. If any one of the components is absent there is no disease development.

Main events in disease cycle are

Inoculation, penetration, infection, invasion, colonization, growth and reproduction, dissemination of pathogen, survival of pathogens.



## Inoculation

Inoculation is the initial contact of a pathogen with a site of plant where infection is possible.

The pathogen that lands on the host plant or is otherwise brought into contact with the plant is called inoculum.

In fungi, the inoculum may be spore, sclerotia, or fragment of the mycelium. In bacteria, mollicutes, protozoa, viruses, and viroids, the inoculum is always the whole individual of the respective organisms. In parasitic higher plants, the inoculum may be plant fragments or seed.

One unit of any pathogen is called a propagule.

## Types of inoculum:

- *primary inoculum*: An inoculum that survive in winter or summer and cause original infection in spring or autumn on any is called the primary inoculum and the infection is called primary infections. Eg. Primary inoculum (Sclerotia, mycelium, oospore)

Generally, more the primary inoculum , more severe is the disease.

- *secondary inoculum*: An inoculum produced from primary infections is called secondary inoculum and the infection it causes are called secondary infections. Eg. Secondary inoculum (conidia, urdospores, zoospores).

## Source of inoculum

- Fungi, bacteria, parasitic higher plants and nematodes generally produce their inoculum on the infected plants or their inoculum reaches the plant surface when the infected tissue break.
- Viruses, viroids, mollecutes , fastidious bacteria and protozoa produce their inoculum within the plants and the inoculum never reaches the surface naturally. So in case, the inoculum may transmitted from one plant to another through some kind of vector
- Soil: Bacteria, Rhizoctonia, Sclerotinia,
- Diseased debris: Alternaria, Phytophthora
- Alternate hosts: Rusts- wheat rust: Barberis vulgaris
- collateral hosts: Viruses: BCMV, PVY, Powdery mildews etc.

## Landing and arrival of inoculum

- The inoculum of most of pathogen is carried to host plant passively by wind water and insects.
- Airborne inoculum reaches the host sometime by gravity or by washing with the rains. Some zoospore and nematodes may attracted toward the suger or amino acids diffusing out from the host.

## **Pre penetration phenomenon**

### Attachment of pathogen

- Mollecutes protozoa and most of virus are placed directly into the cell of plant by their vector and they are immediately surrounded by cytoplasm, cytoplasmic memberanes and cell wall.

- Fungi, bacteria and parasitic higher plants are first brought into contact or are attached with external surface of the plant before they colonize the host .
- The propagule of pathogen have mucilage substances and consisting of water soluble polysaccharides glycoproteins, lipid and febrile materials on their surface which get moistened become sticky and pathogen to adhere on plant surface.

### Spore germination / seed germination and perception of host surface

- Spore germinates by producing a typical mycelium that infects and grows into host plants or they produce a short germ tube that produce aspecialized distinct form of mycelium called haustorium.

### Formation of and maturation of appresorium or infection peg

- Appresorium is the swelling produced at the tip of germ tube which contain lipids, polysacchrides, proteins,and enormous glycerol.
- Apresria in certain cases produce a narrow penetration hypha also called infection peg or penetration peg from the base of appresorium and use primarily physical forces to puncture the plant cuticle with that penetration peg.

### Recognition between host and pathogen

- It is assumed that when pathogen comes in contact with the host cells, an early events takes place that trigger a fairly rapid reponse in each organisms which either aallowsorimpedes further growth of pathogen and development of disease.

## Penetration

Fungi may penetrate in either indirect penetration or direct penetration; bacteria mostly enter through wounds and some time by natural openings and Viruses, viroid's, phytoplasma, RLOs etc. by mechanical means (wounds) and by vectors.

### Direct penetration

- Through Appresorium (e.g. involved in direct penetration (eg. *Colletotrichum* spp. and *M. grisea* )
- Germtube e.g. (Apple scab- *V. inequalis*)
- Appresorium give rise to penetration peg

- Haustoria e.g. powdery mildews
- Infection cushion e.g. Fusarium, Sclerotinia – Includes fungi imperfecti & ascomycetes

## Indirect Penetration

Penetration through natural openings

- Entry through Stomata e.g. Bean Rust – *Uromyces appendiculatus*
- Entry through hydathodes :Bacteria e.g. *Xanthomonas campestris* sp. *Oryzae*
- Nectothodes: *Erwinia amylovora* causing fire blight of apple & pear.
- Lenticels: *E. amylovora*

## Infection

- It is the process by which pathogen establish contact with susceptible cell or tissue of the host and procure nutrients from them
- Successful infection results in the appearance of symptom, on the host plants. Some infection remain latent i.e don't produce symptom right away but at a later when the environmental conditions or the stage of maturity of plants become more favorable
- Symptom may be appear as soon 2-4 days after inoculation or as late 2-3 year after inoculation.
- killing the cells or at least not for long time, and still others kill cells and disorganize surrounding tissue.

Infection process is affected by various factors

- Resistance & susceptibility of the host
- Aggressiveness & virulence of the pathogen
- Environmental factors
- Host nutrition & pH
- Incubation period ( depends upon host- pathogen combination, stage of host and environment etc.

## Invasion

Invasion is the spread of the pathogen in the host. Most fungi spread into all the tissues of the plant organ (leaves, stem and roots) they infect, either by growing directly through cell as intracellular mycelium or by growing between the cell as an intercellular mycelium.

Different pathogens invade their host as

- Ectoparasite e.g. powdery mildew
- Endoparasites e.g. wilts, viruses etc
- Sub-cuticular pathogens (Apple scab- *Venturia inaequalis*) • Sub-epidermal pathogens (wheat rust )
- Vascular pathogens (*Pseudomonas solanacearum*) – Ecto-endo parasites e.g. potato canker (*Corticium solani*)

## **Growth and reproduction of the pathogen and their Colonization**

### a) Growth

- fungi and parasitic higher plants invade and infect tissues by growing. These pathogens continue to grow and branch out within the infected host indefinitely so that the pathogen spreads into more and more plant tissues until the spread of infection is stopped or plant is dead.
- bacteria, mollecutes, viroids, nematodes and protozoa do not increase in size with time. These pathogens invade and effect new tissues within the plant by reproducing at a rapid rate and increasing their number tremendously in infected tissues.
- Their progenies then are carried passively into new cells and tissues through plasmodesmata (viruses and virioids), phloem (viruses, virioids, mollecutes, some fastidious bacteria and protozoa) or xylem (some bacteria) or they move actively by their own power as in case of protozoa, nematodes and some bacteria

### b) Reproduction

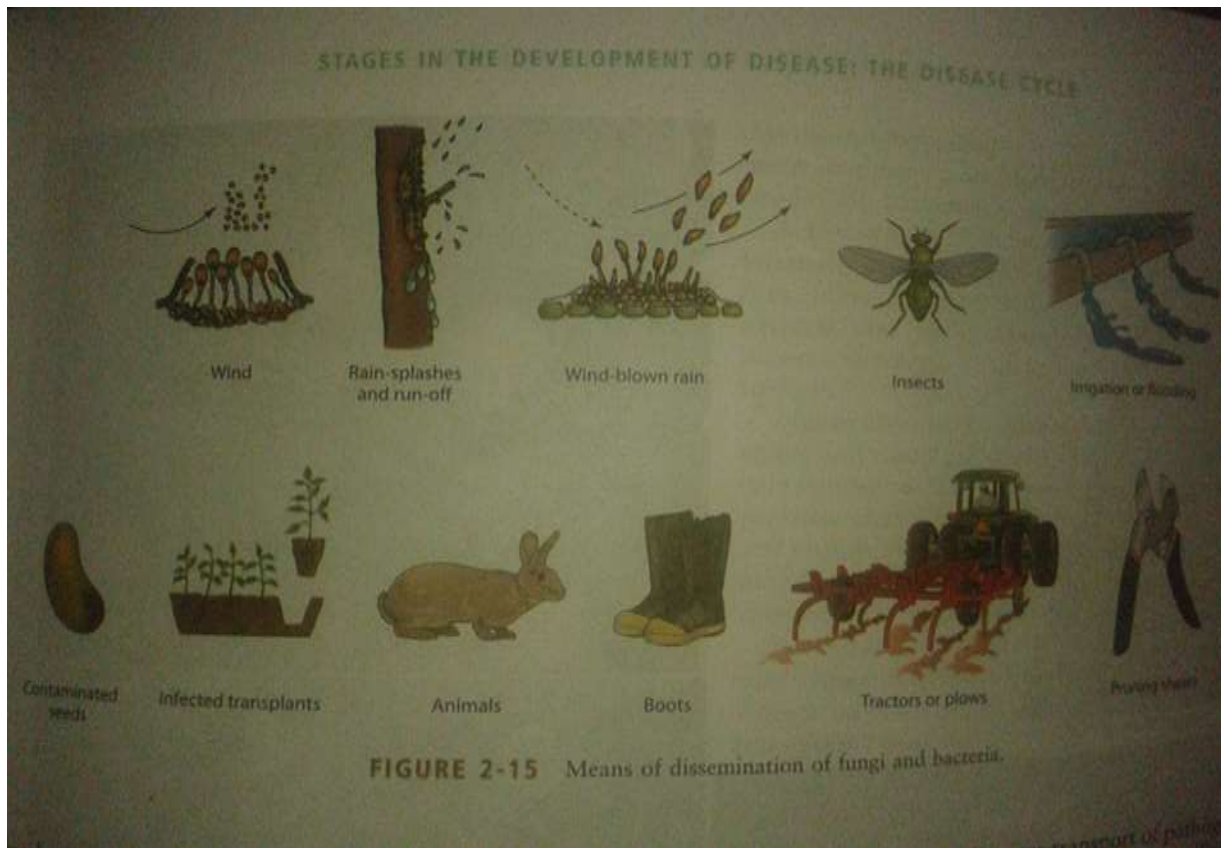
- Fungi reproduce by means of asexual or sexual spores.
- Some fungi produce tremendous spores in one growing season while, others produce them in successive crops. But in any case thousands of spores are produced per square centimetre of infected tissue.
- Parasitic higher plants reproduce by seeds.
- Bacteria and mollecutes reproduce by fission in which one mature individual splits into two equal smaller individuals.
- Under optimum nutritional and environmental conditions, the bacteria divide continuously in the host cells until the nutrients are exhausted..
- Viruses and viroids are replicated by the host cell.
- Nematode female's lay about 300 to 500 eggs and half of them produce females which again will lay the same number of eggs.

### c) Colonization

- Majority of plant pathogenic fungi and oomycetes produce a mycelium only within the plants they infect.
- Few fungi and oomycetes produce a mycelium on the surface of their host plants, but most powdery mildew fungi produce a mycelium only on the surface of their hosts..
- Parasitic higher plants produce their seeds on aerial branches.
- Some nematodes lay their eggs at or near the surface of the host plants.
- Bacteria reproduce between the host cells or in xylem or phloem cells of the hosts and come to the surface only through wounds, cracks, stomata etc.
- Viruses, viroids, protozoa and fastidious bacteria reproduce only inside the cells and often do not reach at the surface of the host plant

## Dissemination of the pathogen

Dispersal means spread of pathogen propagules from one plant to the another or one area to another area for short as well as long distance.



Dispersal may be: a) Active - move on own power bacteria (some) Pythium (Zoospores)  
Fungi- spores expelled forcibly

pathogen disperse with seed- *xanthomonas compestris* pv. *Compestris* black leg of crucifers.

Passive - wind, water, insects, man, animals, machinery

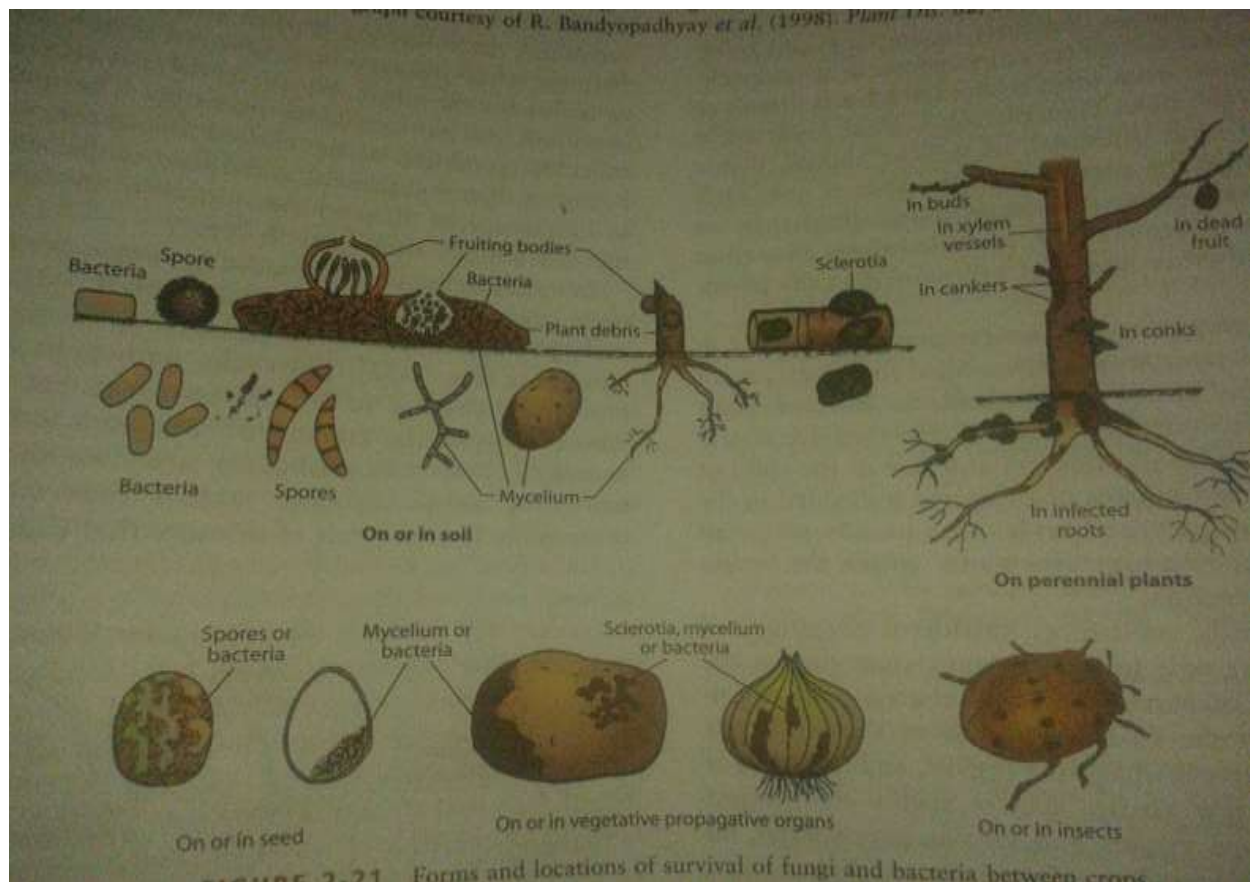
pathogen disperse with seed- *xanthomonas compestris* pv. *Compestris* black leg of crucifers.

## Survival of pathogen in absence of host

Plant pathogens can survive in the absence host. They have evolved several mechanism to survive in too cold and dry summer.

In perennial plants on diseased tissue, canker, buds on fallen leaves, infected leaves and fruits.

In annual plants survive the winter or summer as mycelium ininfected plant debris.



- ✓ In infected crop debris : *Claviceps purpurea*
- ✓ In seed: *Ustilago tritici*
- ✓ In soil: *Pythium, Fusarium, Rhizoctonia etc.*
- ✓ On growing plants: *Monillinia*

- ✓ Infected material on host plant: *Erwinia amylovora*, *venturiinaequalis*.
- ✓ Alternate host: *puccinia graminis tritici*
- ✓ As dormant structures e.g. *sclerotia*, *chlamydospores*

## References

- ✓ Plant pathology by G N Agriose
- ✓ Modern plant pathology H C Dube.
- ✓ Plant pathology by R S Singh