

Department of Plant Pathology

UG and PG Courses

At a Glance

Title of Course	Course No.	Credit Hours	Semester (offered)
Fundamentals of Plant Pathology	Pl. Path. 121	3(2+1)	II nd
Principles of Integrated Disease Management	Pl. Path 352	3(2+1)	I st
Diseases of Field and Horticultural Crops and their Management-I	Pl. Path 353		I st
Diseases of Field and Horticultural Crops and their Management-II	Pl. Path. 364	3(2+1)	II nd

PLANT PATHOLOGY

Fundamentals of Plant Pathology (Pl. Path. 121)

Credit hours: 3(2+1)

Theory

Introduction: Importance of plant diseases, scope and objectives of Plant Pathology. History of Plant Pathology with special reference to Indian work. Terms and concepts in Plant Pathology. Pathogenesis. Cause and classification of plant diseases. Important plant pathogenic organisms, different groups: fungi, bacteria, fastidious vesicular bacteria, phytoplasmas, spiroplasmas, viruses, viroids, algae, protozoa and phanerogamic parasites with examples of diseases caused by them. Diseases and symptoms due to abiotic causes.

Fungi: general characters, definition of fungus, somatic structures, types of fungal thalli, fungal tissues, modifications of thallus, reproduction (asexual and sexual). Nomenclature, Binomial system of nomenclature, rules of nomenclature, classification of fungi. Key to divisions, sub-divisions, orders and classes.

Bacteria and mollicutes: general morphological characters. Basic methods of classification and reproduction.

Viruses: nature, architecture, multiplication and transmission.

Study of phanerogamic plant parasites.

Principles and methods of plant disease management. Role of Biotechnology in Plant Pathology

Nature, chemical combination, classification, mode of action and formulations of fungicides and antibiotics.

Practical

Acquaintance with various laboratory equipment's and microscopy. Preparation of media, isolation and Koch's postulates. General study of different structures of fungi. Study of symptoms of various plant diseases. Study of representative fungal genera. Staining and identification of plant pathogenic bacteria. Transmission of plant viruses. Study of phanerogamic plant parasites.

Study of fungicides and their formulations. Methods of pesticide application and their safe use. Calculation of fungicide sprays concentrations.

Principles of Integrated Disease Management (Pl.Path. 352)

Credit hours: 3(2+1)

Theory

IPM: Introduction, history, importance, concepts, principles and tools of IDM. Economic importance of plant diseases. Methods of detection and diagnosis of plant diseases. Survey, surveillance and forecasting of plant diseases. Study of Plant disease epidemiology. Methods of disease management: Host plant resistance, cultural, physical, legislative, biological and chemical control. Ecological management of crop environment. Introduction to conventional pesticides for the plant disease management. Development and validation of IDM module. Implementation and impact of IDM module for plant disease management. Safety issues in pesticide uses. Case histories of important IDM programmes.

Practical

Methods of diagnosis and detection of various plant diseases. Methods of plant disease measurement. Monitoring of plant diseases in field. Study of disease progress of diseases with relation to environmental factors. Isolation, screening and Identification of biocontrol agents. Mass multiplication of Trichoderma, Pseudomonas, etc. Bio-efficacy of fungicides in plant disease control. Awareness campaign at farmers fields.

Diseases of Field and Horticultural Crops and their Management-I (Pl. Path. 353)

Credit hours: 3(2+1)

Theory

Symptoms, etiology, disease cycle and management of major diseases of following crops:

Field Crops: Rice: blast, brown spot, bacterial blight, sheath blight, false smut, khaira and tungro; Maize: stalk rots, downy mildew, leaf spots; Sorghum: smuts, grain mold and anthracnose, Bajra: downy mildew and ergot; Groundnut: early and late leaf spots, wilt Soybean: Rhizoctonia blight, frog eye leaf spot, bacterial spot, pod blight, seed and seedling rot and mosaic; Pigeonpea: Phytophthora blight, wilt and sterility mosaic; Finger millet: Blast and leaf spot; black & green gram: Cercospora leaf spot and anthracnose, web blight and yellow mosaic; Castor: Phytophthora blight; Cotton: anthracnose, vascular wilt, and black arm; Tobacco: black shank, black root rot and mosaic. Horticultural Crops: Guava: wilt and anthracnose; Banana: Panama wilt, bacterial wilt, Sigatoka and bunchy top; Papaya: foot rot, leaf curl and mosaic, Brinjal: Phomopsis blight and fruit rot and Sclerotinia blight; Tomato: damping off, wilt, early and late blight, buck eye rot and leaf curl and mosaic; Okra: Yellow Vein Mosaic; Beans: anthracnose and bacterial blight; Cucurbits: downy mildew, powdery mildew, wilt; Chilies: anthracnose and fruit rot, wilt and leaf curl; Ginger: soft rot; Turmeric: leaf spot; Colocasia: Phytophthora blight; Coconut: wilt and bud rot; Tea: blister blight; Coffee: rust

Practical

Identification and histopathological studies of selected diseases of field and horticultural crops covered in theory. Field visit for the diagnosis of field problems. Collection and preservation of plant diseased specimens for Herbarium; Note: Students should submit 50 pressed and well-mounted specimens.

Diseases of Field and Horticultural Crops and their Management-II (Pl. Path. 364)

Credit hours: 3(2+1)

Theory

Symptoms, etiology, disease cycle and management of following diseases:

Field Crops:

Wheat: rusts, loose smut, karnal bunt, powdery mildew, alternaria blight, and ear cockle;
Sugarcane: red rot, smut, wilt, grassy shoot, ratoon stunting and Pokkah Boeng;
Sunflower: Sclerotinia stem rot and Alternaria blight; Mustard: Alternaria blight, white rust, downy mildew and Sclerotinia stem rot; Gram: wilt, grey mould and Ascochyta blight; Lentil: rust and wilt;
Pea: downy mildew, powdery mildew, root rot/wilt, Ascochyta blight and rust Horticultural Crops:
Mango: anthracnose, malformation, bacterial blight and powdery mildew; Citrus: canker and gummosis; Grape vine: downy mildew, Powdery mildew and anthracnose; Apple: scab, powdery mildew, collar rot, white root rot, fire blight and crown gall; Peach: leaf curl; Pomegranate: bacterial blight; Strawberry: leaf spot
Potato: early and late blight, black scurf, leaf roll, and mosaic; Cruciferous vegetables: Alternaria leaf spot and black rot; Onion and garlic: downy mildew, purple blotch, and Stemphylium blight;
Coriander: stem gall Marigold: Botrytis blight; Rose: dieback, powdery mildew and black leaf spot.
Carnation; fusarium wilt, leaf blight, Lilium; bulb rot

Practical

Identification and histopathological studies of selected diseases of field and horticultural crops covered in theory. Field visit for the diagnosis of field problems. Collection and preservation of plant diseased specimens for herbarium.

Experiential Learning

Plant Pathogens and Principles of Plant Pathology (Pl. Path.111)

Credit hours: 4(3+1)

Sem.I

Introduction, Important plant pathogenic organisms: fungi, bacteria, fastidious vesicular bacteria, phytoplasmas, spiroplasmas, viruses, virioids, algae, protozoa and phanerogamic parasites with examples of diseases caused by them. Prokaryotes: classification of prokaryotes according to Bergey's Manual of Systematic Bacteriology. General characters of fungi, Definition of fungus, somatic structures, reproduction in fungi (asexual and sexual). Nomenclature and classification of fungi. Definition, objectives and history of Plant Pathology. Terms and concepts in Plant Pathology. Survival and Dispersal of Plant Pathogens. Phenomenon of infection - pre-penetration, penetration and post penetration. Pathogenesis – Role of enzymes, toxins, growth regulators and polysaccharides. Defense mechanism in plants – Structural and bio-chemical (pre and post infection). Plant disease epidemiology. Plant disease forecasting – Remote sensing – General principles of plant diseases management – Importance, general principles – Avoidance, exclusion, protection – Plant Quarantine and Inspection – Quarantine rules and regulations. Cultural methods – Roguing, eradication of alternate and collateral hosts, crop rotation, manure and fertilizer management, mixed cropping, sanitation, hot weather ploughing, soil amendments, time of sowing, seed rate and plant density, irrigation and drainage. Role and mechanisms of biological control and PGPR. Physical Methods – Heat and Chemical methods – Methods of application of fungicides. Host plant resistance – Application of biotechnology in plant disease management – Development of disease resistant transgenic plants. Integrated plant disease management (IDM) – Concept, advantages and importance.

Practical : Acquaintance to plant pathology laboratory and equipments; Preparation of culture media for fungi and bacteria; Isolation techniques, preservation of disease samples; Study of Pythium, Phytophthora, Albugo, Sclerospora, Peronosclerospora, Pseudoperonospora, Peronospora, Plasmopara, Bremia, Ascochyta, Mucor, Rhizopus. Oidium, Oidiopsis, Ovulariopsis, Erysiphe, Phyllactinia,

Uncinula, Podosphaera, Puccinia (different stages), Uromyces, Melampsora, Sphacelotheca, Ustilago, Tolyposporium, Septoria, Colletotrichum, Cercospora, Phaeoisariopsis, Rhizoctonia and Sclerotium; Demonstration of Koch's postulates; Study of different groups of fungicides and antibiotics; Preparation of fungicides – Bordeaux mixture, Bordeaux paste, Chestnut compound; Methods of application of fungicides – seed, soil and foliar; Bio-assay of fungicides – poisoned food technique, inhibition zone technique and slide germination technique; Bio control of plant pathogens – dual culture technique, seed treatment. Visit to quarantine station and remote sensing laboratory.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 1

Plant Protection

– Plant Pathology



Course Title with Credit Load M.Sc. in Plant Pathology

Course Code	Course Title	Credit Hours
PL PATH 501*	Mycology	2+1
PL PATH 502*	Plant Virology	2+1
PL PATH 503*	Plant Pathogenic Prokaryotes	2+1
PL PATH 504*	Plant Nematology	2+1
PL PATH 505*	Principles of Plant Pathology	2+1
PL PATH 506*	Techniques in Detection and Diagnosis of Plant Diseases	0+2
PL PATH 507	Principles of Plant Disease Management	2+1
PL PATH 508	Epidemiology and Forecasting of Plant Diseases	1+0
PL PATH 509	Disease Resistance in Plants	2+0
PL PATH 510	Ecology of Soil-borne Plant Pathogens	1+1
PL PATH 511	Chemicals and Botanicals in Plant Disease Management	2+1
PL PATH 512	Detection and Management of Seed Borne Pathogens	2+1
PL PATH 513	Biological Control of Plant Diseases	1+1
PL PATH 514	Integrated Disease Management	2+1
PL PATH 515*	Diseases of Field and Medicinal Crops	2+1
PL PATH 516	Diseases of Fruits, Plantation and Ornamental Crops	2+1
PL PATH 517	Diseases of Vegetable and Spices Crops	2+1
PL PATH 518	Post Harvest Diseases	2+1
PL PATH 519	Plant Quarantine and Regulatory Measures	1+0
PL PATH 591	Master's Seminar	0+1
PL PATH 521	Master's Research	0+30

*Core Courses for Master's

Course Contents

M.Sc. in Plant Pathology

- I. Course Title** : Mycology
II. Course Code : PL PATH 501
III. Credit Hours : 2+1

IV. Aim of the course

To study the nomenclature, classification and characters of fungi.

V. Theory

Unit I

Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs. History of mycology. Importance of culture collection and herbarium of fungi. Somatic characters and reproduction in fungi. Modern concept of nomenclature and classification, Classification of kingdom fungi: Stramenopila and Protists.

Unit II

The general characteristics of protists and life cycle in the Phyla Plasmodiophoromycota, Dictyosteliomycota, Acrasiomycota and Myxomycota. Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota, Oomycota and Labyrinthulomycota.

Unit III

Kingdom fungi: General characters, ultrastructure and life cycle patterns in representative genera under Chytridiomycota, Zygomycota, Ascomycota; Archiascomycetes, Ascomycetous yeasts, Pyrenomycetes, Plectomycetes, Discomycetes, Loculoascomycetes, Erysiphales and anamorphs of ascomycetous fungi.

Unit IV

Basidiomycota; general characters, mode of reproduction, types of basidiocarps and economic importance of Hymenomycetes. Uridinales and Ustilaginales; variability, host specificity and life cycle pattern in rusts and smuts. Mitosporic fungi; status of asexual fungi, their teliomorphic relationships, Molecular characterization of plant pathogenic fungi.

VI. Practical

- Detailed comparative study of different groups of fungi;
- Collection of cultures and live specimens;
- Saccardoan classification and classification based on conidiogenesis;
- Vegetative structures and different types of fruiting bodies produced by slime molds, stramenopiles and true fungi;
- Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium and aethalia. Oomycota;



- Somatic and reproductive structures of *Pythium*, *Phytophthora*, downy mildews and *Albugo*, Zygomycetes: Sexual and asexual structures of *Mucor*, *Rhizopus*, General characters of VAM fungi. Ascomycetes; fruiting structures, Erysiphales, and Eurotiales;
- General identification characters of Pyrenomycetes, Discomycetes, Loculoascomycetes and Laboulbenio-mycetes, Basidiomycetes; characters, ultrastructures and life cycle patterns in Ustilaginomycetes and Teliomycetes, Deuteromycetes;
- Characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic states, Collection, preservation, culturing and identification of plant parasitic fungi;
- Application of molecular approaches and techniques for identification of fungal pathogens.

VII. Suggested Reading

- Ainsworth GC, Sparrow FK and Susman HS. 1973. *The Fungi – An Advanced Treatise*. Vol. IV (A & B). Academic Press, New York.
- Alexopoulos CJ, Mims CW and Blackwell M. 2000. *Introductory Mycology*. 5th Ed. John Wiley & Sons, New York.
- Maheshwari R. 2016. *Fungi: Experimental Methods in Biology* 2nd edn. CRC Press, US.
- Mehrotra RS and Arneja KR. 1990. *An Introductory Mycology*. Wiley Eastern, New Delhi.
- Sarbhoy AK. 2000. *Text book of Mycology*. ICAR, New Delhi.
- Singh RS. 1982. *Plant Pathogens – The Fungi*. Oxford & IBH, New Delhi.
- Webster J. 1980. *Introduction to Fungi*. 2nd Ed. Cambridge Univ. Press, Cambridge, New York.

I. Course Title : Plant Virology

II. Course Code : PL PATH 502

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint with the structure, virus- vector relationship, biology and management of plant viruses.

V. Theory

Unit I

History and economic significances of plant viruses. General and morphological characters, composition and structure of viruses. Myco-viruses, arbo and baculo viruses, satellite viruses, satellite RNAs, phages, viroids and prions. Origin and evolution of viruses and their nomenclature and classification.

Unit II

Genome organization, replication in selected groups of plant viruses and their movement in host. Response of the host to virus infection: biochemical, physiological, and symptomatic changes. Transmission of viruses and virus-vector relationship. Isolation and purification of viruses.

Unit III

Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques. Natural (R-genes) and engineering resistance to plant viruses.

Unit IV

Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival). Management of diseases caused by plant viruses.



VI. Practical

- Study of symptoms caused by plant viruses (followed by field visit);
- Isolation and biological purification of plant virus cultures;
- Bioassay of virus cultures on indicator plants and host differentials;
- Transmission of plant viruses (Mechanical, graft and vector and study of disease development);
- Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions), Electron microscopy for studying viral particle morphology;
- Antisera production, Detection and diagnosis of plant viruses with serological (ELISA), nucleic acid (Non-PCR–LAMP, Later flow micro array and PCR based techniques);
- Exposure to basic bio-informatic tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software, Bioedit tool, Clustal X/W, MEGA Software).

VII. Suggested Reading

- Bos L. 1964. *Symptoms of Virus Diseases in Plants*. Oxford & IBH., New Delhi.
- Brunt AA, Krabtree K, Dallwitz MJ, Gibbs AJ and Watson L. 1995. *Virus of Plants: Descriptions and Lists from VIDE Database*. CABI, Wallington.
- Gibbs A and Harrison B. 1976. *Plant Virology – The Principles*. Edward Arnold, London.
- Hull R. 2002. *Mathew's Plant Virology*. 4th Ed. Academic Press, New York.
- Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Oxford & IBH, New Delhi.
- Wilson C. 2014. *Applied Plant Virology*. CABI Publishing England.

I. Course Title : Plant Pathogenic Prokaryotes

II. Course Code : PL PATH 503

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint with plant pathogenic prokaryote (procarya) and their structure, nutritional requirements, survival and dissemination.

V. Theory

Unit I

Prokaryotic cell: History and development of Plant bacteriology, history of plant bacteriology in India. Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins. Structure of bacterial cell. Structure and composition of gram negative and gram positive cell wall; synthesis of peptidoglycan; Surface proteins; Lipopolysaccharide structure; Membrane transport; fimbriae and pili (Type IV pili); Mechanism of flagellar rotatory motor and locomotion, and bacterial movement; Glycocalyx (S-layer; capsule); the bacterial chromosomes and plasmids; Operon and other structures in cytoplasm; Morphological feature of fastidious bacteria, spiroplasmas and Phytoplasmas.

Unit II

Growth and nutritional requirements. Infection mechanism, role of virulence factors in expression of symptoms. Survival and dispersal of phytopathogenic prokaryotes.



Unit III

Taxonomy of phytopathogenic prokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma. The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic prokaryotes.

Unit IV

Variability among phytopathogenic prokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteria-conjugation; transformation; transduction); and horizontal gene transfer.

Unit V

Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells; phage multiplication cycle; Classification of phages, Use of phages in plant pathology/ bacteriology, Lysogenic conversion; H Plasmids and their types, plasmid borne phenotypes. Introduction to bacteriocins. Strategies for management of diseases caused by phytopathogenic prokaryotes.

VI. Practical

- Study of symptoms produced by phytopathogenic prokaryotes;
- Isolation, enumeration, purification, identification and host inoculation of phytopathogenic bacteria;
- Stains and staining methods;
- Biochemical and serological characterization;
- Isolation of genomic DNA plasmid;
- Use of antibacterial chemicals/ antibiotics;
- Isolation of fluorescent *Pseudomonas*;
- Preservation of bacterial cultures;
- Identification of prokaryotic organisms by using 16S rDNA, and other gene sequences;
- Diagnosis and management of important diseases caused by bacteria and mollicutes.

VII. Suggested Reading

- Goto M. 1990. *Fundamentals of Plant Bacteriology*. Academic Press, New York.
- Jayaraman J and Verma JP. 2002. *Fundamentals of Plant Bacteriology*. Kalyani Publishers, Ludhiana.
- Mount MS and Lacy GH. 1982. *Phytopathogenic Prokaryotes*. Vols. I, II Academic Press, New York.
- Salle AJ. 1979. *Fundamental Principles of Bacteriology 7th edn*.
- Verma JP, Varma A and Kumar D. (Eds). 1995. *Detection of Plant Pathogens and their Management*. Angkor Publ., New Delhi.

- I. Course Title : Plant Nematology**
- II. Course Code : PL PATH 504**
- III. Credit Hours : 2+1**
- IV. Aim of the course**

To project the importance of nematodes in agriculture and impart basic knowledge on all aspects of plant nematology.

V. Theory

Unit I

Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

Unit II

Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

Unit III

Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

Unit IV

Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

Unit V

Principles and practices of nematode management; integrated nematode management.

Unit VI

Emerging nematode problems, Importance of nematodes in international trade and quarantine.

VI. Practical

- Studies on kinds of nematodes- free-living, animal, insect and plant parasites;
- Nematode extraction from soil;
- Extraction of migratory endoparasites, staining for sedentary endoparasites;
- Examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology.

VII. Suggested Reading

- Dropkin VH. 1980. *An Introduction to Plant Nematology*. John Wiley & Sons, New York.
- Maggenti AR. 1981. *General Nematology*. Springer-Verlag, New York.
- Perry RN and Moens M. 2013. *Plant Nematology*. 2nd Ed. CABI Publishing: Wallingford, UK.
- Perry RN, Moens M, and Starr JL. 2009. *Root-knot nematodes*, CABI Publishing: Wallingford, UK.
- Sikora RA, Coyne D, Hallman J and Timper P. 2018. *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture*. 3rd edn. CABI Publishing, England.
- Thorne G. 1961. *Principles of Nematology*. McGraw Hill, New Delhi.
- Walia RK and Bajaj HK. 2003. *Text Book on Introductory Plant Nematology*. ICAR, New Delhi.
- Walia RK and Khan MR. 2018. *A Compendium of Nematode Diseases of Crop Plants*, ICAR-AICRP (Nematodes), IARI, New Delhi.

I. Course Title : Principles of Plant Pathology

II. Course Code : PL PATH 505

III. Credit Hours : 2+1

IV. Aim of the course

To introduce the subject of Plant Pathology, its concepts and principles.



V. Theory

Unit I

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

Unit II

Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

Unit III

Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

Unit IV

Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

VI. Practical

- Basic plant pathological techniques;
- Isolation, inoculation and purification of plant pathogens and proving Koch's postulates;
- Techniques to study variability in different plant pathogens;
- Purification of enzymes, toxins and their bioassay;
- Estimation of growth regulators, phenols, phytoalexins in resistant and susceptible plants.

VII. Suggested Reading

- Agrios GN. 2005. *Plant Pathology*. 5th Ed. Academic Press, New York.
- Heitefuss R and Williams PH. 1976. *Physiological Plant Pathology*. Springer Verlag, Berlin, New York.
- Mehrotra RS and Aggarwal A. 2003. *Plant Pathology*. 2nd Ed. Oxford & IBH, New Delhi.
- Singh RP. 2012. *Plant Pathology* 2nd edn. Kalyani Publishers, New Delhi.
- Singh RS. 2017. *Introduction to Principles of Plant Pathology*. 5th edn. MedTech, New Delhi.
- Singh DP and Singh A. 2007. *Disease and Insect Resistance in Plants*. Oxford & IBH, New Delhi.
- Upadhyay RK. and Mukherjee KG. 1997. *Toxins in Plant Disease Development and Evolving Biotechnology*. Oxford & IBH, New Delhi.

I. Course Title : Techniques for Detection and Diagnosis of Plant Diseases

II. Course Code : PL PATH 506

III. Credit Hours : 0+2

IV. Aim of the course

To impart training on various methods/ techniques/ instruments used in the study of plant diseases/ pathogens.

V. Practical

- Detection of plant pathogens 1. Based on visual symptoms, 2. Biochemical test 3.

- Using microscopic techniques, 4. Cultural studies; (use of selective media to isolate pathogens). 5. Biological assays (indicator hosts, differential hosts) 6. Serological assays 7. Nucleic acid based techniques (Non-PCR–LAMP, Later flow microarray and PCR based- multiplex, nested, qPCR, immune capture PCR, etc.);
- Phenotypic and genotypic tests for identification of plant pathogens;
 - Molecular identification (16S rDNA and 16s-23S rDNA intergenic spacer region sequences-prokaryotic organisms; and eukaryotic organism by ITS region) and whole genome sequencing;
 - Volatile compounds profiling by using GC-MS and LC-MS;
 - FAME analysis, Fluorescence *in-situ* Hybridization (FISH), Flow Cytometry, Phage display technique, biosensors for detection of plant pathogens;
 - Genotypic tools such as genome/ specific gene sequence homology comparison by BLAST (NCBI and EMBL) and electron microscopy techniques of plant virus detection and diagnosis.

VI. Suggested Reading

- Baudoin ABAM, Hooper GR, Mathre DE and Carroll RB. 1990. *Laboratory Exercises in Plant Pathology: An Instructional Kit*. Scientific Publ., Jodhpur.
- Dhingra OD and Sinclair JB. 1986. *Basic Plant Pathology Methods*. CRC Press, London, Tokyo.
- Fox RTV. 1993. *Principles of Diagnostic Techniques in Plant Pathology*, CABI Wallington.
- Forster D and Taylor SC. 1998. *Plant Virology Protocols: From Virus Isolation to Transgenic Resistance. Methods in Molecular Biology*. Humana Press, Totowa, New Jersey.
- Mathews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Boca Raton, Tokyo.
- Mathews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Florida.
- Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Cent. Agric. Pub. Doc. Wageningen.
- Pathak VN. 1984. *Laboratory Manual of Plant Pathology*. Oxford & IBH, New Delhi.
- Trigiano RN, Windham MT and Windham AS. 2004. *Plant Pathology-Concepts and Laboratory Exercises*. CRC Press, Florida.
- Chakravarti BP. 2005. *Methods of Bacterial Plant Pathology*. Agrotech, Udaipur.

I. Course Title : Principles of Plant Disease Management

II. Course Code : PL PATH 507

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint with different strategies for management of plant diseases.

V. Theory

Unit I

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.

Unit II

History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Label claim of fungicides.

Unit III

Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants, health *vis-a-vis* environmental hazards, residual effects and safety measures



VI. Practical

- Phytopathometry;
- Methods of *in-vitro* evaluation of chemicals, antibiotics, bio agents against plant pathogens;
- Field evaluation of chemicals, antibiotics, bio agents against plant pathogens;
- Soil solarisation, methods of soil fumigation under protected cultivation;
- Methods of application of chemicals and bio control agents;
- ED and MIC values, study of structural details of sprayers and dusters;
- Artificial epiphytotic and screening of resistance.

VII. Suggested Reading

- Fry WE. 1982. *Principles of Plant Disease Management*. Academic Press, New York.
- Hewitt HG. 1998. *Fungicides in Crop Protection*. CABI, Wallington. Marsh RW. 1972. *Systemic Fungicides*. Longman, New York.
- Nene YL and Thapliyal PN. 1993. *Fungicides in Plant Disease Control*. Oxford & IBH, New Delhi.
- Palti J. 1981. *Cultural Practices and Infectious Crop Diseases*. Springer Verlag, New York.
- Vyas SC. 1993 *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

I. Course Title : Epidemiology and Forecasting of Plant Diseases

II. Course Code : PL PATH 508

III. Credit Hours : 1+0

IV. Aim of the course

To acquaint with the principles of epidemiology and its application in disease forecasting.

V. Theory

Unit I

Epidemic concepts, simple interest and compound interest disease, historical development. Elements of epidemics and their interaction. Structures and patterns of epidemics. Modelling, system approaches and expert systems in plant pathology.

Unit II

Genetics of epidemics. Models for development of plant disease epidemics. Common and natural logarithms, function fitting, area under disease progress curve and correction factors, inoculum dynamics. Population biology of pathogens, temporal and spatial variability in plant pathogens.

Unit III

Epidemiological basis of disease management. Survey, surveillance and vigilance. Remote sensing techniques and image analysis. Crop loss assessment.

Unit IV

Principles and pre-requisites of forecasting, systems and factors affecting various components of forecasting, some early forecasting and procedures based on weather and inoculum potential, modelling disease growth and disease prediction. Salient features of important forecasting models.

VI. Suggested Reading

- Campbell CL and Madden LV. 1990. *Introduction to Plant Disease Epidemiology*. John Wiley & Sons, New York



- Cooke B, Jones DM and Gereth KB. 2018 *The Epidemiology of Plant Diseases*. Springer Publications.
- Cowling EB and Horsefall JG. 1978. *Plant Disease*. Vol. II. Academic Press, New York.
- Laurence VM, Gareth H and Frame Van den Bosch (Eds.). *The Study of Plant Disease Epidemics*. APS, St. Paul, Minnesota.
- Nagarajan S and Murlidharan K. 1995. *Dynamics of Plant Diseases*. Allied Publ., New Delhi.
- Thresh JM. 2006. *Plant Virus Epidemiology*. Advances in Virus Research 67, Academic Press, New York.
- Van der Plank JE. 1963. *Plant Diseases Epidemics and Control*. Academic Press, New York.
- Zadoks JC and Schein RD. 1979. *Epidemiology and Plant Disease Management*. Oxford Univ. Press, London.

I. Course Title : Disease Resistance in Plants

II. Course Code : PL PATH 509

III. Credit Hours : 2+0

IV. Aim of the course

To acquaint with the disease resistance mechanisms.

V. Theory

Unit I

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminologies. Disease escape, non-host resistance and disease tolerance.

Unit II

Genetic basis of disease resistance, types of resistance, identification of physiological races of pathogen, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

Unit III

Host defence system, morphological and anatomical resistance, pre-formed chemicals in host defence, post-infectious chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms. Genetic basis of relationships between pathogen and host, Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

VI. Suggested Reading

- Deverall BJ. 1977. *Defence Mechanisms in Plants*. Cambridge Univ. Press, Cambridge, New York.
- Mills Dallice *et al.* 1996. *Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction*. APS, St Paul, Minnesota.
- Parker J. 2008. *Molecular Aspects of Plant Diseases Resistance*. Blackwell Publ.
- Robinson RA. 1976. *Plant Pathosystems*. Springer Verlag, New York.
- Singh BD. 2005. *Plant Breeding – Principles and Methods*. 7th Ed. Kalyani Publishers, Ludhiana
- Van der Plank JE. 1975. *Principles of Plant Infection*. Academic Press, New York.
- Van der Plank JE. 1978. *Genetic and Molecular Basis of Plant Pathogenesis*. Springer Verlag, New York.
- Van der Plank JE. 1982. *Host Pathogen Interactions in Plant Disease*. Academic Press, New York.
- Van der Plank JE. 1984. *Disease Resistance in Plants*. Academic Press, New York.



- I. Course Title** : Ecology of Soil Borne Plant Pathogens
II. Course Code : PL PATH 510
III. Credit Hours : 1+1

IV. Aim of the course

To provide knowledge on soil-plant disease relationship.

V. Theory

Unit I

Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Interaction of microorganisms.

Unit II

Types of biocontrol agents. Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis. Conducive and suppressive soils.

Unit III

Biological control- concepts and potentialities for managing soil borne pathogens. Potential of *Trichoderma* and fluorescent *Pseudomonas* in managing plant diseases.

VI. Practical

- Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens;
- Pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils;
- Suppression of test soil-borne pathogens by antagonistic microorganisms;
- Isolation and identification of different biocontrol agents;
- Study of various plant morphological structures associated with resistance, testing the effect of root exudates and extracts on spore germination and growth of plant pathogens;
- Estimating the phenolic substances, total reducing sugars in susceptible and resistant plants;
- Estimating the rhizosphere and root tissue population of microorganisms (pathogens) in plants.

VII. Suggested Reading

- Baker KF and Snyder WC. 1965. *Ecology of Soil-borne Plant Pathogens*. John Wiley, New York.
- Cook RJ and Baker KF. 1983. *The Nature and Practice of Biological Control of Plant Pathogens*. APS, St Paul, Minnesota.
- Garret SD. 1970. *Pathogenic Root-infecting Fungi*. Cambridge Univ. Press, Cambridge, New York.
- Hillocks RJ and Waller JM. 1997. *Soil-borne Diseases of Tropical Crops*. CABI, Wallington.
- Mondia JL and Timper P 2016. Interactions of microfungi and plant parasitic nematodes. In: *Biology of Microfungi* (De-Wei-Lei Ed.). Springer Publications
- Parker CA, Rovira AD, Moore KJ and Wong PTN. (Eds). 1983. *Ecology and Management of Soil-borne Plant Pathogens*. APS, St. Paul, Minnesota.



- I. Course Title** : **Chemicals and Botanicals in Plant Disease Management**
- II. Course Code** : **PL PATH 511**
- III. Credit Hours** : **2+1**

IV. Aim of the course

To provide knowledge on the concepts, principles and judicious use of chemicals and botanicals in plant disease management.

V. Theory

Unit I

History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals and botanicals.

Unit II

Classification of chemicals used in plant disease management and their characteristics.

Unit III

Chemicals in plant disease control, viz., fungicides, bactericides, nematocides, antiviral chemicals and botanicals. Issues related to label claim.

Unit IV

Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.

Unit V

Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides. New generation fungicides and composite formulations of pesticides.

Unit VI

Efficacy of different botanicals used and their mode of action. Important botanicals used against diseases. General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

VI. Practicals

- Acquaintance with formulation of different fungicides and plant protection appliances;
- Formulation of fungicides, bactericides and nematocides;
- *In-vitro* evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides against pathogens;
- Persistence, compatibility with other agro-chemicals;
- Detection of naturally occurring fungicide resistant mutants of pathogen;
- Methods of application of chemicals.

VII. Suggested Reading

- Bindra OS and Singh H. 1977. *Pesticides – And Application Equipment*. Oxford & IBH, New Delhi.
- Nene YL and Thapliyal PN. 1993. *Fungicides in Plant Disease Control*. 3rd edn. Oxford & IBH, New Delhi.
- Torgeson DC. (Ed.). 1969. *Fungicides*. Vol. II. An Advanced Treatise. Academic Press, New York.
- Vyas SC. 1993. *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.



- I. Course Title : Detection and Management of Seed Borne Pathogens**
II. Course Code : PL PATH 512
III. Credit Hours : 2+1

IV. Aim of the course

To acquaint with seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/ losses and management.

V. Theory

Unit I

History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

Unit II

Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

Unit III

Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.

Unit IV

Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogens/ diseases and procedure for healthy seed production. Seed health testing, methods for detecting microorganism.

VI. Practical

- Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses;
- Relationship between seed-borne infection and expression of the disease in the field.

VII. Suggested Reading

- Agarwal VK and Sinclair JB. 1993. *Principles of Seed Pathology*. Vols. I & II, CBS Publ., New Delhi.
- Hutchins JD and Reeves JE. (Eds.). 1997. *Seed Health Testing: Progress Towards the 21st Century*. CABI, Wallington.
- Paul Neergaard. 1988. *Seed Pathology*. McMillan, London.
- Suryanarayana D. 1978. *Seed Pathology*. Vikash Publ., New Delhi.

- I. Course Title : Biological Control of Plant Pathogens**
II. Course Code : PL PATH 513
III. Credit Hours : 1+1

IV. Aim of the course

To study principles and application of ecofriendly and sustainable management strategies of plant diseases.



V. Theory

Unit I

Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control.

Unit II

Types of biological interactions, competition: mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control.

Unit III

Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of pathogens, pathogens and antagonists and their relationship, biocontrol agents, comparative approaches to biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases. Compatibility of bioagents with agrochemicals and other antagonistic microbes.

Unit IV

Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents.

VI. Practical

- Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen *in-vitro* and *in vivo* conditions;
- Preparation of different formulations of selected bioagents and their mass production;
- Quality parameters of biocontrol agents;
- One week exposure visit to commercial biocontrol agents production unit.

VII. Suggested Reading

- Campbell R. 1989. *Biological Control of Microbial Plant Pathogens*. Cambridge Univ. Press, Cambridge.
- Cook RJ and Baker KF. 1983. *Nature and Practice of Biological Control of Plant Pathogens*. APS, St. Paul, Minnesota.
- Fokkemma MJ. 1986. *Microbiology of the Phyllosphere*. Cambridge Univ. Press, Cambridge.
- Gnanamanickam SS (Eds). 2002. *Biological Control of Crop Diseases*. CRC Press, Florida.
- Heikki MT and Hokkanen James M. (Eds.). 1996. *Biological Control – Benefits and Risks*. Cambridge Univ. Press, Cambridge.
- Mukerji KG, Tewari JP, Arora DK and Saxena G. 1992. *Recent Developments in Biocontrol of Plant Diseases*. Aditya Books, New Delhi.

I. Course Title : Integrated Disease Management

II. Course Code : PL PATH 514

III. Credit Hours : 2+1

IV. Aim of the course

To emphasize the importance and the need of IDM in the management of diseases of important crops.



V. Theory

Unit I

Introduction, definition, concept and tools of disease management, components of integrated disease management- their limitations and implications.

Unit II

Development of IDM-basic principles, biological, chemical and cultural disease management.

Unit III

IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed and mustard, pearl millet, pulses, vegetable crops, fruit, plantation and spice crops.

VI. Practical

- Application of physical, biological and cultural methods;
- Use of chemical and biocontrol agents, their compatibility and integration in IDM. Demonstration of IDM and multiple disease management in crops of regional importance as project work.

VII. Suggested Reading

- Gupta VK and Sharma RC. (Eds). 1995. *Integrated Disease Management and Plant Health*. Scientific Publ., Jodhpur.
- Mayee CD, Manoharachary C, Tilak KVBR, Mukadam DS and Deshpande Jayashree (Eds.). 2004. *Biotechnological Approaches for the Integrated Management of Crop Diseases*. Daya Publ. House, New Delhi.
- Sharma RC and Sharma JN. (Eds). 1995. *Integrated Plant Disease Management*. Scientific Publ., Jodhpur.

I. Course Title : Diseases of Field and Medicinal Crops

II. Course Code : PL PAT 515

III. Credit Hours : 2+1

IV. Theory

Unit I

Diseases of Cereal crops- Rice, wheat, barley, pearl millet, sorghum and maize.

Unit II

Diseases of Pulse crops- Gram, urdbean, mungbean, lentil, pigeonpea, soybean and cowpea.

Unit III

Diseases of Oilseed crops- Rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor.

Unit IV

Diseases of Cash crops- Cotton, sugarcane.

Unit V

Diseases of Fodder legume crops- Berseem, oats, guar, lucerne.

Unit VI

Medicinal crops- *Plantago*, liquorice, mulathi, rosagrass, sacred basil, mentha, ashwagandha, *Aloe vera*.

V. Practical

- Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops;
- Collection and dry preservation of diseased specimens of important crops.

Suggested Reading

- Joshi LM, Singh DV and Srivastava KD. 1984. *Problems and Progress of Wheat Pathology in South Asia*. Malhotra Publ. House, New Delhi.
- Rangaswami G. 1999. *Diseases of Crop Plants in India*. 4th Ed. Prentice Hall of India, New Delhi.
- Ricanel C, Egan BT, Gillaspie Jr AG and Hughes CG. 1989. *Diseases of Sugarcane, Major Diseases*. Academic Press, New York.
- Singh RS. 2017. *Plant Diseases*. 10th Ed. Medtech, New Delhi.
- Singh US, Mukhopadhyay AN, Kumar J and Chaube HS. 1992. *Plant Diseases of International Importance*. Vol. I. *Diseases of Cereals and Pulses*. Prentice Hall, Englewood Cliffs, New Jersey.

- I. Course Title** : **Diseases of Fruits, Plantation and Ornamental Crops**
II. Course Code : **PL PTH 516**
III. Credit Hours : **2+1**

IV. Aim of the course

To acquaint with diseases of fruits, plantation, ornamental plants and their management.

V. Theory

Unit I

Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry, citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm, custard apple and their management.

Unit II

Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber and coconut and their management.

Unit III

Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, gerbera orchids, marigold, chrysanthemum and their management.

VI. Practical

- Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops;
- Collection and dry preservation of diseased specimens of important crops.

VII. Suggested Reading

- Gupta VK and Sharma SK. 2000. *Diseases of Fruit Crops*. Kalyani Publishers, New Delhi.
- Pathak VN. 1980. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.
- Singh RS. 2000. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.
- Walker JC. 2004. *Diseases of Vegetable Crops*. TTPP, India.



- I. Course Title : Diseases of Vegetable and Spices Crops**
II. Course Code : PL PATH 517
III. Credit Hours : 2+1

IV. Aim of the course

To impart knowledge about symptoms, epidemiology of different diseases of vegetables and spices and their management.

V. Theory

Unit I

Nature, prevalence, factors affecting disease development of tuber, bulb, leafy vegetable, crucifers, cucurbits and solanaceous vegetables. Diseases of crops under protected cultivation.

Unit II

Symptoms and management of diseases of different root, tuber, bulb, leafy vegetables, crucifers, cucurbits and solanaceous vegetable crops.

Unit III

Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, nutmeg, saffron, cumin, coriander, turmeric, fennel, fenugreek and ginger. Biotechnological approaches in developing disease resistant transgenics.

VI. Practical

- Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

VII. Suggested Reading

- Chaube HS, Singh US, Mukhopadhyay AN and Kumar J. 1992. *Plant Diseases of International Importance*. Vol. II. *Diseases of Vegetable and Oilseed Crops*. Prentice Hall, Englewood Cliffs, New Jersey.
- Gupta VK and Paul YS. 2001. *Diseases of Vegetable Crops*. Kalyani Publishers, New Delhi
- Gupta SK and Thind TS. 2006. *Disease Problem in Vegetable Production*. Scientific Publ., Jodhpur.
- Sherf AF and McNab AA. 1986. *Vegetable Diseases and their Control*. Wiley Inter Science, Columbia.
- Singh RS. 1999. *Diseases of Vegetable Crops*. Oxford & IBH, New Delhi.
- Walker JC. 1952. *Diseases of Vegetable Crops*. McGraw-Hill, New York.

- I. Course Title : Post-Harvest Diseases**
II. Course Code : PL PATH 518
III. Credit Hours : 1+1

IV. Aim of the course

To acquaint with the post-harvest diseases of agricultural produce and their eco-friendly management.

V. Theory

Unit I

Concept of post-harvest diseases, definitions, importance with reference to management and health, principles of plant disease management as pre-harvest and post-harvest, Types of post-harvest problems both by biotic and abiotic factors.

**Unit II**

Role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists.

Unit III

Integrated approaches in controlling diseases and improving the shelf life of produce using nutritional, bio-control agents and other agents, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for health hazards.

Unit IV

Study of symptoms, toxicosis of various pathogens, knowledge of Codex Alimentarius for each product and commodity. Physical and biological agents/practices responsible for development/ prevention of post-harvest diseases-traditional and improved practices.

VI. Practical

- Isolation, characterization and maintenance of post-harvest pathogens, application of antagonists against pathogens *in vivo* condition;
- Comparative efficacy of different fungicides and bioagents;
- Study of different post-harvest disease symptoms on cereals, pulses, oilseed, commercial crops, vegetables, fruits and flowers;
- Visit to cold storage.

VII. Suggested Reading

Chaddha KL and Pareek OP. 1992. *Advances in Horticulture* Vol. IV, Malhotra Publ. House, New Delhi.
Pathak VN. 1970. *Diseases of Fruit Crops and their Control*. IBH Publ., New Delhi.

I. Course Title : Plant Quarentine and Regulations

II. Course Code : PL PATH 519

III. Credit Hours : 1+0

IV. Aim of the course

To acquaint the learners about the principles and the role of plant quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

V. Theory**Unit I**

Historical development in plant quarantine, Definitions of pest, and transgenics as per Govt. notification; Organizational set up of plant quarantine in India. relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/ diseases and their status.

Unit II

Acts related to registration of pesticides and transgenics. History of quarantine legislations, Salient features of PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.



Unit III

Identification of pest/ disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/ pathogen infestations; VHT and other safer techniques of disinfestation/ salvaging of infected material.

Unit IV

WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures. Visit to plant quarantine station and PEQ facilities.

Suggested Reading

- Rajeev K and Mukherjee RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.
- Rhower GG. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.



Course Course Title with Credit Load Ph.D. in Plant Pathology

Course Code	Course Title	Credits Hours
PL PATH 601	Advances in Mycology	2+1
PL PATH 602	Advances in Virology	2+1
PL PATH 603	Advances in Plant Pathogenic Prokaryotes	2+1
PL PATH 604**	Molecular Basis of Host-pathogen Interaction	2+1
PL PATH 605	Principles and Procedures of Certification	1+0
PL PATH 606	Plant Biosecurity and Biosafety	2+0
PL PATH 691	Doctoral Seminar – I	0+ 1
PL PATH 692	Doctoral Seminar – II	0+ 1
PL PATH 699	Doctoral Research	0+75

**Core Courses for Doctoral Programme



Course Contents

Ph.D. in Plant Pathology

- I. Course Title** : Advances in Mycology
II. Course Code : PL PATH 601
III. Credit Hours : 2+1

IV. Aim of the course

To acquaint with the advances in mycology

V. Theory

Unit I

General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification. Serological, chemical (chemotaxonomy), molecular and numerical (computer based assessment) taxonomy. Interaction between groups: Phylogeny, Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti.

Unit II

Population biology, pathogenic variability/vegetative compatibility. Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra-nuclear inheritance. Biodegradation.

Unit III

Ultra structures and chemical constituents of fungal cells, functions of cell organelles. Mitosis, meiosis, gene action and regulation. Effects of fungal interaction with host plants and other microorganisms; parasitism, symbiosis and commensalism.

Unit IV

Genetic Improvement of Fungal strains. Fungal biotechnology. Fungi mediated synthesis of nano particles – characterization process and application. Mycotoxins problems and its management.

VI. Practical

- Isolation, purification and identification of cultures, spores and mating type determination;
- Study of conidiogenesis-Phialides, porospores, arthrospores;
- Study of fruiting bodies in Ascomycotina;
- Identification of fungi up to species level;
- Study of hyphal anastomosis;
- Morphology of representative plant pathogenic genera from different groups of fungi;
- Molecular characterization of fungi.

VII. Suggested Reading

Alexopoulos CJ, Mims CW and Blackwell M. 1996. *Introductory Mycology*. John Wiley & Sons, New York.

- Dube HC. 2005. *An Introduction to Fungi*. 3rd Ed. Vikas Publ. House, New Delhi.
- Kirk PM, Cannon PF, David JC and Stalpers JA. (Eds.). 2001. *Ainsworth and Bisby's Dictionary of Fungi*. 9th Ed., CABI, Wallington.
- Maheshwari R. 2016. *Fungi: Experimental Methods in Biology* 2nd edn. CRC Press, US.
- Ulloa M and Hanlin RT. 2000. *Illustrated Dictionary of Mycology*. APS, St. Paul, Minnesota.
- Webster J and Weber R. 2007. *Introduction to Fungi*. Cambridge University Press, Cambridge.

- I. Course Title : Advances in Plant Virology**
- II. Course Code : PL PATH 602**
- III. Credit Hours : 2+1**
- IV. Aim of the course**

To educate about the advanced techniques and new developments in plant virology.

V. Theory

Unit I

Origin, evolution and interrelationship with animal viruses. Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus specific cytological effects in infected plant cells. Mechanisms leading to the evolution of new viruses/ strains: mutation, recombination, pseudo-recombination, component re-assortment, etc.

Unit II

Major vector groups of plant viruses and their taxonomy, virus-vector relationship, molecular mechanism of virus transmission by vectors. Terminologies used in immunology and serology. Classification, structure and functions of various domains of Immunoglobulins. Production of Polyclonal and monoclonal antibodies for detection of viruses. Immuno/ serological assays (Slide agglutination tests, Test tube precipitation test, Double agar diffusion test, ELISA (DAC, DAS, TAS), Dot Immuno Binding Assay, and nucleic acid based assays for detection of plant viruses.

Unit III

Polymerase Chain Reaction based (PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/ q PCR) and non PCR based: LAMP, Fluorescent *in situ* hybridization (FISH), dot blot hybridization. Plant virus genome organization (General properties of plant viral genome- information content, coding and non-coding regions), replication, transcription and translational strategies of pararetroviruses, geminiviruses, tobamo-, poty-, bromo, cucumo, ilar, tospoviruses, satellite viruses and satellite RNA.

Unit IV

Gene expression, regulation and viral promoters. Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes. Virus potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture for production of virus free planting materials. Phylogenetic grouping system based on partial/ complete sequences of virus genomes and using of next generation sequencing technology in plant virus discovery.

VI. Practical

- Purification of viruses, SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation;
- Acquaintance with different serological techniques (i) DAC- ELISA (ii) DAS-ELISA



- (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA. Nucleic acid isolation, DOT-blot, southern hybridization, probe preparation, and autoradiography;
- PCR application and viral genome cloning of PCR products, plasmid purification, enzyme digestion, sequencing, annotation of genes, analysis of viral sequences (use of gene bank, blast of viral sequences and phylogeny);
- Bioinformatics analysis tools for virology (ORF finder, Gene mark, Gene ontology, BLAST, Clustal X/W, Tm pred and Phylogeny programs).

VII. Suggested Reading

- Davies 1997. *Molecular Plant Virology: Replication and Gene Expression*. CRC Press, Florida.
- Fauquet *et al.* 2005. *Virus Taxonomy*. VIII Report of ICTV. Academic Press, New York.
- Gibbs A and Harrison B. 1976. *Plant Virology – The Principles*. Edward Arnold, London.
- Jones P, Jones PG and Sutton JM. 1997. *Plant Molecular Biology: Essential Techniques*. John Wiley & Sons, New York.
- Khan J A and Dijkstra. 2002. *Plant Viruses as Molecular Pathogens*. Howarth Press, New York.
- Maramorosch K, Murphy FA and Shatkin AJ. 1996. *Advances in Virus Research*. Vol. 46. Academic Press, New York.
- Pirone TP and Shaw JG. 1990. *Viral Genes and Plant Pathogenesis*. Springer Verlag, New York.
- Roger Hull. 2002. *Mathew's Plant Virology* (4th Ed.). Academic Press, New York.
- Thresh JM. 2006. *Advances in Virus Research*. Academic Press, New York.

I. Course Title : Advances in Plant Pathogenic Prokaryotes

II. Course Code : PL PATH 603

III. Credit Hours : 2+1

IV. Aim of the course

To learn about the latest developments in all the plant pathogenic prokaryotes as a whole.

V. Theory

Unit I

Prokaryotic cell: Molecular basis for origin and evolution of prokaryotic life, RNA world, prokaryotic cytoskeletal proteins. Flagella structure, assembly and regulation. Structure and composition (**bacteria**) cell wall/ envelop, Types of secretion systems (TI to TIV) and their molecular interaction, fimbriae and pili (Type IV pili), Bacterial chromosomes and plasmids, other cell organelles. Growth, nutrition and metabolism in prokaryotes (Embden-Meyerhof-Parnas (EMP) pathway, Phosphoketolase Pathway and Entner Doudoroff Pathway).

Unit II

Current trends in taxonomy and identification of phytopathogenic prokaryotes: International code of nomenclature, Polyphasic approach, New/ special detection methods for identification of bacterial plant pathogens. Taxonomic ranks hierarchy; Identification, Advances in classification and nomenclature.

Unit III

Bacterial genetics: General mechanism of variability (mutation), specialized mechanisms of variability. Transposable genetic elements in bacteria-integron and prophages, Mechanism of gene transfer. Pathogenicity islands, horizontal gene transfer, Bacterial Pan-Genome.

Unit IV

Bacteriophages: Composition, structure and infection. Classification and use of phages in plant pathology/ bacteriology. Host pathogen interactions: Molecular mechanism of pathogenesis: Pathogenicity factors of soft rot, necrosis, wilt, canker, etc. Immunization, induced resistance/ Systemic Acquired Resistance, Quorum sensing. Bacterial pathogenicity and virulence: Molecular mechanism of virulence and pathogenesis, bacterial secretion systems, pathogenicity of bacterial enzymes that degrade the cell walls, Role of hrp/ hrc genes and TALE effectors. Synthesis and regulation of EPSs.

Unit V

Beneficial Prokaryotes-Endophytes, PGPR, Phylloplane bacteria and their role in disease management. Endosymbionts for host defence. Advances in management of diseases caused by prokaryotes: genetic engineering, RNA silencing; CRISPR cas9.

VI. Practical

- Pathogenic studies and race identification, plasmid profiling of bacteria, fatty acid profiling of bacteria, RFLP profiling of bacteria and variability status, Endospore, Flagella staining, Test for secondary metabolite production, cyanides, EPS, siderophore, specific detection of phytopathogenic bacteria using species/ pathovar specific primers;
- Basic techniques in diagnostic kit development, Molecular tools to identify phytoendosymbionts;
- Important and emerging diseases and their management strategies.

VII. Suggested Reading

- Dale JW and Simon P. 2004. *Molecular Genetics of Bacteria*. John Wiley & Sons, New York.
- Garrity GM, Krieg NR and Brenner DJ. 2006. *Bergey's Manual of Systematic Bacteriology: The Proteobacteria*. Vol. II. Springer Verlag, New York.
- Gnanamanickam SS. 2006. *Plant-Associated Bacteria*. Springer Verlag, New York.
- Mount MS and Lacy GH. 1982. *Plant Pathogenic Prokaryotes*. Vols. I, II. Academic Press, New York.
- Sigee DC. 1993. *Bacterial Plant Pathology: Cell and Molecular Aspects*. Cambridge Univ. Press, Cambridge.
- Starr MP. 1992. *The Prokaryotes*. Vols. I-IV. Springer Verlag, New York.

I. Course Title : Molecular Basis of Host-pathogen Interaction

II. Course Code : PL PATH 604

III. Credit Hours : 2+1

IV. Aim of the course

To understand the concepts of molecular biology and biotechnology in relation to host plant- pathogen interactions.

V. Theory

Unit I

History of host plant resistance and importance to Agriculture. Importance and role of biotechnological tools in plant pathology. Basic concepts and principles to study host pathogen relationship. Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes, and their interactions.



Unit II

Different forms of plant-microbe interactions and nature of signals/ effectors underpinning these interactions. Plant innate immunity: PAMP/ DAMP. Molecular basis of host-pathogen interaction-fungi, bacteria, viruses and nematodes; recognition system, signal transduction.

Unit III

Induction of defence responses- HR, Programmed cell death, reactive oxygen species, systemic acquired resistance, induced systemic resistance, pathogenesis related proteins, phytoalexins and virus induced gene silencing. Molecular basis of gene-for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes. Gene for gene systems: Background, genetics, phenotypes, molecular mechanisms, races, breakdown of resistance (boom-and-bust cycles), Coevolution-arms race and trench warfare models, Metapopulations, cost of resistance, cost of unnecessary virulence, GFG in agricultural crops vs. natural populations, Durability of resistance, erosion of quantitative resistance.

Unit IV

Pathogen population genetics and durability, viruses vs cellular pathogens. Gene deployment, cultivar mixtures. Disease emergence, host specialization. Circadian clock genes in relation to innate immunity. Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

VI. Practical

- Protein, DNA and RNA isolation, plasmid extraction, PCR analysis, DNA and Protein electrophoresis, bacterial transformation;
- Gene mapping and marker assisted selection;
- Development and use of molecular markers in identification and characterization of resistance to plant pathogens and their management.

VII. Suggested Reading

- Chet I. 1993. *Biotechnology in Plant Disease Control*. John Wiley & Sons, New York.
- Gurr SJ, McPohersen MJ and Bowlos DJ. (Eds.). 1992. *Molecular Plant Pathology – A Practical Approach*. Vols. I & II, Oxford Univ. Press, Oxford.
- Mathew JD. 2003. *Molecular Plant Pathology*. Bios Scientific Publ., UK.
- Ronald PC. 2007. *Plant-Pathogen Interactions: Methods in Molecular Biology*. Humana Press, New Jersey.
- Stacey G and Keen TN. (Eds.). 1996. *Plant Microbe Interactions*. Vols. I-III. Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.

I. Course Title : Principles and Procedures of Certification

II. Course Code : PL PATH 605

III. Credit Hours : (1+0)

IV. Aim of the course

To acquaint with the certification procedures of seed and planting material.

V. Theory

Unit I

Introduction to certification. International scenario of certification and role of ISTA,

EPPO, OECD, etc. in certification and quality control. Case studies of certification systems of USA and Europe. National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing genetic identity, physical purity, germination percentage, seed health, etc. Fixing tolerance limits for diseases and insect pests in certification and quality control programmes.

Unit II

Methods used in certification of seeds, vegetative propagules and *in-vitro* cultures. Accreditation of seed testing laboratories. Role of seed/ planting material health certification in national and international trade.

VI. Reference

- Association of Official Seed Certifying Agencies. Hutchins D and Reeves JE. (Eds.). 1997. Seed Health Testing: Progress Towards the 21st Century. CABI, UK. ISHI-veg Manual of Seed Health Testing Methods.
ISHI-F Manual of Seed Health Testing Methods.
ISTA Seed Health Testing Methods.
Tunwar NS and Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi. US National Seed Health System.

e-Resources

- <http://www.aosca.org/index.htm>.
http://www.worldseed.org/enus/international_seed/ishi_vegetable.html
http://www.worldseed.org/en-us/international_seed/ishi_f.html
<http://www.seedtest.org/en/content—1—1132—241.html>
<http://www.seedhealth.org>

I. Course Title : Plant Biosecurity and Biosafety

II. Course Code : PATH 606

III. Credit Hours : 2+0

IV. Aim of the course

To facilitate deeper understanding on plant biosecurity and biosafety issues in agriculture.

V. Theory

Unit I

History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases. Introduction and History of biosecurity and its importance.

Unit II

National Regulatory Mechanism and International Agreements/ Conventions, viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures. World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.



Unit III

Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops. Emerging/resurgence of pests and diseases in the changing scenario of climatic conditions. Issues related to release of genetically modified crops.

VI. Suggested Reading

- Biosecurity: A Comprehensive Action Plan.
 Biosecurity Australia.
 Biosecurity for Agriculture and Food Production.
 FAO Biosecurity Toolkit 2008.
 Grotto Andrew J and Jonathan B Tucker. 2006. Biosecurity Guidance.
 Khetarpal RK and Kavita Gupta 2006. Plant Biosecurity in India – Status and Strategy. *Asian Biotechnology and Development Review* 9(2): 3963.
 Randhawa GJ, Khetarpal RK, Tyagi RK and Dhillon BS (Eds.). 2001. *Transgenic Crops and Biosafety Concerns*. NBPGR, New Delhi.

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- <http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.shtm>
www.fao.org/docrep/010/a1140e/a1140e00.htm Laboratory
http://www.who.int/csr/resources/publications/biosafety/WHO_CD_S_EPR_2006.pdf
http://www.americanprogress.org/kf/biosecurity_a_comprehensive_action_plan.pdf
www.biosecurity.govt.nz DEFRA. www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm
www.daff.gov.au/ba; www.affa.gov.au/biosecurityaustralia Biosecurity New Zealand.
<http://www.fao.org/biosecurity/> CFIA.

VII. List of Journals

- *Annals of Applied Biology* – Cambridge University Press, London
- *Annals of Plant Protection Sciences*- Society of Plant Protection, IARI, New Delhi
- *Annual Review of Phytopathology* – Annual Reviews, Palo Alto, California
- *Annual Review of Plant Pathology* – Scientific Publishers, Jodhpur
- *Canadian Journal of Plant Pathology* – Canadian Phytopathological Society, Ottawa
- *Indian Journal of Biotechnology* – National Institute of Science Communication and Information Resources, CSIR, New Delhi
- *Indian Journal of Mycopathological Research* – Indian Society of Mycology, Kolkata.
- *Indian Journal of Plant Protection* – Plant Protection Association of India, NBPGR, Hyderabad.
- *Indian Journal of Virology* – Indian Virological Society, New Delhi
- *Indian Phytopathology*-Indian Phytopathological Society, IARI New Delhi.
- *Journal of Mycology and Plant Pathology* – Society of Mycology and Plant Pathology, Udaipur.
- *Journal of Plant Disease Science*- Association of Plant Pathologists (Central India) PDKV, Akola.
- *Journal of Phytopathology* – Blackwell Verlag, Berlin
- *Mycologia* – New York Botanical Garden, Pennsylvania
- *Mycological Research* – Cambridge University Press, London
- *Physiological Molecular Plant Pathology* – Academic Press, London – *Phytopathology* – American Phytopathological Society, USA
- *Plant Disease* – The American Phytopathological Society, USA
- *Plant Disease Research* – Indian Society of Plant Pathologists, Ludhiana
- *Plant Pathology* – British Society for Plant Pathology, Blackwell Publ.



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- *Review of Plant Pathology* – CAB International, Wallingford
 - *Virology*- New York Academic Press e-Resources
 - www.shopapspress.org
 - www.apsjournals.apsnet.org
 - www.apsnet.org/journals
 - www.cabi_publishing.org
 - www.springer.com/life+Sci/agriculture
 - www.backwellpublishing.com
 - www.csiro.au
 - www.annual-reviews.org

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