DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-14): Immunological Concepts and Applications in Plant Science

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Immunological Concepts and Applications in Plant Science DSE-14	**4**	**2**	**0**	**2**	Semester VII	Nil

Learning Objectives:

- Comprehend innate and induced plant immune responses. Recognize major plant pathogens—fungi, bacteria, viruses, and nematodes—and study their interactions with host defense systems.
- Examine the molecular and physiological basis of plant-microbe interactions and the dynamic strategies used by both.
- Utilize immunological tools and diagnostics for plant disease management, including detection and characterization of plant pathogens.
- Apply knowledge of plant immunology to develop eco-friendly, sustainable control strategies using beneficial microbes and natural compounds.
- Understand and apply plant immune principles for breeding disease-resistant crops and enhancing plant health.
- Design and conduct laboratory experiments to investigate plant immune responses and assess disease control strategies.

Learning Outcomes:

At the end of this course students will be able to:

- Describe the fundamental principles of plant immunity, including innate and induced defense mechanisms.
- Analyze interactions between plants and pathogens at the molecular and cellular levels.
- Apply immunological methods for diagnosing and managing plant diseases effectively.
- Identify major types of plant pathogens—fungi, bacteria, viruses, and nematodes—and their disease strategies.

- Explain the concept of ISR and its role in enhancing plant defense against diverse pathogens.
- Outline key signaling pathways involved in plant defense, such as MAPK cascades and calcium signaling.
- Integrate knowledge of plant immunity to design eco-friendly and sustainable disease control measures.
- Evaluate the use of plant immunity in breeding disease-resistant crops and applying beneficial microbes or natural products.

Unit 1: (i) Introduction to Immunological Concepts: 10 hours

Basic concepts of immunology, Innate and Acquired (Adaptive) immunity, Human Immune system, Humoral (antibody-mediated) and cellular (cell-mediated) Immunity, Concepts of antigen, epitope, hapten, valence, antibodies (immunoglobulins)- structure, types (IgG, IgM, IgA, IgD, and IgE) and functions, antigen-antibody reaction, antisera and vaccines. Immune system in plants, Comparison between the plant and animal immune system.

(ii) Plant Immunity:

Plant pathogens and pests (viruses, bacteria, fungi, insects, mites and nematodes), Plant-pathogen interactions; Compatible interactions (parasite virulence and host plant susceptibility), Incompatible interactions (parasite avirulence and host plant resistance), non-host and host - resistance, Horizontal and vertical resistance, concept of host range, coevolution of plant defence and pathogen attack mechanisms: the Zigzag Model.

Unit 2: Components of Plant Immunity: 10 hours

(i) Innate Immunity/ Resistance

- **Non-specific or Basal Resistance: Passive (Constitutive defenses**) including pre-existing mechanical defences (cuticle, waxes, lignified cell wall, bark, trichomes, thorns); pre-existing biochemical defences (alkaloids, phenolic compounds, terpenoids, nutrient deprivation, phytoanticipins); **Active (Inducible Defences):** Pathogen-associated molecular patterns (PAMPs), pattern-recognition receptors (PRRs), PAMP-triggered Immunity (PTI). Popular Models of PTI in plants- Flagellin-induced Resistance, Elongation Factor (Ef-tu)-induced Basal Resistance.
- **Pathogen Race-specific resistance:** Molecular Models of specific Host-pathogen Recognition, gene-for-gene or receptor-ligand model (Flor's Model), Pathogen effectors, Intracellular nucleotide-binding leucine-rich repeat receptors (NLRs), Plant Resistance (R) genes, Avirulence (Avr) proteins/ Effectors, Effector-triggered susceptibility (ETS), Effector-triggered immunity (ETI), Hypersensitive response.

(ii) Acquired Resistance : Systemic Acquired Resistance (SAR), Induced Systemic Resistance (ISR)

Unit 3: Signal Transduction Pathways activated during Plant resistance: 5 hours

- Phytohormone signaling: salicylic acid, jasmonic acid, ethylene
- Calcium signaling: Calmodulin (CaM), Calcineurin B-like proteins (CBLs) in *Arabidopsis*
- Mitogen-activated protein kinase (MAPK) Cascades
- The Oxidative burst (ROS)
- Major transcription factor families in plant immunity (WRKY, NAC, MYB, bZIP)

Unit 4: Applications of immunology in Plant Science: 5 hours

Development of disease-resistant crops, enhanced nutrient uptake, engineering enhanced resistance in crops via gene editing (e.g., CRISPR-Cas9), developing novel biopesticides/ biocontrol agents based on induced systemic resistance (ISR), genetic engineering strategies for broad-spectrum resistance by Pseudo-Response Regulator (PRR) and chimeric PRR transgenes. RNAi based antiviral resistance (siRNA).

PRACTICALS 60 hours

1. To study the structure of antibody (diagrammatic and crystal structure) digitally.

2. Study of diseased plants and identification of its causal pathogen based on visually observed symptoms (Viral, bacterial, Fungal - one disease each)

3. Analysis and interpretation of digitally represented zig-zag model

4. Analysis and Interpretation of Western blots

5.Understanding the concept of immunoprecipitation by performing immunodiffusion.

6. To study the antigen-antibody reaction by ABO blood group system and Rh factor

7. Study and applications of immunological techniques: ELISA, Immunodiffusion, Radioimmunoassay.

Suggested Readings:

- Dhia Bouktila and Yosra Habachi (2021) *An Introduction to Plant Immunity*: Bentham Science Publishers, Sharjah, UAE.
- Iakovidis, M., Chung, E. H., Saile, S. C., Sauberzweig, E., & El Kasmi, F. (2023). *The emerging frontier of plant immunity's core hubs. The FEBS journal, 290(13), 3311–3335. https://doi.org/10.1111/febs.16549*
- Prescott, L.M., Harley J.P., Klein D. A. (2005). *Microbiology*, 6th edition: McGraw Hill, New Delhi.

Additional Reading:

Agrios, G.S. (2005) Plant Pathology 5th Edition: Elsewhere Academic Press, Amsterdam.