PLANT PATHOLOGY

Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
PL PATH 501*	MYCOLOGY PLANT	2+1
PL PATH 502*	VIROLOGY PLANT	2+1
PL PATH 503*	BACTERIOLOGY	2+1
PL PATH 504*	PRINCIPLES OF PLANT PATHOLOGY	3+0
PL PATH 505*	DETECTION AND DIAGNOSIS OF PLANT DISEASES	0+2
PL PATH 506	PRINCIPLES OF PLANT DISEASE MANAGEMENT	2+1
PL PATH 507	DISEASES OF FIELD AND MEDICINAL CROPS	2+1
PL PATH 508	DISEASES OF FRUITS, PLANTATION AND ORNAMENTAL CROPS	2+1
PL PATH 509	DISEASES OF VEGETABLE AND SPICES CROPS	2+1
PL PATH 510	SEED HEALTH TECHNOLOGY	2+1
PL PATH 511	CHEMICALS IN PLANT DISEASE MANAGEMENT	2+1
PL PATH 512	ECOLOGY OF SOIL-BORNE PLANT PATHOGENS	2+1
PL PATH 513	DISEASE RESISTANCE IN PLANTS	2+0
PL PATH 514/ ENT 514$	INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS	1+1
PL PATH 515	BIOLOGICAL CONTROL OF PLANT DISEASES	2+1
PL PATH 516	INTEGRATED DISEASE MANAGEMENT	2+1
PL PATH 517	MUSHROOM PRODUCTION TECHNOLOGY	2+1
PL PATH 518	EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES	2+1
PL PATH 519	POST HARVEST DISEASES	2+1
PL PATH 520/ ENT 520$	PLANT QUARANTINE	2+0
PL PATH 591	MASTER'S SEMINAR	1+0
PL PATH 599	MASTER'S RESEARCH	20
PL PATH 601	ADVANCED MYCOLOGY	2+1
PL PATH 602	ADVANCED VIROLOGY	2+1
PL PATH 603	ADVANCED BACTERIOLOGY	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	1+0
PL PATH 692	DOCTORAL SEMINAR II	1+0
PL PATH 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme
** Compulsory for Ph. D. programme
$ Cross listed with Entomology

Minor Departments **9**

Entomology

Microbiology

Supporting Departments **5**

Computers and Mathematics

Biochemistry

Plant Molecular Biology and Biotechnology

Seed Science and Technology

Non credit compulsory courses

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATION SKILLS	0+1
PGS 503 (e-course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e-course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e-course)	DISASTER MANAGEMENT	1+0

PL PATH 501 MYCOLOGY 2+1

Objective

To study the nomenclature, classification and characteristics of fungi.

Theory

UNIT I

Introduction: Scope and importance of Mycology in Agriculture **–** Plant and animal diseases, biodegradation, mycorrhizae, biological control.

Terms and basic concepts: Fungus, thallus, septate and aseptate forms, dolipore septum, holocarpic and eucarpic mycelium, fungal tissue, modifications of mycelium. Asexual reproductive spores – zoospores, sporangiospores, conidia, arthrospores, blastospores and chlamydospores**.** Sexual spores – oospores, zygospores, ascospores and basidiospores. Monoecious, Dioecious and sexually undifferentiated forms. Homothallism and heterothallism. Anamorphs and teleomorphs. Parasitism.

UNIT II

Relation of fungi to human affairs: Beneficial and harmful effects of fung

History of mycology: Ancient history – Greek and Roman periods. Middle ages – Albert Magnus, B. Angleus, Pre de Baryan period (17^{th} – mid 18^{th} century) - Clusius, Bauhin, Robert Hooke, van Sterbeek, Tournefort, Micheli, Linneaus, Persoon, Fries. Post de Baryan period (mid 19^{th} century to date) – de Bary, Saccardo, Tulasne brothers, Berkeley.

History of mycology in India: Kirthikar, Cunnigham, Barclay, Butler, Dastur, Mundkur, Thirumalachar and Vasudeva.

UNIT III

Fungal Biodiversity – Distribution of fungal species in different habitats and their number.

Reproduction – Methods of asexual reproduction. Asexual fruiting bodies – Pycnidium, acervulus, synnemma, sporodochium. Methods of sexual reproduction. Sexual fruiting bodies- ascocarps and basidiocarps.

Ultrastructures – fungal cell and cell wall composition in different fungal groups.

Nomenclature: Binomial nomenclature – rules governing nomenclature, ICBN, nomenclatural filter.

Classification – classification of fungi according to Ainsworth 1973

UNIT IV

Important characteristics of different fungal groups – division, sub-division, class, order, family, genus

Division Myxomycota - Classes Acrasiomycetes , Myxomycetes and Plasmodiophoromycetes - Order Plasmodiophorales – Family Plasmodiophoraceae - Genus *Plasmodiophora*

Division Eumycota: Sub divisions – Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina.

Sub division Mastigomycotina – Class Chytridiomycetes - order Chytridiales – Genus *Synchytrium.* Class Oomycetes - Orders Saprolegniales, Leptomitales, Lagenidiales and

Peronosporales – Families Pythiaceae, Albuginaceae, Peronosporaceae - Genera *Pythium, Phytophthora, Albugo, Sclerospora, Peronospora, Plasmopara, Bremia, Bremiella Basidiophora, Pseudoperonospora, Sclerophthora, Peronosclerospora*

Subdivision Zygomycotina - Class Zygomycetes - Order Mucorales – Family Mucoraceae -Genus *Rhizopus*. Family Choanephoraceae - Genus *Choanephora*

Subdivision Ascomycotina - classes Hemiascomycetes, Plectomycetes, Pyrenomycetes, Discomycetes and Loculoascomycetes

Class: Hemiascomycetes - Orders Endomycetales, Taphrinales and Protomycetales. Genera: *Taphrina* and *Protomyces*

Class Plectomycetes - Order Erysiphales – Family Erypsiphaceae - *Genera - Erysiphae, Leveillula, Phyllactinia, Uncinula, Sphaerotheca, Podosphaera* and *Microsphaera*. Order Eurotiales – Family Eurotiaceae – Genera *Eurotium, Sartorya, Emericella, Hemicarpenteles, Eupenicillium* and *Talaromyces* Class Pyrenomycetes – Order Hypocreales – Family Clavicipitaceae – Genus *Claviceps* – Family Nectriaceae – Genus *Nectria.* Order Phyllochorales – Genera *Glomerella, Phyllochora, Polystigma.* Order Ophiostomatales – Genus *Ophiostoma.* Order Diaporthales – Genera *Diaporthe, Magnaporthe, Gaeumannomyces.* Order Xylariales – Genus *Rosellina.* Order Microascales – Genus *Ceratocystis.* Order Sordariales - Genera *Neurosopra* and *Chaetomium*

Class Discomycetes – Order Pezizales – Family Pezizaceae – Genus *Peziza.* Family Morchellaceae – Genus *Morchella.* Family Helvellaceae – Genus *Helvella.* Order Helotiales – Family Sclerotiniaceae – Genus *Monilinia.* Order Tuberales – Genus *Tuber*

Class Loculoascomycetes – Order Myriangiales – Family Myriangiaceae – Genus *Elsinoe.* Order Dothidiales – Family Dothidiaceae – Genus *Mycosphaerella.* Order Pleosporales – Families Pleosporaceae and Venturiaceae Genera *Pleospora, Cochliobolus* and *Venturia*

Subdivision Basidiomycotina - Class Teliomycetes, Order Uredinales – Family Pucciniaceae - Genera *Puccinia, Uromyces, Hemileia* and *Gymnosporangium.* Family Melampsoraceae – Genus Melampsora. Order Ustilaginales – Family Ustilaginaceae – Genera *Usitlago, Spacelotheca, Tolyposporium, melanopsichium*. Family Tilletiaceae – Genera *Tilletia, Neovossia, Entyloma* and *Urocystis*

Class Hymenomycetes – Sub class Holobasidiomycetidae – Order Agaricales – Family Agaricaceae – Genus *Agaricus.* Order Aphyllophorales – Family Polyporaceae – Genera *Polyporus, Fomes* and *Poria.* Family Ganodermataceae – Genus *Ganoderma.* Sub class Phragmobasidiomycetidae Orders Tremellales, Auriculariales and Septobasidiales – Genera *Exidia, Auricularia* and *Septobasidium*

Class Gasteromycetes – Orders Lycoperdales, Phallales, Nidulariales and Sclerodermatales.

Subdivision Deuteromycotina – Class Coelomycetes – Order Sphaeropsidales – Genera *Phoma, Macrophoma, Phomopsis, Macrophomina* and *Ascochyta.* Order Melanconiales – Genera *Colletotrichum, Pestalotia* and *Pestalotiopsis*

Class Hyphomycetes – Order Hyphomycetales – Family Moniliacae – Genera *Pyricularia* and *Verticillium.* Family Dematiaceae – Genera *Alternaria, Helminthosporium, Drechslera, Bipolaris* and *Curvularia.* Order Stilbellales – Genus *Graphium.* Order Tuberculariales - Genus *Fusarium.* Order Agonomycetales – Genera – *Sclerotium* and *Rhizoctonia*

Fungal genetics – fungal genome – chromosomal genes, mitochondrial genes, plasmids and transposans. Haploid forms

Fungal variability – nonsexual variability – heterokaryosis, mutations and parasexuality. Sexual variability

Lichens – Symbiotic association between fungi and fungi-Mycobiont and Photobiont-different groups of lichen forming fungi – importance of lichens

Practical

Outline classification of fungi, General methods to study fungi, Study of somatic structures in fungi, Study of myxomycotina-Acrasiomycetes(*Dictyostelium*), Myxomycetes (*Ceratiomyxa,Physarum,Stemonitis*, *Hemitrichia. Lycogala*) and Plasmodio-phoromycetes(*Plasmodiophora*), Study of Mastigomycotina- study of Chytridiomycetes (*Synchytrium, Physoderma, Allomyces*), Study of Masigomycotina – study of oomycetes(*Pythium, Phytophthora, Albug*), Albug of Mastigomycotina – study of Oomycetes (*Peronospora, Bremia, Plasmopara, Sclerospora*), Study of Zygomycotina- Study of Zygomycetes(*Mucor, Absidia, Rhizopus, Circinella, Thamnosylum, Choanephora, Cunninghamella, Syncephalastrium*), Ascomycotina – Types of Ascocarps of the sub-division and study of Hemiascomycetes. Study of Eurotiales and Erysiphales, Ascomycotina – Study of Sphaeriales and Hypocreales, Ascomycotina – Study of Discomycetes and Loculoascomycetes, Basidiomycotina – Study of Teliomycetes - Uredinales, Basidiomycotina - Study of Teliomycetes – Ustilaginales and Gasteromycetes, Deuteromycotina – study of Hyphomycetes, Deuteromycotina – study of Hyphomycetes,Deuteromycotina – Study of Coelomycetes

Suggested Readings

Ainsworth G C, Sparrow F K & Susman H S. 1973. *The Fungi – An Advanced Treatise*. Vol. IV (A & B). Academic Press, New York.

Alexopoulos C J, Mims C W & Blackwell M.2000. *Introductory Mycology.* 5th Ed. John Wiley & Sons, New York.

Mehrotra R S & Arneja K R. 1990. *An Introductory Mycology*. Wiley Eastern, New Delhi.

Sarbhoy A K. 2000. *Text book of Mycology*. ICAR, New Delhi.

Singh R S. 1982. *Plant Pathogens – The Fungi*. Oxford & IBH, New Delhi.

Webster J. 1980. *Introduction to Fungi*. 2nd Ed. Cambridge Univ. Press, Cambridge, New York.

PL PATH 502 PLANT VIROLOGY 2+1

Objective

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

Theory

Unit I

- History of plant viruses-Introduction-historical background-contribution of different scientists to the development of science of virology-Mayer, Beijerinck, Baur, Ivanowski, Purdy, Stanley, Bawden and Pierie, Rawlins, Best, Ruska, Fukushi, Kunkel, Kausche et al., Williams & Wycoff, Markham & Smith, Hershey & Chase,Gierer & Schram, Fraenkel-Conrat, Caspar&Klug, Anderer et al., Wittaman, Nishimura Kassanis, Brakke, Takabe, Clarks & Adam, Kohler & Milstein, Dietzen &Sanderer, Teakle, Doi et al., Diener & Raymer, Shepherd et al., Harrison et al., Beale, Gratia

- Definition of virus- they are living /non living with evidence; how plant viruses differ from animal viruses broadly
- **Composition of plant viruses**
- Viral nucleic acid (ss /ds RNA, ss/ds DNA, negative /positive/ambisense , segmentation, circular/linear etc.,) and its genome size with examples, Proteins (structural and non-structural including glycoproteins, End group structures(Cap , VPg , PolyA tail and tRNA like structure), polyamines, lipids, metals and water
- **Virus Structure**

  Principles of basic virus structure (explain terms capsid and its formation, structural unit, subunits, nucleocapsid, virion, capsomers -Study of various shapes of viruses.

Unit II

- **Symptomatology**

  External symptoms (foliar, stem &root); Internal symptoms (Histological- necrosis, hypo- and hyperplasia; cytological effects- nuclei, mitochondria, chloroplasts); Virus induced structures in cytoplasm (pin-wheel &crystalline inclusions); effect of environment on symptoms.

- **Transmission, host virus interactions and virus-vector relationship**

- Mechanical transmission- vegetative, graft, dodder transmission with examples
- Seed and pollen transmission- plant virus groups transmitted through seed, factors affecting seed transmission, mechanism of seed transmission, localization of virus in seed, reasons for failure of seed transmission (Gemini viruses and others).
- Transmission of plant viruses by insects- explain terms of acquisition feeding period, latent period, inoculation feeding period, retention period, transmission threshold period; Virus –vector relationship- Non-persistent, semi-persistant, bimodal and persistant transmission (circulative with uptake route in vector ,and propagative type with evidence for multiplication) with examples.
- Transmission of plant viruses by aphids in non-persistant and persistant mode, mouth parts, Vector –virus relationship-molecular interactions-direct (AMV/CMV) and indirect (PAMV/PVY).
- Plant virus transmission by leaf and plant hoppers-kinds of virus-vector relationship;
- Transmission of viruses by thrips –life cycle and route of virus transmission;
- Transmission of viruses by whiteflies, mealy bugs, beetles, mites— their virus –vector relationship with examples for each.
- Plant virus transmission by fungi- groups of viruses transmitted by fungi, mechanism of virus acquisition and transmission by fungi.
- Plant virus transmission by Nematodes-Groups of viruses transmitted by nematodes-differences among these 2 groups-evidence for nematode transmission and mechanism with examples
- Chemical and physical properties of plant viruses, host virus interaction (R-gene, Avr-gene, recognition phenomena, hypersensitive response etc.,)

Unit III

- **Virus nomenclature and classification**

  Historical aspects of virus nomenclature (Jhonson, Jhonson and Hoggan, Smith, Holmes, Baltimore and ICTV);Descriptors used in virus Taxonomy (Virion properties, Genome organization and replication , antigenic and biological properties);Criteria demarcating different virus taxa (at order, family, genus and species level);-Outline diagram depicting classification of plant viruses (7^{th}/8^{th} report of ICTV)

- **Genome organization**

  Genome of typical RNA virus (TMV) and DNA virus (CaMV) and its coding strategies (transcription, translation, ORFs), Proteins /enzymes commonly encoded by plant viruses and their functions, sub genomic RNAs,

Unit IV

- **Replication and Movement of viruses**
- **Isolation and Purification of Viruses**

  Replication of Plant virus by taking TMV as an example

  Plant virus movement in plant system : long distance and short distance movement. Different movement strategies.

1. Choice of plant material (assay host, propagative host); 2. Extraction of virus in suitable buffer (buffers, pH, ionic strength, reducing agents, additives, enzymes and detergents etc.); 3. Clarification of virus in suitable solvents (chloroform, butanol etc.,); 4. Concentration of virus (Differential centrifugation /PEG/salt precipitation); 5. Final purification (Density gradient centrifugation-isopycnic, rate zonal &equilibrium) and 6. Dialysis and storage

- **Electron Microscopy**

  Preparation of samples (leaf dip), Negative staining (principle behind it), trapping with antiserum, observation under EM and particle size calculation.

- **Diagnostics-Protein based diagnostics**

  Explanation about antigen, antibody, antiserum, titre, epitope and paratope. ELISA and its variants (DAS, DAC), ISEM, Western blot (explain principle behind each techniques and advantages and disadvantages)

- **Nucleic Acid based diagnostics**

  Detection of viruses by nucleic acid hybridization, PCR, RT-PCR, multiplex-PCR (explain principle behind each techniques and advantages and disadvantages)

Unit V

- **Mycoviruses**- discovery, definition, genome properties, hypo virulence, mechanism of biological control

  Phytoplasma- structure, classification, diseases, symptoms and transmission

  Arbo- and baculoviruses- morphology, size, genome properties, diseases they cause in animals and in insects

  Satellite viruses- definition, genome properties, classification (ICTV), diseases they cause in plants

  Satellite RNAs- discovery, definition, genome properties, diseases they cause

Phages- discovery, structure of T2phage, classification and its importance

Viroids- définition, structure, réplication, classification, diseases, symptoms Transmission

Prions- discovery- structure- replication- diseases they cause-Principles of working Electron Microscope and ultra microtome

Evolution of viruses- Micro &macro evolution, sequence divergence/ convergence, modular evolution, evidence for virus evolution(sequence comparison and phylogenetic studies)

Unit VI

- **Origin of viruses**- viruses of pro and eukaryotes, viruses infecting photosynthetic eukaryotes below angiosperms (refer latest articles on this topic from website)

  Mechanism of resistance and Genetic engineering-a brief introduction to development of transgenics (gene gun/Agrobacterium mediated transformation), Protein based resistance (coat and movement protein, replicase &protease); Nucleic acid based protection (RNA mediated,, satellite mediated); detailed mechanism behind coat protein mediated and RNA mediated resistance.

- **Ecology and management of plant viruses**-Removal source of infection, production of virus free seed and vegetative stocks, Propagation and maintenance of virus free stocks, modified planting and harvesting procedure, control or avoidance of vectors, cross protection, Effect of environment on virus-vector –host relation (disease triangle)

Practical

Study of symptoms caused by plant viruses, Transmission of Plant Vruses Mechanical Transmission using local lesion host and systemic host, Seed Transmission, Insect transmission (non-persistent transmission by Aphids)**,** Assay of Plant Viruses using local lesion host, Physical properties of plant viruses (DEP, TIP), Purification of Plant Viruses(Purification protocol for TMV), Methods of raising antiserum to plant virus Raring of rabbit, injection, blood collection, separation of antiserum, testing antiserum titre Serological Tests Oucterlony double diffusion test, Serological tests ELISA (direct), Serological tests ELISA (indirect), Electron Microscopy Preparation of grids for virus observation (leaf dip and purified virus), Ultratomy – taking ultrathin sections of virus infected leaf material, PCR – Acquaintance and its use in plant virology

***** experiments that can spread throughout the semester as per the convenient

Suggested Readings

Bos L. 1964. *Symptoms of Virus Diseases in Plants*. Oxford & IBH., New Delhi.

Brunt AA, Krabtree K, Dallwitz MJ, Gibbs AJ & Watson L. 1995. *Virus of Plants: Descriptions and Lists from VIDE Database*. CABI, Wallington.

Gibbs A & 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.

PL PATH 503 PLANT BACTERIOLOGY 2+1

Objective

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

Theory

UNIT I

History and introduction to phytopathogenic procarya, viz., bacteria, MLOs, spiroplasmas and other fastidious procarya. Importance of phytopathogenic bacteria.

UNIT II

Evolution, classification and nomenclature of phytopathogenic procarya and important diseases caused by them.

UNIT III

Growth, nutrition requirements, reproduction, preservation of bacterial cultures and variability among phytopathogenic procarya.

UNIT IV

General biology of bacteriophages, L form bacteria, plasmids and bdellovibrios.

UNIT V

Procaryotic inhibitors and their mode of action against phytopathogenic bacteria.

UNIT VI

Survival and dissemination of phytopathogenic bacteria.

Practical

Isolation, purification, identification and host inoculation of phytopathogenic bacteria, staining methods, biochemical and serological, characterization, isolation of plasmid and use of antibacterial, chemicals/antibiotics. Isolation and purification of phytopathogenic bacteria Eg. *Xanthomonas citri* (or) any other, Host inoculation of Phytopathogenic bacteria – Confirmation of Koch's postulates, Staining Methods : Simple staining, Negative staining, Gram staining, Biochemical characterization : Extraction of total proteins and SDS-PAGE analysis, Serological characterization : Immunodiffusion, Immuno electrophoresis, ELISA , Isolation of plasmids – Isolation and Agarose Gel Electrophoresis, Antibacterial chemicals / Antibiotics : Evaluation of different antibiotics against bacteria by inhibition zone technique and spectrophotometric method, Study of symptoms of bacterial diseases of important crops * , Amplification of 16S rRNA by PCR and Agarose Gel Electrophoresis

Suggested Readings

Goto M. 1990. *Fundamentals of Plant Bacteriology*. Academic Press, New York.

Jayaraman J & Verma JP. 2002. *Fundamentals of Plant Bacteriology*. Kalyani Publ., Ludhiana.

Mount MS & Lacy GH. 1982. *Phytopathogenic Prokaryotes*. Vols. I, II. Academic Press, New York.

Verma JP, Varma A & Kumar D. (Eds). 1995. *Detection of Plant Pathogens and their Management*. Angkor Publ., New Delhi.

Verma JP. 1998. *The Bacteria*. Malhotra Publ. House, New Delhi.

PL PATH 504 PRINCIPLES OF PLANT PATHOLOGY 3+0

Objective

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

Theory

Unit-I

Introduction, concept of disease, importance of plant diseases, history (as included in the previous syllabus) and growth of plant pathology, Definitions: etiology, Pathogenicity, Pathogenesis, Inoculum, Inoculum potential, Pathotype, Primary inoculum, Secondary inoculum, Penetration, Infection, Incubation period. Disease development, Symptoms, Signs, Syndrome, Disease cycle, Infectious organism, Infectious disease, Types of parasitism, Virulence, predisposition, Susceptibility, Resistance, Hypersensitivity, Symptomless carrier, Biotype, Immunity, Disease triangle, Disease tetrahedron, Fungitoxic, Fungistatic Fungicidal, classification of plant diseases based on spread or occurrence, Symptoms, host and causal factors.

Unit-II

Pathogenesis – Growth, reproduction, kinds of inoculum, survival and dispersal of important plant pathogens by various agents, infection process – Pre-penetration, Penetration and Post penetration activities of pathogens, development inside host tissue, Role of environment, Effect of temperature, moisture, wind, light, soil pH, soil structure, herbicides, Air pollutants.Effect of host plant nutrition. Effects of pathogens on plant physiological functions : Effect on photosynthesis, translocation of water and nutrients, host plant respiration, permeability of cell membranes, transcription and translation, reproduction.

Unit-III

How pathogens attack plants : Mechanical forces, chemical weapons : Role of enzymes, toxins, growth regulators, Polysaccharides. Defense strategies : Pre-exisitng structural and biochemical defenses, Induced structural and biochemical changes, hypersensitive response, classes of R Gene proteins, Recognition of pathogen Avr proteins by the host – How do R and Avr gene products activate plant responses – Some examples, oxidative bursts, co function of two or more genes, Active oxygen species, lipoxygenases, disruption of cell membranes, PR-proteins, phenolic compounds, phytoalexins. Defense through plantibodies, SAR etc.

Unit-IV

Genetics of Resistance : Vertical and horizontal resistance, Mechanisms of genetic variation in fungi, bacteria, viruses, Apparent resistance, Gene for Gene concept, Pathogenecity genes in plant pathogens, genes involved in pathogenesis and virulence by pathogens, Signal transduction between pathogenecity genes and resistance genes.

Unit-V

DISEASE MANAGEMENT STRATEGIES:

Cultural methods, Avoidance of the pathogen, methods that exclude the pathogen from the host: Quarantines, Inspection, Eradication methods, Biological methods: Suppressive soils, Antagonistic Microorganism's, weeds, Physical Methods, Chemical methods, Disease control by immunizing or improving the resistance of host, Cross protection, SAR, Use of transgenic plants.

Suggested Readings

Agrios GN. 2005. *Plant Pathology*. 5th Ed. Academic Press, New York.

Heitefuss R & Williams PH. 1976. *Physiological Plant Pathology*. Springer Verlag, Berlin, New York.

Mehrotra RS & Aggarwal A. 2003. *Plant Pathology*. 2nd Ed. Oxford & IBH, New Delhi. Singh RS. 2002. *Introduction to Principles of Plant Pathology*. Oxford & IBH, New Delhi. Singh DP & Singh A. 2007. *Disease and Insect Resistance in Plants*. Oxford & IBH, New Delhi.

Upadhyay RK & Mukherjee KG. 1997. *Toxins in Plant Disease Development and Evolving Biotechnology*. Oxford & IBH, New Delhi.

PL PATH 505 DETECTION AND DIAGNOSIS OF PLANT DISEASES 0+2

Objective

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

Practical

UNIT I

Methods to prove Koch's postulates with biotroph and necrotroph pathogens, pure culture techniques, use of selective media to isolate pathogens.

UNIT II

Preservation of plant pathogens and disease specimens, use of haemocytometer, micrometer, centrifuge, pH meter, camera lucida.

UNIT III

Microscopic techniques and staining methods, phase contrast system, chromatography, use of electron microscope, spectrophotometer, ultracentrifuge and electrophoretic apparatus, disease diagnostics, serological and molecular techniques for detection of plant pathogens. Evaluation of fungicides, bactericides etc.; field experiments, data collection and preparation of references.

Suggested Readings

Baudoin ABAM, Hooper GR, Mathre DE & Carroll RB. 1990. *Laboratory Exercises in Plant Pathology: An Instructional Kit*. Scientific Publ., Jodhpur.

Dhingra OD & Sinclair JB. 1986. *Basic Plant Pathology Methods*. CRC Press, London, Tokyo.

Fox RTV. 1993. *Principles of Diagnostic Techniques in Plant Pathology*. CABI Wallington.

Mathews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Boca Raton, Tokyo.

Pathak VN. 1984. *Laboratory Manual of Plant Pathology*. Oxford & IBH, New Delhi.

Forster D & Taylor SC. 1998. *Plant Virology Protocols: From Virus Isolation to Transgenic Resistance*. *Methods in Molecular Biology*. Humana Press, ttowa, New Jersey.

Matthews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Florida.

Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Cent. Agic. Pub. Doc. Wageningen.

Trigiano RN, Windham MT & Windham AS. 2004. *Plant Pathology- Concepts and Laboratory Exercises*. CRC Press, Florida.

Chakravarti BP. 2005. *Methods of Bacterial Plant Pathology*. Agrotech, Udaipur.

PL PATH 506 PRINCIPLES OF PLANT DISEASE MANAGEMENT 2+1

Objectives

To acquaint with different strategies for management of plant diseases.

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

Foliage, seed and soil application of chemicals, role of stickers, spreaders and other adjuvants, health vis-a-vis environmental hazards, residual effects and safety measures.

UNIT III

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.

Practical

In vitro and *in vivo* evaluation of chemicals against plant pathogens; ED and MIC values, study of structural details of sprayers and dusters.

Suggested Readings

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 & 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.

PL PATH 507 DISEASES OF FIELD AND MEDICINAL CROPS 2+1

Objective

To educate about the nature, prevalence, etiology, factors affecting disease development and control measures of field and medicinal crop diseases.

Theory

UNIT I

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

UNIT II

Diseases of Pulse crops- gram, urdbean, mungbean, lentil, pigeonpea, soybean.

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, cowpea.

UNIT VI

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

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 Readings

Joshi LM, Singh DV & 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 & Hughes CG. 1989. *Diseases of Sugarcane, Major Diseases*. Academic Press, New York.

Singh RS. 1998. *Plant Diseases*. 7th Ed. Oxford & IBH, New Delhi.

Singh US, Mukhopadhyay AN, Kumar J & Chaube HS. 1992. *Plant Diseases of Internatiobnal Importance*. Vol. I. *Diseases of Cereals and Pulses*. Prentice Hall, Englewood Cliffs, New Jersey.

PL PATH 508 DISEASES OF FRUITS, PLANTATION AND ORNAMENTAL CROPS 2+1

Objective

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

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, banana, pineapple, papaya, fig, pomegranate, date palm and management of the fruits diseases.

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, orchids, marigold, chrysanthemum and their management.

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.

Suggested Readings

Gupta V K & Sharma S K. 2000. *Diseases of Fruit Crops*. Kalyani Publ., New Delhi.

Pathak V N. 1980. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.

Singh R S. 2000. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.

Walker J C. 2004. *Diseases of Vegetable Crops*. TTPP, India.

PL PATH 509 DISEASES OF VEGETABLE AND SPICES CROPS 2+1

Objective

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

Theory

UNIT I

Nature, prevalence, factors affecting disease development of bulb, leafy vegetables, crucifers, cucurbits and solanaceaous vegetables. Diseases under protected cultivation.

UNIT II

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

UNIT III

Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, saffron, cumin, coriander, turmeric, fennel, fenugreek and ginger.

Practical

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

Suggested Readings

Chaube HS, Singh US, Mukhopadhyay AN & Kumar J. 1992. *Plant Diseases of International Importance*. Vol. II. *Diseases of Vegetable and Oilseed Crops*. Prentice Hall, Englewood Cliffs, New Jersey.

Gupta VK & Paul YS. 2001. *Diseases of Vegetable Crops*. Kalyani Publ., New Delhi

Sherf AF & Mcnab AA. 1986. *Vegetable Diseases and their Control*.

Wiley InterScience, Columbia.

Singh RS. 1999. *Diseases of Vegetable Crops*. Oxford & IBH, New Delhi.

Gupta SK & Thind TS. 2006. *Disease Problem in Vegetable Production*. Scientific Publ., Jodhpur.

Walker JC. 1952. *Diseases of Vegetable Crops*. McGraw-Hill, New York.

PL PATH 510 SEED HEALTH TECHNOLOGY 2+1

Objective

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

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 pathogen/diseases and procedure for healthy seed production, seed health testing, methods for detecting microorganism.

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.

Suggested Readings

Agarwal VK & JB Sinclair. 1993. *Principles of Seed Pathology*. Vols. I & II, CBS Publ., New Delhi.

Hutchins JD & Reeves JE. (Eds.). 1997. *Seed Health Testing: Progress Towards the 21st Century*. CABI, Wallington.

Paul Neergaard. 1988. *Seed Pathology*. MacMillan, London.

Suryanarayana D. 1978. *Seed Pathology*. Vikash Publ., New Delhi.

PL PATH 511 CHEMICALS IN PLANT DISEASE MANAGEMENT 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

Chemicals in plant disease control, viz., fungicides, bactericides, nematicides, antiviral chemicals and botanicals.

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.

UNIT VI

General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

Practical

Acquaintance with formulation of different fungicides and plant protection appliances. Formulation of fungicides, Bactericides and nematicides; *in vitro* evaluation techniques, Preparation of different concentrations of chemicals including botanical pesticides based on active ingredients against pathogens; Persistence, Compatibility with other agro-chemicals; Detection of naturally occurring fungicide resistant mutants of pathogen; Methods of application of chemicals.

Suggested Readings

Bindra OS & Singh H. 1977. *Pesticides - An Application Equipment*. Oxford & IBH, New Delhi.

Nene YL & Thapliyal PN. 1993. *Fungicides in Plant Disease Control.* 3rd Ed. 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.

PL PATH 512 ECOLOGY OF SOIL-BORNE PLANT PATHOGENS 2+1

Objective

To provide knowledge on soil-plant disease relationship.

Theory

UNIT I

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

UNIT II

Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis.

UNIT III

Suppressive soils, biological control- concepts and potentialities for managing soil borne pathogens.

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.

Suggested Readings

Baker KF & Snyder WC. 1965. *Ecology of Soil-borne Plant Pathogens*. John Wiley, New York.

Cook RJ & 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 & Waller JM. 1997. *Soil-borne Diseases of Tropical Crops*. CABI, Wallington.

Parker CA, Rovira AD, Moore KJ & Wong PTN. (Eds). 1983. *Ecology and Management of Soil-borne Plant Pathogens*. APS, St. Paul, Minnesota.

PL PATH 513 DISEASE RESISTANCE IN PLANTS 2+0

Objective

To acquaint with disease resistance mechanisms in plants.

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 terminology.

UNIT II

Disease escape, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

UNIT III

Host defence system, morphological and anatomical resistance, preformed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms.

UNIT IV

Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

Suggested Readings

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 Publ., 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.

PL PATH 514/ ENT 514 **INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS** **1+1**

Objective

To teach the students about the different groups of insects that vector plant pathogens, vector-plant pathogen interaction, management of vectors for controlling diseases.

Theory

UNIT I

History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.

UNIT II

Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.

UNIT III

Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.

UNIT IV

Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.

UNIT V

Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

Practical

Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, Nematodes; Culturing and handling of vectors; Demonstration of virus transmission through vectors- aphids, Leafhoppers and whiteflies.

Suggested Readings

Basu AN. 1995. *Bemisia tabaci (*Gennadius*) - Crop Pest and Principal Whitefly Vector of Plant Viruses.* Oxford & IBH, New Delhi.

Harris KF & Maramarosh K. (Eds.).1980. *Vectors of Plant Pathogens*. Academic Press, London.

Maramorosch K & Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.

Youdeovei A & Service MW. 1983. *Pest and Vector Management in the Tropics*. English Language Books Series, Longman, London.

PL PATH 515 Biological control of plant diseases (2+1)

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

Theory

UNIT I

Concept of biological control, Definitions of Garret (1965), Baker and Cook (1974) and Cook (1987), Importance of biological control in managing soil borne plant pathogens, foliar pathogens, post harvest diseases and role of biocontrol agents in plant growth promotion and induction of resistance in plants. History of biological control – Weindling, Garret, K F Baker, R Cook, Elad, Chet, A N Mukhopadhyay, B L Jalali, Bineeta Sen, K G Mukherjee, Gnanamanickam, R D Prasad. Merits and demerits of biological control of plant pathogens.

UNIT II

Types of biological interactions – neutral, mutual and antagonistic, Antagonistic interactions – Competition - Meaning of Competitive Saprophytic Ability (CSA), qualities of microorganism for high CSA Mycoparasitism – steps in mycoparasitism, enzymes involved in mycoparasitism Hypovirulence – principle and exploitation as a biocontrol tool Rhizosphere colonization – rhizosphere, rhizoplane, exudates of plant roots, rhizosphere effect, beneficial rhizosphere colonizing microbes and Plant growth promotion. Antibiosis – principle, role of antibiosis in biological control of plant pathogens, Agrocin, antibiotics produced by *Trichoderma, Bacillus subtilis, Pseudomonas fluorescens*. Siderophores and their involvement in antibiosis. Induced resistance – concepts of ISR and SAR Mycorrhizae and their involvement in biological control

UNIT III

Factors governing biological control, Role of physical environment – soil moisture, pH, temperature etc., Role of agroecosystem – host – pathogen – antagonist interactions, root exudates, carbon sources on the plant surface, microbial interactions on spermosphere, rhizosphere and phyllosphere in relation to pathogen and antagonist survival and proliferation., Cultural practices – soil solarization, deep summer ploughing, organic and

inorganic amendments, flood fallow / fallow, crop rotation, green manure crops, irrigation practices, Biological control agents, Approaches to biological control – inundative and augmentative, Comparison between biocontrol of plant pathogens using resident and introduced antagonists., Important soil borne and foliar plant pathogens and biocontrol agents used against them. Biological control of post harvest plant diseases.Compatibility of different Bioagents and microbial consortia in biological control

UNIT IV

Commercialization of antagonists.Mass production, Delivery systems and formulations, Monitoring efficacy and population of applied biocontrol agents, Biopesticides (Registered) available in the market for the management of plant diseases, Quality control system of biocontrol formulations, Role of biological control as a componenet in IDM, IPM and organic farming.

Practical

Isolation of rhizosphere and phyllosphere microorganisms of biocontrol potential, Characterization of isolated biocontrol agents based on cultural and morphological features, *In vitro* assay of antagonistic efficacy of isolated BCA against soil borne plant pathogens – dual culture plate technique, *In vitro* assay of antagonistic efficacy of isolated BCA against soil borne plant pathogens – diffusible non volatile metabolites, *In vitro* assay of antagonistic efficacy of isolated BCA against soil borne plant pathogens – volatile metabolites – determination of HCN producing ability of BCA, *In vitro* assay of antagonistic efficacy of isolated BCA against soil borne plant pathogens – mycoparasitism, *In vitro* evaluation of compatibility of fungicides with BCA, Mass multiplication techniques for BCA and formulations, Seed bacterization and biopriming with BCA, *In vivo* evaluation of BCA on soil borne disease, Visit to biocontrol labs and production units

Suggested Readings

Campbell R. 1989. *Biological Control of Microbial Plant Pathogens*. Cambridge Univ. Press, Cambridge.

Cook RJ & Baker KF. 1983. *Nature and Practice of Biological Control of Plant Pathogens*. APS, St. Paul, Mennisota.

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 & Hokkanen James M (Eds.). 1996. *Biological Control - Benefits and Risks*. Cambridge Univ. Press, Cambridge.

Mukerji KG, Tewari JP, Arora DK & Saxena G. 1992. *Recent Developments in Biocontrol of Plant Diseases*. Aditya Books, New Delhi.

PL PATH 516 INTEGRATED DISEASE MANAGEMENT 2+1

Objective

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

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, rapeseedmustard, pearlmillet, *kharif* pulses, vegetable crops and fruit crops.

Practical

Application of biological, cultural, chemical and biocontrol agents, Their compatibility and integration in IDM; Demonstration of IDM in certain crops as project work.

Suggested Readings

Gupta VK & Sharma RC. (Eds). 1995. *Integrated Disease Management and Plant Health*. Scientific Publ., Jodhpur.

Mayee CD, Manoharachary C, Tilak KVBR, Mukadam DS & Deshpande Jayashree (Eds.). 2004. *Biotechnological Approaches for the Integrated Management of Crop Diseases*. Daya Publ. House, New Delhi.

Sharma RC & Sharma JN. (Eds). 1995. *Integrated Plant Disease Management*. Scientific Publ., Jodhpur.

PL PATH 517 MUSHROOM PRODUCTION TECHNOLOGY 2+1

Objective

To develop mushroom cultivation skills for entrepreneurial activity. Historical development of mushroom cultivation and present status of mushroom industry in India.

Theory

UNIT I

Historical development of mushroom cultivation and present status, taxonomy, classification, food, medicinal value, uses of mushroom, edible and poisonous mushrooms.

UNIT II

Life cycle of cultivated mushrooms, reproduction and strain improvement, maintenance of pure culture, preparation of spawn and facilities required for establishing commercial spawn lab.

UNIT III

Preparation of substrate for mushroom cultivation, long, short and indoor composting methods, formulae for different composts and their computation, qualities and testing of compost, uses of spent mushroom compost/substrate.

UNIT IV

Facilities for setting up mushroom farm for seasonal and environmentally control cultivation, requirement and maintenance of temperature, relative humidity, CO2, ventilation in cropping rooms, cultivation technology of *Agaricus bisporus, Pleurotus* sp.*, Calocybe indica, Lentinus edodes* and *Ganoderma lucidum.*

UNIT V

Insect pests, diseases and abnormalities of cultivated mushroom and their management, post harvest processing and value addition, economics of mushroom cultivation, biotechnology and mushroom cultivation.

Practical

Preparation of spawn, Compost, Spawning, Casing, Harvesting and postharvest handling of edible mushroom; Identification of various pathogens, Competitors of various mushroom.

Suggested Readings

Chadha KL & Sharma SR. 2001. *Advances in Horticulture* (*Mushroom*). Vol. XIII. Malhotra Publ. House, New Delhi.

Chang ST & Hays WA. 1997. *The Biology and Cultivation of Edible Mushrooms*. Academic Press, New York.

Chang ST & Miles PG. 2002. *Edible Mushrooms and their Cultivation*. CRC Press, Florida.

Kapur JN. 1989. *Mushroom Cultivation*. DIPA, ICAR, New Delhi.

Dhar BL. 2005. *Cultivation Technology of High Temperature Tolerant White Button Mushroom*. DIPA, ICAR, New Delhi.

PL PATH 518 EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES 2+1

Objective

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

Theory

UNIT I

Epidemic concept and historical development, pathometry and crop growth stages, epidemic growth and analysis.

UNIT II

Common and natural logarithms, function fitting area under disease progress curve and correction factors, inoculum dynamics, population biology of pathogens, temporal spatial variability in plant pathogens.

UNIT III

Survey, surveillance and vigilance, crop loss assessment and models.

UNIT IV

Principles and pre-requisites of forecasting, systems and factors affecting various components of forecastings, some early forecasting, procedures based on weather and inoculum potential, modeling disease growth and disease prediction.

Practical

Measuring diseases, Spore dispersal and trapping, Weather recording, Survey, Multiplication of inoculum, Computerized data analysis, Function fitting, Model preparation and validation.

Suggested Readings

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

Cowling EB & Horsefall JG. 1978. *Plant Disease*. Vol. II. Academic Press, New York.

Laurence VM, Gareth H & Frame Van den Bosch (Eds.). *The Study of Plant Disease Epidemics*. APS, St. Paul, Minnesota.

Nagarajan S & 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 & Schein RD. 1979. *Epidemiology and Plant Disease Management*. Oxford Univ. Press, London.

PL PATH 519 POST HARVEST DISEASES 2+1

Objective

To acquaint with post harvest diseases of agricultural produce and their ecofriendly management.

Theory

UNIT I

Concept of post harvest diseases, definitions, importance with reference to environment and health, principles of plant disease management as preharvest and post-harvest, merits and demerits of biological/phytoextracts in controlling post-harvest diseases.

UNIT II

Types of post harvest problems both by biotic and abiotic causes, rhizosphere colonization, competitive, saprophytic ability, antibiosis, induced resistance, microbial associations, concept, operational mechanisms and its relevance in control.

UNIT III

Factors governing post harvest problems both as biotic and abiotic, role of physical environment, agro-ecocystem 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. Isolation, characterization and maintenance of pathogens, role of different storage.

UNIT IV

Integrated approach in controlling diseases and improving the shelf life of produce, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for any health hazard, knowledge of Codex Alimentarious for each product and commodity.

Practical

Isolation characterization and maintenance of pathogens, role of different storage conditions on disease development, application of antagonists against pathogens *in vivo* and *in vitro* conditions. Comparative efficacy of different chemicals, fungicides, phytoextracts and bioagents.

Suggested Readings

Pathak VN. 1970. *Diseases of Fruit Crops and their Control*. IBH Publ., New Delhi.

Chaddha KL & Pareek OP. 1992. *Advances in Horticulture* Vol. IV, Malhotra Publ. House, New Delhi.

PL PATH 520/ ENT 520 **PLANT QUARANTINE** **2+0**

Objective

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.

Theory

UNIT I

Definition of pest, pesticides and transgenics as per Govt. notification; 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

Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, 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.

Suggested Readings

Rajeev K & 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.

PL PATH 601 **ADVANCED MYCOLOGY** **2+1**

Objective

To acquaint with the latest advances in Mycology.

Theory

UNIT I

General introduction, historical development and advances in mycology.

UNIT II

Recent taxonomic criteria, morphological criteria for classification. Serological, Chemical
(chemotaxonomy), Molecular and Numerical (Computer based assessment) taxonomy.

UNIT III

Interaction between groups: Phylogeny. Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti. Morphology and reproduction of representative plant pathogenic genera from different groups of fungi. Sexual reproduction in different groups of fungi.

UNIT IV

Population biology, pathogenic variability/vegetative compatibility.

UNIT V

Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra-nuclear inheritance. Biodegradation.

Practical

Study of conidiogenesis- phialides, porospores, arthroospores. 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.

Suggested Readings

Alexopoulos CJ, Mimms CW & 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 & Stalpers JA. (Eds.). 2001. *Ainswsorth and Bisby's Dictionary of Fungi.* 9th Ed., CABI, Wallington.

Ulloa M & Hanlin RT. 2000. *Illustrated Dictionary of Mycology*. APS, St. Paul, Mennisota.

Webster J & Weber R. 2007. *Introduction to Fungi*. Cambridge Univ. Press, Cambridge.

PL PATH 602 ADVANCED VIROLOGY 2+1

Objective

To educate about the advanced techniques and new developments in the field of Plant Virology.

Theory

UNIT I

Mechanism of virus transmission by vectors, virus-vector relationship, bimodal transmission and taxonomy of vectors and viruses, vector specificity for classes of viruses, virus replication, assembly and architecture, ultrastructural changes due to virus infection, variation, mutation and virus strains.

UNIT II

Immunoglobulin structure and functions of various domains, methods of immunodiagnosis, hybridoma technology and use of monoclonal antibodies in identification of viruses and their strains, Polymerase Chain Reaction.

UNIT III

Genome organization, replication, transcription and translational strategies of pararetroviruses and gemini viruses, satellite viruses and satellite RNA genome organization in tobamo-, poty, bromo, cucummo, ilar and tospoviruses.

UNIT IV

Gene expression and regulation, viral promoters, molecular mechanism of host virus interactions, virus induced gene, molecular mechanism of vector transmission, symptom expression, viroids and prions.

UNIT V

Genetic engineering with plant viruses, viral suppressors, a RNAi dynamics, resistant genes. Viruses potential as vectors, genetically engineered resistance, transgenic plants.

UNIT VI

Techniques and application of tissue culture. Origin, evolution and interrelationship with animal viruses.

Practical

Purification of virus(es), SDS-PAGE for molecular weight determination, Production of polyclonal antiserum, Purification of IgG and conjugate preparation, Serological techniques (i) DAC-ELISA (ii) DAS -ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA, Vector transmission (one each with aphid, leaf hopper and whitefly), Methods for collecting vectors and their maintenance, Nucleic acid isolation, DOT-blot, southern hybridization, Probe preparation and autoradiography, PCR application and viral genome cloning, Sequencing annotation of genes.

Suggested Readings

Davies 1997. *Molecular Plant Virology: Replication and Gene Expression*. CRC Press, Florida. Fauquet *et al*. 2005. *Vius Taxonomy*. VIII Report of ICTV. Academic Press, New York.

Gibbs A & Harrison B. 1976. *Plant Virology - The Principles.* Edward Arnold, London.

Jones P, Jones PG & Sutton JM. 1997. *Plant Molecular Biology: Essential Techniques*. John Wiley & Sons, New York.

Khan JA & Dijkstra. 2002. *Plant Viruses as Molecular Pathogens*. Howarth Press, New York.

Maramorosch K, Murphy FA & Shatkin AJ. 1996. *Advances in Virus Research*. Vol. 46. Academic Press, New York.

Pirone TP & 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. *Plant Virus Epidemiology.* Advances in Virus Research Academic Press, New York.

PL PATH 603 ADVANCED BACTERIOLOGY 2+1

Objective

To provide knowledge about the latest advances in phytobacteriology.

Theory

UNIT I

Current approaches for the characterization and identification of phytopathogenic bacteria. Ultrastructures and biology of bacteria.

UNIT II

Current trends in taxonomy of phytopathogenic procarya.

UNIT III

Role of enzyme, toxin, expolysaccharide, polypeptide signals in disease development. Mechanism of wilt (*Ralstonia solanacearum*) development, mechanism of soft rot (*Erwinia* spp.) development, mechanism of Crown gall formation (*Agrobacterium tumifaciens*).

UNIT IV

Host-bacterial pathogen interaction, quorum-sensing phenomenon, Type III secretion system, HR/SR reactions, R-genes, Avr-genes, hrp genes, Effector protein.

UNIT V

Molecular variability among phytopathogenic prokayotoes and possible host defense mechanism(s). Genetic engineering for management of bacterial plant pasthogens-gene silencing, RNAi technology.

UNIT VI

Epidemiology in relation to bacterial plant pathogens. Development of diagnostic kit.

UNIT VII

Beneficial prokaryotes- Endophytes, PGPR, phylloplane bacteria and their role in disease management. Endosymbionts for host defence.

Practical

Pathogenic studies and race identification; Plasmid profiling of bacteria; Fatty acid profiling of bacteria; RAPD prolfiling 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.

Suggested Readings

Dale JW & Simon P. 2004. *Molecular Genetics of Bacteria*. John Wiley & Sons, New York.

Garrity GM, Krieg NR & 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 & 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.

PL PATH 604 MOLECULAR BASIS OF HOST-PATHOGEN INTERACTION 2+1

Objective

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

Theory

UNIT I

Importance and role of biotechnological tools in Plant Pathology- Basic concepts and principles to study host pathogen relationship.

UNIT II

Molecular basis of host-pathogen interaction- fungi, bacteria and viruses; recognition system, signal transduction.

UNIT III

Induction of defense responses- pathogenesis related proteins, HR, reactiveoxygen species, phytoalexins and systemic acquired resistance, Programmed Cell Death, Viral induced gene silencing.

UNIT IV

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.

UNIT V

Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

Practical

Protein, DNA and RNA isolation, Plasmids extraction,PCR analysis, DNA and Protein electrophoresis, bacterial transformation.

Suggested Readings

Chet I. 1993. *Biotechnology in Plant Disease Control*. John Wiley & Sons, New York.

Gurr SJ, Mc Pohersen MJ & 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 & Keen TN. (Eds.). 1996. *Plant Microbe Interactions*. Vols. I-III.

Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.

Practical

Isolation and SDS-PAGE analysis of proteins from pathogen infected (Stress) and non-infected plant (Non-stress), Isolation and quantification of Nucleic Acids by Spectrophotometric method and Agarose gel electrophoresis, Isolation of genomic DNA from Bacteria and Agarose gel electrophoresis, Isolation of plasmid from Bacteria, RAPD analysis of plant pathogens like fungi and Bacteria, RAPD analysis of disease resistant plants Vs susceptible plants. (In any crop based on the availability), ITS-PCR analysis of different isolates of fungi, 16s rDNA analysis of Bacterial population Amplification with specific primers, Preparation of competent cells, Cloning of amplified 16s rDNA into plasmid vector, Transformation into Bacteria: Confirmation by

restriction digestion and PCR, Sequencing - Comparing the sequence data by using the suitable software programme

Suggested Readings

Chet I. 1993. *Biotechnology in Plant Disease Control*. John Wiley & Sons, New York.

Gurr SJ, Mc Pohersen MJ & 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 & Keen TN. (Eds.). 1996. *Plant Microbe Interactions*. Vols. I-III.

Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota

PL PATH 605 PRINCIPLES AND PROCEDURES OF CERTIFICATION 1+0

Objective

To acquaint with certification procedures of seed and planting material.

Theory

UNIT I

Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD etc. in certification and quality control.

UNIT II

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.

UNIT III

Fixing tolerance limits for diseases and insect pests in certification and quality control programmes. 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.

Suggested Readings

Association of Official Seed Certifying

Agencies.http://www.aosca.org/index.htm.

Hutchins D & Reeves JE. (Eds.). 1997. *Seed Health Testing: Progress Towards the 21st Century*. CABI, UK.

ISHI-v*eg Manual of Seed Health Testing Methods.*

http://www.worldseed.org/enus/

international_seed/ishi_vegetable.html

ISHI-F *Manual of Seed Health Testing Methods*.

http://www.worldseed.org/en-us/international_seed/ishi_f.html

ISTA *Seed Health Testing Methods*. http://www.seedtest.org/en/content—1—1132—241.html

Tunwar NS & 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. http://www.seedhealth.org/

PL PATH 606 PLANT BIOSECURITY AND BIOSAFETY 2+0

Objective

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

Theory

UNIT I

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

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.

Suggested Readings

FAO Biosecurity Toolkit 2008.

www.fao.org/docrep/010/a1140e/a1140e00.htm

Laboratory Biosecurity Guidance.

http://www.who.int/csr/resources/publications/biosafety/WHO_CD S_EPR_2006.pdf

Grotto Andrew J & Jonathan B Tucker. 2006. *Biosecurity: A* Comprehensive Action Plan.

http://www.americanprogress.org/kf/biosecurity_a_comprehensive_ action_plan.pdf

Biosecurity Australia.

www.daff.gov.au/ba;www.affa.gov.au/biosecurityaustralia

Biosecurity New Zealand. www.biosecurity.govt.nz DEFRA.

www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm

Randhawa GJ, Khetarpal RK, Tyagi RK & Dhillon. BS (Eds.). 2001.

Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.

Khetarpal RK & Kavita Gupta 2006. *Plant Biosecurity in India - Status and Strategy*. Asian Biotechnology and Development Review 9(2): 39-Biosecurity for Agriculture and Food Production. http://www.fao.org/biosecurity/

CFIA.http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.sht ml

List of Journals

Annals of Applied Biology – Cambridge University Press, London

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

I*ndian 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 Virology - Indian Virological Society, New Delhi

Indian Phytopathology - Indian Phytopathological Society, New Delhi

Journal of Mycology and Plant Pathology - Society of Mycology and Plant Pathology, Udaipur

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.

Review of Plant Pathology - CAB International, Wallingford

Virology- New York Academic Press

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www.apsnet.org/journals

www.cabi_publishing.org

www.springer.com/life+Sci/agriculture

www.backwellpublishing.com

www.csiro.au

www.annual-reviews.org

Suggested Broad Topics for Master's and Doctoral Research

Pathogenesis and characterization of plant pathogens

Survey and surveillance

Induction of resistance using biotic and abiotic elicitors

Variability in plant pathogens
Plant-Virus-Vector relationships
Genome organization of plant pathogens
Dynamics of plant pathogen propagules and their biology
Molecular tools in disease diagnosis
Molecular mechanisms of pathogenesis in crops and seeds
Rhizosphere in pathogenesis of seed-borne plant pathogens
Transgenic resistance
Development of disease prediction models in disease forecasting
Integrated Disease Management
Molecular Taxonomy of different plant pathogens
Development of Rapid Diagnostic methods
Development and Formulation of Improved Biocontrol Agent