Survival and Dispersal of Plant Pathogens

Survival of Plant Pathogens

In absence of their cultivated host, animate pathogens must find some alternate source of their survival to maintain the infection chain. The means of survival are the first link in the infection chain or the disease cycle.

Infection chain:

Gaumann (1950) had used the term "infection chain" for the chain of events leading to completion of pathogenesis". The infection chain can be divided into 4 types

1. Continuous infection chain: When the pathogen continuously lives in active form by moving from one host to another. It is called continuous infection chain. Most viral and some of the diseases caused by fungi have this type of infection chain.
2. Intermittent infection chain: When the pathogens survive in dormant resting structures or as active saprophytes to maintain continuity of the chain. It is called intermittent infection chain. Intermittent infection chain is found in diseases caused by bacteria, fungi and nematodes.
3. Homogeneous infection chain: When the pathogen survives on only one genus or species of plants it is known as homogeneous infection chain.
4. Heterogeneous infection chain: If many plants species are involved in the disease cycle the chain is heterogeneous. The heterogeneous infection chain can be facultative or obligate in nature according to the nature of fungus or the bacterium.

Inoculum (pl. Inocula): The inoculum is any part of the pathogen that initiates infection. Thus, in fungi the inoculum may be spores, conidia, mycelia, sclerotia etc. In bacteria the inoculum maybe bacterial cells, viruses – virus particles, viroids – free RNA molecules and phytoplasma, the inoculum is always individual cell. In nematodes, the inoculum may be adult, juvenile or eggs of nematodes. In parasitic higher plants inoculum may be plant fragments or seeds.

Primary and secondary Infection:

The initial infection that occurs from these sources (infected host as reservoir of inoculum, saprophytic survival and dormant spores and other structures etc.) in the crop is primary infection and the propagules that cause this infection are called primary inoculum. After initiation of the disease in the crop, the spores or cells or other structures of the pathogens are sources of secondary inoculum and cause secondary infection, thereby spreading the disease in the field.

In a word, the first infection of plant by the overwintering or over summering pathogen is called primary infection and the pathogens or its part is called primary inoculum. On the contrary, any infection caused by inoculum produced as a result of a primary or subsequently infection that is called secondary infection and the pathogens or its part is called secondary inoculum.

These sources of survival of the pathogens or the sources for renewal of the infection chain can be grouped as below:

1. Survival by means of specialized resting structures
2. Survival as saprophytes
3. Survival in vital association with living plants
4. Survival in association with nematodes and fungi
5. Survival in association with insects
6. Survival on agricultural materials
7. Survival on surface water

1. Survival by means of specialized resting structures

Enduring structures of plant pathogens may be as simple as conidia. Conidia of *Alternaria solani*, the pathogen of early blight of potato and tomato, survive for 18 months in dried diseased leaves. Specialized thick-walled chlamydospores of *Fusarium* and other Imperfect fungi, spores of many smut fungi and the uredospores and teliospores of certain rust fungi also are important enduring structures. Some fungi survive unfavourable seasons in the form of sclerotia. Those produced by the omnivorous cottony-rot fungus, *Sclerotinia sclerotiorum*, can survive for years in a dry atmosphere. Parasitic phanerogams survive in the form of seeds and as eggs, cysts and larvae of parasitic nematodes serve as over seasoning structures.

2. Survival as saprophytes

The ability to live saprophytically; enable many plant pathogens to survive in the absence of growing susceptible plants. Saprophytic survival usually occurs in the soil. Waksman (1971) distinguished between soil inhabitants and soil invaders; the former comprise the basic fungal flora of the soil, whereas the latter are short-lived exotics. As applied to the root infecting fungi soil inhabitants are unspecialized parasites with a wide host range that are able to survive-indefinitely in the soil as saprophytes; soil invaders (root inhabiting fungi) are more specialized parasites that survive in soils in close association with their hosts. Most plant pathogenic fungi and bacteria are soil invaders, but some pathogens, notably *Rhizoctonia solani* and *Pythium sp.* that cause seedling blights and root rots, live saprophytically in the soils.

3. Survival in vital association with living plants

Survival of the plant pathogens in vital association with living plants is grouped into

a. Seed

The pathogen of loose smut of wheat, *Ustilago nuda tritici,* enters the stigma and style and infects the young seed, in which it survives as mycelium. The seed-infecting pathogens that cause loose smut of wheat and loose smut of barley are strikingly different from other smut fungi that attack cereal crops.

b. Collateral hosts

When original host absent then the pathogens if can attack the wild host of the same family, those host are called Collateral hosts. Collateral hosts are susceptible to the plant pathogens of crop plants and provide adequate facilities for their growth and reproduction of these pathogens. For example, the fungal pathogen for blast disease of rice, *Pyricularia oryzae* can infect the grass weeds and survive during off-season of rice-crop.

c. Alternate hosts

When original host absent then the pathogens if can attack the wild host of the others family, those host are called alternate hosts. These alternate hosts are very important for the completion of the lifecycle of heteroecious rust pathogens. e.g. *Berberis vulgaris* (Barberry plant) acts as alternate host of *Puccinia graminis tritici* (Stem rust pathogen on wheat).

d. Self-sown crops

Self-sown plants, voluntary crops and early sown crops are reservoirs of many plant pathogens. Self-sown rice plants harbour the pathogen as well as vector. e.g., *Rice tungro virus* and its vector, *Nephotettix virescens* (Green leafhopper).

e. Ratoon Crops

Sometimes ratoon crop also harbour the plant pathogens e.g., *Sugarcane mosaic virus*.

f. Survival by latent infection

Latent infection refers to the conditions in which the plant pathogens may survive for a long time in plant tissue without development of visible symptoms. e.g. *Pseudomonas syringae* pv. *syringae* can survive in apparently healthy bark tissues of their tree hosts.

g. Survival as residents

Plant pathogenic bacteria have the capacity to grow on the surface of host and non-host plants utilizing the small amount of nutrients that are secreted on the plant surface. e.g. Soft rot of chinese cabbage *Erwinia carotovora* subsp. *carotovora.*

4. Survival in association with nematodes and fungi

Plant viruses like wheat mosaic, wheat spindle streak virus, lettuce big vein, tobacco necrosis, tobacco rattle and tobacco ring spot viruses survive with nematodes or fungi found in the soil between crop seasons. *Tobacco ring spot virus* is associated with the nematode, *Xiphinema americanum.*

5. Survival in association with insects

Many insects are carriers of inocula during the growing season and several important plant pathogens survive between growing seasons within insects. Some bacterial plant pathogens may survive within the insect body and over winter therein. e.g. *Rice tungro virus* survival in association with Green leaf hopper.

6. Survival on agricultural materials

Clavibacter michiganensis subsp. *michiganensis* has been shown to survive in air-dried conditions for 7 to 8 months on the surface of wooden stakes and boxes or wires or for 15 months in air-dried tissues of diseased tomato plants.

7. Survival on surface water

Some of the pathogens can survive on surface water. Such as *Erwinia carotovora* subsp. *carotovora* is detected from water from drains, ditches, streams, rivers and lakes in mountainous upland and arable areas of Scotland and Colorado throughout the year.

Dispersal of Plant Pathogens

Transport of spores or infectious bodies, acting as inoculum, from one host to another host at various distances resulting in the spread of disease, is called dissemination, dispersal or transmission of plant pathogens. It is very important for spread of plant diseases, for continuity of the life cycle and evolution of the pathogen.

The knowledge of these methods of dispersal is essential for effective control of plant diseases because possibilities of preventing dispersal and thereby breaking the infection chain exist.

The dispersal of infectious plant pathogens occurs through two ways,

I. Autonomous or direct or active dispersal

II. Indirect or passive dispersal

I. Autonomous dispersal

It is also known as active or direct dispersal. In this method the dispersal of plant pathogens (fungi, bacteria, and viruses) takes place through soil and seed or planting materials during normal agronomic operations.

1. Soil as means of autonomous dispersal

Soil-borne facultative saprophytes or facultative parasites may survive through soil. The dispersal may be by movement of the pathogen in the soil or by its growth in soil or by movement of the soil containing the pathogen. The former is known as dispersal in soil while the latter is called dispersal by soil.

a. Dispersal in soil

The following are the three stages of dispersal in soil.

I. Contamination of soil
II. Growth and spread of the pathogen in soil
III. Persistence of the pathogen

i. Contamination of soil

Contamination of the soil takes place by gradual spread of the pathogen from an infested area to a new area or by introduction of contaminated soil, plant debris to a new area or by introduction of infected seed or planting materials.

ii. Growth and spread of the pathogen in soil

Once the pathogen has reached the soil it can grow and spread "depending on the multiplication and spread. Multiplication and spread depends on the characters of the pathogen, presence of susceptible host and cultural practices. The adaptability of the pathogen to the soil environment includes saprophytic survival ability. The survival ability of the pathogen is governed by high growth rate, rapid spore germination, better enzymatic activity, capability to produce antibiotics and tolerance to antibiotics produced by other soil microorganisms. e.g., *Fusarium.* The non-specialized facultative parasites can pass their entire life in the soil. e:g., *Pythium* sp., *Phytophthora* sp., The soil-borne obligate parasites such as *Synchytrium endohioticum* requires the presence of active host.

iii. Persistence of the pathogen

The pathogens persist in the soil as dormant structures like oospores *(Pythium; Phytophthora, Sclerospora,* etc.) chlamydospores *(Fusarium)* or smut spores *(Ustilago)* or sclerotia *(Rhizoctonia, Sclerotium,* etc.)

b. Dispersal by the soil

The pathogen enters the soil, grow and spread in the soil. During the cultural operations in the field, soil is moved from one place to the nearby place through the agricultural implements and irrigation, worker's feet. Propagules of fungi or the dormant structures of fungi and the plant debris containing the fungal and bacterial pathogens thus spread throughout the field.

2. Seed and seed materials as the source of autonomous dispersal

The seeds serve as medium for autonomous dispersal of pathogens. Since most of the cultivated crops are raised from seed the transmission of diseases and transport of pathogens by seeds has much importance. The dormant structures of the pathogen are found mixed with seed lots and they are dispersed as seed contaminant. The bacterial cells or spores of fungi present on the seed coat (such as in smuts of barley, sorghum, etc.,) are transported to long distances. Dormant mycelium of many fungi present in the seed is transmitted to long distances.

There are three types of dispersal by seed *viz.*,

a. Contamination of the seed
b. Externally seed - borne, and
c. Internally seed - borne

a. Contamination of the seed

Seed -borne pathogens move in seed lot as separate contaminants without being in intimate contact with the viable crop seeds. The seeds of the pathogen or parasite and the host are getting mixed during harvest of the crop.

b. Externally seed-borne

Close contact between structure of the pathogen and seed is established in diseases like covered smut and loose smut of wheat and bacterial blight of cotton. In many pathogens the externally seed-borne structures such as smut spores can persist for many years due to their inherent capacity for long survival. The spores of *Tilletia caries* (stinking smut of wheat) remain viable even after 18 years and those of *Ustilago avenae* (oat smut) for 13 years.

c. Internally seed-borne

The pathogen may penetrate into the ovary and cause infection of the embryo while it is developing. They become internally seed-borne. Internally seed borne pathogens like *Ustilago nuda tritici* are viable for more than 15 years.

II. Passive dispersal

Passive dispersal of plant pathogens happens through

1. Animate agents

a. Insects
b. Mites
c. Fungi
d. Nematodes
e. Human beings
f. Farm and wild animals
g. Birds
h. Phanerogamic parasites

2. Inanimate agents

a. Wind

b. Water

1. Animate agents

a. Insects

Insects carry plant pathogens either externally or internally. Gaumann (1950) used the terms epizoic and endozoic respectively for these two types of transmission. e.g. The black leg of potato caused by *Erwinia carotovora* is disseminated by maggots. Different types of insects spread more than 80 per cent of the viral and phytoplasmal diseases. The insect, which act as specific carriers in disseminating the diseases, are called insect vector.

b. Mites

Mites such as eriophid mite and spider mite transmit plant viruses.

C. Fungi

Some soil - borne fungal plant pathogens transmit plant viruses. *Synchytrium endobioticum,* is the fungi involved in transmission of Potato virus disease.

d. Nematodes

Nematodes are soil borne organisms. Some of the nematodes act as agents for dissemination of pathogenic fungi, bacteria and viruses. For example, the bacterium *Corynebacterium tritici* that causes yellow ear rot of wheat is disseminated by ear cockle nematode. Similarly, some pathogenic fungi such as, *Phytophthora, Fusarium, Rhizoctonia,* etc., are carried on the body of nematodes.

e. Human being

Man is the most important factor responsible for.' short distance and 'long distance dispersal of plant pathogens. He helps in dissemination unknowingly by his usual agricultural practices. Human being's role in dissemination of plant pathogens is more direct of plant pathogens by human beings is known anthropochory.

The ways and means by which human beings help in dispersal are as follows.

i. Transportation of seeds (Seed trade)

ii. Planting diseased seed materials (Vegetative propagated materials)

iii. By adopting farming practices

iv. Through clothing

v. By use of contaminated implements

vi. By use of diseased grafting and budding materials

f. Farm and wild animals

Farm animals (cattle) while feeding on diseased fodder ingest the viable fungal propagules (spores or oospores or sclerotia) into their digestive system. Animals which feed on downy mildew affected pearlmillet or sorghum take the oospores along with the fodder. Oospores pass out as such in the dung. This dung when used as manure spread in the field and act as source of inoculum. Animals passing through the tobacco fields help in transmission of TMV.

g. Birds

In general, transmission by birds is of minor importance. But this method is important in dissemination of seeds of flowering parasites and certain fungi.

h. Phanerogamic parasites

Plant viruses are transmitted from one plant to another through the bridge formed between the two plants by the twining stems of the parasitic plant dodder *(Cuscuta* spp).

2. Inanimate agents

a. Wind

The wind dispersal of plant pathogens is known as anemochory. It is one of the most common methods of the dispersal of plant pathogens. It is the most dangerous and potent mode of travel for plant pathogenic fungi. It acts as potent carrier of propagules of fungi, bacteria and viruses. Usually the fungal pathogens are light in weight and are well adapted to wind dispersal. Some pathogenic bacteria and viruses are carried along with the infected material to short distances by wind. Blast of rice *(Pyricularia oryzae*), Stem rust of wheat *(Puccinia graminis* f. sp. *tritici),* Soybean rust *(Phakopsora pachyrhizi),* Powdery mildews (*Erysiphe graminis*) etc., and seeds of phanerogamic parasites witch weed *(Striga)* are efficiently carried by wind. Viruses and phytoplasmas are not directly transmitted by wind, but the insect and mite vectors that carry the viruses move to different directions and distances depending upon the direction and speed of air.

b. Water

Transmission of plant pathogens by water (hydrochory as called by Gaumann, 1950) is not as significant as wind transmission. Although water is less important than air in long-distance transport of pathogens, water dissemination of pathogens is more efficient, in that the pathogens land on an already wet surface and can move or germinate immediately. In case of some diseases the surface flow of water after heavy showers of rains or irrigation water from canals and wells carries the pathogens to short distances. Soil inhabiting fungi like, *Fusarium, Macrophomina Phytophthora, Plasmodiophora, Pythium, Rhizoctonia, Sclerotium, Sclerotinia,* etc., in the form of mycelial fragments, spores or sclerotia, soil-borne bacteria and nematodes carrying viruses are transmitted through the above process. They are transmitted through rain or irrigation water that moves on the surface or through the soil.