

Seed

Since most cultivated crops are derived from seed, disease transmission and transportation of pathogens are very important. Three methods of seed dispersal are available, including seed contamination, external seed borne and internal seed borne.

Seed Contaminants - Pathogenic seeds in seed lots migrate as distinct contaminants without direct touch with viable cultivated seeds. The pathogen or parasite seeds and the host are combined during cultivation. In many circumstances, it is difficult to differentiate the identity of the seeds of the two organisms (host and pathogens). E.g. Cuscutan seeds, rye ergot, Smut sori etc., easily combine and thresh with crop seed.

External Seed borne- Close contact is formed between pathogen structure and seeds in which the pathogens are placed in the form of latent spores or bacteria throughout crop growth or during harvest and threshing. E.g. sorghum smut, cotton bacterial blight, barley smut, etc.

Many infections can withstand externally conceived structures such as smut spores for many years because of their innate survival capacity. e.g. *Tilletia caries* spores stay viable even after 18 years and *Ustilaga avenae* (Oat smut) spores remain viable for 13 years.

Internal Seed borne- The pathogen may penetrate into the ovary and cause infection of the embryo while it is developing. They become internally seed borne. Ex: Loose smut of wheat.

Soil

Soil borne facultative saprophytes or facultative parasites may survive through soil. The dispersal may be by movement of pathogen in the soil or by its growth in soil or by movement of the soil containing 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.

ii) Growth and spread of a pathogen in soil: Once the pathogen has reached the soil it can grow and spread based on its ability to multiply and spread. 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.

On the basis of this competitive saprophytic ability the pathogens in soil are of three types.-

- **Specialized facultative parasites** (Saprophytes) can pass their life in soil in the absence of host plants, but they depend more on the residues of the host plant (ex: *Armillariella mellea*, *Ophiobolous graminis* etc.).
- **Unspecialized facultative parasites** can pass their entire life in the soil (*Pythium* sp., and *Phytophthora* sp.).
- **Obligate parasites** - Some soil borne pathogens such as *Plasmodiophora brassicae*, *Synchytrium endobioticum* require the presence of active host.

iii) Persistence of the pathogen in soil: The pathogens persist in the soil as dormant structures like **oospores** (*Pythium*, *Phytophthora*, *Sclerospora* etc.), **Chlamydospores** (*Fusarium*), smut spores (*Ustilago*) and **sclerotia** (*Rhizoctonia*, *Sclerotium*).

iv) Dispersal by the soil: The pathogen is dispersed by the soil during cultural operations through the agricultural implements, irrigation water, workers feet etc. Propagules of fungi and the plant debris containing the fungal and bacterial pathogens thus spread throughout the field.

The transfer of soil from one place to another along with propagating materials is the most important method of dispersal of pathogen.

II) Passive or Indirect dispersal - Passive dispersal of plant pathogens happens through inanimate agents like wind, water and animate agents like Insects, animals etc.

Wind/Air

Air pathogen dispersal is known as anemochory. It is a technique of passive dispersal and functions as a powerful carrier of fungal, bacterial and viral propaguli.

Fungal infections are usually lightweight and suitable for wind dispersion. Many spores and conidia are produced in fungal pathogens. Which discharge with enough host encourages air dispersion. For instance, powdery mildew, rust, smut, etc.

Short and long distance wind dispersal is conceivable. The basidiospores of Rust, Conidia, etc., are spread over a short distance. During Rust uredospore, smut chlamadospore, *Alternaria* conidia, *Helminthosporium* are adjusted for long distance dissemination. The *Puccinia graminis* Uredispore may fly around 10,000 kilometers.

In addition to fungal air, the bacterial inoculum can also be dispersed to a short distance. Eg: *Erwinia amylovora* that causes fire, apple blight creates dried bacterial exudate file stands that are spread by air.

Viruses and phytoplasmas are not transferred directly by air, however insects and vectors carrying viruses can migrate to different directions and distances based on air expansion and direction.

Nematodal cysts and parasite plant seeds are conveyed by air. Eg: soft nematode cysts Dust storms are the principal cause of molya diseases of wheat and barley. From Haryana to Rajasthan.

Water

It's more passive dispersal. Water transmission of pathogenic plants is known as hydrochory. Water is less essential than long-term pathogens dispersal air. However, it is the most efficient as the pathogen earth instantly germinates on the weight surface.

The distribution of water occurs mostly through running surface water and rain. Surface water flow transmits pathogen for a short distance after heavy rain or during irrigation.

Colletotrichum falcatum causing red sugar cane rot. *Fusarium* wilt, *phytophthora pythium* (blight), etc., are transferred by irrigating water.

Dispersion is possible across long distances when floods cover broad areas. Air flash dispersal is one effective way of bacterial pathogen spreading.

Rain drops, which fall forcefully over sori, pustules, cancers or even the top of the soil, can splash the propagula into a little droplet and allow them to land on the surrounding surface of a healthy host. The water droplets can be carried by air for a long time.

Xanthomonas campestris citri bacterium caused in citrus cancers is transported by the windy rains.

Fungal spores and bacteria existing in the air or on the surface of the plant are carried down by rain and deposited in a vulnerable healthy plant.

Water not only plays a vital function in the dissemination of pathogens but helps in the growth and spore discharge of several fungi.

Insect

Aphids, white flies, leaf hoppers in particular are major viral vectors and mycoplasma. Over 80% of viral and mycoplasma illnesses are spread by various types of insects.

Bhendi's viral disease yellow vein mosaic is spread by *Bemisia tabaci*, the white fly.

In general, mycoplasmic infections are spread via leaf hoppers. E.g. *Hishimonus phycitis* is transmitted to a little leaf of Brinjal.

If insect feeds on diseased plant bacterial pathogens contaminate the mouth of an insect and this pathogens are transferred to the healthy plant while reaching the healthy plant. 30 / 162

In some circumstances the infection travels into the intestine of the beetle and into the winter. Insects in particular benefit bacteria in two ways. i.e. pathogen transmission and survival.

Insects also spread bacterial infections, the *Erwinia amylovora* that causes apple fire and peach are transferred through fly and ants.

The bacterium of Cucumber wilt *Erwinia tracheiphila* is transmitted by the beetle of Cucumber.

Few insect-borne fungal infections are also transmitted. Fungi producing conidia, spermatia, honey-based oidia with appealing hues, carbohydrates or sugar content. Eg: sorghum sugar sickness, Bajra honeydew stage ergot. Where conidia and a sticky honey like material are supplied. When insects visit pollinating plants, they also spread conidia from infected plants to healthy plants while adhering to the different portions of insects.

Animals

Some animals that pass through the plants and contact the diseased plants transmit pathogenic agents.

Conidia of *Mycosphaerella linorum* can be transported by a spider, mouse, frog, bird, dog etc from infected plant to a healthy plant.

Man is a major dispersion agent within a crop region or between land masses.

Within the field the contaminated instruments are handled and contaminated dirt is transported.