IMPORTANCE OF INSECT PESTS, DISEASES, WEEDS AND DISORDERS IN SEED PRODUCTION

Introduction

Since the beginning of agriculture almost 10,000 yrs ago, farmers/growers had to compete with harmful organisms. These include organisms such as pests, pathogens and Weeds. The pests include mites, aphids, nematodes, rodents, birds, slugs and snails whereas plant pathogens include fungi, bacteria and viruses. Weeds have also affected agricultural production by competing for nutrients with crops. These organisms are collectively called as pests (biotic stresses) of crops which are meant for human consumption.

Apart from the above pests, humans also suffer crop losses from other abiotic causes like lack or excess water during the crops' growth season, extreme temperatures (high or low) as well as improper nutrient supply.

Biotic stresses have the ability to reduce production substantially in various ways which can either be qualitative and/or quantitative.

Quantitative losses are through reduced productivity leading to a lower yield per unit area, while qualitative losses are reduced contents of valuable seed ingredients, reduced market value due to loss of aesthetic features, reduced germination, production of toxic substances like mycotoxins and finally disease transmission.

Pests and diseases have continued to affect production of crops and have a serious impact on the economic output of a farm. Farmers need to vary their management methods depending on the crops they grow and the pests or diseases they are susceptible to, since they affect crops differently. Farmers also need to ensure that they balance pests and disease prevention and treatment methods against damage to the environment.

Certifying seed is one way to reduce pests and diseases. Crop losses due to these harmful organisms can be substantial and they may be prevented, or reduced when they are understood and proper management measures employed.

Definitions

Pathogen: This is a parasitic organism that causes disease in a plant.

Parasite: This a living organism that attacks and obtains nourishment from cells of another living organism, the host, while contributing nothing to the host's survival.

Note: All pathogens are parasites but not all parasites are pathogenic to plants

Infection: It is the invasion of an organism (plants, animals etc) by a disease causing agent (pathogen), their establishment and their multiplication.

Host: It is a living organism or plant that supports the activities of a pathogen or a plant from which a pathogen derives its nourishment or nutrition. A host plant could either be *susceptible* or *resistant* to an invading pathogen.

Biotroph: This is a pathogen or harmful organism which obtains nourishment from the living cells of the host they infect e.g. powdery mildews: cereals powdery mildew – *Erysiphe graminis*

Necrotroph: This is a pathogen which kills the host cells and lives on the dead remains of the host e.g. pathogens causing root rots, e.g. *Fusarium solani, Gaumannomyces graminis*, etc.

Hemibiotroph: They are pathogens which attack a host and obtain nourishment from the living cells in some phases of the disease and upon the death of the host they live on the dead host, e.g. *Colletotrichum lindemuthianum* causing bean anthracnose.

Obligate pathogen: This is a harmful organism which cannot be grown in the absence of a favourable host e.g. cereal powdery mildews.

Facultative pathogen: This refers to any harmful organism (pathogens) which can be grown on artificial media in the absence of the favourable host.

Disease:

- Is the deviation from normal functioning of physiological processes, of sufficient duration to cause disturbance in vital activity of an organism.
- is any abnormal condition that alters the appearance or function of a plant

Diseases can be classified into two categories based on the causal agents:

Pathogenic disease: This is the prolonged change from normal state of an organism due to physiological disturbance of normal functions of plant and is caused by living pathogens (or biotic factors) such as fungi, bacteria and viruses.

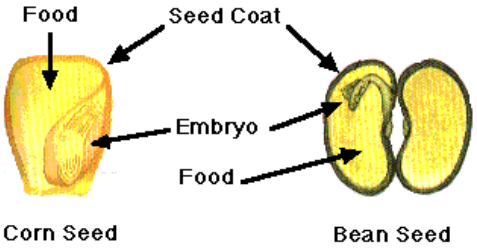
Non-pathogenic disease: This is the prolonged change from normal state of an organism due to physiological disturbance of normal functions of plant caused abiotic factors such as water, chemical injury or damage, nutrient deficiency, etc leading to development of non-infectious or non-transmissible disease.

Pathogenicity: This is the ability of an organism to cause disease on given members of a host species.

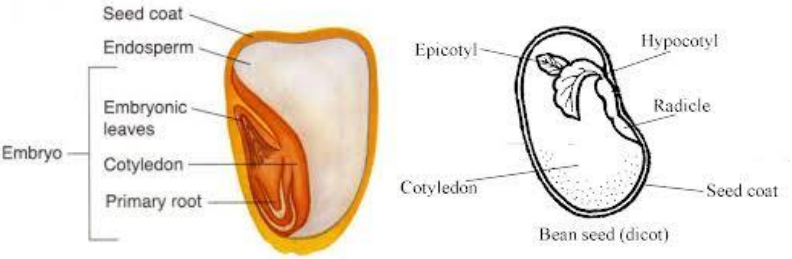
Seed, Seed infection and types of seed infection

Seed is the plant material (grain or vegetative parts) for planting or intended for planting and not for consumption or processing. This is different from grains which are a commodity class of seeds intended for processing or consumption and not for planting.

The seed consists of three basic parts: a) embryo, b) storage tissues and c) seed coat.



Basic outer parts of a seed



Internal parts of a seed

Seed infection is the invasion of a plant's propagation material (the seed) by disease-causing agents, their multiplication, and the reaction of host tissues to these organisms. The area of science that studies the relationship between pathogens and seeds is known as Seed Pathology. It not only identifies the pathogens but also includes the role of the seed as source of inoculum, the survival of the pathogen and the actions taken to control the pathogens associated to it. It uses the knowledge of General Pathology, Microbiology and Seed Analysis.

Types of seed infection

The process of seed infection is influenced by the conditions under which the crop grows. These conditions/factors include: the host (and its genotype), the pathogen (and its genotype) and environment.

There are different ways in which the seed gets infected:

1.)Seed infection refers to when the inoculum is within the seed tissue

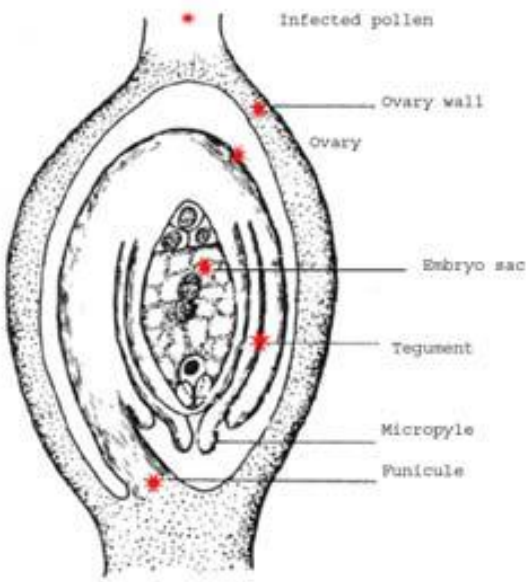
2.)Seed infestation refers to where the inoculum is superficial, being confined to the surface of the seed usually as adhering propagules.

1. SEED INFECTION

Seed infection can result through the vascular system or plasmodesmata or directly by natural or artificial wounds. Pathogens can infect the seed using one or more of the mechanisms like below.

a.) Systemic infection through flowers, fruits or funiculus

Most of the systemic seed-borne bacteria and fungi reach and infect the embryo through the flower or from the peduncule of the fruit. Viruses and other systemically infectious pathogens go to the embryo from the systemically infected mother plant and the infected or contaminated pollen. They rarely reach the embryo during the formation of the seed or formation of the embryo itself. Examples of some infections that occur through the vascular system are like *Fusarium oxysporum* in pumpkin and tomato and other crops, *Verticilium dahliae* in spinach; *Xanthomonas campestris* in cabbage and rice, *Xanthomonas axeonpodis* and *Colletotrichum lindemuthianum* in beans.

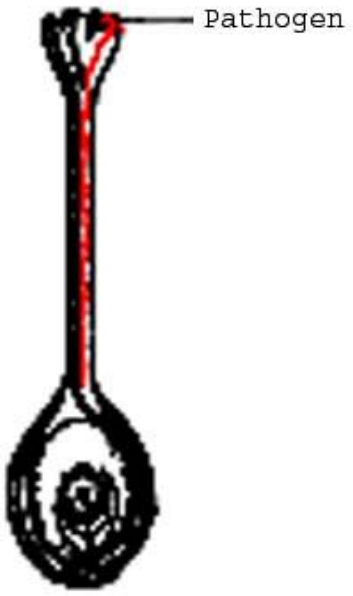


Infected pollen (red spots) entering the flower during fertilization

Penetration through the stigma

In some systemic infections, pathogens follow the same path as the pollen grains do. The spores of some fungi reach the stigma and germinate, producing hyphal strands that reach the ovary through the style, where they can stay as dormant mycelium until seed germination. For example: *Ustilago nuda* and *U. triticci* in wheat, and *Alternaria alternata* in sweet pepper.

Viruses can infect through infected pollen where the male gamete carries the virus and generates an infected embryo on joining the ovule. An infected endosperm may occur if both, the male and female gametes are infected.



Pathogen growing through the stigma infecting the ovary

b.) Penetration through the wall of the ovary or immature seed covers

Some fungi, like *Ustilago nuda* and *U. tritici* penetrate through the wall of the ovary as a result of the germination of the Teliospores on the stigma or the wall of the ovary. The pro-mycelium goes through the wall and other tissues until it reaches the embryo. In some other cases, penetration occurs through

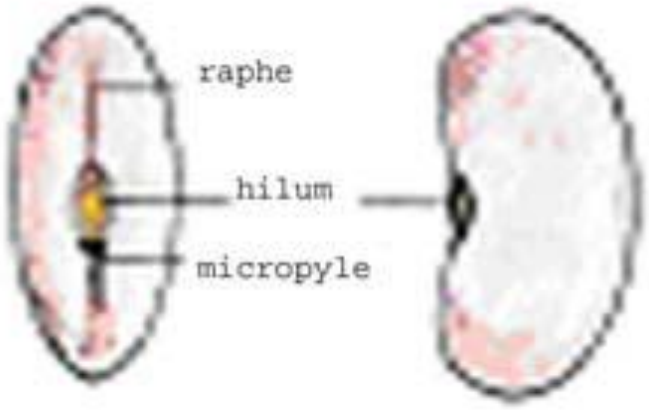
breakages on the testa, establishing itself in the endopleura or the endosperm. In fleshy fruits, like cucumber, melon, eggplant, tomato, sweet pepper and others, contamination can occur directly through the funiculus or in the tegument, during the process of seed formation.

Examples of this are *Colletotrichum lagenarium* in watermelon and other cucurbits; *Rhizoctonia solani*, when it invades fleshy fruits, like the ones mentioned above, is capable of infecting from the placenta and penetrate to the developing ovule or seeds that are still in its formation process and have not lignified its cover.

c.)Penetration through wounds and natural openings

Natural openings like the hilum and the micropyle or wounds generated during the threshing are spots where pathogens like *Xanthomonas campestris* pv. p*haseolicola* in bean infect the seed.

Seed is penetrated via the vascular system of the pedicel and funiculus. The micropyle also serves as a point of entry into the seed.



Hilum and micropyle: natural openings through which pathogens can infect seed

2.) SEED CONTAMINATION/INFESTATION

Seed contamination is the passive relationship of a pathogens and seeds. Seeds can be contaminated with other seeds, pathogens insects and soil particles. The pathogen itself or parts of it like sclerotium, mycelia, spores etc, can stick to surface of the seed or get mixed with the seeds during processes such as seed recollection: harvesting, extraction, threshing, selection and packing. There are two types of contamination:

a.) Pathogens that stick to the surface of the seed

Pathogens stick to seeds during harvest or postharvest by their spores which may include: Clamidospores, Oospores, Teliospores, Uredospores for fungi; bacterial cells and in some cases, virions. Examples of some fungal spores carried on seed coat surfaces are: *Alternaria brassicae* and *A. brassicicola* in crucifers; *A. radicina* in carrot; *Ascochyta pinodella* in pea; *Drechslera oryzae* in rice; Sclerotia *of Rhizoctonia solani* in eggplant, pepper, and tomato and *Urocystis agropyri* in wheat.

Examples of bacteria that contaminate seed surfaces include: *Corynebacterium flaccumfaciens* pv*. flaccumfaciens* in beans, *Pseudomonas syringae* pv. *phaseolicola* in bean, *P. syringae* pv. *tomato* in tomato, *Corynebacterium michiganense* pv*. michiganense* in pepper, *Xanthomonas campestris* pv*. campestris* in cabbage.

Black-rot of cabbage caused by *Xanthomonas campestris pv campestris* (left); healthy and uninfected cabbage on the right

Some viruses such as Tobacco mosaic virus, Tomato mosaic virus, Pepper Mosaic virus may also occur as contaminants.

Tobacco plants infected by Tobacco mosaic virus; some symptoms of the infection include mosaic

Mottling of tobacco leaves infected by Tobacco mosaic virus

b.) Accompanying contamination

This refers to physical mixing of the seed with the pathogen's propagation organs like the sclerotia, nematode galls, contaminated seed or soil particles containing pathogens.

Roots of maize plant infested by Striga when maize seed is contaminated with striga seed

Anthracnose infected seed

INSECT PESTS

A pest can be described as any organism capable of causing damage to crop plants. Pests are organisms considered harmful or detrimental to humans, his possessions and other human interests. Pests have been defined by FAO as any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products.

Economic importance of insect pests

1. Insect pests destroy crops in the field through their biting, chewing, boring, sucking and defoliation activities.

Tomato fruit damaged by boll worm *Helicoverpa amigera*

Flea beetle damage on bean plants (*Epitrix hirtipennis*)

2. Spots of injuries by insects may predispose crops to disease attack.

Bean fly larva tunnel under the surface of the stem (left). Infestations can cause plant death (right)

3. They increase the cost of production during the course of controlling them as a result of purchasing chemicals and labour incurred it their application.



Aerial pesticide spraying Boom sprayer Knapsack sprayer

4. Some are carriers or vectors of diseases e.g. Aphids are vectors of bean common mosaic virus and white flies as vectors of tomato leaf curl virus

Bean Common Mosaic Virus (Potyvirus BCMV) on common bean (*Phaseolus vulgaris*)


Symptoms of tomato yellow leaf curl Adult and nymph of *Bemisia tabacci* whitefly (right), a vector of TYLCV

5. They reduce the quality of produce in the field as well as in the store e.g. Potato tuber moth (PTM) on Irish Potatoes

Potato tuber moth damage on tubers Leaves of potato mined by PTM larvae

Larvae and adult of the potato tuber moth

6. They render vegetables and fruits unattractive and unmarketable e.g. damage on crucifer leaves by diamond back moth (*Plutella xylostella*)

Cabbage damaged by Diamondback moth Kales damaged by Diamondback moth

7. They generally reduce the yield of crops due to their feeding on the leaves and the harvestable parts of the crop.

Mine on tomato leaf caused by the larvae of *Tuta absoluta*

Tomato fruit damage by *Tuta absoluta*

8. They cause reduction in viability of stored produce.

Bean seed infested by bean bruchid (*Callosobruchus Maculatus*)

Maize damaged by maize weevil (*Sitophilus zeamais*)

9. They can also cause total death of crop plants where the whole plant succumbs to the pest damage leading to reduction of profits or total loss. Example banana weevil *Cosmopolites sordidus,* burrowing nematode

Banana crop destroyed by Banana weevil *Cosmopolites sordidus*

Split banana pseudo stem infested with banana weevil (*Cosmopolites sordidus*)

Banana toppling disease caused by burrowing nematodes *Radopholus similis*

Damaged roots due to burrowing nematode infection *Radopholus similis*

PLANT DISEASES

Disease is a change from normal or healthy state due to physiological disturbance of normal functions of plants and is caused by pathogens such as fungi, bacteria, viruses and nematodes. A plant disease is any abnormal condition that alters the appearance or function of a plant. It is a physiological process that affects some or all plant functions. Disease may also reduce yield and quality of harvested product. Disease is a process or a change that occurs over time. It does not occur instantly like injury.

Economic importance of plant diseases

a. Disease Transmission

Seed borne pathogens transmit diseases between fields, regions and countries through seed and other planting material. For example, diseases like Bacterial blight of paddy rice, Sclerotinia diseases of broad beans, common beans and recently cauliflower, are transmitted through movement of improved seed.

Rice field infected by bacterial blight (*Xanthomonas campestris p.v. oryzae*)

A healthy rice field

Cassava plant with early symptoms of Cassava mosaic virus infection

Leaf curling and yellowing of plant tissue

b. Complete loss or reduction in seed germination

Seed borne diseases/pathogens can be spread from the seed and infect the new plant in several ways. Upon sowing, moisture activates pathogens causing pre- and post-emergence damping off, e.g. bean seeds infected with *Macrophomina phaseolina* cause 59% loss of germination. Some of the pathogens like different species of *Fusarium*, *Pythium*, *Rhizoctonia*, *Sclerotinia*, *Alternaria* when present also cause similar diseases in several other crops.

Sorghum ergot caused by *Claviceps africana*

c. Seed abortion

Some of the seed borne pathogens like smut fungi in a number of cereals and viruses like pigeon pea sterility mosaic virus cause heavy seed abortion resulting in 80-100% yield losses.

Head smut of maize caused by *Sphacelotheca reliana*

Loose smut of Maize caused by *Ustilago maydis*

d. Reduction in seed quality

Pathogen infections of seed often substantially reduce seed size resulting in weight reduction. E.g. leaf blight of sunflower, *Alternaria helianthi* and *A. zinnniae* infect the crop resulting in severe leaf blight and yield loss of 80%. *Anguina tritici* in wheat causes seed galls. Seed discolouration is a very important and wide spread symptom produced on seed indicating presence of pathogen e.g. *Fusarium moniliformae* of sorghum and *Aschochyta pisi* of sweet pea all result in reduction in market value. Infected seeds are at risk of being contaminated with mycotoxins and nutritional changes. Biochemical changes in seed products e.g. groundnuts infected with *A. flavus* gives inferior quality of oil through reduction of the refractive index.

Seed-borne mosaic virus on Field pea

Grey mould by *Botrytis* on chickpea seed

Shrivelled wheat seed caused by the nematode *Anguina tritici* compared to healthy wheat seed

Fusarium head blight of wheat - infected seed

Heads of wheat infected by *Fusarium* haed blight

Maize cob infected with *Fusarium* ear rot

e. Reduction in yield

Great yield losses are experienced worldwide through seed borne pathogens

Banana plantation infected by Sigatoka disease caused by *Mycosphaerella musicola*

Infected seedlings, plantations and leaves, which are used often in the developing world as packing materials, are usually responsible for the long-distance spread of the disease.

WEEDS

A weed is a plant that does more harm than good and has a habit of encroaching where it is not wanted. Weeds can be classified in several ways that include life cycle, habitat, nutritional habit and morphological characteristics.

1) Life cycle: Based on the length of time it takes to die, e.g. Annual weeds, perennial weeds,

2) Habitat: Based on the location of the weed, such as terrestrial (upland) weeds, aquatic weeds, weeds of arable crops, weeds of plantations, etc

3) Morphology: such as Narrows leaf weeds - Grasses are usually characterized by narrow leaves, parallel veins and are generally monocotyledons. Broad leaf weeds are generally characterized by net venation, tap root system and are dicotyledons.

Importance of weeds

Weed Problems

1. Crop competition to resources and its effect on crop yield and quality of seed

2. Interference with harvesting operations

3. Allelopathic effect

4. Ability of weeds to reproduce in cropping systems

5. Weeds can harbor diseases and pests

6. Seed contamination from parasitic weeds such as striga in maize.

Striga hamonthica weed on a maize plantation