

Lecture 01 - Introduction

Definition and History of Plant Pathology

Plant Pathology

Plant pathology or phytopathology is the science, which deals with the plant diseases. It is concerned with health and productivity of growing plants. Phytopathology (Greek *Phyton* = plant + *pathos* - disease, ailments + *logos* = discourse, knowledge) is the branch of agricultural, botanical or biological science which deals with the cause, etiology (aetiology), resulting in losses and management methods of plant diseases.

Plant pathology can also be defined as the study of the nature, cause and prevention of plant diseases. Plant pathology is related to most of the old and new sciences like biology, physics, chemistry, physiology, mathematics, genetics, soil science, biochemistry, biotechnology etc. Plant pathology has the following major objectives.

1. To study biotic (living), mesobiotic and abiotic (non-living and environmental) causes of diseases or disorders
2. To study the mechanisms of disease development by pathogens
3. To study the plant (host)-pathogen interaction in relation to environment
4. To develop methods of management of plant diseases

Plant diseases

Plant diseases are recognized by the symptoms (external or internal) produced by them or by sick appearance of the plant. The term plant disease signifies the condition of the plant due to disease or cause of the disease. Plant disease is mainly defined in terms of the damage caused to the plant or to its organ. The other definitions for the term disease are:

1. Disease is a malfunctioning process that is caused by continuous irritation, which results in some suffering producing symptoms. This definition is accepted by both American Phytopathological Society and British Mycological Society.

2. Disease is an alteration in one or more of the ordered sequential series of physiological processes culminating in a loss of coordination of energy utilization in a plant as a result of the continuous irritation from the presence or absence of some factor or agent.

3. A plant is said to be 'diseased' when there is a harmful deviation from normal functioning of physiological process (Federation of British Plant Pathologists, 1973).

4. The disease can also be defined as 'any disturbance brought about by a living entity or non-living agents or environmental factors which interfere with manufacture, translocation or utilization of food, mineral nutrients and water in such a way that the affected plant changes in appearance with or without much loss in yield than that of a normal healthy plant of the same variety. In general disease is an interaction among the host, parasite and the environment.

Man became painfully aware of plant diseases in the early times of antiquity. This is evidenced by the inclusion of blasting and mildew in the Old Testament. Our ancient religious literature gives informations on plant diseases much before their mention by the Greek philosopher, Theophrastus. *Rigveda*, *Atharvanaveda* (1500-500 B.C.), the *Artha Shashtra* of Kautilya (321-186 B.C.), *Sushrute Samhita* (200-500 A.D.), *Vishnu Puran* (500 A.D.), *Agnipurana* (500-700 A.D.) and *Vishnudharmottara* (500-700 A.D.) are some of the ancient books from India where diseases and other enemies of plants are mentioned. In *Rigveda*, classification of plant diseases and germ theory of disease were discussed.

The learned men during Vedic period were aware that the diseases are caused by microbes. The book "*Vraksha Ayurveda*" written by *Surapal* in ancient India contained information on plant diseases. This is the Indian book, which gave first information on plant diseases. He divided plant diseases into two groups viz., internal and external. Plant diseases like rust, smut, downy mildew, powdery mildew and blight were mentioned in the Bible.

The Greek Philosopher, *Theophrastus* (370-286 B.C.) was the first to study and write about the diseases of trees, cereals and legumes. In his book '*Enquiry into plants*' Theophrastus has recorded his observations, imaginations and experiences but they were not based on any experiments. He had mentioned that plants of different groups have different diseases, which are autonomous or spontaneous i.e., no external causes were associated with the plant diseases.

The history in several aspects of plant pathology is given as below.

Mycology

1675 - Dutch worker Anton von Leeuwenhoek developed the first microscope.

1729 - Italian botanist **P. A. Micheli** proposed fungi comes from spores; **father of Mycology**.

1755 - French botanist Tillet published a paper on bunt or stinking smut of wheat; discovered bunt is a disease of wheat.

1807 - French scientist I. B. Prevost showed bunt of wheat is a fungus and showed evidence that a disease is caused by a microorganism.

1821 - E. M. Fries published *Systema Mycologicum* for naming of fungi; he was named as Linnaeus of Mycology.

1821 - Robertson of England stated that sulphur is effective against peach mildew.

1845 - Irish Potato famine due to *Phytophthora infestans* caused starvation of million and immigration of 1.5 million people.

1858 - J. G. Kuhn published first textbook in Plant Pathology – *The Diseases of Cultivated Crops, their Causes and their Control*.

1861 -Anton de Bary (Germany) worked out the life cycle of potato late blight and first to prove experimentally *Phytophthora infestans* is the cause of potato late blight. He proved that fungi are causes but not the results of diseases. He is the Father of Modern Plant Pathology.

1865 – Anton de Bary reported heteroecious nature of wheat stem rust.

1869 – England loses coffee production to coffee rust, forced to grow tea.

1874 -Robert Hartig published a book entitled, “Important Diseases of Forest Trees”.

1875-1912 - Brefeld discovered the methods of artificial culture of microorganisms; he also illustrated the complete life cycles of cereal smut fungi and diseases caused by them.

1877 – M. S. Woronin discovered and named the Club root of Cabbage pathogen as *Plasmodiophora brassicae*.

1878 – M. S. Woronin found out the life cycle of potato wart disease.

1878 -Downy mildew of grapevine was introduced into Europe from America. The disease almost ruined the wine industry.

1881 -H.M. Ward worked out the life cycle of coffee leaf rust. He is called as Father of Tropical Plant Pathology.

1882 -Robert Hartig published a textbook -*Diseases of Trees*. He is called as "Father of Forest Pathology".

1885 -Pierre Marie Alexis Millardet accidentally discovered the Bordeaux mixture for the control of downy mildew of grapevine.

1885 – A. B. Frank defined and named mycorrhizal associations in plant roots.

1887 -Burgundy mixture was introduced by Mason of France.

1894 -Swedish scientist Eriksson described the phenomenon of physiologic races in cereal rust fungus, *Puccinia graminis*.

1899 – W. A. Orton selected and bred water-melon, cowpea and cotton for resistance to *Fusarium* wilt diseases. He is considered as a pioneer worker in the development of disease-resistant varieties.

1904 – A. F. Blakeslee, American Geneticist founded heterothallism in *Rhizopus*

1904 – R. H. Biffen was the first to show that resistance to pathogens in plants can be inherited as a Mendelian character; pioneer in genetics of plant disease resistance.

1912 – H. Burgeff reported that within a cell of a fungus, fusion between dissimilar nuclei can occur. He called this phenomenon as heterokaryosis.

1917 -E. C. Stakman demonstrated physiologic forms in stem rust of wheat.

1918 -E.J.Butler published book on *Fungi and Disease in Plants*; he made exhaustive study on Indian fungi and the diseases caused by them. He is called as the Father of Modern Plant Pathology in India; He joined as the first Director of Imperial Bureau of Mycology (Commonwealth Mycological Institute, CMI) now CAB International Mycological Institute in Kew, England in 1920. He began the journal *Review of Applied Mycology*; with S.G. Jones he wrote, '*Plant Pathology*' in 1949.

1929 -Sir Alexander Fleming isolated the antibiotic, Penicillin from the fungus, *Penicillium notatum*.

1932 – H. N. Hansen and R. E. Smith were the first to demonstrate the origin of physiologic races through heterokaryosis.

1934 -W. H. Tisdale and I. Williams studied the organic fungicides by discovering alkyl dithiocarbamates.

1938 – H. N. Hansen found out dual phenomenon in Fungi Imperfecti.

1942 – H. H. Flor developed gene-for-gene hypothesis in flax rust.

1943 – Great Bengal Famine due to *Helminthosporium oryzae* caused death of 2 million people in India.

1943 -Dimond, Heuberger and Horsfall discovered the ethylene bis dithiocarbamates.

1945 -J. G. Horsfall explored the mechanism of fungicidal action.

1948 -B. B. Mundkur started Indian Phytopathological Society with its journal Indian Phytopathology. He has written a book '*Fungi and Plant Diseases*' in 1949, which is the second, book in plant pathology in India.

1951-57 -E. A. Gaümann was one of the first to investigate the physiology of the wilts caused by *Fusarium* spp. He put forth the involvement of toxin (toxin theory) in wilt diseases.

1952 -N.F. Jensen suggested blending of different resistant genotypes of similar agronomic characters in fields of oats to reduce the spread of rust and losses from rust.

1953 -N. E. Borlaug and associates developed multiline cultivars for wheat.

1953 – Pontecorvo and his associates demonstrated parasexualism in fungi.

1956 -J. G. Horsfall published a book entitled "Principles of Fungicidal action"

1957 – E. C. Stakman with J. G. Harrar wrote a book *Principles of Plant Pathology*.

1963 - J. E. Van der Plank found out vertical and horizontal types of resistance in crop plants.

1966 -van Schmeling and Marshall Kulka were the first to find out systemic fungicides (oxathiin compounds – carboxin and oxycarboxin).

1970 -S. D. Garrett investigated the management of root diseases and he is the pioneer worker in the field of biological control. 1972 – G. Rangaswami wrote a book on Diseases of Crop Plants in India.

Plant Bacteriology

1683 – Anton von Leeuwenhoek first observed bacteria.

1876 -Louis Pasteur and Robert Koch -They proved that anthrax disease of cattle was caused by specific bacterium.

1876 -Robert Koch of Germany described the theory called "Koch's postulates." He established the principles of pure culture technique.

1876 -Robert Koch and Pasteur disproved the theory of spontaneous generation of diseases and propose germ theory in relation to the diseases of man and animal.

1882 -American Plant Pathologist -T. J. Burrill first time proved that fire blight of apple and pear was caused by a bacterium (now known as *Erwinia amylovora*).

1901-1920 E.F.Smith of U.S.A gave the final proof of the fact that bacteria could be incitants of plant diseases. He also worked on the bacterial wilt of cucurbits and crown gall disease. He is also called as "Father of Phytobacteriology". Chilton and his coworkers demonstrated that crown gall bacterium transforms plant cell to tumour cell by introducing into them a plasmid.

1910 -C. O. Jensen related crown gall of plants to cancer of animals.

1952 -J. Lederberg coined the term plasmid 1952 – S. A. Waksman won Nobel prize for the discovery of streptomycin.

1952 – Zinder and J. Lederberg discovered transduction in bacteria 1962 – H. Stolp discovered bdellovibrios.

1972 – P. B. New and A. Kerr success in biological control of *A. radiobacter* strain K.

1972 – I. M. Windsor and L. M. Black observed a new kind of phloem inhabiting bacterium causing clover club leaf disease.

1974 – I. Zanen et al. demonstrated Ti plasmid in *Agrobacterium tumefaciens*.

1980 – D. W. Dye et al. introduced the pathovar in the taxonomy of plant pathogenic bacteria.

Plant Virology

1886 -Adolf Mayer described a disease of tobacco called mosaikkranheit (tobacco mosaic). Adolf Mayer demonstrated the sap transmission of Tobacco Mosaic Virus disease.

1892 -Dimitri Ivanowski demonstrated that the causal agent of tobacco mosaic could pass through bacterial filter.

1895 -E.F. Smith of U.S.A. showed the peach yellows was a contagious disease.

1898 -M.W. Beijerinck -a Dutch microbiologist and founder of virology proved that the virus inciting tobacco mosaic is not a microorganism. He believed it to be *contagium vivum fluidum* (infectious living fluid). He was the first to use the term *virus*, which is the Latin word for poison.

1929 -F. O. Holmes provided a tool by which the virus could be measured by showing that the amount of virus present in a plant sample preparation is proportional to the number of local lesions produced on appropriate host plant leaves rubbed with the contaminated sap.

1935 -W. M. Stanley proved that viruses can be made as crystals. He got Nobel Prize in 1946.

1936 -F. C. Bawden and, N.W. Pirie (Britain) found that the crystalline nature of the virus contains nucleic acid and protein.

1939 -Kausche and colleagues first time saw the TMV virus particles with the help of Electron microscope.

1956 -Gierer and Schramm proved that the nucleic acid fraction of the virus is actually the infectious agent.

1959 -Munday succeeded in inducing TMV mutations.

1966 -Kassanis discovered the satellite viruses.

1971 -T. O. Diener discovered viroids, which only consist of nucleic acids. Smaller than viruses, caused potato spindle tuber disease (250-400 bases long of single-stranded circular molecule of infectious RNA).

Phytoplasma

1967 – Doi *et al* and Ishiie *et al*, the Japanese scientists found that mycoplasma-like organisms (MLO) could be responsible for the disease of the yellows type. Doi observed that MLO's are constantly present in phloem while Ishiie observed MLO's temporarily disappeared when the plants are treated with tetracycline antibiotics.

Spiroplasma

1972-Davies *et al.*, observed that a motile, helical wall-less microorganism associated with corn stunt diseases, which could be cultured and characterized and they named it as spiroplasma.