FACULTY OF AGRICULTURE SCIENCES AND ALLIED INDUSTRIES

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LECTURE 2

HISTORY OF PLANT PATHOLOGY (EARLY DEVELOPMENTS AND ROLE OF FUNGI IN PLANT DISEASES

ANCIENT HISTORY

- Since organized agriculture developed 4000 years ago, special attention was given to plant diseases and pests. Symptoms such as blight, wilt, root rot, etc. were known to the people at that time.
- In Rig Veda, germ theory of disease was also advocated and the men of learning in Vedic period (Ca. 1500-500 BC) were aware that the diseases were caused by microorganisms. While this fact was not perceived by majority of the scientists in Europe only until 120 years ago.
- Vraksha Ayurveda, a book written by Surapal in 11th century in Ancient India is the first book in which much light has been thrown on plant diseases. The diseases have been divided in 2 groups: i). Internal (probably physiological disorders), and ii) External (probably infectious diseases).
- Symptoms of plant diseases are also mentioned in old testaments like Bible, Shakespear‘s poems and dramas and other Christian literature. Rust, smut, mildewand blights are very often quoted in Bible.
- In his book, ‑Enquiry into Plants‖, Theophrastus (286 BC), a Greek philosopher, recorded his experiences about plant diseases in a book. His experiences were based on imagination and not on experimentation.
- After Theophrastus, no definite opinion could be formed about plant diseases for the next 2000 years, although diseases continued to harm the crops and puzzle scientistsof those days.
- During this period, the plant diseases were attributed to many causes which included divine power, religious belief, superstitions and effects of stars and wrath of God, etc.
- The Romans used to celebrate a festival called Robigalia‘ to ward off rust. It is reported to be initiated by the king Numa Pompilus around about 700 BC to pleasethe Rust God‘ Robigo and continued with modifications in the Christian era.
- The association of barberry with stem rust of wheat has been recognized by the farmers for centuries. In 1660, the farmers in France secured passage of law which required destruction of barberry bushes in that area. Similar laws were made and executed strictly in United States in early 18th century.
- Antony van Leeuwenhoek observed the microorganismic cells for the first time under microscope in 1674.
- The Italian botanist Pier Antonio Micheli, also known as Father of Mycology first observed fungi and saw their spores. He also demonstrated that if spores of thesefungi are placed on the pieces of fruit, they grew into new thalli of the fungus. Thoughthis was a successful experiment, it was not accepted universally.
- He wrote a book entitled, ‗Nova Plantarum Genera‘ in 1729. Many of such early researches were not accepted because of the strong belief of the people in the ‗Theory of Spontaneous Generation‘ in which microorganisms spontaneously or

automatically originate from inanimate or non-living matter.

- In 1743, Needham, an English Clergyman and naturalist upheld strongly this theory. To prove his point, he boiled meat broth in flask which was corked.
- In 1775, Lazarro Spallanzani, an Italian investigator challenged Needham and set out to prove that decay of meat broth by bacteria and other lower forms of life could be prevented by heating the material in a flask which was sealed off in such a way as to exclude contamination from the air. He, however, did not receive recognition and wasrefuted by opponents who did not get the results due to their faulty techniques.
- Carl von Linne (Linnaeus), a Swedish scientist wrote a book entitled, ‑Species Plantarum‖ in 1753 and is credited with giving binomial nomenclature.
- C.H. Persoon‘s ‑Synopsis Methodica Fungorum‖ (1793) is the chief starting point for the nomenclature of the Uredinales, Ustilaginales and Gasteromycetes.
- E.M. Fries (1821-1832) was a Swedish scientist and is regarded as ‗Linnaeus of Mycology‘. His Systema Mycologicum is the chief starting point for the nomenclature of fungi.
- In 1775, Tillet, a French botanist published a paper on bunt or stinking smut of wheat. He proved that such wheat seeds that contained a black powder on their surface produced more diseased plants than the clean seeds. He believed that the disease was caused by some poisonous substance produced by the black powder. He also observeda reduction in disease incidence when the seeds were treated with salt and lime. Therefore, it can be said that he was an experimenter who lived ahead of his times.
- Felice Fontana, an Italian physicist and naturalist published a paper in 1767 in which he expressed the view that grain rust was a distinct parasitic entity. He distinguished the red and black stages of wheat rust and made microscopic drawings.
- Benedict Prevost, who was Swiss Professor of Philosophy at the Academy of France, in 1807 discovered the life cycle of bunt fungus. He studied germination of wheatbunt fungus spores and conceived the idea that this organism penetrated the young wheat plant and was the actual cause of the disease.
- Prevost‘s experiments provided the first proof and interpretation of the role of microorganisms in the causation of the disease. He also demonstrated the control of smut by steeping seeds in a solution of copper sulphate.
- Tulasne brothers (R.L. and C. Tulasne) of France who have produced illustrated descriptions of rust and smut fungi, had also confirmed the findings of Prevost.
- In 1845, late blight devastated the potato crop in Ireland and other parts of Europe which attracted the attention of mycologists and plant pathologists to plant diseases. Much of early literature on this disease is found in ‗Gardener‘s Chronicle‘.
- M.J. Berkeley who was the most prominent British mycologist was at first somewhat conservative in supporting of the parasitic theory, but advocated it strongly in 1846.
- Montague in France in 1845 described the causal fungus as Botrytis infestans. However, the fungus was real cause of this disease and not the result was proven experimentally by Speers and Schneider in 1857 and Anton de Bary (1861, 63).

MODERN EXPERIMENTAL PLANT PATHOLOGY

- The foundation of modern experimental plant pathology was laid by the German scientist Heinrich Anton de Bary (1831-1888). He made a great contribution to the understanding of science of Plant Pathology and is suitably regarded as Father of Modern Plant Pathology. His major contributions are:
- He confirmed the findings of Prevost in 1853.
- In 1861, he experimentally proved that Phytophthora infestans was the cause of late blight of potato. He is credited with the ultimate proof of the organisms being plant pathogens.
- He studied other diseases like rusts, smuts, downy mildews and rots.
- He reported the heteroecious nature of rust fungus in 1885.
- He also reported the role of enzymes and toxins in tissue degradation caused bySclerotinia sclerotiorum in 1886.
- de Bary was first to report that lichen consists of a fungus and an alga, and coined the term symbiosis.
- He studied in detail the life cycle of downy mildew fungi and their parasitism.
- His well known text book ‑Morphologie und Physiologie der Pilze Flechten und Myxomyceten‖ written in 1866 and 1884 records the broad classification of fungi.
- He trained a large number of students from all over the world who came to hislaboratory.
- More than 60 of them became prominent in field and carried his techniques.
- Famous among them were M.S. Woronin of Russia, who studied club root of crucifers caused by Plasmodiophora brassicae; P.A. Millardet of France; HM ward of England, who studied coffee rust in Sri Lanka and gave ‗bridging host theory', Fallow of U.S.A., who spent his long active career as cryptogamic botanist, and provided leadership in study of parasitic fungi; and A. Fisher of Switzerland worked on bacterial Plant Pathology and is known for the infamous Fisher –Smith controversy regarding the role of bacteria in causing plant diseases.
- J.G. Kuhn, who was a contemporary of de Bary and his countryman, was, initially a farm manager. He contributed significantly to the studies on infection and development of smut in wheat plant and development and application of control measures, particularly seed treatment for cereals.
- He wrote the first book on Plant Pathology ‑Diseases of Cultivated Crops, Their Causes and Their Control‖ in 1858 in which he recognized that plant diseases are caused not only by an unfavourable environment, but can also be caused by parasitic organisms such as insects, fungi and parasitic plants.
- The theory of spontaneous generation was a major impediment in the development of science of Plant Pathology, which was finally disproved by Louis Pasteur who established the ‗germ theory of the disease' in case of anthrax in relation to man and animals. It changed the way of thinking of scientists and led to a tremendous progress.
- Significant impetus to this progress was added by Robert Petri, who developed

artificial nutrient media for culturing of microorganisms and Brefeld (1875,1883,1912) who contributed greatly to Plant Pathology by introducing and developing modern techniques for growing microorganisms in pure culture.

- Robert Koch (1876) who was a Germen Physician and co-worker of Pasteur established that for proving that a certain microorganism was the cause of some infectious disease, certain necessary steps (Koch's postulates) must be carried out and certain conditions must be satisfied. They are:
- A specific organism must always be associated with the disease.
- The organism has to be isolated in pure culture.
- The organism must produce specific disease in a healthy susceptible host when the latter are inoculated with it.
- The organism must be re-isolated from the experimental (diseased) host in pure culture and its identity be established and it must have the characteristics as the organism in step 2.

HISTORY OF PLANT PATHOLOGY (ROLE OF OTHER PLANT PATHOGENS)

ROLE OF OTHER PLANT PATHOGENS

Bacteria as Plant Pathogens

- In 1882, T.J. Burrill of USA for the first time reported that a plant disease (fire blight of apple and pear) was caused by a bacterium (now known as Erwinia amylovora).
- Wakker (1883) showed that yellows disease of hyacinth was also caused by a bacterium.
- E.E. Smith of USA is regarded the most outstanding and main contributor to the discovery of most of plant diseases due to bacteria since 1895. He is considered Father of Phytobacteriology for his discoveries and methodologies.
- Smith's name is still remembered as he resolved the controversy with the German scientist A. Fischer (1897, 99) who did not agree that bacteria were the causes of diseases in plants.
- Smith was also among the first to notice and study the crown gall disease (1893, 1894). He considered crown gall similar to cancerous tumors of humans and animals.
- Later in 1977, it was demonstrated by Chilton and his team that the crown gall bacterium, Agrobacterium tumefaciens transforms the normal plant cells in tumour cells by introducing into them a part of plasmid which becomes inserted into the plant cell chromosome DNA.

Viruses

- Virus diseases of plants have a long history. Among many diseases of unknowncause,

potato leaf roll, as ‗leaf curl' gave concern in the 2nd half of 18th century and broken tulips were illustrated by painters 200 years before that.

- There were many methods of transmission of leaf mottling of jasmine and passion flower by grafting.
- In 1886, Adolf Mayer, a Germen Director of Agricultural Experiment Station at Wageningen, Netherland, introduced the term ‗mosaic' and showed that the mosaic was infectious and the juice from infected plants if applied to the healthy plants could reproduce the disease.
- In 1891, Smith showed that the peach yellows was contagious disease and could be bud transmitted.
- In 1892, Dimitri Ivanowski proved that the causal agent of tobacco mosaic disease could pass through bacteria proof filters.
- In 1898, Beijerinck, (Father of Plant Virology) a distinguished Dutch microbiologist, demonstrated that the causal agent of tobacco mosaic could diffuse through an agar-agar membrane and concluded that the tobacco mosaic was caused by a non-corpuscular ‗contagium vivum fluidum' (or contagious living fluid) and called founder of virology and it's a virus.
- Stanley (1935) obtained a crystalline protein by treating the juice of the tobacco mosaic infected leaves with ammonium sulphate, which when placed on the healthy leaves could produce the disease symptoms. It was the first major contribution regarding the nature of the viruses and was awarded Noble Prize for it.
- In1936, Bawden and Pirie discovered the real nature of the Tobacco mosaic virus and demonstrated that the crystalline preparations of the virus actually consisted of not only proteins but also small amount of nucleic acid (RNA).
- In 1939, Kausche et al. viewed first Tobacco mosaic virus particles under electron microscope.
- Finally in 1956, Gierrer and Schramm showed that the nucleic acid fraction of the virus is actually required for infection and multiplication in the host and protein coat provided the protective covering to it.

Viroids

- In 1971, Diener and Raymer reported that the potato spindle tuber disease was caused by a small (250-400 base pair long), single stranded circular molecule of infectious RNA, which he called a viroid.
- Viroids seem to be the smallest nucleic acid molecules to infect plants but no viroid has so far been found in animals.
- Since then a dozen more viroids have been reported.
- In 1982, a circular single stranded viroid-like RNA (300-400 base pairs long) was found encapsidated together with the single stranded linear RNA (about 4500 base pairs long) of velvet tobacco mottle virus. This small circular RNA was called Virusoid which seems to form an obligatory association with the viral RNA in many plant viruses.

Phytoplasma and Rickettsia like Organisms

- Doi et al. (1967) and Ishiie et al. (1967) independently observed Mycoplasma Like Organisms (MLOs) now called as phytoplasma in the phloem of plants exhibiting yellows and witches' broom symptoms (earlier thought to be caused by viruses).
- The number of plant diseases of phytoplasma etiology is large. Some examples are aster yellows, mulberry dwarf, potato witches' broom and sandal spike.
- These organisms resembling mycoplasma could not be isolated and cultivated on artificial cell free media and they have shown more relatedness to acholeplasma than the mycoplasma, and are called phytoplasma.
- Later in 1973, some of the mycoplasmas such as the causal agent of citrus stubborn and corn stunt diseases could be grown in cell free media, and were helical in morphology and had motile stages and were named as spiroplasma. The agent Spiroplasma citri causing citrus stubborn is the type species of the genus and S. kunkelli causes corn stunt.

Fastidious Vascular Bacteria

- Some organisms were also observed in grapevines infected with Pierce's disease, in peach infected with phony peach and others.
- More recently such diseases have been reported to be caused by fastidious vascular xylem limited bacteria Xylella fastidiosa, and phloem limited bacteria Candidatus librobacter.
- Examples of xylem inhabiting fastidious bacteria causing diseases: Pierce's disease of grapevine, citrus variegated chlorosis, almond leaf scorch.
- Examples of phloem inhabiting fastidious bacteria are: Club leaf of clover, citrus greening, yellow vine disease of watermelon, bunchy top of papaya.

Flagellate Protozoa

- In 1909, Lafont observed flagellate protozoa in the latex bearing cells of laticiferous plants of Euphorbiaceae family without causing any harm to their hosts.
- However, in 1931, Stahel found the flagellates infecting phloem of coffee plants and causing abnormal phloem formation and wilting of trees.
- Vermeulen in 1963 presented additional and more convincing evidence of the pathogenicity of flagellates to coffee trees and in 1976, flagellates were also found in the phloem of coconut palm trees infected with the hart rot disease.

HISTORY OF PLANT PATHOLOGY IN INDIA

- The development of science of Plant Pathology in the modern era in India as in other countries followed the development of mycology. The study of fungi in India was initiated by Europeans in the 19th century. They used to collect fungi and send the

specimens for identification to the laboratories in Europe.

- During 1850-1875, D.D. Cunningham and A. Barclay started identification of fungi in India itself. Cunningham made a special study of rusts and smuts.
- K.R. Kirtikar was the first Indian scientist who collected and identified the fungi in the country.
- E.J. Bulter who is also known as the _Father of Plant Pathology in India, initiated an exhaustive study of fungi and diseases caused by them in 1901 at Imperial Agricultural Research Institute at Pusa (Bihar).
- During his stay of 20 years in this country, he made a scientific study of mostly fungal plant diseases known in India at that time. The diseases studied by him for the first time included wilt of cotton and pigeon pea, different diseases of rice, toddy palm, sugarcane, potato and rusts of cereals.
- He wrote a monograph on Pythiaceous and Allied Fungi'; and a classic text book,Fungi and Diseases in Plants' in 1918.
- J.F. Dastur (1886-1971), a colleague of Butler, was the first Indian Plant Pathologist who is credited with a detailed studies of fungi and diseases in plants.
- He studied the genus Phytophthora and diseases caused by it in castor and potato. Heis internationally known for the establishment of Phytophthora parasitica from castor.
- G.S. Kulkarni published exhaustive information on downy mildew and smuts of sugarcane and pearl millet.
- B.B. Mundkur started work on control of cotton wilt through varietal resistance.
- He was also responsible for the identification and classification of large number of Indian smut fungi.
- His most significant contribution to plant pathology will be remembered through the _Indian Phytopathological Society' which he started almost single handedly in 1948with its journal _Indian Phytopathology'.
- He also authored a text book entitled, _Fungi and Plant Diseases'.
- Dr. K.C. Mehta of Agra College, Agra investigated the life cycle of cereal rusts in India during the first half of 20th century.
- Dr. R. Prasada trained by Dr K.C. Mehta continued the work on rusts and added to the knowledge of linseed rust.
- Luthra and Sattar (1953) developed the solar heat treatment of wheat seed for the control of loose smut. SN Dasgupta carried out exhaustive studies on black tip of mango.
- T.S. Sadasivan worked out the mechanism of wilting in cotton due to Fusarium oxysporum f. sp. vasinfectum.
- M.K. Patel, V.P. Bhide and G. Rangaswami pioneered the work on bacterial plant pathogens in India.
- M.J. Thirumalachar conducted exhaustive studies on rusts and smuts, and developed anumber of antibiotics for controlling plant diseases in India.
- Afterwards, Plant Pathology became a major subject in various agricultural colleges and universities and organized research was conducted on major plant diseases affecting crop plants in India.

- Notable contributions included the works of B.L. Chona on sugarcane diseases and Agnihothrudu in tea diseases, R.K. Agrawala on apple diseases and G.S. Saharan on oilseed plant diseases to name a few.