

UTTARANCHAL UNIVERSITY

(Established vide Uttaranchal University Act, 2012)

(Uttarakhand Act No. 11 of 2013)

Arcadia Grant, P.O. Chandanwari, Premnagar, Dehradun, Uttarakhand

Detailed Syllabus of Ph.D. in different disciplines of Agriculture

- **Ph.D. Agronomy**
- **Ph.D. (Forestry) Silviculture and Agroforestry**
- **Ph.D. (Horticulture) Vegetable Science**
- **Ph.D. (Horticulture) Fruit Science**
- **Ph.D. Entomology**
- **Ph.D. Plant Pathology**
- **Ph.D. Genetics and Plant Breeding**

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Detailed Syllabus of Ph.D. in Agronomy

Major courses (Gradual courses)

Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C601	Credit	3(3+0)
Year/Sem	1/I	L-T-P	3-0-0
Course Name	Current Trends in Agronomy	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To acquaint with the recent advances in agricultural production.2. To impart detailed knowledge of the physiology of various crops in diversified environments.3. To compare the new technology with traditional cultivation practices.4. To understand the current worldwide food requirements.5. To impart the knowledge of sustainable agriculture.6. To develop the knowledge of GIS, GPS, seed certification and GM crops.			
UNIT I (Total Topics - 3 and Hrs -3) Agro-physiological basis of variation in yield, recent advances in soil plant-water relationship.			
UNIT II (Total Topics - 4 and Hrs -5) Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming			
UNIT- III (Total Topics - 5 and Hrs -7) Crop residue management in multiple cropping systems; latest developments in plant management Mechanization in crop production: modern agricultural precision tools and technologies, weed management, cropping systems, grassland management, agro-forestry, allelopathy.			
UNIT-IV (Total Topics - 25 and Hrs. -25) Water management of the crops and cropping systems; quality of irrigation water and management of saline water for irrigation; water use efficiency. GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production, Crop insurance, etc. Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy. Conservation agriculture, principles, prospects and importance, potential benefits of CA under climate change scenario, policy issues.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Acquaint with the recent advances in agricultural production.• CO.2: Impart detailed knowledge of the physiology of various crops in diversified environments.• CO.3: Compare the new technology with traditional cultivation practices.• CO.4: Understand the current worldwide food requirements.• CO.5: Impart the knowledge of sustainable agriculture.• CO.6: Develop the knowledge of GIS, GPS, seed certification and GM crops.			

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Suggested readings:

- Agarwal RL. 1995. Seed Technology. Oxford & IBH.
- Dahiya BS and Rai KN. 1997. Seed Technology. Kalyani.
- Govardhan V. 2000. Remote Sensing and Water Management in Command Areas: Agroecological Prospectives. IBDC.
- ICAR. 2006. Hand Book of Agriculture. ICAR.
- Narasaiah ML. 2004. World Trade Organization and Agriculture. Sonali Publ.
- Palaniappan SP and Annadurai K. 2006. Organic Farming - Theory and Practice. Scientific Publ.
- Sen S and Ghosh N. 1999. Seed Science and Technology. Kalyani.
- Tarafdar JC, Tripathi KP and Kumar M. 2007. Organic Agriculture Scientific Publ.
- Kumar, R, Swarnkar KS, Singh KS and Narayan S. 2016. A Text Book of Seed Technology. Kalyani Publication.
- Reddy SR and Prabhakara G. 2015. Dryland Agriculture. Kalyani Publishers.
- Gururajan B, Balasubhranian R and Swaminath V. 2013. Recent Strategies on Crop Production. Kalyani Publishers.
- Venkateswarlu B and Shanker Arun K. 2009. Climate change and agriculture: Adaptation and mitigation strategies. Indian Journal of Agronomy 54(2): 226-230.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	2	2	1	1	2	1	2	1	2	2
CO-2	1	1	2	1	-	-	1	1	-	1	1
CO-3	2	2	2	1	1	2	-	2	2	1	1
CO-4	2	2	1	1	-	1	1	1	1	-	-
CO-5	2	2	2	1	1	-	1	1	1	-	-
CO-6	1	2	2	1	1	1	-	1	-	1	1
Average	1.7	1.8	1.8	1.0	1.0	1.5	1.0	1.3	1.2	1.2	1.2

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPA C601	Current Trends in Agronomy	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C602	Credit	3(2+1)
Year/Sem	1/I	L-T-P	2-0-1
Course Name	Recent Trends in Crop Growth and Productivity	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To study the physiology of vegetative and reproductive growth in relation to productivity of different crops in various environments.2. To understand various cropping system and its advantages.3. To educate the role of photosynthesis and its influence in crop productivity.4. To develop knowledge of growth and development.5. To evaluate the different yield functions, drawbacks and remedial approaches.6. To study different plant ideotypes and its role in agriculture.			
UNIT I (Total Topics - 10 and Hrs -12) <p>Plant density and crop productivity; plant and environmental factors, yield, plant distribution, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation.</p>			
UNIT II (Total Topics – 10 and Hrs -12) <p>Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and Limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems; root-shoot relationship; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.</p>			
UNIT- III (Total Topics - 6 and Hrs -9) <p>Competitive relationship and competition functions; biological and agronomic basis of yield advantage under intercropping; physiological principles of dry land crop production, constraints and remedial measures; heat unit concept of crop maturity: concept and types of heat units.</p>			
UNIT-IV (Total Topics – 6 and Hrs. -8) <p>Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize, etc.; concept and types of growth hormones; their role in field crop production; efficient use of resources.</p>			
Practical: (Total Topics-8 and Hrs- 16) <p>Field measurement of root-shoot relationship in crops at different growth stages, Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at different stages of crop growth, Computation of harvest index of various crops, Assessment of crop yield on the basis of yield attributing characters, Construction of crop growth curves based on growth analysis data, Computation of competition functions, viz. LER, IER aggressivity competition index etc in intercropping, Senescence and abscission indices, Analysis of productivity trend in un-irrigated areas, Analysis of productivity trend in irrigated areas.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Describe the physiology of vegetative and reproductive growth in relation to			

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productivity of different crops in various environments.

- CO2: Understand various cropping systems and its advantages.
- CO3: Acquaint with the role of photosynthesis and its influence in crop productivity.
- CO4: Develop knowledge of growth and development.
- CO5: Evaluate the different yield functions, drawbacks and remedial approaches.
- CO6: Study different plant ideotypes and its role in agriculture.

Suggested readings:

- Chopra VL and Paroda RS. 1984. Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants. Oxford & IBH.
- Delvin RM and Vitham FH. 1986. Plant Physiology. CBS Publ.
- Evans LT. 1975. Crop Physiology. Cambridge Univ. Press.
- Evans LT. 1996. Crop Evolution, Adaptation and Yield. Cambridge Univ. Press.
- Kramer PJ and Boyer JS. 1995. Water Relations of Plant and Soils. Academic Press.
- Mukherjee S and Ghosh AK. 1996. Plant Physiology. Tata McGraw Hill.
- Narwal SS, Politycka B and Goswami CL. 2007. Plant Physiology: Research Methods. Scientific Pub.
- Tiaz L. and Zeiger E. 2006. Plant Physiology. Sinauer Associates, Inc.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	2	2	1	1	2	1	2	1	2	1
CO-2	1	1	1	1	-	-	1	1	-	1	-
CO-3	2	2	2	1	1	2	-	2	2	1	2
CO-4	1	2	1	1	-	1	1	1	1	1	1
CO-5	2	1	2	1	1	1	1	1	1	1	1
CO-6	1	2	2	1	1	1	1	1	1	1	1
Average	1.7	1.7	1.8	1.0	0.6	1.1	0.8	1.3	1.0	1.3	1.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPA C602	Recent Trends in Crop Growth and Productivity Agronomy	2	0	1	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C603	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Irrigation Management	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To educate about irrigation optimization in various crops under varying agro climatic circumstances.2. To introduce concepts of research processes in hydrology, water resources and water management.3. To impart knowledge of irrigation water management to maximizing crop yield and quality by developing irrigation and water management techniques.4. To develop knowledge of different irrigation techniques that are more effective in terms of minimizing water waste and enhancing agricultural water use efficiency.5. To impart knowledge on crop water needs, soil-plant relationships, irrigation requirements, duty and delta, irrigation water quality, transpiration and anti-transparent.6. To impart knowledge on economic planning in order to allow sustainable resource distribution in the irrigation sector.			
UNIT I (Total Topics - 15 and Hrs -20) <p>Global water resources; Water resources of India, irrigation projects during pre and post independence period and their significance in crop production; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth. Movement of water in soil-water movement under saturated and unsaturated conditions, Poiseuille's and Darcy's law, general equation of saturated and unsaturated flow of water in soil. Soil-plant-water relationships, evaporation, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.</p>			
UNIT- II (Total Topics - 8 and Hrs -8) <p>Water requirement, irrigation needs, factors affecting irrigation need; water use efficiency, Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops. Soil and plant water potential, SPAC, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, factors affecting ET, control of ET by mulching and use of anti-transparent; fertilizer use in relation to irrigation.</p>			
UNIT-III (Total Topics - 8 and Hrs. -9) <p>Crop water stress – water deficits and crop growth, adoptability to the crops. Water availability with relation to nutrient availability. Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management. Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transparent; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.</p>			
UNIT-IV (Total Topics - 5 and Hrs. -6) <p>Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation. Economic analysis of irrigation and crop planning for</p>			

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optimum use of irrigation water. Crop water production function.

Practical: (Total Topics-8 and Hrs- 16)

Determination of water infiltration characteristics and water holding capacity of soil profiles, Determination Moisture extraction pattern of crops, Determination of water balance component of transplanted rice by drum culture technique, Determination of consumptive use and water requirement of a given cropping pattern, Determination of crop efficient of one important crop, Planning, designing and installation of drip irrigation system, Planning, designing and installation of sprinkler irrigation system, Designing of drainage channel, Measurement of irrigation efficiencies, Determination of irrigation timing under different methods of irrigation, Visit to irrigation command area.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1: Study irrigation optimization in various crops under varying agro climatic circumstances.
- CO.2: Develop concepts of research process in hydrology, water resources and water management.
- CO.3: Impart knowledge of irrigation water management to maximising crop yield and quality by developing irrigation and water management techniques.
- CO.4: Develop knowledge of different irrigation techniques that are more effective in terms of minimising water waste and enhancing agricultural water use efficiency.
- CO.5: Impart knowledge on crop water needs, soil-plant relationships, irrigation requirements, duty and delta, irrigation water quality, transpiration and anti-transparent.
- CO.6: Impart knowledge on economic planning in order to allow sustainable resource distribution in the irrigation sector.

Suggested readings:

- MP. Singh 2017. Recent advances in Irrigation water management. Kalyani Publishers
- FAO. 1984. Irrigation Practice and Water Management. Oxford & IBH.
- Michael AM. 1978. Irrigation: Theory and Practice. Vikas Publ.
- Mishra RR and Ahmad M. 1987. Manual on Irrigation and Agronomy. Oxford & IBH.
- Panda SC. 2003. Principles and Practices of Water Management. Agrobios.
- Reddy SR. 2000. Principles of Crop Production. Kalyani.
- Sankara Reddy GH and Yellamananda Reddy. 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH.
- Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US.(Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	2	2	1	1	2	1	2	1	2	2
CO-2	1	1	1	1	1	-	1	1	-	1	1
CO-3	2	2	2	1	1	2	1	2	2	1	1
CO-4	1	2	1	1	-	1	1	1	1	1	1
CO-5	2	1	2	1	1	1	1	1	1	1	1
CO-6	1	2	2	1	1	1	1	1	1	1	1
Average	1.7	1.7	1.8	1.0	0.6	1.1	0.8	1.3	1.0	1.3	1.3

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CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPA C603	Irrigation Management	2	0	1	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C604	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Recent Trends in Weed Management	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To familiarize about the weeds, herbicides and methods of weed control.2. To impart knowledge of weed biology and the environment interact to influence weed ecology.3. To educate undertake environmental weed control and the impact of weeds.4. To educate about shifting weed flora, new herbicides, tolerance, and toxicity.5. To develop ecologically-based weed management systems for rangeland, natural areas, cropping systems, horticultural and landscape settings, and non-crop areas.6. To impart knowledge of physical, cultural, chemical, and biological control methods and understand how these are woven into management systems.			
UNIT I (Total Topics - 8 and Hrs -8) <p>Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; different methods of weed management. Migration, introduction, adaptation of weeds, Invasive weeds – biology and management. Different mechanisms of invasion – present status and factors influencing weed invasion. Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.</p>			
UNIT II (Total Topics - 5 and Hrs -5) <p>Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, Degradation of herbicides in soil and plants- factors affecting it, primary and secondary metabolites, residue management of herbicides, adjuvants.</p>			
UNIT- III (Total Topics - 5 and Hrs -7) <p>Advances in herbicide products and application techniques and methods; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; herbicide rotation and herbicide mixtures.</p>			
UNIT-IV (Total Topics - 6 and Hrs. -8) <p>Development of transgenic herbicide resistant crops; herbicide development, registration procedures. Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelochemical and alleloherbicides, herbicide bioassays. Recent advances in nonchemical weed management including deleterious rhizobacteria, Nano-enabled herbicides, Artificial Intelligence (AI), Internet of Things (IoT), robotics, biodegradable film, etc.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Familiarize about the weeds, herbicides and methods of weed control.• CO.2: Impart knowledge of weed biology and the environment interact to influence weed ecology.• CO.3: Study environmental weed control and the impact of weeds.• CO.4: Study shifting weed flora, new herbicides, tolerance, and toxicity.• CO.5: Develop ecologically-based weed management systems for rangeland, natural areas,			

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cropping systems, horticultural and landscape settings, and non-crop areas.

- CO.6: Impart knowledge of physical, cultural, chemical, and biological control methods and understand how these are woven into management systems.

Suggested readings:

- Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry. Springer.
- Das TK. 2008. Weed Science: Basics and Applications, Jain Brothers (New Delhi)
- Fennimore, Steven A and Bell, Carl. 2014. Principles of Weed Control, 4th Ed, California Weed Sci. Soc.
- Gupta OP. 2007. Weed Management: Principles and Practices, 2nd Ed.
- Jugulan M, (ed). 2017. Biology, Physiology and Molecular Biology of Weeds. CRC Press
- Monaco TJ, Weller SC and Ashton FM. 2014. Weed Science Principles and Practices, Wiley
- Powles SB and Shaner DL. 2001. Herbicide Resistance and World Grains, CRC Press.
- Walia US. 2006. Weed Management, Kalyani.
- Zimdahl RL. (ed). 2018. Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	2	2	1	1	2	1	2	1	2	2
CO-2	1	1	1	1	-	1	1	1	-	1	1
CO-3	2	2	2	1	1	2	-	2	2	1	1
CO-4	1	2	1	1	2	1	1	1	1	1	1
CO-5	2	1	2	1	1	1	1	1	1	1	1
CO-6	1	2	2	1	1	1	1	1	1	1	1
Average	1.7	1.7	1.8	1.0	0.6	1.1	0.8	1.3	1.0	1.3	1.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPA C604	Recent Trends in Weed Management	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C605	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Integrated Farming Systems and Sustainable Agriculture	Course Type	Elective

Course Objectives:

1. To apprise about different enterprises suitable for different agro-climatic conditions for sustainable agriculture.
2. To impart the concepts of cropping and farming systems adopted in India.
3. To develop an understanding of crop rotation, distinct forms of cropping systems, allopathic effects, and various methods for managing nutrients in various cropping systems.
4. To understand how to evaluate agricultural waste and use all natural resources for sustainable cultivation.
5. To implement the integrated farming system and sustainable method of agriculture.
6. To provide knowledge about the emerging systems such as organic farming and modern agriculture.

UNIT I (Total Topics - 5 and Hrs -6)

Integrated Farming systems (IFS): definition, scope and importance; classification of IFS based on enterprises as well as under rainfed/irrigated condition in different land situation. farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

UNIT II (Total Topics – 11 and Hrs - 11)

Concept of sustainability in of Integrated farming systems; efficient Integrated farming systems based on economic viability and natural resources - identification and management. Production potential of different components of Integrated farming systems; interaction and mechanism of different production factors; stability of Integrated Farming system based on research/long term information. in different systemsthrough research; eco-physiological approaches to intercropping. Integration of components and adaptability of different farming system based on land situations and climatic condition of a region; evaluation of IFS.

UNIT-III (Total Topics - 5 and Hrs. -6)

Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems. Formation of different Integrated Farming system Models; evaluation of different Integrated Farming system models. Recycling of organic waste in farming system, in IFS.

UNIT-IV (Total Topics - 8 and Hrs. -8)

New concepts and approaches of farming system and organic farming; value addition, waste recycling, quantification and mitigation of Green House gases; case studies/ success stories of different Integrated Farming systems. cropping systems and organic farming; case studies on different farming systems. Possible use of ITK in Integrated farming system.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1: Study different enterprises suitable for different agro-climatic conditions for sustainable agriculture.

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- CO.2: Impart the concepts of cropping and farming systems adopted in India.
- CO.3: Develop an understanding of crop rotation, distinct forms of cropping systems, allopathic effects, and various methods for managing nutrients in various cropping systems.
- CO.4: Understand how to evaluate agricultural waste and use all natural resources for sustainable cultivation.
- CO.5: Implement the integrated farming system and sustainable method of agriculture.
- CO.6: Analyze the emerging systems such as organic farming and modern agriculture.

Suggested readings:

- Baishya A, Borah M, Das AK, Hazarika J, Gogoi B and Borah AS 2017. Waste Recycling Through Integrated Farming systems. An Assam Agriculture Experience. Omni Scriptum Gmbh& Co. KG, Germany.
- Balasubramanian P and Palaniappan SP. 2006. Principles and Practices of Agronomy. Agrobios.
- Edens T. 1984. Sustainable agriculture and integrated farming system. Michigan State Univ. press.
- Jayanthi C. 2006. Integrated Farming systems-A way to sustainable Agriculture. Tamil Nadu Agricultural University, Coimbatore
- Joshi M and Parbhakarasetty TK. 2005. Sustainability through Organic Farming. Kalyani.
- Palaniappan SP and Anandurai K. 1999. Organic Farming - Theory and Practice. Scientific Publ.
- Panda SC. 2004. Cropping systems and Farming Systems. Agribios.
- Ravisankar D and Jayanthi C. 2015. Farming systems: concepts and approaches. Agrobios,

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	3	3	1	1	2	1	2	1	2	2
CO-2	1	1	1	1	-	-	1	1	-	1	1
CO-3	2	2	2	2	1	2	-	2	2	3	3
CO-4	1	2	1	1	1	1	1	1	1	1	1
CO-5	2	1	2	1	1	2	1	1	1	1	1
CO-6	1	2	2	1	1	1	1	1	1	1	1
Average	1.7	1.8	1.8	1.1	0.8	1.3	1.6	1.6	1.0	1.5	1.5

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CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPA C605	Integrated Farming Systems and Sustainable	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C606	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Soil Conservation and Watershed Management	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To educate about different soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.2. To acquaint knowledge on meaning, concept, objectives, principles, of soil and water conservation.3. To make students able to estimate the runoff and soil loss, design contour bunds, grassed waterways, terraces, drainage structures, gully control structures, small storage structures etc.4. To be able to interpret runoff data and quantify erosion by using various modelling methods.5. To understand land use classification and impact of land use changes on hydrological cycle parameters.6. To understand different watershed behaviour.			
UNIT I (Total Topics - 3 and Hrs -5) Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion. Universal Soil Loss Equation.			
UNIT II (Total Topics - 4 and Hrs -5) Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; mulching, tillage, cropping system vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.			
UNIT- III (Total Topics - 5 and Hrs -5) Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.			
UNIT-IV (Total Topics - 10 and Hrs. - 15) Land use capability classification, alternate land use systems; agro-forestry; ley farming; jhum management - basic concepts, socio-ethnic aspects, its layout. Drainage, methods of drainage, Drainage considerations and agronomic management; rehabilitation of abandoned jhum lands and measures to prevent soil erosion.			
Practical (Total Topics - 8 and Hrs. -16) Study of different types of erosion, Determination of dispersion ratio, Estimation of soil loss by Universal Soil Loss Equation, Estimation of soil loss by wind erosion, Measurement of runoff and soil loss, Field studies of different soil conservation measures, Laying out run-off plot and deciding treatments, Identification of different grasses and trees for soil conservation, Visit to watershed areas, Visit to a soil conservation research centre, demonstration and training centre.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Explain about different soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.• CO.2: Explain meaning, concept, objectives, principles, of soil and water conservation.• CO.3: Estimate the runoff and soil loss, design contour bunds, grassed waterways, terraces, drainage structures, gully control structures, small storage structures etc.			

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- CO.4: Interpret runoff data and quantify erosion by using various modelling methods.
- CO.5: Explain land use classification and impact of land use changes on hydrological cycle parameters.
- CO.6: Explain different watershed behaviors.

Suggested readings:

- Arakeri HR and Roy D. 1984. Principles of Soil Conservation and Water Management. Oxford & IBH.
- Dhruvanarayana VV. 1993. Soil and Water Conservation Research in India. ICAR.
- FAO. 2004. Soil and Water Conservation in Semi-Arid Areas. Soils Bull., Paper 57.
- Frederick RT, Hobbs J, Arthur D and Roy L. 1999. Soil and Water Conservation: Productivity and Environment Protection. 3rd Ed. Prentice Hall Gurnel Singh, Venkataraman CG, Sastry B and Joshi P. 1990.
- Manual of Soil and Water Conservation Practices. Oxford & IBH.
- Murthy VVN. 1995. Land and Water Management Engineering. Kalyani.
- Tripathi RP and Singh HP. 1993. Soil Erosion and Conservation. Wiley Eastern.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	3	1	1	2	1	2	1	2	2
CO-2	1	1	1	1	1	1	1	1	1	1	1
CO-3	2	2	2	2	1	2	1	2	2	3	3
CO-4	1	2	1	1	1	1	1	1	1	1	1
CO-5	2	1	2	1	1	2	1	1	1	1	1
CO-6	1	2	2	1	1	1	1	1	1	1	1
Average	1.7	1.8	1.8	1.1	0.8	1.3	1.6	1.6	1.0	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPA C606	Soil Conservation and Watershed Management	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C607	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Stress Crop Production	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To impart the basic concepts of thermodynamics, temperature, and temperature measurement techniques in the plant sciences.2. To discuss the plant morphological and physiological responses to both high and low temperature stress.3. To describe the plant physiological responses to temperature stress when combined with other abiotic stress factors including drought and salinity.4. To conduct a scientific literature utilizing refereed journal sources and to critically evaluate and understand temperature stress physiology technical knowledge and research techniques.5. To formulate research hypotheses, goals, objectives, and methods related to plant temperature stress physiology.6. To educate concepts of osmotic and ionic stress on seed germination and seedling growth, measurement of low temperature injury under field conditions.			
UNIT I (Total Topics - 3 and Hrs -3) <p>Stress and strain terminology; nature and stress injury and resistance; causes of stress. Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature stress through, soil and crop manipulations.</p>			
UNIT II (Total Topics - 4 and Hrs -5) <p>High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations. Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations.</p>			
UNIT- III (Total Topics - 5 and Hrs -7) <p>Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations. Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.</p>			
UNIT-IV (Total Topics - 5 and Hrs. -5) <p>Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance. Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.</p>			
Practical (Total Topics - 5 and Hrs. -5) <p>Determination of electrical conductivity of plant cell sap, Determination of osmotic potential and tissue water potential, Measurement of transpiration rate, Measurement of stomatal frequency, Measurement of Relative Water Content of leaf, Measurement of electrolytic leakage, Growing of plants in sand culture under salt stress for biochemical and physiological studies, Studies on effect of osmotic and ionic stress on seed germination and seedling growth, Measurement of low</p>			

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temperature injury under field conditions, Studies on plant responses to excess water.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1: Impart the basic concepts of thermodynamics, temperature, and temperature measurement techniques in the plant sciences.
- CO.2: Discuss the plant morphological and physiological responses to both high and low temperature stress.
- CO.3: Explain plant physiological responses to temperature stress when combined with other abiotic stress factors including drought and salinity.
- CO.4: Conduct a scientific literature utilizing refereed journal sources and to critically evaluate and understand temperature stress physiology technical knowledge and research techniques.
- CO.5: Formulate research hypotheses, goals, objectives, and methods related to plant temperature stress physiology.
- CO.6: Explain concepts of osmotic and ionic stress on seed germination and seedling growth, measurement of low temperature injury under field conditions.

Suggested readings:

- Michael AM and Ojha TP. 1981. Principles of Agricultural Engineering. Vol II. Jain Bros.
- Nilsen ET and Orcut DM. 1996. Physiology of Plants under Stress – Abiotic Factors. John Wiley & Sons.
- Singh K. 2000. Plant Productivity under Environmental Stress. Agribios.
- Singh KN and Singh RP. 1990. Agronomic Research Towards Sustainable Agriculture. Indian Society of Agronomy, New Delhi.
- Somani LL and Totawat KL. 1992. Management of Salt-affected Soils and Waters. Agrotech Publ.
- Virmani SM, Katyal JC, Eswaran H and Abrol IP. 1994. Stressed Ecosystem and Sustainable Agriculture. Oxford & IBH.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	2	3	3	1	1	2	1	2	1	2	2
CO-2	1	1	1	1	1	1	2	1	1	1	1
CO-3	2	2	2	2	1	2	1	2	2	3	3
CO-4	2	2	1	1	1	1	2	1	1	1	1
CO-5	2	1	2	1	1	2	1	1	2	1	1
CO-6	1	2	2	1	1	1	1	1	2	1	1
Average	1.8	1.8	1.8	1.1	0.8	1.3	1.3	1.6	1.5	1.5	1.5

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CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPA C607	Stress Crop Production	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C608	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Organic farming and precision agriculture	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To educate the key concepts and terminologies related to organic farming, including nutrient recycling, soil fertility management, and precision agriculture techniques.2. To understand the principles and relevance of organic farming practices in India and globally, focusing on soil fertility, water management, and crop rotation systems.3. To apply the techniques of organic farming, such as composting, use of biofertilizers, and vermicomposting, in maintaining soil productivity and managing pests and diseases.4. To analyze the socio-economic impacts of organic farming and the marketing and export potential of organic products, including the processes of inspection, certification, labeling, and accreditation.5. To evaluate the effectiveness of precision agriculture techniques and geospatial technologies in improving agricultural productivity, including crop discrimination, yield monitoring, and soil mapping.6. To develop practical strategies for integrating geo-informatics, GPS, and crop simulation models in precision agriculture to optimize agricultural inputs and enhance smart farming.			
UNIT I (Total Topics - 7 and Hrs -5) <p>Organic farming; concept and definition, its relevance to India and global agriculture and future prospects. Land and water management; land use, minimum tillage. Shelter zones, hedges, pasture management, agro-forestry. Organic farming and water use efficiency. Soil fertility; nutrient recycling, organic residues, organic manures composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures and biofertilizers.</p>			
UNIT II (Total Topics - 8 and Hrs -4) <p>Farming systems, crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity. Control of weeds, diseases and insect pest management, biological agents and pheromones, biopesticides</p>			
UNIT-III (Total Topics - 6 and Hrs. -6) <p>Socio-economic impacts. Marketing and export potential; inspection, certification, labeling and accreditation procedures; Organic farming and national economy.</p>			
UNIT-IV (Total Topics - 16 and Hrs. -15) <p>Precision agriculture: concepts and techniques, their issues and concerns for Indian agriculture. Geo-informatics- definition, concepts, tool and techniques, their use in precision agriculture. Crop discrimination and yield monitoring, soil mapping, fertilizer recommendation using geospatial technologies. Spatial data and their management in GIS; remote sensing concepts and application in agriculture, image processing and interpretation. Global positioning system (GPS); components and its functions. Introduction to crop simulation models and their uses for optimization of agricultural inputs, STCR approach for precision agriculture. Robotics and autonomous systems in agriculture, smart Farming. Current stream of thought.</p>			
Practical (Total Experiments- 12 and Hrs. - 24) <p>Precision agriculture: concepts and techniques, their issues and concerns for Indian agriculture. Geo-informatics- definition, concepts, tool and techniques, their use in precision agriculture. Crop discrimination and yield monitoring, soil mapping, fertilizer recommendation using geospatial</p>			

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technologies. Spatial data and their management in GIS; remote sensing concepts and application in agriculture, image processing and interpretation. Global positioning system (GPS); components and its functions. Introduction to crop simulation models and their uses for optimization of agricultural inputs, STCR approach for precision agriculture. Robotics and autonomous systems in agriculture, smart Farming. Current stream of thought.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1: Explain the key concepts and terminologies related to organic farming, including nutrient recycling, soil fertility management, and precision agriculture techniques.
- CO.2: Understand the principles and relevance of organic farming practices in India and globally, focusing on soil fertility, water management, and crop rotation systems.
- CO.3: Apply the techniques of organic farming, such as composting, use of biofertilizers, and vermicomposting, in maintaining soil productivity and managing pests and diseases.
- CO.4: Analyze the socio-economic impacts of organic farming and the marketing and export potential of organic products, including the processes of inspection, certification, labeling, and accreditation.
- CO.5: Evaluate the effectiveness of precision agriculture techniques and geospatial technologies in improving agricultural productivity, including crop discrimination, yield monitoring, and soil mapping.
- CO.6: Develop practical strategies for integrating geo-informatics, GPS, and crop simulation models in precision agriculture to optimize agricultural inputs and enhance smart farming.

Suggested readings:

- Altieri, M. A. (1995). *Agroecology: The Science of Sustainable Agriculture*. CRC Press.
- Lampkin, N. (1990). *Organic Farming*. Farming Press Books.
- Gliessman, S. R. (2015). *Agroecology: The Ecology of Sustainable Food Systems*. CRC Press.
- Lal, R., & Stewart, B. A. (Eds.). (2015). *Soil Management for Sustainable Agriculture*. CRC Press.
- Pretty, J. (2005). *The Earth Only Endures: On Reconnecting with Nature and Our Place in It*. Earthscan.
- Halberg, N., Alrøe, H. F., Knudsen, M. T., & Kristensen, E. S. (Eds.). (2006). *Global Development of Organic Agriculture: Challenges and Prospects*. CABI.
- Roberts, M. J., & Winter-Nelson, A. (2007). *Agriculture and the Environment: Perspectives on Sustainable Rural Development*. World Bank Publications.
- Srinath, K. (2016). *Precision Farming: A New Approach to Crop Management*. New India Publishing Agency.
- Singh, R. P., & Misra, U. K. (2017). *Precision Agriculture: Research and Development in India*. Scientific Publishers.
- Gebbers, R., & Adamchuk, V. I. (Eds.). (2010). *Precision Agriculture and Food Security*. Springer.
- Wollen, A. R., & Hughey, L. F. (Eds.). (2021). *Introduction to Precision Agriculture: Concept and Applications*. CRC Press.
- Corwin, D. L., Loague, K., & Ellsworth, T. R. (Eds.). (2010). *GIS Applications in Agriculture, Volume Two: Nutrient Management for Energy Efficiency*. CRC Press.

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	2	2	1	1	1	-	2	1	2	-
CO-2	1	1	1	1	1	1	1	1	1	1	1
CO-3	2	2	2	1	1	1	1	2	-	-	3
CO-4	1	2	2	1	1	1	1	1	1	1	1
CO-5	2	1	1	1	1	1	-	1	2	1	1
CO-6	1	1	2	1	1	1	1	1	2	1	-
Average	1.5	1.5	1.7	1.0	1.0	1.0	1.0	1.3	1.4	1.2	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPA C608	Organic farming and precision agriculture	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C609	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Advances in Crop Ecology	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To educate about the basic ecological principles relevant to agricultural systems, including crop distribution, adaptation, and world food supply.2. To understand the characteristics, types, and functions of ecosystems, focusing on terrestrial ecology, energy flow, and ecosystem productivity.3. To demonstrate the physiological responses of crop plants to various environmental factors such as light, temperature, CO₂, moisture, and solar radiation.4. To analyze the impact of global climate change on photosynthesis, crop productivity, and overall crop production.5. To evaluate different agronomic practices aimed at manipulating the environment and managing unproductive lands through crop selection and management techniques.6. To develop practical strategies for improving crop production efficiency by exploiting solar energy, understanding vertical temperature distribution, and applying environmental management principles.			
UNIT I (Total Topics - 4 and Hrs -5) Ecology of agricultural systems, ecology of cropping systems, principles of plant distribution and adaptation, crop and world food supply.			
UNIT II (Total Topics - 7 and Hrs - 7) Ecosystem characteristics, types and functions, terrestrial ecology, flow of energy in ecosystem, ecosystem productivity, biomass, succession and climax concept.			
UNIT- III (Total Topics - 3 and Hrs -3) Physiological response of crop plants to light, temperature, CO ₂ , moisture and solar radiation; influence of climate on photosynthesis and productivity of crops; effect of global climate change on crop production.			
UNIT-IV (Total Topics - 14 and Hrs. -15) Exploitation of solar energy in crops; vertical distribution of temperature; efficiency in crop production. Solar corridors accept different latitudes. Competition in crop plants; environmental pollution, ecological basis of environmental management and environment manipulation through agronomic practices; improvement of unproductive lands through crop selection and management. Current stream of taught.			
Practical (Experiments - 5 and Hrs. -10) Different growth stages of field crops - Growth analysis - Role of climatic factors on crop growth - Impact of environmental pollution on crop yields - Waste land development techniques - Light measurement amidst crop canopy in cropping system.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1. Explain about the basic ecological principles relevant to agricultural systems, including crop distribution, adaptation, and world food supply.• CO.2. Understand the characteristics, types, and functions of ecosystems, focusing on terrestrial ecology, energy flow, and ecosystem productivity.• CO.3. Demonstrate the physiological responses of crop plants to various environmental factors such as light, temperature, CO₂, moisture, and solar radiation.• CO.4. Analyze the impact of global climate change on photosynthesis, crop productivity, and overall crop production.			

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- CO.5. Evaluate different agronomic practices aimed at manipulating the environment and managing unproductive lands through crop selection and management techniques.
- CO.6. Develop practical strategies for improving crop production efficiency by exploiting solar energy, understanding vertical temperature distribution, and applying environmental management principles.

Suggested readings:

- Alteri, M. A.1995. Agroecology; the science of sustainable agriculture (2nd Ed.) Westview Press, Boulder, Colorado, USA.
- Dwivedi P, Dwivedi SK &Kalita MC. 2007. Biodiversity and Environmental Biotechnology. Scientific Publishers, Jodhpur.
- David. J. Connor, Robert S. Loomis and Kenneth. G. Gassman. 2011. Crop ecology productivity and management in Agricultural systems. Cambridge University press. UK.
- Jen-huchang. 2009. Climate and agriculture: An ecological survey. Routledge publishers. UK
- Kumar HD. 1992. Modern Concepts of Ecology (7Ed). Vikas. Publishers, Noida, Uttar Pradesh.
- Lenka D. 1998. Climate, Weather and Crops in India. Kalyani Publishers.
- Misra KC. 1989. Manual of Plant Ecology (3rd Ed). Oxford & IBH. New Delhi
- Pandey SN &Sinha BK. 1995. Plant Physiology. Vikas Publications, Noida, Uttar Pradesh.
- Sharma PD. 1998. Ecology and Environment. Rastogi Publishers, Meerut, Uttar Pradesh.
- Singh J &Dhillon SS. 1984. Agricultural Geography. Tata McGraw Hill. New York, USA.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	2	1	1	-	1	-	2	1	2	-
CO-2	1	1	1	1	-	1	1	1	1	1	1
CO-3	1	-	1	1	1	1	1	-	-	-	3
CO-4	1	-	1	1	1	1	1	1	1	1	1
CO-5	2	-	1	1	1	1	-	1	-	1	1
CO-6	1	1	2	1	1	1	1	1	-	1	-
Average	1.2	1.3	1.2	1.0	1.0	1.0	1.0	1.2	1.0	1.2	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPA C609	Advances in Crop Ecology	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C608	Credit	3 (2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Regenerative Agronomy for Soil Health	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none">1. To familiarize students with the principles and scientific foundations of regenerative agriculture and soil health management.2. To develop an understanding of soil ecological processes and their interactions with agronomic practices.3. To enable students to evaluate regenerative cropping systems for enhancing soil biodiversity, fertility, and resilience.4. To build competencies in designing and managing regenerative agronomic interventions for sustainable crop production.5. To train students in modern tools and techniques used to assess soil health indicators under regenerative systems.6. To promote critical thinking for integrating regenerative practices in research, extension, and policy frameworks.			
Unit. I: (Total Topics- 8 and Hours-7)			
Concept and evolution of regenerative agriculture; Principles and pillars of regenerative agronomy; Soil health: definition, dimensions and indicators; Soil ecology and ecosystem services; Soil organic matter dynamics and carbon sequestration; Diversity in cropping systems and resilience; Role of indigenous technical knowledge (ITK) in regenerative practices; Global and Indian perspectives on regenerative agriculture.			
Unit. II:(Total Topics- 8 and Hours- 7)			
Soil microbiome and its functional diversity; Rhizosphere ecology and plant–microbe interactions; Mycorrhizae, rhizobia and other beneficial microbes in regenerative systems; Soil fauna including earthworms, nematodes and arthropods as indicators; Biological nitrogen fixation and nutrient cycling; Carbon, nitrogen and phosphorus dynamics under regenerative practices; Biochar, composts and organic amendments; Soil enzyme activities and biological soil health indicators.			
Unit. III: (Total Topics - 8 and Hours- 8)			
Conservation tillage and no-till systems; Cover cropping and green manuring; Crop rotations and diversified cropping systems; Agroforestry and tree-based farming for soil health; Integrated nutrient management (INM) in regenerative systems; Water-efficient agronomy including mulching and micro-irrigation; Regenerative weed, pest and disease management; Assessing trade-offs and synergies in regenerative versus conventional agronomy.			
Unit. IV: (Total Topics- 8 and Hours- 8)			
Soil health assessment frameworks including physical, chemical and biological indicators; Tools and techniques such as soil health cards, sensors, remote sensing and GIS; Modeling soil health and carbon sequestration; Climate resilience through regenerative agriculture; Economic evaluation of regenerative practices; Farmer field schools and participatory approaches for adoption; Challenges, constraints and opportunities in regenerative agronomy; National and international policies supporting regenerative agriculture.			

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Practical: (Experiments 10 & Hours - 20)

Sampling techniques for soil health assessment; Estimation of soil organic carbon and active carbon; Measurement of soil bulk density, porosity and aggregate stability; Assessment of soil microbial biomass carbon (MBC) and nitrogen (MBN); Qualitative and quantitative analysis of soil fauna including earthworms and arthropods; Estimation of soil enzyme activities such as dehydrogenase, phosphatase and urease; Preparation and characterization of compost, vermicompost and biochar; Evaluation of biomass productivity of cover crops and green manures; Field demonstration of conservation tillage, mulching and water-saving agronomic practices; Soil health evaluation using soil health card framework and digital tools.

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1. Explain key concepts, principles, and frameworks of regenerative agronomy and soil health.
- CO.2. Assess the role of soil biology, carbon dynamics, and nutrient cycling in sustainable crop production.
- CO.3. Analyze regenerative cropping systems and compare their effectiveness with conventional approaches.
- CO.4. Design regenerative agronomic strategies tailored to agroecosystem needs and constraints.
- CO.5. Apply analytical tools and soil health indicators to evaluate soil quality under regenerative management.
- CO.6. Formulate research ideas and extension strategies for advancing regenerative agriculture in India and globally.

Suggested readings:

- Lal, R. (2020). *Soil health and climate change*. Springer.
- Magdoff, F., & Van Es, H. (2021). *Building soils for better crops: Sustainable soil management* (5th ed.). SARE Publishing.
- Montgomery, D. R. (2017). *Growing a revolution: Bringing our soil back to life*. W. W. Norton.
- Schreefel, L., Schulte, R. P. O., de Boer, I. J. M., Schrijver, A. P., & van Zanten, H. H. E. (2020). Regenerative agriculture: The soil is the base. *Global Food Security*, 26, 100404.
- Six, J., & Paustian, K. (2014). Aggregate stability and soil organic matter. In F. J. Magdoff (Ed.), *Soil organic matter in sustainable agriculture* (pp. 29–50). CRC Press.
- Smith, P., & Olesen, J. E. (2010). Synergies between mitigation of, and adaptation to, climate change in agriculture. *Journal of Agricultural Science*, 148(5), 543–552.
- Stevenson, F. J., & Cole, M. A. (1999). *Cycles of soil: Carbon, nitrogen, phosphorus, sulfur, micronutrients* (2nd ed.). Wiley.
- Tugel, A., Lewandowski, A., & Happe-vonArb, D. (2000). *Soil biology primer*. USDA Natural Resources Conservation Service.
- Weil, R. R., & Brady, N. C. (2016). *The nature and properties of soils* (15th ed.). Pearson.
- White, P. J. (2020). *Principles of soil and plant nutrition*. Cambridge University Press.

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Articulated Attainment

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	1	1	1	-	1	1	1	-	2
CO2	2	2	1	1	1	-	-	1	1	1	1
CO3	2	1	1	-	1	-	1	1	1	-	1
CO4	2	1	2	-	1	1	-	1	-	1	1
CO5	2	-	2	-	1	-	1	1	1	-	1
CO6	2	2	2	-	1	1	-	1	1	1	1
Average	2.2	1.8	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.2

Evaluation Scheme

Course Code	Course Title	Periods per week			Progressive Assessment/ Quiz/ Assignment	Practical	Internal Theory (Mid-Term)	External Theory (End Term)	Total	Credit (Theory + Practical)
		L	T	P						
DPA C610	Modern technologies in beekeeping	2	0	1	20	20	20	40	100	3 (2+1)

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Minor courses (Gradiual courses)

Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA M601	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Recent Trends in Soil Physics	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To state the knowledge of soil water interactions2. To identify fundamentals of saturated and unsaturated flow3. To demonstrate theories of infiltration4. To illustrate different models of salt movement5. To summarize the relation soil crop system and temperature leaf diffusion6. To express the vertical and horizontal movement of water in soil with different models			
UNIT I (Total Topics - 3 and Hrs -3) <p>Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system, soil-plant-atmospheric continuum (SPAC).</p>			
UNIT II (Total Topics - 4 and Hrs -5) <p>Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated waterflow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional waterflow.</p>			
UNIT- III (Total Topics - 10 and Hrs -12) <p>Theories of horizontal and vertical infiltration under different boundary conditions. Movement of salts in soils, models formiscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves.</p>			
UNIT-IV (Total Topics - 10 and Hrs. -10) <p>Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heatflow, measurement of thermal conductivity of soil; Soil, Plant, Water relations- Plant uptake of soil moisture, Water balance and energy balance in the field; irrigation and water use efficiency. Soil crust and clod formation; structural management of puddled rice soils; soil conditioning-concept, soils conditioners-types, characteristics, working principles, significance in agriculture.</p>			
UNIT-VII (Total Topics - 5 and Hrs. -5) <p>Solar and terrestrial radiation measurement, dissipation and distribution in soil crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infrared thermometer.</p>			
Course Outcomes (COs): After completion of course, students will be able to: CO1: State the knowledge of soil water interactions			

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CO.2 Identify fundamentals of saturated and unsaturated flow
CO.3 Demonstrate theories of infiltration
CO.4 Illustrate different models of salt movement
CO.5 Summarize the relation soil crop system and temperature leaf diffusion
CO.6 Express the vertical and horizontal movement of water in soil with different models

Suggested readings:

- Baver LD, Gardner WH and Gardner WR. 1972. Soil Physics. John Wiley & Sons.
- Hanks and Ascheroff. 1980. Applied Soil Physics. Springer Verlag.
- Hillel D. 1980. Applications of Soil Physics. Academic Press.
- Hillel D. 1980. Environmental Soil Physics. Academic Press.
- Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
- Kirkham D and Powers WL. 1972. Advanced Soil Physics. Wiley Interscience.
- Lal R and Shukla MK. 2004. Principles of Soil Physics. Marcel Dekker.
- Oswal MC. 1994. Soil Physics. Oxford & IBH.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	2	3	3	1	1	2	1	2	1	2	2
CO-2	2	2	2	1	1	1	2	1	1	1	1
CO-3	2	2	2	2	1	2	1	2	2	2	2
CO-4	2	1	1	1	1	1	2	1	1	1	1
CO-5	2	1	1	1	1	2	1	1	2	1	1
CO-6	1	2	2	1	1	1	1	1	2	2	2
Average	1.8	1.8	1.8	1.1	0.8	1.3	1.3	1.6	1.5	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPA M601	Recent Trends in Soil Physics	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA M602	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Modern Concept in Soil Fertility	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To discuss modern concept of nutrient availability in soil for plant growth2. To explain nutrient movement in soil and plants uptake3. To understand chemical reactions involving nutrient ions in soil4. To demonstrate modern concept of fertilizers evaluation, application and applied use efficiency5. To illustrate agricultural productivity and environmental quality6. To assess soil carbon dynamics in relation to fertility and crop productivity			
UNIT I (Total Topics - 3 and Hrs -3) Nutrient availability-concept and relationships, modern concepts of nutrient availability; soil colloids and nutrient availability; soil amendments and availability maintenance of nutrients, soil solution and plant growth; nutrient response functions and availability indices.			
UNIT II (Total Topics - 4 and Hrs -5) Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.			
UNIT- III (Total Topics - 5 and Hrs -7) Chemical equilibria (including solid-solution equilibria) involving nutrient ions in soils, particularly in submerged soils; Kinetic studies of nutrients in soils.			
UNIT-IV (Total Topics - 5 and Hrs. -5) Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.			
UNIT-V (Total Topics - 5 and Hrs. -5) Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.			
UNIT-VI (Total Topics - 5 and Hrs. -5) Monitoring physical, chemical, hydrological, and biological changes in soils; permanent manorial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.			
UNIT-VII (Total Topics - 5 and Hrs. -5) Carbon– a nutrient central to soil fertility; carbon cycle in nature, stocks, pools and fluxes; greenhouse effect and climate change; carbon sequestration vis-à-vis sustenance of soil quality and crop productivity.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Explain modern concept of nutrient availability in soil for plant growth.• CO.2 Explain nutrient movement in soil and plants uptake.• CO.3 Understand chemical reactions involving nutrient ions in soil.• CO.4 Demonstrate modern concept of fertilizers evaluation, application and applied use efficiency.• CO.5 Illustrate agricultural productivity and environmental quality.• CO.6 Assess soil carbon dynamics in relation to fertility and crop productivity.			
Suggested readings: <ul style="list-style-type: none">• Barber SA. 1995. Soil Nutrient Bioavailability. John Wiley & Sons.			

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- Barker V Allen and Pilbeam David J. 2007. Handbook of Plant Nutrition. CRC / Taylor & Francis.
- Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Educ.
- Cooke GW. 1979. The Control of Soil Fertility. Crossby Lockwood & Sons.
- Epstein E. 1987. Mineral Nutrition of Plants - Principles and Perspectives. International Potash Institute, Switzerland.
- Kabata- Pendias Alina 2001. Trace Elements in Soils and Plants. CRC / Taylor & Francis.
- Kannaiyan S, Kumar K and Govindarajan K. 2004. Biofertilizers Technology. Scientific Publ.
- Mortvedt JJ, Shuman LM, Cox FR and Welch RM. (Eds.). 1991. Micronutrients in Agriculture. 2nd Ed. Soil Science Society of America, Madison.
- Prasad R and Power JF. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Press.
- Stevenson FJ and Cole MA. 1999. Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients. John Wiley & Sons.
- Stevenson FJ. (Ed.). 1982. Nitrogen in Agricultural Soils. Soil Science Society of America, Madison.
- Tisdale SL, Nelson WL, Beaton JD and Havlin JL. 1990. Soil Fertility and Fertilizers. 5th Ed. Macmillan Publ.
- Wild A. (Ed.). 1988. Russell's Soil Conditions and Plant Growth. 11th Ed. Longman.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	2	1	2	2	1	2	1	2	2
CO-2	1	1	1	1	1	1	2	2	1	1	1
CO-3	2	2	2	2	2	2	1	2	2	2	2
CO-4	2	2	2	1	2	1	2	1	1	2	2
CO-5	2	1	2	1	1	2	1	1	2	1	1
CO-6	1	2	2	1	1	1	1	1	2	1	1
Average	1.8	1.8	1.8	1.1	1.5	1.3	1.3	1.5	1.5	1.5	1.5

Code	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPA M602	Modern Concept in Soil Fertility	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA M603	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Physical Chemistry of Soil	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none">1. To understand the knowledge about colloidal chemistry of soils2. To discuss the predictive approaches for cation exchange equilibria3. To interpret the thermodynamics of nutrient transformations in soils4. To articulate adsorption/desorption isotherms5. To illustrate common solubility equilibria of carbonates, iron oxide and hydroxides6. To illustrate common solubility equilibria of aluminum silicate, aluminum phosphate			
UNIT I (Total Topics - 3 and Hrs -3)			
Colloidal chemistry of inorganic and organic components of soils—their formation, clay organic interaction.			
UNIT II (Total Topics - 4 and Hrs -5)			
Predictive approaches for cation exchange equilibria- thermodynamics, empirical and diffuse double layer theory (DDL)- relationships among different selectivity coefficients; structure and properties of diffuse double layer.			
UNIT- III (Total Topics - 5 and Hrs -7)			
Thermodynamics of nutrient transformations in soils; Climate change effects on mineralogy and surface properties of variable charge; cationic and anionic exchange and their models, molecular interaction.			
UNIT-IV (Total Topics - 5 and Hrs. -5)			
Adsorption/desorption isotherms-Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agricultural system).			
UNIT-V (Total Topics - 5 and Hrs. -5)			
Common solubility equilibria-carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none">• CO1: Understand the knowledge about colloidal chemistry of soils• CO.2 Discuss the predictive approaches for cation exchange equilibria• CO.3 Interpret the thermodynamics of nutrient transformations in soils• CO.4 Articulate adsorption/desorption isotherms• CO.5 Illustrate common solubility equilibria of carbonates, iron oxide and hydroxides• CO.6 Illustrate common solubility equilibria of aluminum silicate, aluminum phosphate			
Suggested readings:			
<ul style="list-style-type: none">• Bear RE. 1964. Chemistry of the Soil. Oxford & IBH.• Bolt GH and Bruggenwert MGM. 1978. Soil Chemistry. Elsevier.• Fried M and Broeshart H. 1967. Soil Plant System in Relation to Inorganic Nutrition. Academic Press.• Greenland DJ and Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley & Sons.			

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- Greenland DJ and Hayes MHB. 1978. Chemistry of Soil Constituents. John Wiley & Sons.
- Jurinak JJ. 1978. Chemistry of Aquatic Systems. Department of Soil Science and Biometeorology, Utah State University
- McBride MB. 1994. Environmental Chemistry of Soils. Oxford University Press.
- Sparks DL. 1999. Soil Physical Chemistry. 2nd Ed. CRC Press.
- Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford University Press.
- Sposito G. 1984. The Surface Chemistry of Soils. Oxford University Press.
- Sposito G. 1989. The Chemistry of Soils. Oxford University Press.
- Stevenson FJ. 1994. Humus Chemistry. 2nd Ed. John Wiley.
- Van Olphan H. 1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	3	3	2	1	2	2	2	2	2	2
CO-2	2	2	1	1	1	1	2	1	2	1	1
CO-3	2	2	2	2	1	2	1	2	2	1	1
CO-4	2	1	1	1	1	1	2	1	1	1	1
CO-5	2	1	2	2	1	2	0	1	2	1	1
CO-6	1	2	2	1	1	1	1	1	2	1	1
Average	1.8	1.8	1.8	1.5	0.8	1.3	1.3	1.6	1.8	1.1	1.1

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPA M603	Physical Chemistry of Soil	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA M604	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Soil Genesis and Micromorphology	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To enumerate pedogenic evolution of soils.2. To determining soil composition and characterization.3. To relate about weathering and soil formation-factors and pedogenic processes4. To analyze the stability and weathering sequences of minerals5. To estimate and compare the assessment of soil profile development by mineralogical and chemical analysis.6. To plan the study related to micro-pedological features of soils-their structure, fabric analysis, role in genesis and classification			
UNIT I (Total Topics - 3 and Hrs -3) Pedogenic evolution of soils; soil composition and characterization.			
UNIT II (Total Topics - 4 and Hrs -5) Weathering and soil formation–factors and pedogenic processes; stability and weathering sequences of minerals.			
UNIT- III (Total Topics - 5 and Hrs -7) Assessment of soil profile development by mineralogical and chemical analysis.			
UNIT-IV (Total Topics - 5 and Hrs. -5) Micro-pedological features of soils–their structure, fabric analysis, role in genesis and classification.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Enumerate pedogenic evolution of soils• CO.2 Determining soil composition and characterization• CO.3 Relate about weathering and soil formation-factors and pedogenic processes• CO.4 Analyze the stability and weathering sequences of minerals• CO.5 Estimate and compare the assessment of soil profile development by mineralogical and chemical analysis• CO.6 Prepare plan the study related to micro-pedological features of soils-their structure, fabric analysis, role in genesis and classification			
Suggested readings: <ul style="list-style-type: none">• Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.• Buol EW, Hole ED, MacCracken RJ & Southard RJ. 1997. Soil Genesis and Classification. 4th Ed. Panima Publ.• Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.• Sehgal J. 2002. Introductory Pedology: Concepts and Applications. New Delhi• Sehgal J. 2002. Pedology - Concepts and Applications. Kalyani.• USDA. 1999. Soil Taxonomy. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.• Wade FA and Mattox RB. 1960. Elements of Crystallography and Mineralogy. Oxford & IBH.			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	2	1	2	2	2	2	1	2	2
CO-2	1	1	2	1	1	1	2	2	1	2	2
CO-3	2	2	2	2	1	2	1	1	2	1	1
CO-4	2	2	1	1	2	1	1	1	1	2	2
CO-5	2	1	2	1	1	2	1	1	2	1	1
CO-6	1	2	2	1	1	1	1	1	2	1	1
Average	1.8	1.8	1.8	1.1	1.3	1.3	1.3	1.6	1.5	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPA M604	Soil Genesis and Micromorphology	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA M606	Credit	3(3+0)
Year/Sem	Elective	L-T-P	3-0-0
Course Name	Soil Resource Management	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To study soil management for sustainable agriculture.2. To discuss the concept of sustainable land management.3. To list the strategies for erosion control and conservation.4. To explore the techniques of soil conservation planning.5. To summarize the concept of watershed management.6. To collect the potentials and constraints of soils of different agro-ecological regions.			
UNIT I (Total Topics - 8 and Hrs -8) <p>Relevance of soil management to sustainable agriculture; soil as a natural resource for biomass production, filtering, buffering, transportation of solutes, genereserves, and geogenic source of raw materials; soil as a source and sink of greenhouse gases. Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security; soil quality indices, conservation agriculture in relation to soil quality; soil resilience and resistance.</p>			
UNIT- II (Total Topics - 5 and Hrs -7) <p>Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS, Artificial Intelligence (AI) and Machine Learning and remote sensing in monitoring, diagnosis and mapping land degradation; history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion-on-site and off-site effects; strategies for erosion control and conservation; soil conservation in hilly, arid, semiarid, coastal and diarlalands. Management of forest, peat and muck soils.</p>			
UNIT-III (Total Topics - 5 and Hrs. -5) <p>Soil conservation planning; land capability classification; soil conservation in special problem is as such as hilly, arid and semi-arid regions, waterlogged and wetlands; land restoration and conservation techniques–erosion control, reclamation of salt affected soils; mine land reclamation, afforestation, organic products, soil fauna and biodegradation.</p>			
UNIT-IV (Total Topics - 5 and Hrs. -5) <p>Watershed management-concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socio-economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Explain the soil management for sustainable agriculture.• CO.2 Explain the concept of sustainable land management.• CO.3 List the strategies for erosion control and conservation.• CO.4 Explore the techniques of soil conservation planning.• CO.5 Summarize the concept of watershed management.• CO.6 Collect the potentials and constraints of soils of different agro-ecological regions.			
Suggested readings: <ul style="list-style-type: none">• Abrol IP and Dhruvanarayana VV. 1990. Technology for Wasteland Development. ICAR, New Delhi.			

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- Dan Binkley D and Fisher R. 2012. Ecology and Management of Forest Soils, 4th Edition, Wiley.
- Faroq M and Siddique K. (Ed.). 2015. Conservation Agriculture, Springer Nature, Chennai, India.
- ISSS. 1994. Management of Land and Water Resources for Sustainable Agriculture and Environment. Diamond Jubilee Symposium Publication, Indian Society of Soil Science, New Delhi.
- Mulders MA. 1987. Remote Sensing in Soil Science. Elsevier Science Publishers, Amsterdam.
- Sehgal J. 2014. A Text Book of Pedology Concepts and Application. Kalyani publishers, New Delhi.
- SSSA 1996. Methods for Assessing Soil Quality. SSSA Publication Number 49, Madison, Wisconsin, USA.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	2	3	1	2	2	1	2	2	2	2
CO-2	1	1	1	1	1	1	2	1	2	1	1
CO-3	2	2	2	2	1	2	1	2	2	3	3
CO-4	2	2	1	1	2	1	2	1	1	1	1
CO-5	2	2	2	1	1	2	1	1	1	1	1
CO-6	1	2	2	1	1	1	1	1	2	1	1
Average	1.8	1.8	1.8	1.1	1.3	1.3	1.3	1.6	1.6	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPA M606	Soil Resource Management	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA M607	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Modelling of Soil Plant System	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To study the soil management for sustainable agriculture2. To discuss the concept of sustainable land management3. To list the strategies for erosion control and conservation4. To explore the techniques of soil conservation planning5. To summarize the concept of watershed management6. To collect the potentials and constraints of soils of different agro-ecological regions			
UNIT I (Total Topics - 3 and Hrs -3) <p>Relevance of soil management to sustainable agriculture; soil as a natural resource for biomass production, filtering, buffering, transportation of solutes, genes, and geogenic source of raw materials; soil as a source and sink of greenhouse gases.</p>			
UNIT II (Total Topics - 4 and Hrs -5) <p>Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security; soil quality indices, conservation agriculture in relation to soil quality; soil resilience and resistance.</p>			
UNIT- III (Total Topics - 5 and Hrs -7) <p>Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation; history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion-on-site and off-site effects; strategies for erosion control and conservation; soil conservation in hilly, arid, semiarid, coastal and diaralands. Management of forest, peat and muck soils.</p>			
UNIT-IV (Total Topics - 5 and Hrs. -5) <p>Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wetlands; land restoration and conservation techniques—erosion control, reclamation of salt affected soils; mine land reclamation, afforestation, organic products, soil fauna and biodegradation.</p>			
UNIT-V (Total Topics - 5 and Hrs. -5) <p>Watershed management-concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socio-economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <p>CO1: Explain the soil management for sustainable agriculture. CO.2 Explain the concept of sustainable land management. CO.3 Prepare the strategies for erosion control and conservation. CO.4 Explore the techniques of soil conservation planning. CO.5 Summarize the concept of watershed management. CO.6 Collect the potentials and constraints of soils of different agro-ecological regions.</p>			
Suggested readings: <ul style="list-style-type: none">• Abrol IP and Dhruvanarayana VV. 1990. Technology for Wasteland Development. ICAR, New Delhi.			

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- Burrough A and McDonnell RK. 1998. Principles of Geographical Information System. Oxford University Press.
- Dan Binkley D and Fisher R. 2012. Ecology and Management of Forest Soils, 4th Edition, Wiley.
- FAO. 1996. Land Quality Indicators and their Use in Sustainable Agriculture and Rural Development. FAO Land and Water Bulletin.5. FAO, Rome.
- Faroq M and Siddique K. (Ed.). 2015. Conservation Agriculture, Springer Nature, Chennai, India.
- Mulders MA. 1987. Remote Sensing in Soil Science. Elsevier Science Publishers, Amsterdam.
- Sehgal J. 2014. A Text Book of Pedology Concepts and Application. Kalyani publishers, New Delhi.
- SSSA 1996. Methods for Assessing Soil Quality. SSSA Publication Number 49, Madison, Wisconsin, USA.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	2	3	1	2	2	2	1	2	2
CO-2	1	2	2	1	1	1	1	1	1	1	1
CO-3	2	2	2	2	1	2	2	2	2	3	3
CO-4	2	2	2	1	1	1	1	1	1	1	1
CO-5	2	1	2	2	1	2	1	1	2	1	1
CO-6	1	1	2	1	1	1	1	1	2	1	1
Average	1.8	1.8	2.0	1.6	0.8	1.3	1.3	1.6	1.5	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPA M607	Modelling of Soil Plant System	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA M610	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Analytical Techniques and Instrumental Methods in Soil and Plant Analysis	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To differentiate the principles and protocols of commonly used instruments in soil sciences.2. To develop the understanding of methods of qualitative and quantities tests in soil science.3. To develop skills in reagent preparation and handling of instruments.4. To develop the ability to analyze soil samples and interpretation of results.5. To test the ability to analyze plant samples and interpretation of results.6. To demonstrate the different methods of identification of minerals			
UNIT- I (Total Topics - 9 and Hrs -5) General principles of Analytical chemistry-introduction to volumetric analysis Acidimetry, Alkalimetry- Redox reactions – Complexometry, Precipitation reactions – types of indicators and theory of indicators, Gravimetry Principles			
UNIT-II (Total Topics - 16 and Hrs -10) Introduction to instrumental methods of analysis – Electrochemical methods Potentiometry- -pH measurement – Potentiometric titration. Conductometry conductivity measurement- conductometric titration- theory and principles X ray diffraction- Differential thermal analysis-Chromatography-partition, column, paper, Thin, Gas, Gas-Liquid, HPLC- Principles and instrumentation			
UNIT- III (Total Topics - 5 and Hrs -5) Theory and Principles of Spectral methods of Analysis, Nature of electromagnetic radiation, Interaction of EMR with matter, Colorimetry / Spectrophotometry- turbidimetry /Nephelometry.			
UNIT-IV (Total Topics - 10 and Hrs -10) Theory and Principles of Emission spectroscopy, Flame photometry, Plasma emission spectroscopy Atomic absorption spectrophotometry, mass spectrometry and X-ray diffractrometry, Nuclear magnetic resonance spectroscopy (NMR). Identification of minerals by X-ray by different methods.			
Practical (Experiments- 12 and Hrs -24) Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base; Oxidation reduction and complexometric titration; Soil, water and plant sampling techniques, their processing and handling; Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; Estimation of phosphorus, ammonium and potassium fixation capacities of soils; Electrochemical titration of clays; Determination of cation and anion exchange capacities of soils; Estimation of exchangeable cations (Na, Ca, Mg, K); Estimation of root cation exchange capacity; Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; Analysis of plant materials by digesting plant materials by wet and dry ashing and soil by wet digestion methods; Measurement of redox potential.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO 1: Explain basic principles of analytical chemistry• CO 2: Explain the techniques of stand preparations and various methods of qualitative and quantitative analysis• CO3: Understand on the principles of different instrumental techniques followed for soil and			

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plant analysis.

- CO 4. Analyze soil and plant samples and interpretation of results.
- CO 5. Develop the skills in reagent preparation and handling of instruments.
- CO 6. Understanding of methods of qualitative and quantitative tests in soil science.

Suggested readings:

- Gary, D. Christian 2007. Analytical Chemistry. 6th edition. John Wiley & Sons, Inc New York
- Choker, S.M. 2008. Basic Concepts of Analytical Chemistry. New Age International Pvt Ltd. Chennai
- Verma, R.M. 2007. Analytical Chemistry: Theory and Practice. 3rd edition. CBS Publishers & Distributors. New Delhi
- Sharma, P.K. 2004. Instrumental methods of chemical analysis. 23rd edition. Goel Publication House, Meerut.
- Arnikar, H.J. 2011. Essentials of Nuclear Chemistry. 4th edition. New Age International Private Limited, Chennai
- <https://nou.edu.ng/coursewarecontent/AGR%20503.pdf>
- <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.987.8645&rep=rep1&type=pdf>

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	1	1	-	-	-	1	-	1	1	1
CO-2	-	-	1	-	-	-	-	-	1	-	-
CO-3	-	-	-	-	-	-	-	-	-	-	-
CO-4	-	1	1	2	1	1	-	1	-	-	-
CO-5	1	-	1	2	1	-	1	-	1	1	1
CO-6	1	1	-	1	-	-	-	1	-	-	-
Average	1.0	1.0	1.0	1.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPA M610	Analytical Techniques and Instrumental Methods In Soil And Plant Analysis	2	0	0	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA M611	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Recent Trends in Soil Microbial Bio-Diversity	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To acquaint with concepts of microbial evaluation and biodiversity, including microbial communities in ecosystems and below-ground diversity impacting plant performance.2. To understand the qualitative ecology of microorganisms, focusing on biomass and their ecological activities.3. To demonstrate the identification and characterization of nitrogen-fixing organisms using molecular approaches.4. To analyze the ecological aspects of bioremediation and the role of microorganisms in soil, waste, and water management.5. To evaluate the biodegradability of pollutants and the effectiveness of bacterial fertilizers through testing and monitoring bioremediation processes.6. To develop and perform practical experiments to estimate soil microbial populations, microbial biomass, and enzyme production, enhancing the understanding of microbial roles in ecological systems.			
UNIT I (Total Topics - 3 and Hrs -3) Microbial evaluation and biodiversity, Microbial communities in ecosystems, new insights in below ground diverse of plant performance.			
UNIT II (Total Topics - 2 and Hrs -2) Qualitative ecology of microorganisms; Biomass and activities.			
UNIT- III (Total Topics - 3 and Hrs -3) Nitrogen fixing organisms, Trends in diversity of N fixing organisms. Molecular approaches in characterizing N fixing microorganisms.			
UNIT-IV (Total Topics - 3 and Hrs. -3) Serology and molecular characterization, ecological aspects of bio determination, soil waste and water management.			
UNIT-V (Total Topics - 3 and Hrs. -4) Biodegradability, testing and monitoring of the bioremediation of xerobiotic pollutants and bacterial fertilizers.			
Practical (Total Experiments - 14 and Hrs. -28) Conn's Direct microscopic count for estimating soil microbial population; Standard plate count of estimating soil microbial population; Most probable number method for estimating soil microbial population; Buried slide techniques; Determination of soil microbial biomass using molecular techniques; Amylase production test (Demonstration of starch hydrolysis); Cellulase production test (Degradation of cellulose); Production of pectinolytic enzymes (Degradation of pectin); Isolation of root nodule bacterium Rhizobium; Isolation and purification of Azotobacter; Estimation of Soil microbial biomass carbon; Estimation of Soil microbial biomass nitrogen; Estimation of Soil microbial biomass Phosphorus; Community level Physiological profiling of bacteria.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Explain concepts of microbial evaluation and biodiversity, including microbial			

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communities in ecosystems and below-ground diversity impacting plant performance.

- CO.2: Understand the qualitative ecology of microorganisms, focusing on biomass and their ecological activities.
- CO.3: Identify and characterize the nitrogen-fixing organisms using molecular approaches.
- CO.4: Analyze the ecological aspects of bioremediation and the role of microorganisms in soil, waste, and water management.
- CO.5: Evaluate the biodegradability of pollutants and the effectiveness of bacterial fertilizers through testing and monitoring bioremediation processes.
- CO.6: Develop and perform practical experiments to estimate soil microbial populations, microbial biomass, and enzyme production, enhancing the understanding of microbial roles in ecological systems.

Suggested readings:

- Aneja K.R.2007. Experiments in Microbiology, plant pathology, Tissue culture and Mushroom Cultivation, New Age International, New Delhi
- Atlas R.M. 1988. Microbiology – Fundamentals and Applications, Macmillan Publishing Company, New York.
- Benson Harold J. 2002.Microbiological Applications, WCB McGraw – Hill, New York
- Brock T.D. and Madigan M.T.2006. Biology of Microorganisms, Prentice Hall of India Private Limited
- Martin Alexander. 1977. Introduction to Soil Microbiology. John Wiley Publication New Delhi.
- Paul, EA. 2007. Soil Microbiology, Ecology and Biochemistry. 3rd Ed. Academic Press, New Delhi
- Pelczar .J. Chan E.C.S. and Krieg N.R.2001. Microbiology, McGraw Hill Book Company, New York
- Ravindra Nath, Fundamentals of Biology Courses for Biotechnology, - Vol.1, Special Bangalore University edition, Kalyani Publishers
- Salle A.J. 2007. Fundamental Principles of Bacteriology, Tata McGraw – Hill Publishing Company Limited, New Delhi
- Stanier R.Y., Ingraham J.L., 1999. General Microbiology, Prentice Hall of India Private Limited, New Delhi

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	2	2	3	1	1	-	2	1	2	1
CO-2	1	2	2	2	3	1	1	1	1	1	1
CO-3	2	2	2	1	3	1	2	2	1	-	3
CO-4	2	2	2	2	2	1	2	3	1	1	1
CO-5	2	2	2	2	2	1	2	1	2	1	1
CO-6	2	2	2	1	1	1	1	1	2	1	2
Average	1.7	2.0	2.0	1.8	2.0	1.0	1.6	1.7	1.3	1.2	1.5

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CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPA M611	Recent Trends in Soil Microbial Bio-Diversity	2	0	2	20	20	20	40	100	2(1+1)

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Supporting Courses (Compulsory for students of all disciplines of Agriculture) (Gradual courses)

Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	SOA S601	Credit	3(3+0)
Year/Sem	Year -1; Semester-I	L-T-P	3-0-0
Course Name	Research Methodology in Agronomy	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To Equip the Students with the Concept and Methodology of Research.2. To provide knowledge about type of research, preparation of reports and thesis, designing of Research using Scientific Methods.3. To develop the ability to apply principles and procedure for data analysis and interpretation of results.4. To analyze various sampling methods and probability of research analysis.5. To evaluate interpretations and significance of report writing.6. To develop the ability to create appropriate hypothesis, select experimental design and presentation of results after analysis of data.			
UNIT I (Total Topics- 7 and Hrs-12) <p>Introduction to Research: Definition, Nature and significance, Role and Objectives; Types of Research: exploratory, descriptive, experimental and diagnostic research, social and legal research and traditional, analytical, empirical & fundamental research, Doctrinal and non-doctrinal research methods; Various Research Designs; Scientific Research Process: Overview, Problem identification and formulation of research statement.</p>			
UNIT II (Total Topics- 7 and Hrs- 12) <p>Data Collection: sources, primary and secondary methods, significance of Primary and Secondary Data, questionnaire Vs. schedules; Data Processing: Editing, Coding Organization and Presentation; Attitude Measurement and scaling: Measurement Scales, Sources of Errors in Measurement, Techniques of Developing Measurement Tools, Classification and Testing (Reliability, Verification and Validity) Scales, Designing Questionnaires and Interviews.</p>			
UNIT- III (Total Topics- 5 and Hrs- 10) <p>Sampling, Sampling Methods, Sampling Plans, Sampling Error, Sampling Distributions: Theory and Design of Sample Survey, Census Vs Sample Enumerations, Objectives and Principles of Sampling, Types of Sampling, Sampling and Non-Sampling Errors, Concept of Permutation, Combination & Probability for research analysis.</p>			
UNIT-IV(Total Topics- 5 and Hrs- 10) <p>Interpretations and Report Writing: Meaning of Interpretation, Techniques of Interpretation, Precautions in Interpretation, Significance of Report Writing, Steps in Report Writing, Layout of Report and Precautions in Writing Research Reports. Limitations of RM: Ethics in Research, Philosophical Issues in Research.</p>			
Practical)- NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1. Explain fundamentals, theories and principles relatto the research and apply the acquired			

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knowledge in carrying out research studies in the area of interest.

- CO2. Identify, formulate and critically investigate research problems by applying research-oriented knowledge and analyze relevant data to reach certain conclusions in the form of alternative solutions to these problems.
- CO3. Apply the acquired knowledge and skills to develop minds to think out of the box while carrying out research operations to conclude something.
- CO4. Apply parametric and non-parametric statistical tests to verify the developed hypothesis to suggest innovative solutions to the problem being investigated.
- CO5. Evaluate interpretations and significance of report writing.
- CO6. Create of appropriate hypothesis, select experimental design and presentation of results after analysis of data.

Suggested readings:

- William G. Zikmund, "Business Research Methods", Orlando: Dryden Press.
- C. William Emory and Cooper R. Donald, "Business Research Methods", Boston, Irwin.
- Fred N Kerlinger, "Foundations of Behavioural Research", New Delhi: Surjeet Publications.
- Naresh Malhotra, Marketing Research: An Applied Orientation, Pearson publication David Nachmias and Chava Nachmias, "Research Methods in the Social Sciences", New York: St.Marlia's Press.
- Bhattacharya, D. K. (2004) Research Methodology, New Delhi, Excel Books

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO - 2	PSO - 3	PSO - 4	PSO - 5	PSO - 6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
SOA S601	Research Methodology in Agronomy	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	SOA S602	Credit	1(1+0)
Year/Sem	Year -1; Semester-I	L-T-P	1-0-0
Course Name	Computer & Stats Application in Research	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To appraise computational skills for research application.2. To assess statistical method for research analysis.3. To create skills in methods of collection of any type of data, classification of data, presentation of data, analysis of data, descriptive statistics, parametric and non-parametric tests, etc.4. To analyse statistical calculations and their validation.5. To justify the decision in the reference of data analysis, formation and Analysis of data.6. To create ANOVA through different methods and their interpretation.			
UNIT I (Total Topics- 7 and Hrs-12) <p>Characteristics of Computers, Evolution of computers, computer memory, computer generations, Basic computer organization; System software, Application software, introduction to operating system, single user, multi-user, multitasking single tasking, application of computer for business and research, MS-windows, Linux .Application of Internet in research: INFLIBNET, Use of Internet, sights (DOAJ), Use of E Journals, Use of E library, use of EBSCO HOST online database of Academic Libraries. Subject/field specific tools on www.freeware.com</p>			
UNIT II(Total Topics- 7 and Hrs- 12) <p>Computer Application in Research, Basic concept of Computer, Use of Internet for Research Purpose: E-mail, WWW, Web browsing, technical skills, drawing inferences from data, Research publishing tools-MS Word, Adobe acrobat, Graphics tool-MS Excel, Presentation tool-MS Power, Data Analysis Software and Analysis Techniques point. Creating presentation and adding effects, Introduction to Data analysis software-SPSS: Definition, objectives and features, data analysis using SPSS.</p>			
UNIT- III (Total Topics- 5 and Hrs- 10) <p>Statistical methods for research application in analysis of data, Measurement in Research, data interpretation, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), std deviation, Measures of Relationship, Simple Regression Analysis, Correlation and Regression, Partial Correlation.</p>			
UNIT-IV(Total Topics- 5 and Hrs- 10) <p>Statistical Tools-Hypothesis and Hypothesis Testing: Parametric & Non-Parametric Tests, Important Parametric Tests ,Hypothesis Testing of Correlation Coefficients ,U Test, Chi Square Test, ,T-Test. Analysis of Variance (ANOVA) , The Basic Principle of ANOVA ,ANOVA Technique, Setting up Analysis of Variance Table, Short-cut Method for One-way ANOVA, Coding Method, Two-way ANOVA .</p>			
Practical- NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Explain basics terms used in collection, classification, presentation and analysis of data, descriptive statistics, parametric and non-parametric tests, etc.• CO.2: Understand the use of various formulas, principles and methods of statistical calculations			

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used in agriculture.

- CO.3: Apply the methods of collection of any type of data, classification of data, presentation of data, analysis of data, descriptive statistics, parametric and non-parametric tests, etc.
- CO.4: Analyse statistical calculations and their validation.
- CO.5: Evaluate the various data through statistical tests.
- CO.6: Perform of ANOVA tests through different methods and its interpretation..

Suggested readings:

- C. R. Kothari, “Research Methodology: Methods and techniques”, New Delhi: Vishwa Prakashan.
- Brymann, Alan and Carmer, D. (1995) Qualitative data analysis for social scientist, New York, Routledge Publication.
- Jain, Satish: “Introduction to Computer Science and basic Programming.” BPB Publications, New Delhi, 1990. • Rajaraman, V., “Fundamental of Computers”, Prentice Hall of India, New Delhi, 1996.
- Hogg, R.V.& Craig, T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
- [\(PDF\) Statistical Methods and their Applications \(researchgate.net\)](#)
- [Welcome to Web Agri Stat Package \(icar.gov.in\)](#)
- [\(PDF\) BASIC STATISTICAL TECHNIQUES IN RESEARCH \(researchgate.net\)](#)
- [Statistical Methods & Applications | Home \(springer.com\)](#)
- [Statistical Methodology - Journal - Elsevier](#)

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
SOA S602	Computer & Stats Application in Research	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA S603	Credit	1(1+0)
Year/Sem	Year -1; Semester-I	L-T-P	1-0-0
Course Name	Research & Publication Ethics	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To acquaint with knowledge about basics of Agricultural Research and research ethics2. To understand research ethics including research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards, and problems in research ethics.3. To apply research ethics in collection and interpretation of data.4. To analyze the major publication ethics to be followed during research.5. To evaluate violation of publication ethics, authorship and contributor ship6. To develop ability to identify different predatory publishers and journals.			
UNIT I (Total Topics- 2 and Hrs-8) Introduction to philosophy: definition, nature and scope, concept, branches; Ethics: definition, moral philosophy, nature of moral judgments and reactions			
UNIT II (Total Topics- 5 and Hrs- 5) Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP); Redundant publications: duplicate and overlapping publications, salami slicing; Selective reporting and misrepresentation of data			
UNIT- III (Total Topics-7 and Hrs-7) Publication ethics: definition, introduction and importance; Best practices/ standards setting initiatives and guidelines: COPE, WAME, etc.; Conflicts of interest; Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types; Violation of publication ethics, authorship and contributor ship; Identification of publication misconduct, complaints and appeals; Predatory publishers and journals			
UNIT- IV (Total Topics-4and Hrs-4) Open access publications and initiatives; SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies; Software tool to identify predatory publications developed by SPPU; Journal finder/ Journal suggestion tools viz. JANE, Elsevier Journal finder, Springer Journal Suggester, etc.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1. Recognize the basics of philosophy of science & ethics, research integrity, publication ethics and theories of research ethics.• CO2. Explain the important issues in research ethics, research integrity, scientific misconduct and misinterpretation of data.• CO3. Analyze the best practices for publications, publication ethics and identify the predatory publishers & journals.• CO4. Demonstrate & use plagiarism software tools, open-source software tools, citation databases and research metrics.• CO5. Evaluate credible & scholarly publications in reputed peer-reviewed journals.• CO6. Create the ethical publications for high impact peer reviewed journals.			

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Suggested readings:

- Research and Publication Ethics, Dr Sumanta Dutta, Bharti Publications, 2021
- Research and Publication Ethics, Dr Santosh Kumar Yadav, Anne Publications, 2020
- Kumar, R. 2014. Research Methodology: A Step-by-Step Guide for Beginners. 4th Edition. SAGE Publications Ltd.
- Parikh, M.N, Gogtay, N. 2009. ABC of Research Methodology and Applied Biostatistics. Jaypee Publishers, New Delhi.
- <https://www.sciencedirect.com/journal/library-and-information-science-research>
- <https://www.researchgate.net/publication/306097844> Library and Information Science Research
- <http://isca.in/RJLS/>
- <https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm>
- <https://www.springer.com/journal/10892>

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPA S603	Research & Publication Ethics	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DAP C691	Credit	1(0+1)
Year/Sem	Year 1; Semester – I	L-T-P	0-0-1
Course Name	Doctoral Seminar -I	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscript/article and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPA C691	Doctoral Seminar-I	0	0	2	-	-	100	-	100	1(0+1)

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Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C692	Credit	1(0+1)
Year/Sem	Year 1; Semester – II	L-T-P	0-0-1
Course Name	Doctoral Seminar-II	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscripts/article and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPA C691	Doctoral Seminar-II	0	0	2	-	-	100	-	100	1(0+1)

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Doctoral Research Work

Programme Name	Ph.D. Agronomy	Programme Code	
Course Code	DPA C699	Credit	75(0+75)
Year/Sem	Not Applicable	L-T-P	Not Applicable
Course Name	Doctoral Research	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To develop a comprehensive understanding of research philosophies, theories, and types of scientific inquiry in agricultural sciences.2. To identify research gaps through systematic literature review and formulate appropriate research problems, objectives, and hypotheses.3. To apply suitable research methodologies, experimental designs, and sampling techniques relevant to agricultural research.4. To enhance skills in data collection, statistical analysis, and interpretation using advanced analytical tools.5. To strengthen scientific writing, academic communication, and referencing skills for research publications and proposals.6. To promote ethical research practices, scientific integrity, and responsible conduct in agricultural research.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs-) <p>Synopsis, Research Work & Thesis writing provides the students an excellent opportunity to develop analytical research and entrepreneurial skills, and knowledge through meaningful hands on experience, confidence in their ability to design and investigate the things.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Recall and describe fundamental research concepts, methodologies, and statistical tools used in agricultural research.• CO2: Explain research processes, interpret scientific literature, and summarize research gaps in agriculture.• CO3: Apply suitable research designs, data collection methods, and sampling strategies in field, laboratory, and socio-economic studies.• CO4: Analyze research data, identify trends and relationships, and interpret results using appropriate statistical techniques.• CO5: Evaluate the quality, rigor, and validity of research findings and assess scientific articles using standardized evaluation criteria.• CO6: Develop an original research proposal, formulate hypotheses, design experimental models, and produce publishable scientific writing.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	3	3	3	3	3	3	3	3	3
CO-2	3	3	3	3	3	3	3	3	3	3	3
CO-3	3	3	3	3	3	3	3	3	3	3	3
CO-4	3	3	3	3	3	3	3	3	3	3	3
CO-5	3	3	3	3	3	3	3	3	3	3	3
CO-6	3	3	3	3	3	3	3	3	3	3	3
Average	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPA C699	Doctoral Research	N A	N A	N A	NA	NA	NA	NA	NA	75(0+75)

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Detailed syllabus of Ph.D. (Forestry) Silviculture and Agroforestry

Major Courses (Gradiual Courses)

Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C601	Credit	3(2+1)
Year/Sem	Year 1; Semester - I	L-T-P	2-0-1
Course name	Quantitative Silviculture	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To acquaint the students with forest stand growth and yield.2. To understand the quantitative techniques used for evaluating site quality.3. To measure the stand density.4. To predict forest growth and yield.5. To learn about Nursery management practices.6. To assess the existing forest growth and yield simulators.			
UNITS I (Total Topics- 6 and Hrs- 8) Principles of tree and stand growth and yield. Habitat types; site quality; site index. Growth functions – empirical, exponential, allometry and Backman’s growth functions. Growth pattern and growth increment curve. Growth cycle and phases. Quantifying site quality: Methods – tree and stand height data, periodic height growth. Techniques – guide curves, difference equations, parameter prediction.			
UNIT II (Total Topics -8 and Hrs-8) Stand density and stocking, measures of density: $-3/2$ power rule of self-thinning, point density, competition indices. Control of growing stock to achieve specific management objectives – growth-growing stock relations, Full site occupancy, Onset of competitive interactions. Langsaeter’s hypothesis, stand density index and techniques for translating this understanding into rational density management regimes			
UNIT- III (Total Topics -8 and Hrs-6) Techniques: stand density management diagrams and stocking charts. Construction and use of stand density management diagrams. Designing density management regimes to suit specific management objectives			
UNIT-IV (Total Topics -8 and Hrs-8) Predicting growth and yield: normal and empirical yield tables, stand growth and yield equations, stand table projections. Simulation models: whole-stand models, size-class distribution models, single tree/ distance independent and distance- dependent models, process models, linkage of models at different levels. Evaluation, calibration, verification, and validation of forest growth and yield prediction systems. Introduction to existing forest growth and yield simulators.			
Practical (Total Experiments-8 and Hrs-16) Assessment of growth characteristics; Preparation of growth and increment curves; Site quality assessment, Stand density diagrams; Growth prediction models; Yield simulation techniques.			
Course Outcomes (CO): After completion of course, students will be able to:			

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- CO.1 Remembe the techniques of guide curves, difference equations, parameter prediction.
- CO.2 Understand various growth functions.
- CO.3 Apply growth prediction models.
- CO.4 Analyz growth cycle and phases.
- CO.5 Evaluate Forest growth and yield prediction systems.
- CO.6 Design the density management regimes to suit specific management objectives.

Suggested readings:

- Clutter JL, Fortson JC, Pienaar LV, Brister GH and Bailey RL. 1992. Timber Management: A Quantitative Approach. Krieger Publishing Company.
- Davis LS and Johnson KN. 1987. Forest Management. 3rd Ed. McGraw-Hill. Evans J. 1982. Plantation Forestry in the Tropics. Clarendon Press.
- Johnson PS, Shifley SR and R. Rogers. 2009. Self-thinning and Stand Density. The Ecology and Silviculture of Oaks. CABI, Cambridge, MA.
- Luna RK. 1989. Plantation Forestry in India. International Book distributors.
- Vanclay JK. 1994. Modeling Forest Growth and Yield: Application to Mixed Tropical Forests. CAB International.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	2	3	-	-	-	1	1	1	1	2	1
CO-2	2	3	3	1	2	-	2	3	-	1	1
CO-3	3	3	2	2	-	-	1	2	2	-	3
CO-4	2	3	2	1	3	2	1	-	-	1	-
CO-5	-	3	3	-	2	3	3	3	3	2	2
CO-6	3	2	2	3	-	1	2	-	1	1	2
Average	2.0	2.8	2.8	1.1	1.1	1.1	1.6	1.5	1.1	1.1	1.5

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
					Internal Exam			End Term Exam	Subject Total	
		L	T	P	Midterm Theory Exam	Assignment	Practical			
DPT C601	Quantitative Silviculture	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C602	Credit	2(2+0)
Year/Sem	Year 1; Semester - II	L-T-P	2-0-0
Course name	Agroforestry Research and Management	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember various agroforestry system for production and protection purpose.2. To understand the refinement of the agroforestry systems.3. To apply various Agroforestry models increase land use system.4. To analyze management practices and their integration for developing suitable agroforestry systems.5. To evaluate Carbon and nutrient dynamics in agroforestry- carbon sequestration6. To create a working plan of capacity building of farmer and farm forest associations.			
UNITS I (Total Topics- 6 and Hrs- 8) Recent trends in agroforestry research and development. Agroforestry land use systems and their salient features. Research designs and analysis in agroforestry. Multi-functionality of agroforestry systems-multiplicity of products and services, food and nutritional security, livelihood security, gender related aspects. Constraints in agroforestry research – research prioritization			
UNIT II (Total Topics -8 and Hrs-8) Study of systems specification, prioritizing potential interventions and technology specifications; space and time related considerations. Introduction to on-farm and on-station research experiments. Biomass production and allocation patterns- changes thorough agroforestry interventions			
UNIT- III (Total Topics -8 and Hrs-6) Belowground dynamics- role of fine roots in agroforestry productivity. Tree husbandry practices in agroforestry for productivity optimization. Soil-site sustainability and environmental resource sharing. Site-species compatibility. Competition, predation, mutualism, commensalisms. Simulation modeling of agroforestry systems. Carbon and nutrient dynamics in agroforestry- carbon sequestration- carbon credits- mitigatory and adaptive roles of agroforestry in the climate negotiations and agroforestry, context of climate change			
UNIT-IV (Total Topics -8 and Hrs-8) Management of multifunctional agroforestry – sustainability, links with UNFCCC, UNCCD and UNCBD. Carbon conservation, sequestration, and substitution functions of agroforestry trees. Domestication of useful species and crafting market regimes for the products derived from agroforestry and ethno-forestry systems. Contract fuel wood schemes, small-scale nursery enterprises, charcoal policy reform, novel market information systems, facilitating and capacity building of farmer and farm forest associations. Climate change and reforestation incentive policies. Market intelligence for agroforestry products. Agroforestry value chain models: consortia concepts. Successful case studies.			
Course Outcomes (CO): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1: Remembering different Agroforestry system.• CO.2: Understanding Agroforestry land usesystems• CO.3: Applying Biomass production and allocation patterns- changes thorough agroforestry			

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interventions

- CO.4: Analyzing, market intelligence for agroforestry products.
- CO.5: Evaluation of Carbon and nutrient dynamics in agroforestry- carbon sequestration- carbon credits- mitigatory and adaptive roles of agroforestry
- CO.6 Creating simulation modeling of agroforestry systems.

Suggested readings:

- Chin K Ong, Colin Black and Julia Wilson. 2015. Tree-Crop Interactions, 2nd Edition: Agroforestry in a Changing Climate. CAB International.
- Kumar BM and Nair PKR. 2011. Carbon Sequestration Potential of Agroforestry Systems: Opportunities and Challenges. Springer.
- Nair PKR, Rai MR and Buck LE. 2004. New Vistas in Agroforestry. Kluwer
- Ong CK and HuXley PK. 1996. Tree Crop Interactions – A Physiological Approach.
- ICRAF. Snelder DJ and Lasco RD. 2008. Smallholder Tree Growing for Rural Development and Environmental Services. Springer Science, Amsterdam.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	1	2	1	2	2	1	2	1	1	1	1
CO-2	1	1	2	2	1	1	1	1	1	1	1
CO-3	1	2	1	2	3	1	3	1	1	1	2
CO-4	1	1	1	2	2	1	2	1	1	1	1
CO-5	1	2	2	2	2	1	2	1	1	1	2
CO-6	1	1	1	2	2	1	2	1	1	1	1
Average	1.0	1.5	1.3	2.0	2.0	1.0	2.0	1.0	1.0	1.0	1.3

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
		L	T	P	Internal Exam			End Term Exam	Subject Total	
					Midterm Theory Exam	Assignment	Practical			
DPT C602	Agroforestry Research and Management	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C603	Credit	1(1+0)
Year/Sem	Year 1; Semester I/II	L-T-P	1-0-0
Course name	Forest Stand Dynamics	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> 1. To remember tree architecture and growth- general growth pattern. 2. To understand and anticipate how forests grow and respond to intentional manipulations and natural disturbances. 3. To apply Disturbances and stand development – impact of disturbances. 4. To study temporal and spatial patterns of tree invasion. 5. To evaluate quantification of stand development. 6. To create resilience to disturbances. 			
UNITS I (Total Topics- 6 and Hrs- 8)			
Introduction-plant interactions and limitations of growth – mutualism and competition – the niche – limitations of growth – concept of growing space. Tree architecture and growth-general growth patterns – shoot development patterns, crown shapes, height growth, root growth, and tree development			
UNIT II (Total Topics -8 and Hrs-8)			
Disturbances and stand development – impact of disturbances – major and minor-classification of disturbances – characteristics of disturbance agents. Stand structure and fire behaviour. Building resilience to disturbances			
UNIT- III (Total Topics -8 and Hrs-6)			
Overview of stand development patterns – temporal and spatial patterns of tree invasion – stand initiation stage – stem exclusion stage – understorey reinitiation stage – old growth stage – multicohort stands – behavior of component cohorts- development of multicohort stands – quantification of stand development – forest patterns over long times and large areas. Gap dynamics.			
Course Outcomes (CO): After completion of course, students will be able to:			
CO.1 Remember the plant interactions and limitations of growth.			
CO.2 Understand concept of growing space.			
CO.3 Apply disturbance in Forest stand.			
CO.4 Analyz the impact of disturabance.			
CO.5 Evaluate behaviour of component.			
CO.6 Create the various regeneration practices.			
Suggested readings:			
<ul style="list-style-type: none"> • Chin K Ong, Colin Black and Julia Wilson. 2015. Tree-Crop Interactions, 2nd Edition: Agroforestry in a Changing Climate. CAB International. • Kumar BM and Nair PKR. 2011. Carbon Sequestration Potential of Agroforestry Systems: Oportunities and Challenges. Springer. • Nair PKR, Rai MR and Buck LE. 2004. New Vistas in Agroforestry. Kluwer • Ong CK and HuXley PK. 1996. Tree Crop Interactions – A Physiological Approach. ICRAF. Snelder DJ and Lasco RD. 2008. Smallholder Tree Growing for Rural Development and Environmental Services. Springer Science, Amsterdam. 			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	1	2	1	2	2	1	1	1	1	1	1	1
CO-2	1	1	2	2	1	1	1	1	1	1	1	1
CO-3	1	2	1	2	3	1	1	1	1	2	2	2
CO-4	1	1	1	2	2	1	1	1	1	1	1	1
CO-5	1	2	2	2	2	1	1	1	1	2	2	2
CO-6	1	1	1	2	2	1	1	1	1	1	1	1
Average	1.0	1.5	1.3	2.0	2.0	1.0	1.0	1.0	1.0	1.3	1.3	1.3

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
					Internal Exam			End Term Exam	Subject Total	
		L	T	P	Midterm Theory Exam	Assignment	Practical			
DPT C603	Forest Stand Dynamics	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C604	Credit	3(2+1)
Year/Sem	Year 1; Semester I/II	L-T-P	2-0-1
Course name	Productivity and Evaluation of Agroforestry Systems	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> 1. To acquaint the students with concepts in agroforestry systems productivity, managing the factors of production and sustained yield levels. 2. To understand System complementarity, supplementarity, competitiveness, sustainability and management techniques. 3. To apply biological yield and harvest index. 4. To analyze strategies to improve the efficiency and productivity of different land use systems. 5. To evaluate combined productivity and profitability of different agroforestry systems 6. To create Growth and yield functions and role of various financing agencies in agroforestry 			
UNITS I (Total Topics- 6 and Hrs- 8)			
Concept of crop productivity. Productivity potential in relation to light, water and nutrients.			
UNIT II (Total Topics -8 and Hrs-8)			
System complementarity, supplementarity, competitiveness, sustainability and management techniques. Tree root architecture, re-allocation of resources within the plant system.			
UNIT- III (Total Topics -8 and Hrs-6)			
Biological yield and harvest index. Growth and yield functions. Land equivalent ratio. Water use efficiency, photosynthetic efficiency, radiation balance, canopy transmissivity, canopy management, plant geometry and crop yield. Allelopathic effects. Strategies to improve the efficiency and productivity of different land use systems.			
Unit IV			
Role of various financing agencies in agroforestry and critical evaluation of different credit systems with emphasis on agroforestry. Methodologies for evaluating agroforestry hedonic pricing, PES, LER and LEV. Financial, economic and social accounting of agroforestry projects. Advances in marketing management of agroforestry products. Evaluating combined productivity and profitability of different agroforestry systems <i>vis-a-vis</i> other competitive agro-based systems. Tree insurance schemes.			
Practical			
Techniques for leaf area index; Photosynthetically active radiation ; Soil moisture and leaf water potential; Canopy density measurements; Exercises on developing alternative optimal agroforestry plans under perfect and imperfect knowledge situations; Socio-economic and financial evaluation of agroforestry projects.			
Course Outcomes (CO): After completion of course, students will be able to:			
<ul style="list-style-type: none"> • CO.1: Remember productivity potential in relation to light, water and nutrients. • CO.2: Understand concept of re-allocation of resources within the plant system. • CO.3: Apply plant geometry and crop yield. • CO.4: Analyze strategies to improve the efficiency and productivity of different land use systems. 			

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- CO.5: Evaluate various competitive agro- based systems.
- CO.6: Creating sustainability and management techniques for different agroforestry system

Suggested readings:

- Alavalapati JRR and D Evan Mercer. 2004. Valuing Agroforestry Systems: Methods and applications, Kluwer Academic Publishers.
- Kant Shashi and Janaki Alavalapati. 2014. Handbook of Forest Resource Economics, Publisher: Routledge.
- Nair PKR, Rai MR and Buck LE. 2004. New Vistas in Agroforestry. Kluwer. Nair PKR. 1993. An Introduction to Agroforestry. Kluwer.
- Ong CK and Huxley PK. 1996. Tree Crop Interactions – A Physiological Approach. ICRAF. Sullivan, Gregory M, Susan M Hoke and Jefferson M Fox (editors). 1992. Financial and Economic
- Analyses of Agroforestry Systems. Proceedings of a workshop held in Honolulu, Hawaii, USA. July 1991. Paia, Ill: Nitrogen Fixing Tree Association.
- Tejwani KG 1994. Agroforestry in India Oxford and IBH publishing Co. Pvt. Ltd.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	1	2	1	2	2	1	1	1	1	1	1
CO-2	1	1	2	2	1	1	1	1	1	1	1
CO-3	1	2	1	2	3	1	1	1	1	2	1
CO-4	1	1	1	2	2	1	1	1	1	1	1
CO-5	1	2	2	2	2	1	1	1	1	2	1
CO-6	1	1	1	2	2	1	1	1	1	1	1
Average	1.0	1.5	1.3	2.0	2.0	1.0	1.0	1.0	1.0	1.3	1.0

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
		L	T	P	Internal Exam			End Term Exam	Subject Total	
					Midterm Theory Exam	Assignment	Practical			
DPT C604	Productivity and Evaluation of Agroforestry Systems	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C605	Credit	2(1+1)
Year/Sem	Year 1; Semester I/II	L-T-P	1-0-1
Course name	Forest Stand Management Techniques	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To develop understanding of students about advances in silviculture.2. To Understand and silvicultural practice, effect of silvicultural practices on forest stand management.3. To apply new Technique for stand development.4. To analyse, advances in coppice silviculture.5. To evaluate status of silviculture in India and abroad.6. To create problem solving procedures for silviculture.			
UNITS I (Total Topics- 6 and Hrs- 8) Philosophy of silviculture – advance reproduction methods and their role in silviculture – Judging successful establishment; Analysis of active and passive site preparation – Silviculture with an ecosystem approach. Advances in silvicultural practices; tropical forest, sub-tropical forest and temperate forest.			
UNIT II (Total Topics -8 and Hrs-8) Analysis of different techniques of silviculture in forest stand management, Technique for early stand development; Analysis of thinning methods and its impact on wood yield and quality; Stand protection and health management. Silvicultural use of prescribed fire. Mechanization and role in silviculture.			
UNIT- III (Total Topics -8 and Hrs-8) Advance silviculture techniques for plantation forestry; Case studies of advance silviculture in India and abroad; mixed plantation forestry, Precision silviculture, silviculture of intensively managed plantations, silviculture for climate change mitigation. Sewage silviculture. Silviculture management for watershed and catchment areas. Silviculture for wildlife habitat improvement.			
Unit IV (Total Topics -4 and Hrs-6) Adjusting silviculture to meet industrial demands – silviculture in perspective – Problem solving procedure for silviculture – silviculture in retrospect			
Practical Study of components of silvicultural system for sustained yield; Management strategies for even aged and uneven aged stands; Choice of site preparation methods, Plantation map, Quality planting stock, Planning for tree planting, Release cutting operation; Selection of thinning methods, Intensity of thinning; Analysis of site quality and biomass production for timber, pulp wood and fuel wood species; Problems in silviculture in tropical, subtropical plantation and their solutions.			
Course Outcomes (CO): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1: Remember reproduction methods and their role in silviculture.• CO.2: Understand concept of re-allocation of resources within the plant system.• CO.3: Apply plant geometry and crop yield.			

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- CO.4: Analyz Analysis of active and passive site preparation – Silviculture with an ecosystem approach.
- CO.5: Evaluate of various competitive agro-based systems.
- CO.6: Create sustainability and management techniques for different agro -forestry system.

Suggested readings:

- Brang P, Spathelf P, Larsen JB, Bauhus J, Bonèina A and Chauvin C. 2014. Suitability of Close-To-Nature Silviculture for Adapting Temperate European Forests to Climate Change. *Forestry*.
- Colak AH, Rotherham ID and Calikoglu M. 2003. Combining ‘Naturalness Concepts’ with Close-to-Nature Silviculture. *Forstwiss. Centralbl.* 122, 421–431.
- Cole DN and Yung L. (eds) 2010. *Beyond Naturalness: Rethinking Park and Wilderness Stewardship in an Era of Rapid Change*. Island Press.
- Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture*, 2nd edition, McGraw-Hill, 2nd ed.
- Fettig CJ, Reid ML, Bentz BJ, Sevanto S, Spittlehouse DL and Wang T. 2013. Changing climates, changing forests: A western North American perspective.
- Franklin JF. 1989. *Towards a New Forestry*. Am. For.
- Holm-Nielsen LB, Nielsen IC and Balsev H. (eds.) 1989. *Tropical Forests*, Academic Press, London.
- Pukkala T and Gadow KV. 2012. *Continuous Cover Forestry*. 2nd Edition Springer.
- Sairll PS, Evans J, Auclair D and Flack J. 1997. *Plantation Silviculture in Europe*. Oxford University Press.
- Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture: Applied Forest Ecology*. John Wiley & Sons.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	3	2	1	1	1	1	-	1	1	1
CO-2	3	2	1	1	1	1	1	-	-	1	1
CO-3	3	2	1	1	2	1	1	-	1	1	1
CO-4	3	2	2	1	1	2	1	1	-	1	2
CO-5	3	2	2	1	1	-	1	-	1	1	1
CO-6	3	2	2	1	1	1	1	1	-	1	1
Average	3.0	2.2	1.7	1.0	1.2	1.2	1	1.0	1.0	1.0	1.2

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
					Internal Exam			End Term Exam	Subject Total	
		L	T	P	Midterm Theory Exam	Assignment	Practical			
DPT C605	Forest Stand Management Techniques	1	0	2	20	20	20	40	100	2(1+1)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C606	Credit	2(2+0)
Year/Sem	Year 1; Semester I/II	L-T-P	2-0-0
Course name	Agroforestry for Ecosystem Services and Environmental Benefits	Course Type	Elective

Course Objectives:

1. To develop understanding of students about ecosystem services.
2. To understand environmental benefits and quantification of ecosystem services.
3. To apply soil enrichment – mechanisms – litter and fine root dynamics.
4. To analyze Agroforestry for biodiversity conservation.
5. To evaluate carbon sequestration potential – measurement – prospects and problems of Agroforestry.
6. To create Landscape connectivity for wildlife, supporting the pollinators of plant species.

UNITS I (Total Topics- 6 and Hrs- 8)

Multifunctionality of agroforestry. Major ecosystem services and environmental benefits and international conventions and charters on climate change (UNFCCC, UNCCD, agroforestry and climate change negotiations: CoP) and biodiversity conservation (CBD) – an overview.

UNIT II (Total Topics -8 and Hrs-8)

Agroforestry for carbon conservation, sequestration, substitution – role and potentials of various agroforestry systems. Estimates of carbon sequestration potential – measurement – prospects and problems. Factors affecting above and belowground carbon sequestration potential

UNIT- III (Total Topics -8 and Hrs-6)

Agroforestry for soil enrichment – mechanisms – litter and fine root dynamics, rhizo-deposition and other rhizosphere effects, symbiotic and free-living N₂ fixation, mycorrhizal associations. Soil and water conservation benefits.

Agroforestry for biodiversity conservation. Synergy with climate change mitigation. Landscape connectivity for wildlife, supporting the pollinators of plant species. Agroforestry for improved air and water quality. Non-point source pollution in Indian agro-ecosystems. Riparian buffers for alleviating agricultural non-point source pollution.

Unit IV

Private profitability vs. social profitability – exclusion or inclusion of social benefits and costs and non-market values, or externalities. Theory of externalities, effect of environmental costs and benefits on the profitability of agroforestry practices. Valuing environmental services. Profitability of timber-based agroforestry systems. Costs and benefits in agroforestry- valuation of inputs and outputs- environmental outputs.

Course Outcomes (CO): After completion of course, students will be able to:

- CO.1: Remember multifunctionality of agroforestry.
- CO.2: Understand concept of Agroforestry for carbon conservation, sequestration, substitution – role and potentials of various agroforestry systems.
- CO.3: Apply mechanisms of soil enrichment- litter and fine root dynamics, rhizo-deposition and other rhizosphere.
- CO.4: Analyz non-point source pollution in Indian agro-ecosystems.

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- CO.5: Evaluate the various Riparian buffers for alleviating agricultural non-point source pollution.
- CO.6: Value the environmental services, Profitability of timber-based agroforestry systems.

Suggested readings:

- Alavalapati JRR, Shrestha RK, Stainback GA and Matta JR. 2004. Agroforestry development: An environmental Economic Perspective. *Agroforestry Systems*. 61: 299–310.
- IPCC. 2007. “Climate Change 2007”. Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
- Jain SK and Singh P. 2000. Economic Analysis of Industrial Agroforestry: Poplar (*Populus deltoides*) In Uttar Pradesh (India). *Agroforestry Systems*. 49: 255–273.
- Jeffers JNR. 1978. An Introduction to System Analysis with Ecological Application. Edward Arnold.
- Jose S. 2009. Agroforestry for Ecosystem Services and Environmental Benefits: An Overview. *Agroforestry Systems*. 76: 1-10.
- Lyngbaek AE, Muschler RG and Sinclair FL. 2001. Productivity and Profitability of Multistrata Organic Versus Conventional Coffee Farms in Costa Rica. *Agroforest. Syst.* 53: 205–213.
- Schroth G and Sinclair F. 2003. Tree Crops and Soil Fertility: Concepts and Research Methods, CABI, Wallingford, UK.
- Young A. 1997. Agroforestry for Soil Management. 2nd ed. CABI, Wallingford, UK. Edition Springer.
- Sairll PS, Evans J, Auclair D and Flack J. 1997. Plantation Silviculture in Europe. Oxford University Press.

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	3	2	1	1	1	-	1	1	1	-
CO-2	3	2	1	1	1	1	-	-	1	1	1
CO-3	3	2	1	1	2	1	-	1	1	1	-
CO-4	3	2	2	1	1	1	1	-	1	2	2
CO-5	3	2	2	1	1	1	-	1	1	1	-
CO-6	3	2	2	1	1	1	1	-	1	1	1
Average	3.0	2.2	1.7	1.0	1.2	1	1.0	1.0	1.0	1.2	1.3

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
		L	T	P	Internal Exam			End Term Exam	Subject Total	
					Midterm Theory Exam	Assignment	Practical			
DPT-C606	Agroforestry for Ecosystem Services and Environmental Benefits	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C607	Credit	2(1+1)
Year/Sem	Year 1; Semester I/II	L-T-P	1-0-2
Course name	Plantation Forest Productivity	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To develop understanding of students about plantation forest productivity.2. To understand dynamics of plantation growth.3. To apply the various tending operation, thinning and fertilization of plantation.4. To analyse the effect of silvicultural interventions.5. To evaluate productivity decline in plantation forests second rotation, decline harvest related.6. To create clonal forests, their management and productivity comparisons.			
UNITS I (Total Topics- 6 and Hrs- 8) Plantation forests – scope and perspectives, international and national scenario. Dynamics of plantation growth – site quality, stand density, dynamics of nutrient cycling, thinning, spacing and crown efficiency, nutrient pools and dynamics, biological factors in nutrient supply.			
UNIT II (Total Topics -8 and Hrs-8) Advances in site preparation techniques. Recent trends in fertilization and irrigation of plantations. Tending and cultural operations and plantation productivity – prospects of mechanization in tropical plantations. Reduced impact logging. Clonal forests, their management and productivity comparisons.			
UNIT- III (Total Topics -8 and Hrs-6) Productivity decline in plantation forests – second rotation decline – harvest related resource export – Modern silvicultural interventions. Project formulation, designing and appraisal of different kinds of plantations to meet specific objectives.			
Practical Plantation productivity analysis – growing stock and MAI assessment – stand density estimation; Fertilizers and fertilizer application in plantation; Response of plantation to irrigation; Productivity of clonal forestry; Modern tools in site preparation; Weed management methods; Management strategies for enhancing plantation productivity.			
Course Outcomes (CO): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1: Remember dynamics of plantation growth, thinning and fertilization of plantation.• CO.2: Understand concept site quality, stand density, dynamics of nutrient cycling, thinning, spacing and crown efficiency,• CO.3: Apply recent trends in fertilization and irrigation of plantations.• CO.4: Analyz impact logging. Clonal forests, their management and productivity comparisons.• CO.5: Evaluate the harvest related resource export and modern silvicultural interventions.• CO.6: Prepare projects, designing and appraisal of different kinds of plantations to meet specific objectives.			

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Suggested readings:

- Evans J. 1982. Plantation Forestry in the Tropics. Clarendon Press. Ford ED. 1984. Nutrition of Plantation Forests. Academic Press.
- Krishnapillay B. 2000. Silviculture and Management of teak plantations. Unasy. 201. 51:14-21p.
- Nambiar EKS, Cossalter C and Tiarks A. 1998. Site Management and Productivity in Tropical Plantation Forests. Workshop Proceedings, South Africa.
- Sairll PS, Evans J, Auclair D and Flack J. 1997. Plantation Silviculture in Europe. Oxford University Press.
- Smith DM. 1980. The Practice of Silviculture. 8th ed., John Wiley & Sons.
- Suzuki K, Ishii K, Sakurai S and Sasaki S. 2006. Plantation Forestry in the Tropics. Springer Tokyo.
- Zobel BJ, Wyk G and Stahlper P. 1987. Growing Exotic Forests. John Wiley & Sons.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	2	2	-	2	1	1	-	1	3	2
CO-2	3	2	2	-	1	1	1	-	1	2	2
CO-3	3	1	2	1	1	-	-	-	-	1	1
CO-4	2	1	2	2	2	1	-	1	-	1	1
CO-5	1	1	-	-	-	1	1	-	-	-	1
CO-6	1	-	-	-	1	-	1	1	1	-	-
Average	2.2	1.4	2.0	1.5	1.4	1.0	1.0	1.0	1.0	1.8	1.4

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
					Internal Exam			End Term Exam	Subject Total	
		L	T	P	Midterm Theory Exam	Assignment	Practical			
DPT C607	Plantation Forest Productivity	2	0	0	20	20	20	40	100	2(1+1)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C608	Credit	1(1+0)
Year/Sem	Year 1; Semester I/II	L-T-P	1-0-0
Course name	Restoration Forestry	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> 1. To develop understanding of students about advances in restoration forestry and forest landscape restoration 2. To understand Forest restoration techniques, tools for prioritization 3. To apply the various methods of natural regeneration, 4. To Analyse adaptive management for forested landscapes in transformation 5. To evaluate resilient and genetically diverse forests. 6. To design plan for mangrove restoration. 			
UNITS I (Total Topics- 6 and Hrs- 8)			
Introduction to restoration forestry, scope and opportunities for forest restoration, Natural regeneration, forest and land degradation in the Asia-Pacific region. Forest restoration techniques, tools for prioritization, decision-making and monitoring to enhance restoration success, The Bonn Challenge, The Bonn Challenge in Asia, Africa and Latin America.			
UNIT II (Total Topics -8 and Hrs-8)			
Forest landscape restoration, environment for natural regeneration in forest and landscape restoration, economic and social aspects for successful integration of natural regeneration in forest landscape restoration, adaptive management for forested landscapes in transformation, measures to improve resilient and genetically diverse forests.			
UNIT- III (Total Topics -8 and Hrs-6)			
Mangrove restoration. Case studies on successful forest landscape restoration.			
Course Outcomes (CO): After completion of course, students will be able to:			
<ul style="list-style-type: none"> • CO1: Remember the concepts of restoration forestry, its scope, and opportunities for forest restoration. • CO2: Understand the causes and extent of forest and land degradation in the Asia-Pacific region. • CO3: Apply forest restoration techniques and tools for prioritization in restoration planning. • CO4: Analyze the economic and social aspects essential for successful integration of natural regeneration in forest landscape restoration. • CO5: Evaluate approaches to improve resilient and genetically diverse forest ecosystems. • CO6: Assess case studies related to successful forest landscape restoration initiatives. 			
Suggested readings:			
<ul style="list-style-type: none"> • Beatty CR, Cox NA and Kuzee ME. 2018. Biodiversity Guidelines for Forest Landscape Restoration Opportunities Assessments. First edition. Gland, Switzerland: IUCN. • Blakesley D and Buckley P. 2016. Grassland Management and Restoration. Conservation handbooks. Pelagic Publishing. Food and Agriculture Organization of the United Nations. Chokkalingam U, Shono K, Sarigumba MP, Durst PB and Leslie R. (eds). 2018. Advancing the Role of Natural Regeneration in Large-Scale Forest and Landscape Restoration in the Asia-Pacific Region. FAO and APFNet. Bangkok. 			

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- FAO. 2010. Forests Beneath the Grass. Proceedings of the Regional Workshop on Advancing The Application of Assisted Natural Regeneration for Effective Low-Cost Forest Restoration. Bangkok, FAO.
- FAO/ RECOFTC. 2016. Forest Landscape Restoration in Asia-Pacific Forests. by Appanah, S. (ed.). Bangkok, Thailand.198p
- Prober SM, Byrne M, McLean EH, Steane DA, Potts BM, Vaillancourt RE and Stock WD. 2015. Climate-Adjusted Provenancing: A Strategy for Climate-Resilient Ecological Restoration. Frontiers in Ecology and Evolution, 23 June.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	2	2	1	2	1	1	2	1	1	2
CO-2	2	1	2	1	1	2	2	2	1	1	3
CO-3	2	2	3	1	2	2	3	1	2	2	1
CO-4	2	3	3	2	1	1	1	1	2	1	1
CO-5	2	1	1	1	2	1	2	1	3	2	1
CO-6	1	1	2	1	1	-	1	2	1	1	2
Average	2.0	1.6	2.1	1.1	1.3	1.3	1.6	1.4	1.6	1.3	1.6

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
					Internal Exam			End Term Exam	Subject Total	
		L	T	P	Midterm Theory Exam	Assignment	Practical			
DPT C608	Restoration Forestry	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	2
Course Code	DPT C609	Credit	3(2+1)
Year/Sem	Year 1; Semester I/II	L-T-P	2-0-1
Course name	Regeneration Silviculture	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To develop understanding of students understanding of students about advances in regeneration silviculture2. To understand forest continuum3. To apply advancement in artificial regeneration.4. To Analyse Plant quality assessment tools. Nursery production system of important timber and Non-Timber Forest Products,5. To evaluate regeneration problems of important conifers and broad leaved species-case studies.6. To create quality planting stock.			
UNITS I (Total Topics- 6 and Hrs- 8) Planning for regeneration, setting the objectives for regeneration, principles and methodologies of forest regeneration, ecological basis of natural regeneration techniques Basic Concepts in forest regeneration, importance of different combinations of light, moisture, soil in determining success or failure of regeneration. Factors affecting natural and artificial regeneration- kinds, extent and quality of sites.			
UNIT II (Total Topics -8 and Hrs-8) Techniques of canopy manipulation and forest continuum in regular and irregular forests canopy, light pattern and regeneration establishment. Regeneration survey and methodology. Major silvicultural systems of tropical and temperate parts of the world. Continuous cover forestry. Advances in coppice silviculture. Silviculture in a changing.			
UNIT- III (Total Topics -8 and Hrs-6) Advances in artificial regeneration techniques, advances in vegetative propagation techniques like mini and micro-cutting techniques, production technology for quality planting stock, carbon enrichment techniques for production of quality planting stock. Integrated nutrient management in nursery production. Plant quality assessment tools. Nursery production system of important timber and Non-Timber Forest Products, NTFP's yielding species in the region.			
UNIT- IV (Total Topics -8 and Hrs-6) Sustainable site establishment practices, Novel tree establishment techniques. Regeneration problems of important conifers and broad leaved species-case studies.			
Practical Factors affecting natural and artificial regeneration; Advances in vegetative propagation techniques like mini and micro-cutting techniques; Production technology for quality planting stock; Carbon enrichment techniques for production of quality planting stock; Integrated nutrient management in nursery production; Novel tree establishment techniques. Modern approaches in containerized seedling production.			
Course Outcomes (CO): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Remember the principles and methodologies of forest regeneration.• CO2: Understand the various methodologies and processes involved in forest regeneration.			

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- CO3: Apply techniques of canopy manipulation and concepts of forest continuum in regular and irregular forest canopies.
- CO4: Analyze major silvicultural systems practiced in tropical and temperate regions of the world.
- CO5: Evaluate Non-Timber Forest Products (NTFP)–yielding species of the region.
- CO6: Create sustainable site-establishment practices for effective forest regeneration.

Suggested readings:

- Colak AH, Rotherham ID and Calikoglu M. 2003. *Combining 'naturalness concepts' with close- to-nature silviculture*. Forstwiss. Centralbl. 122, 421–431.
- Sairll PS, Evans J, Auclair D and Flack J. 1997. *Plantation Silviculture in Europe*. Oxford University Press.
- Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture: Applied Forest Ecology*. John Wiley & Sons.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	1	2	1	1	1	1	1	1	1	1
CO-2	2	2	1	2	1	1	-	1	1	-	
CO-3	2	2	2	1	-	-	1	1	1	1	1
CO-4	1	2	1	1	2	1	-	1	1	1	-
CO-5	-	1	-	-	2	-	-	1	1	3	1
CO-6	1	1	1	1	1	1	1	1	1	1	1
Average	1.8	1.5	1.4	1.2	1.4	1.0	1.0	1.0	1.0	1.4	1.0

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
					Internal Exam			End Term Exam	Subject Total	
		L	T	P	Midterm Theory Exam	Assignment	Practical			
DPT C609	Regeneration Silviculture	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Forestry (Silviculture and Agroforestry)	Programme Code	
Course Code	DPT C610	Credit	2(1+1)
Year/Sem	Year 1; Semester I/II	L-T-P	1-0-1
Course name	Forest Soil Management (Elective Course)	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> To develop understanding of students about advances in forest soil management. To understand forest soils and vegetation management. To apply techniques for management of long-term soil productivity. To Analyse Soil organic matter. To evaluate Nitrogen fixation in tropical forest plantations: N₂ fixation process, species, rates of N₂ fixation. To create management strategies for future management. 			
UNITS I (Total Topics- 6 and Hrs- 8)			
Forest soil and vegetation development. Physical properties of forest soils. Forest soil classification. Soils of the major forest biomes – soils under different forest types – tropical rainforest soils – moist deciduous forests – dry deciduous. Soils and plant roots.			
UNIT II (Total Topics -8 and Hrs-8)			
Soil chemistry and nutrient uptake. Soil organic matter – maintenance and buildup. Biology of forest soils – role of microorganisms in ameliorating soils; N and C cycles. Forest biogeochemistry. Mycorrhizae. Role of forests in conserving soils.			
UNIT- III (Total Topics -8 and Hrs-6)			
Nutrient transformation in soils. Nitrogen fixation in tropical forest plantations: N ₂ fixation process, species, rates of N ₂ fixation, factors influencing N ₂ fixation; nutrient cycling – comparison of plantation productivity – case studies. Nutrition management: nutrient limitations, fertilization. Soil carbon sequestration – processes and mechanisms.			
UNIT- IV (Total Topics -8 and Hrs-6)			
Soil management for reforestation of salt affected soils, acid soils, coastal soils. Effects of fire on soils and their properties. Management of long term soil productivity – soil compaction and erosion – harvest removal and nutrient budgeting – harvest effect on water quality – strategies for future management.			
Practical			
Nutrient budgeting for different plantation systems; Quantification of physical and chemical soil constraints in plantation and agroforestry systems; Evolving new strategies for soil and site development.			
Course Outcomes (CO): After completion of course, students will be able to:			
<ul style="list-style-type: none"> CO1: Remember the physical properties of forest soils, forest soil classification systems, and the characteristics of soils in major forest biomes. CO2: Understand the role of forests in soil conservation. CO3: Apply appropriate techniques for forest soil management. CO4: Analyze the nutrient status of forest soils across different biomes. CO5: Evaluate biological nitrogen (N₂) fixation and the factors influencing it. CO6: Apply suitable reforestation strategies for salt-affected, acidic, and coastal soils. 			

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Suggested readings:

- Binkley D and R. Fisher. 2012. Ecology and Management of Forest Soils (4th Edition), John Wiley & Sons Singapore Pte. Ltd., Singapore.
- Fisher RF, Binkley D and Pritchett WL. 2000. Ecology and Management of Forest Soils. 3rd Ed. John Wiley & Sons Inc., New York.
- Havlin et al. 2014. Soil Fertility and Fertilizers: An Introduction to Nutrient Management (8th Edition), PHI Learning Pvt. Ltd., Delhi.
- Khan TO. 2013 Forest Soils: Properties and Management, Springer International Publishing, Switzerland.
- Pritchett and Fisher RF 1987. Properties and Management of Forest Soils. John Wiley, New York.
- Reddy MV. 2001. Management of Tropical Plantation Forests and Their Soil Litter System-Litter, Biota and Soil Nutrient Dynamics. Science Publishers, U.S.
- Sadanandan Nambiar EK and Grown AG. (Eds.). 1997. Management of Soil, Nutrients and Water in Tropical Plantation Forests. ACIAR, CSIR and CIFOR, Australia.
- Schulte A and Ruhiyat D. 1998. Soils of Tropical Forest Ecosystems: Characteristics, Ecology, and Management. Springer Verlag, Berlin, New York.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	2	-	-	2	1	-	-	1	1	1
CO-2	3	2	2	2	1	1	2	2	2	2	1
CO-3	1	1	1	1	2	-	-	-		1	
CO-4	2	2	1	1	2	1	-	-	-	1	-
CO-5	1	1	-	-	1	1	-	-	1	1	-
CO-6	3	2	2	-	1	1	2	2	2	2	1
Average	2.2	1.7	1.5	1.3	1.5	1.0	2.0	2.0	1.5	1.3	1.0

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
		L	T	P	Internal Exam			End Term Exam	Subject Total	
					Midterm Theory Exam	Assignment	Practical			
DPT C610	Forest Soil Management	1	0	2	20	20	20	40	100	2(1+1)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C611	Credit	1(2+1)
Year/Sem	Year 1; Semester I/II	L-T-P	2-0-1
Course name	Agroforestry For Sustainable Agriculture	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> To develop understanding of sustainable agriculture. To understand land use changes- through agroforestry. To apply Strategies on integration of trees suitable for different cropping systems for important agro-ecological regions. To analyse tree management for productivity optimization. To evaluate Agroforestry for different land holdings. To create opportunities for value addition and marketing of agroforestry products. 			
UNITS I (Total Topics- 6 and Hrs- 8)			
Current Agricultural scenario in India. Sustainable agriculture: issues and challenges. Land use changes- agroforestry: an opportunity for sustainability and rainfed agriculture.			
UNIT II (Total Topics -8 and Hrs-8)			
Agroforestry options for sustainable agriculture: integration of perennial components in agriculture. Role of trees in enhancing the productivity of traditional agriculture. Strategies on integration of trees suitable for different cropping systems for important agro-ecological regions. Tree management for productivity optimization.			
UNIT- III (Total Topics -8 and Hrs-6)			
Agroforestry for different land holdings. Integrated farming systems. Agroforestry strategies for short term and long term returns.			
UNIT- IV (Total Topics -8 and Hrs-6)			
Processing, value addition and marketing of agroforestry products.			
Suggested readings:			
<ul style="list-style-type: none"> Chin K Ong, Colin Black and Julia Wilson. 2015. Tree-Crop Interactions, 2nd Edition: Agroforestry in a Changing Climate. CAB International ICRAF. Nair PKR, Rai MR and Buck LE. 2004. New Vistas in Agroforestry. Kluwer. Nair PKR. 1993. An Introduction to Agroforestry. Kluwer, Netherlands. Ong CK and Huxley PK. 1996. Tree Crop Interactions – A Physiological Approach. Schroth G and Sinclair F. 2003. Tree Crops and Soil Fertility: Concepts and Research Methods. CABI, Wallingford, UK. Snelder DJ and Lasco RD. 2008. Smallholder Tree Growing for Rural Development and Environmental Services. Springer Science, Amsterdam. 			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none"> CO.1: Develop understanding of sustainable agriculture. CO.2: Understand land use changes- through agroforestry. CO.3: Apply Strategies on integration of trees suitable for different cropping systems for important agro-ecological regions. CO.4: Analyse tree management for productivity optimization. CO.5: Evaluate Agroforestry for different land holdings. 			

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- CO.6: Create opportunities for value addition and marketing of agroforestry products.

Suggested Readings:

- Alavalapati JRR, Shrestha RK, Stainback GA and Matta JR. 2004. Agroforestry development: An environmental Economic Perspective. Agroforestry Systems. 61: 299–310.
- IPCC. 2007. “Climate Change 2007”. Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
- Jain SK and Singh P. 2000. Economic Analysis of Industrial Agroforestry: Poplar (Populus deltoides) In Uttar Pradesh (India). Agroforestry Systems. 49: 255–273.
- Jeffers JNR. 1978. An Introduction to System Analysis with Ecological Application. Edward Arnold.
- Jose S. 2009. Agroforestry for Ecosystem Services and Environmental Benefits: An Overview. Agroforestry Systems. 76: 1-10.
- Lyngbaek AE, Muschler RG and Sinclair FL. 2001. Productivity and Profitability of Multistrata Organic Versus Conventional Coffee Farms in Costa Rica. Agroforest. Syst. 53: 205–213.
- Schroth G and Sinclair F. 2003. Tree Crops and Soil Fertility: Concepts and Research Methods, CABI, Wallingford, UK.
- Young A. 1997. Agroforestry for Soil Management. 2nd ed. CABI, Wallingofrd, UK. Edition Springer.
- Sairll PS, Evans J, Auclair D and Flack J. 1997. Plantation Silviculture in Europe. Oxford University Press.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	1.3	-	-	1	-	-	-	-	1	1
CO-2	3	2	-	-	1	-	-	-	-	1	1
CO-3	3	1.3	2	1	1	-	-	-	-	1	1
CO-4	3	1.3	2	1	1	-	-	-	-	1	1
CO-5	3	1.3	-	3	-	-	-	-	-	1	-
CO-6	3	1.3	2	1	1	1	-	-	1	1	1
Average	3.0	1.4	2.0	1.5	1.0	1.0	-	-	1.0	1.0	1.0

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
		L	T	P	Internal Exam			End Term Exam	Subject Total	
					Midterm Theory Exam	Assignment	Practical			
DPT C610	Agroforestry For Sustainable Agriculture	1	0	0	30	20	-	50	100	1(1+0)

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Minor Courses (Gradiual courses)

Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT M606	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course name	Processing Technology of Forest Products	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To identification of harvesting period based on active content of drugs.2. To develop understanding Harvesting method of underground parts, leaves, stem, bark3. To apply Storage and value addition.4. To analyze Deterioration degradation of active principles during storage and their control5. To evaluate technological advances in collection of Forest products6. To create Latest methods of extraction of volatile and fixed oil.			
UNITS I (Total Topics- 6 and Hrs- 8) Identification of harvesting period based on active content of drugs. Harvesting method of underground parts, leaves, stem, bark, wood, fruits, flowers, etc.			
UNIT II (Total Topics -8 and Hrs-8) Processing of harvested crops of various forest products (<i>e.g.</i> Gums, Resin, Katha, Cutch, Tans, Dyes and fixed oil). Storage and value addition. Deterioration degradation of active principles during storage and their control.			
UNIT- III (Total Topics -8 and Hrs-6) Isolation of major bioactive compounds. Preparation of active content enriched extracts.			
UNIT- IV (Total Topics -8 and Hrs-6) Latest methods of extraction of volatile and fixed oil.			
Practical Harvesting, drying, grading, and packaging of various forest products; Assessment of deterioration of active principles during storage and their control; Preparation of active content enriched extracts of important forest products.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1: Remembering harvesting period based on active content of drugs.• CO.2: Understanding harvesting method of underground parts.• CO.3: Applying Isolation of major bioactive compounds.• CO.4: Analyzing Major silvicultural systems of tropical and temperate parts of the world.• CO.5: Evaluation of degradation of active principles during storage and their control.• CO.6: Creating latest methods of extraction of volatile and fixed oil.			

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Suggested readings:

- Bedi S, Singh T and Vyas SP. 2012. A Handbook of Aromatic and Essential Oil Plants: Cultivation, Chemistry, Processing and Uses. Agrobios (India).
- Dawn CPA, Annamalai M and Naik R. 2016. Leafy Medicinal Herbs: Botany, Chemistry, Postharvest Technology and Uses. CABI.
- Serdar O and Milan M. 2014. Medicinal and Aromatic Crops: Harvesting, Drying and Processing. CRC Press.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	1.3	-	-	1	1	1	-	3	1	-
CO-2	3	2	-	-	1	1	1	-	3	1	-
CO-3	3	1.3	2	1	1	1	1	-	3	1	-
CO-4	3	1.3	2	1	1	1	1	-	3	1	-
CO-5	3	1.3	-	3	-	1	-	-	3	-	-
CO-6	3	1.3	2	1	1	1	1	1	3	1	1
Average	3.0	1.4	2.0	1.5	1.0	1.0	1.0	1.0	3.0	1.0	1.0

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
					Internal Exam			End Term Exam	Subject Total	
		L	T	P	Midterm Theory Exam	Assignment	Practical			
DPT M606	Processing Technology of Forest Products	1	0	0	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT M607	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course name	Value Addition and Marketing of Forest Products	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To develop understanding of students for marketing under disorganized and organized sector2. To understand extraction methods of forest products.3. To apply Concept of e-market and quality standards.4. To analyse pharmaceutical concern for understanding value addition processes,5. To evaluate high value forest products6. To create local market and data collection of sale and sale procedure			
UNITS I (Total Topics- 6 and Hrs- 8) Value addition – concepts and procedures. Drying and grading of various forest products. Preparation of powders, aqueous and alcoholic extracts essences, etc. Preparation of tablets, mixtures, balms, ointments, etc. Bulk storage and packaging.			
UNIT II (Total Topics -8 and Hrs-8) Basic and advanced concepts of trade and marketing, marketing under disorganized and organized sector. Village and regional markets, state, national and international market of forest products. Internet marketing practices for latest market value and other pattern of fluctuations for high value forest products. Concept of e-market and quality standards.			
<i>Practical</i> Visit to nearby pharmaceutical concern for understanding value addition processes; Visit to local market and data collection of sale and sale procedure – organized and unorganized; Internet surfing for latest market value of high value forest products.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1: Remembering Value addition – concepts and procedures• CO.2: Understanding Drying and grading of various forest products.• CO.3: Applying the Techniques Preparation of powders, aqueous and alcoholic extracts essences, etc.• CO.4: Analyzing Basic and advanced concepts of trade and marketing, marketing under disorganized and organized sector.• CO.5: Evaluation Preparation of tablets, mixtures, balms, ointments, etc. Bulk storage and packaging.• CO.6: Creating Internet marketing practices for latest market value and other pattern of fluctuations for high value forest products.			

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Suggested readings:

- Govil JN, Arunachalam C and Singh VK. 2006. *Recent Progress in Medicinal Plants*. Volume 11: drug development from molecules. Studium Press LLC.
- Sharma AK and Singh VK, Govil JN and Goyal NK. 2006. *Recent Progress in Medicinal Plants*. Volume 12: Globalization Of Herbal Health. Studium Press LLC.
- Singh MP and Somadey. 2015. *Indian Medicinal Plants*. Satish Serial Publishing House.
- Singh VK, Govil JN and Singh G. 2002. *Ethnomedicine and Pharmacognosy*. Science Technology, Publishing LLC.
- Syamal MM. 2008. *Production Technology of Medicinal and Aromatic Plants*. IBDC Publishers.

Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PO-8	PO-9	PSO-1	PSO-2	PSO-3	PSO-4	PO-6	PO-7
CO-1	3	3	2	1	1	-	1	1	1	-	2	1	1
CO-2	3	2	1	1	1	-	-	1	1	1	1	1	1
CO-3	3	2	1	1	2	-	1	1	1	-	1	1	1
CO-4	3	2	2	1	1	1	-	1	2	2	2	2	1
CO-5	3	2	2	1	1	-	1	1	1	-	1	-	1
CO-6	3	2	2	1	1	1	-	1	1	1	1	1	1
Average	3.0	2.2	1.7	1.0	1.2	1.0	1.0	1.0	1.2	1.3	1.3	1.2	1

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
		L	T	P	Internal Exam			End Term Exam	Subject Total	
					Midterm Theory Exam	Assignment	Practical			
DPT M607	Value Addition and Marketing of Forest Products	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT M608	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course name	Modern Trends in Wood Modification	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> To remember wood polymer hybrid composites. To understand engineered wood products. To apply testing of biological performance of modified wood products. To Analyse Degradation of cellular structure of wood during use. To evaluate Environmental issues. To create Substation of wood modification. 			
UNITS I (Total Topics- 6 and Hrs- 11)			
Engineered wood products. Wooden furniture, Transparent wood, Conductive wood, Biochar, Briquette etc. Wood polymer hybrid composites. Stabilization of wood preservatives.			
UNIT II (Total Topics - 6 and Hrs - 8)			
Thermal, Chemical and Mechanical modification of wood, Testing of biological performance of modified wood products. Degradation of cellular structure of wood during use.			
UNIT III (Total Topics -2 and Hrs - 6)			
Testing of biological performance of modified wood products. Degradation of cellular structure of wood during use.			
UNIT IV (Total Topics -1 and Hrs-5)			
Environmental issues related to wood modification.			
Practical			
Different preservative treatments of wood; Chemical modification of wood; Testing of biological performance of modified wood; Treated wood finishing.			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none"> CO.1: Remembering wood chemistry and its utilization CO.2: Understanding Advances in wood working CO-3 Applying various wood modification in different types of timber CO-4 Analyzing performance of modified wood CO-5 Evaluation of Treated wood finishing. CO- 6. Creating Sustainable site establishment practices 			
Suggested readings:			
<ul style="list-style-type: none"> Ansell MP. 2015. Wood Composites. Elsevier-Science-Technology. FAO. 2007. Wood Preservation Manual. International Book Distributor, Dehradun. Hill CAS. 2006. Wood Modification: Chemical, Thermal and Other Processes. John Wiley and Sons Ltd. Pizzi A and Mittal KL. 2011. Wood Adhesives. CRC Press. Rowell RM. 2013. Handbook of Wood Chemistry and Wood Composites. 2nd Ed. CRC Press. USDA. 1999. Wood Handbook – Wood as an Engineered Material. US Department of Agriculture, Forest Service. Forest Products Laboratory, Madison. 			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	-	-	2	-	1	-	3	-	2	-
CO-2	1	1	1	1	1	1	3	-	3	-	3
CO-3	-	1	3	2	3	3	2	2	-	3	2
CO-4	-	-	2	-	3	2	2	-	2	-	2
CO-5	2	2	1	2	2	2	1	2	1	2	1
CO-6	2	2	1	3	1	3	1	1	1	1	1
Average	1.0	1.0	1.3	1.3	1.3	2.0	1.3	1.3	1.1	1.3	1.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPT M608	Modern Trends in Wood Modification	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT M609	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course name	Development in Pulp and Paper Technology	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> To understand the development of the pulp and paper industry To understand Chemistry of fibrous raw material – raw material preparation. To apply advances in pulping processes for softwood, hardwoods and other fibrous material To analyse the Bio-pulping, To evaluate chlorine free bleaching, organo solve pulping. To design plans for making quality paper. 			
UNITS I (Total Topics- 6 and Hrs- 8)			
Historical development of the pulp and paper industry. Chemistry of fibrous raw material – raw material preparation.			
UNIT II (Total Topics -8 and Hrs-8)			
Advances in pulping processes for softwood, hardwoods, and other fibrous material. Recent trends in Bio-pulping, Chlorine free bleaching, organo solve pulping.			
UNIT III (Total Topics -8 and Hrs-8)			
Nanotechnology in pulp and paper making. Substitution of wood with recycled fibers.			
UNIT IV (Total Topics -8 and Hrs-8)			
Reduction in water utilization and effluent discharge.			
Practical (Experiment - & Hrs -)- Not applicable			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none"> CO.1: Remembering Historical development of the pulp and paper industry CO.2: Understanding Advances in pulping processes for softwood CO.3: Applying the Techniques Chemistry of fibrous raw material – raw material preparation. CO.4: Analyzing Major silvicultural systems of tropical and temperate parts of the world. CO.5: Evaluation Chemistry of fibrous raw material – raw material preparation. CO.6: Make quality paper by using Nanotechnology. 			
Suggested readings:			
Rowell RM. 2013. <i>Handbook of Wood Chemistry and Wood Composites</i> . 2nd Ed. CRC Press.			

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Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	POS-6	PSO-7
CO-1	3	3	2	1	1	1	1	-	2	1	1
CO-2	3	2	1	1	1	1	1	1	1	1	1
CO-3	3	2	1	1	2	1	1	-	1	1	1
CO-4	3	2	2	1	1	1	2	2	2	2	1
CO-5	3	2	2	1	1	1	1	-	1	-	1
CO-6	3	2	2	1	1	1	1	1	1	1	1
Average	3.0	2.2	1.7	1.0	1.2	1.0	1.2	1.3	1.3	1.2	1

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit (Theory + Practical)
		L	T	P	Internal Exam			End Term Exam	Subject Total	
					Midterm Theory Exam	Assignment	Practical			
DPT M609	Development in Pulp and Paper Technology	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT M610	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course name	Application of Traditional Knowledge	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To develop understanding traditional remedies for treating specific diseases2. To understand difference between traditional therapies <i>vis-a-vis</i> modern therapies.3. To apply scientific validation of traditional systems of medicines.4. To analyse integration of herbal remedies with allopathic system of medicine,5. To evaluate allopathic drugs based on medicines herbs.6. To develop ITK for different agroforestry systems.			
UNIT I (Total Topics- 6 and Hrs- 8) Traditional remedies for treating specific diseases like cardiovascular disease, mental disorders, rheumatic arthritis, diabetes, cough and asthma, fatigue, liver diseases, kidney and bladder stones, wounds stomach disorders, etc. Traditional therapies <i>vis-a-vis</i> modern therapies.			
UNIT II (Total Topics -8 and Hrs-8) Scientific validation of traditional systems of medicines/ remedies – case studies. Important herbs used in traditional medicines. Integration of herbal remedies with allopathic system of medicine. Allopathic drugs based on medicines herbs.			
UNIT III (Total Topics -8 and Hrs-8) National and international research and other institutions involved in scientific validation of traditional knowledge e.g., CDRI, CIMAP, RRL's, CCRAS, WHO, etc., their role and major achievements.			
UNIT IV (Total Topics -8 and Hrs-8) Composition of major herbal formulations e.g. Chavanprash, Vasavaleha, Arjunarishta, Pachakchurna, etc. Major herbal pharmaceutical companies and their products like Dabur, Zandhu, Baidyanath, Himalayan Drug Company, Charak Pharmaceuticals, etc. Role of local health traditions in primary health care.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1: Developing understanding Traditional remedies for treating specific diseases• CO.2: Understanding difference between traditional therapies <i>vis-a-vis</i> modern therapies.• CO.3: Apply scientific validation of traditional systems of medicines.• CO.4: Analyzing ITK for different agroforestry system of the world.• CO.5: Evaluation of different Advance and Traditional therapies• CO.6: creation of Pharmaceuticals, etc. for well being of human and plants			

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Suggested readings:

- Alikhan I and Khanum A. 2008. Role of Biotechnology in Medicinal and Aromatic Plants. UKAZ Publishers.
- Chadha KL and Gupta R. 2006. Advances in Horticulture. Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.
- Gupta AK and Sharma M. 2008. Reviews on Indian Medicinal Plants. ICMR.
- Johnson CB and Franz C. 2005. Breeding Research on Aromatic and Medicinal Plants. International Book Distr.
- Sharma R. 2004. Agrotechniques of Medicinal Plants. Daya Publ.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	-	-	2	-	1	-	3	-	2	2
CO-2	1	1	1	1	1	1	3	-	3	-	-
CO-3	-	1	3	2	3	3	2	2	-	3	3
CO-4	-	-	2	-	3	2	2	-	2	-	-
CO-5	2	2	1	2	2	2	1	2	1	2	2
CO-6	2	2	1	3	1	3	1	1	1	1	1
Average	1.0	1.0	1.3	1.3	1.3	2.0	1.3	1.3	1.1	1.3	1.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPT M610	Application of traditional Knowledge	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT M611	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course name	Value Additions and Marketing of Medicinal and Aromatic Plants	Course Type	Elective

Course Objectives:

1. To educate methods of harvesting of yieldable plant/ plant parts of herb, shrub, trees, climber, lianas and epiphytes.
2. To understand the post-harvest technology of medicinal and aromatic plants.
3. To apply value addition procedures for preparation of powders, aqueous and alcoholic extracts, essences, etc. from medicinal and aromatic plants.
4. To analyse village and regional markets, state, national and international market of herbs and herbal products.
5. To evaluate the market value and other pattern of fluctuations for high value medicinal and aromatic plants.
6. To prepare standard operating methods for extraction of essential oil and prepare tablets, mixture, tinctures, etc.

UNIT I (Total Topics- 8 and Hrs- 10)

Value addition for higher economic returns. Concepts and procedures. Preparation of powders, aqueous and alcoholic extracts, essences, etc. Preparation of tablets, mixtures, balms, ointments, etc. Bulk storage and packaging of medicinal and aromatic plants.

UNIT II (Total Topics -6 and Hrs-10)

Basic and advanced concepts of trade and marketing, marketing under disorganized and organized sector. Village and regional markets, state, national and international market of herbs and herbal products.

UNIT III (Total Topics -5 and Hrs-10)

Internet marketing practices for latest market value and other pattern of fluctuations for high value medicinal and aromatic plants/ plant parts and products. Concept of e-market and quality standards.

Practical (Total Experiments - 5 and Hrs-15)

Visit to nearby pharmaceutical concern for understanding value addition processes; Visit to local market and data collection on sale and sale procedure – organized and unorganized; Internet surfing for latest market value of high value of medicinal and aromatic plants.

Course Outcomes (CO): After completion of course, students will be able to:

- CO-1. Educate methods of harvesting of yieldable plant/ plant parts of herb, shrub, trees, climber, lianas and epiphytes.
- CO-2. Understand the post-harvest technology of medicinal and aromatic plants.
- CO-3. Apply value addition procedures for preparation of powders, aqueous and alcoholic extracts, essences, etc. from medicinal and aromatic plants.
- CO-4. Analyse village and regional markets, state, national and international market of herbs and herbal products.
- CO-5. Evaluate the market value and other pattern of fluctuations for high value medicinal and aromatic plants.

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- CO-6. Prepare standard operating methods for extraction of essential oil and prepare tablets, mixture, tinctures, etc.

Suggested readings:

- Alikhan I and Khanum A. 2008. Role of Biotechnology in Medicinal and Aromatic Plants. UKAZ Publishers.
- Chadha KL and Gupta R. 2006. Advances in Horticulture. Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.
- Gupta K and Sharma M. 2008. Reviews on Indian Medicinal Plants. ICMR.
- Gupta AK, Tandon N and Sharma M. 2008. Quality Standards of Indian Medicinal Plants.
- Mann J 1994. Chemical Aspects of Biosynthesis. Oxford Chemistry Primers.
- Sharma R. 2004. Agrotechniques of Medicinal Plants. Daya Publ.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -5
CO-1	1	-	-	2	-	1	-	2	-	2	2
CO-2	1	1	1	1	1	1	2	1	2	1	-
CO-3	-	1	2	2	2	2	2	2	-	2	2
CO-4	-	-	2	-	2	2	2	-	2	-	-
CO-5	2	2	1	2	2	2	1	2	1	2	2
CO-6	2	2	1	3	1	3	1	1	1	1	1
Average	1.5	1.5	1.4	2.0	1.6	1.8	1.6	1.6	1.5	1.6	1.8

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPT M611	Value Additions and Marketing of Medicinal and Aromatic Plants	2	0	2	20	20	20	40	100	3(2+1)

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Supporting courses (Compulsory for all students) (Gradiual courses)

Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT S601	Credit	3(3+0)
Year/Sem	Year 1; Semester – I	L-T-P	3-0-0
Course Name	Research Methodology in Forestry	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To Equip the Students with the Concept and Methodology of Research.2. To provide knowledge about type of research, preparation of reports and thesis, designing of Research using Scientific Methods.3. To develop the ability to apply principles and procedure for data analysis and interpretation of results.4. To analyze various sampling methods and probability of research analysis.5. To evaluate interpretations and significance of report writing.6. To develop the ability to create appropriate hypothesis, select experimental design and presentation of results after analysis of data.			
UNIT I (Total Topics- 7 and Hrs-12) <p>Introduction to Research: Definition, Nature and significance, Role and Objectives; Types of Research: exploratory, descriptive, experimental and diagnostic research, social and legal research and traditional, analytical, empirical & fundamental research, Doctrinal and non-doctrinal research methods; Various Research Designs; Scientific Research Process: Overview, Problem identification and formulation of research statement.</p>			
UNIT II(Total Topics- 7 and Hrs- 12) <p>Data Collection: sources, primary and secondary methods, significance of Primary and Secondary Data, questionnaire Vs. schedules; Data Processing: Editing, Coding Organization and Presentation; Attitude Measurement and scaling: Measurement Scales, Sources of Errors in Measurement, Techniques of Developing Measurement Tools, Classification and Testing (Reliability, Verification and Validity) Scales, Designing Questionnaires and Interviews.</p>			
UNIT- III (Total Topics- 5 and Hrs- 10) <p>Sampling, Sampling Methods, Sampling Plans, Sampling Error, Sampling Distributions: Theory and Design of Sample Survey, Census Vs Sample Enumerations, Objectives and Principles of Sampling, Types of Sampling, Sampling and Non-Sampling Errors, Concept of Permutation, Combination & Probability for research analysis.</p>			
UNIT-IV(Total Topics- 5 and Hrs- 10) <p>Interpretations and Report Writing: Meaning of Interpretation, Techniques of Interpretation, Precautions in Interpretation, Significance of Report Writing, Steps in Report Writing, Layout of Report and Precautions in Writing Research Reports. Limitations of RM: Ethics in Research, Philosophical Issues in Research.</p>			
Practical)- NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Acquire in-depth knowledge of the fundamentals, theories, and principles related to research, and apply this knowledge to conduct research studies in the chosen area of interest.			

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- CO2: Identify, formulate, and critically investigate research problems by applying research-oriented knowledge, and analyze relevant data to propose appropriate alternative solutions.
- CO3: Apply acquired knowledge and skills to think creatively and innovatively while conducting research and drawing meaningful conclusions.
- CO4: Apply parametric and non-parametric statistical tests to verify hypotheses and suggest innovative solutions to the research problem under investigation.
- CO5: Evaluate the interpretation, significance, and structure of scientific report writing.
- CO6: Create appropriate hypotheses, select suitable experimental designs, analyze data, and effectively present the results.

Suggested readings:

1. William G. Zikmund, "Business Research Methods", Orlando: Dryden Press.
2. C. William Emory and Cooper R. Donald, "Business Research Methods", Boston, Irwin.
3. Fred N Kerlinger, "Foundations of Behavioural Research", New Delhi: Surjeet Publications.
4. Naresh Malhotra, Marketing Research: An Applied Orientation, Pearson publication David Nachmias and Chava Nachmias, "Research Methods in the Social Sciences", New York: St.Marlia's Press.
5. Bhattacharya, D. K. (2004) Research Methodology, New Delhi, Excel Books

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPT S601	Research Methodology in Forestry	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT S602	Credit	1(1+0)
Year/Sem	Year 1; Semester - I	L-T-P	1-0-0
Course Name	Computer & Stats Application in Research	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To appraise computational skills for research application.2. To assess statistical methods for research analysis.3. To create skills in methods of collection of any type of data, classification of data, presentation of data, analysis of data, descriptive statistics, parametric and non-parametric tests, etc.4. To analyze statistical calculations and their validation.5. To justify the decision in the reference of data analysis, formation and Analysis of data.6. To create ANOVA through different methods and their interpretation.			
UNIT I (Total Topics- 7 and Hrs-12) <p>Characteristics of Computers, Evolution of computers, computer memory, computer generations, Basic computer organization; System software, Application software, introduction to operating system, single user, multi-user, multitasking single tasking, application of computer for business and research, MS-windows, Linux .Application of Internet in research: INFLIBNET, Use of Internet, sights (DOAJ), Use of E Journals, Use of E library, use of EBSCO HOST online database of Academic Libraries. Subject/field specific tools on www.freeware.com</p>			
UNIT II(Total Topics- 7 and Hrs- 12) <p>Computer Application in Research,. Basic concept of Computer, Use of Internet for Research Purpose: E-mail, WWW, Web browsing, technical skills, drawing inferences from data, Research publishing tools-MS Word, Adobe acrobat, Graphics tool-MS Excel, Presentation tool-MS Power, Data Analysis Software and Analysis Techniques point. Creating presentation and adding effects, Introduction to Data analysis software-SPSS: Definition, objectives and features, data analysis using SPSS.</p>			
UNIT- III (Total Topics- 5 and Hrs- 10) <p>Statistical methods for research application in analysis of data, Measurement in Research , data interpretation, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), std deviation, Measures of Relationship, Simple Regression Analysis, Correlation and Regression, Partial Correlation.</p>			
UNIT-IV(Total Topics- 5 and Hrs- 10) <p>Statistical Tools-Hypothesis and Hypothesis Testing: Parametric & Non-Parametric Tests, Important Parametric Tests, Hypothesis Testing of Correlation Coefficients ,U Test, Chi Square Test, ,T-Test. Analysis of Variance (ANOVA) , The Basic Principle of ANOVA, ANOVA Technique, Setting up Analysis of Variance Table, Short-cut Method for One-way ANOVA, Coding Method, Two-way ANOVA .</p>			
Practical- NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Remember the basic terms used in data collection, classification, presentation, and analysis, including descriptive statistics and parametric and non-parametric tests.			

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- CO2: Understand the use of various formulas, principles, and statistical methods applied in agricultural sciences.
- CO3: Apply appropriate skills in collecting, classifying, presenting, and analyzing different types of data using descriptive statistics, parametric, and non-parametric tests.
- CO4: Analyze statistical calculations and validate the results obtained.
- CO5: Evaluate datasets using suitable statistical tests for meaningful interpretation.
- CO6: Create ANOVA tables using different methods and interpret the results effectively.

Suggested readings:

- C. R. Kothari, “Research Methodology: Methods and techniques”, New Delhi: Vishwa Prakashan.
- Brymann, Alan and Carmer, D. (1995) Qualitative data analysis for social scientist, New York, Routledge Publication.
- Jain, Satish: “Introduction to Computer Science and basic Programming.” BPB Publications, New Delhi, 1990. • Rajaraman, V., “Fundamental of Computers”, Prentice Hall of India, New Delhi, 1996.
- Hogg, R.V.& Craig, T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
- [\(PDF\) Statistical Methods and their Applications \(researchgate.net\)](#)
- [Welcome to Web Agri Stat Package \(icar.gov.in\)](#)
- [\(PDF\) BASIC STATISTICAL TECHNIQUES IN RESEARCH \(researchgate.net\)](#)
- [Statistical Methods & Applications | Home \(springer.com\)](#)
- [Statistical Methodology - Journal - Elsevier](#)

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

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CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPT S602	Computer & Stats Application in Research	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT S603	Credit	1(1+0)
Year/Sem	Year 1; Semester - I	L-T-P	1-0-0
Course Name	Research & Publication Ethics	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none"> To acquaint with knowledge about basics of Agricultural Research and research ethics To understand research ethics including research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards, and problems in research ethics. To apply research ethics in collection and interpretation of data. To analyze the major publication ethics to be followed during research. To evaluate violation of publication ethics, authorship, and contributor ship To develop ability to identify different predatory publishers and journals. 			
UNIT I (Total Topics- 2 and Hrs-8) <ol style="list-style-type: none"> Introduction to philosophy: definition, nature and scope, concept, branches Ethics: definition, moral philosophy, nature of moral judgments and reactions 			
UNIT II (Total Topics- 5 and Hrs- 5) <ol style="list-style-type: none"> Ethics with respect to science and research Intellectual honesty and research integrity Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP) Redundant publications: duplicate and overlapping publications, salami slicing Selective reporting and misrepresentation of data 			
UNIT- III (Total Topics-7 and Hrs-7) <ol style="list-style-type: none"> Publication ethics: definition, introduction, and importance Best practices/ standards setting initiatives and guidelines: COPE, WAME, etc. Conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types Violation of publication ethics, authorship and contributor ship Identification of publication misconduct, complaints and appeals Predatory publishers and journals 			
UNIT- IV (Total Topics-4and Hrs-4) <p>Practice</p> <p>Open Access Publishing</p> <ol style="list-style-type: none"> Open access publications and initiatives SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies Software tool to identify predatory publications developed by SPPU Journal finder/ Journal suggestion tools viz. JANE, Elsevier Journal finder, Springer Journal Suggester, etc. 			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none"> CO1: Recognize the fundamentals of the philosophy of science and ethics, research integrity, publication ethics, and theories of research ethics. CO2: Familiarize with major issues related to research ethics, research integrity, scientific 			

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misconduct, and data misinterpretation.

- CO3: Analyze best practices in scholarly publishing, understand publication ethics, and identify predatory publishers and journals.
- CO4: Demonstrate the use of plagiarism-detection tools, open-source research tools, citation databases, and research metrics.
- CO5: Evaluate credible and scholarly publications published in reputed peer-reviewed journals.
- CO6: Create ethically sound research publications suitable for high-impact, peer-reviewed journals.

Suggested readings:

Research and Publication Ethics, Dr Sumanta Dutta, Bharti Publications, 2021

Research and Publication Ethics, Dr Santosh kumar Yadav, Anne Publications, 2020

- Kumar, R. 2014. Research Methodology: A Step-by-Step Guide for Beginners. 4th Edition. SAGE Publications Ltd.
- Parikh, M.N, Gogtay, N. 2009. ABC of Research Methodology and Applied Biostatistics. Jaypee Publishers, New Delhi.
- [Library & Information Science Research | Journal | ScienceDirect.com by Elsevier](#)
- [\(PDF\) Library and Information Science Research \(researchgate.net\)](#)
- [Research Journal of Library Sciences Introduction :ISCA](#)
- [Research Ethics: Definition, Principles and Advantages - Public Health Notes](#)
- [What Is Ethics in Research & Why Is It Important? - by David B. Resnik, J.D., Ph.D. \(nih.gov\)](#)
- [The Journal of Ethics | Home \(springer.com\)](#)

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPT S603	Research & Publication Ethics	1	0	0	30	20	-	50	100	1(1+0)

5th BOS/2025-26

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C691	Credit	1(0+1)
Year/Sem	Year -1; Semester-I	L-T-P	0-0-1
Course Name	Doctoral Seminar – I	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscripts/articles and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPT C691	Doctoral Seminar	0	0	2	-	-	100	-	100	1(0+1)

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Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C691	Credit	1(0+1)
Year/Sem	Year 1; Semester - II	L-T-P	0-0-1
Course Name	Doctoral Seminar – I	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscripts/article and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPT S691	Doctoral Seminar -I	0	0	2	-	-	100	-	100	1(0+1)

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Doctoral Research Work

Programme Name	Ph.D. (Forestry) Silviculture and Agroforestry	Programme Code	
Course Code	DPT C699	Credit	75(0+75)
Year/Sem	Not Applicable	L-T-P	Not Applicable
Course Name	Doctoral Research	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To develop a comprehensive understanding of research philosophies, theories, and types of scientific inquiry in agricultural/forestry sciences.2. To identify research gaps through systematic literature review and formulate appropriate research problems, objectives, and hypotheses.3. To apply suitable research methodologies, experimental designs, and sampling techniques relevant to agricultural research.4. To enhance skills in data collection, statistical analysis, and interpretation using advanced analytical tools.5. To strengthen scientific writing, academic communication, and referencing skills for research publications and proposals.6. To promote ethical research practices, scientific integrity, and responsible conduct in agricultural research.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs-) <p>Synopsis, Research Work & Thesis writing provides the students an excellent opportunity to develop analytical research and entrepreneurial skills, and knowledge through meaningful hands on experience, confidence in their ability to design and investigate the things.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Recall and describe fundamental research concepts, methodologies, and statistical tools used in agricultural or forestry research.• CO2: Explain research processes, interpret scientific literature, and summarize research gaps in agriculture.• CO3: Apply suitable research designs, data collection methods, and sampling strategies in field, laboratory, and socio-economic studies.• CO4: Analyze research data, identify trends and relationships, and interpret results using appropriate statistical techniques.• CO5: Evaluate the quality, rigor, and validity of research findings and assess scientific articles using standardized evaluation criteria.• CO6: Develop an original research proposal, formulate hypotheses, design experimental models, and produce publishable scientific writing.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee</p>			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	3	3	3	3	3	3	3	3	3
CO-2	3	3	3	3	3	3	3	3	3	3	3
CO-3	3	3	3	3	3	3	3	3	3	3	3
CO-4	3	3	3	3	3	3	3	3	3	3	3
CO-5	3	3	3	3	3	3	3	3	3	3	3
CO-6	3	3	3	3	3	3	3	3	3	3	3
Average	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPT C699	Doctoral Research	N A	N A	N A	NA	NA	NA	NA	NA	75(0+75)

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Detailed Syllabus of Ph.D. (Hort.) Vegetable Science

Major courses (Gradiual courses)

Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV C601	Credit	3(3+0)
Year/Sem	Elective	L-T-P	3-0-0
Course Name	Recent Trends in Vegetable Production	Course Type	Compulsory
Course Objectives:			
<ol style="list-style-type: none">1. To Familiarize with the production technology of vegetables and spices with recent trends and technologies.2. To acquaint with the new system of planting and application of fertilizers adopted in production technology of vegetables and spices.3. To develop skills to production seeds from existing vegetables crops.4. To identify the various types of problems related to biotic and abiotic stress occurred during the cultivation of vegetables and spices crops.5. To classify and cultivate the crop based on their basic requirement for cultivation.6. To judge the harvesting time and techniques of various vegetable and spices crops, storage conditions.			
UNITS I (Total Topics- 5 and Hrs- 6) Recent trends in vegetable production Solanaceous crops: Tomato, brinjal, chilli, sweet pepper and potato.			
UNIT II (Total Topics -5 and Hrs-7) Recent trends in vegetable production Cole crops: Cabbage (Napa' Cabbage, Michihili' Cabbage, Wong Bok' Cabbage, and Hilton' Cabbage), cauliflower and knol-khol, sprouting broccoli.			
UNIT- III (Total Topics -6 and Hrs-8) Recent trends in vegetable production: Okra, onion, peas and beans, amaranth and drumstick.			
UNIT-IV (Total Topics -15 and Hrs- 10) Recent trends in vegetable production, Root crops Carrot, beet root, turnip and radish and cucurbits.			
UNIT- V (Total Topics -5 and Hrs- 7) Recent trends in vegetable production, Tuber crops: Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none">• CO.1: Explain the production technology of vegetables and spices with recent trends and technologies.• CO.2: Acquaint with the new system of planting and application of fertilizers adopted in production technology of vegetables and spices.• CO.3: Develop skills to production seeds from existing vegetables crops.• CO.4: Identify the various types of problems related to biotic and abiotic stress occurred during the cultivation of vegetables and spices crops.• CO.5: Classify and cultivate the crop on the basis of their basic requirement for cultivation.• CO.6: Judge harvesting time and techniques of various vegetable and spices crops with proper			

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storage system.

Suggested readings:

- Bose TK and Som NG. 1986. *Vegetable crops of India*. Naya prokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya Udyog.
- Brewster JL. 1994. *Onions and other vegetable alliums*. CABI.
- Chadha KL and Kalloo G (Eds.). 1993-94. *Advances in Horticulture* Vols. V-X. Malhotra Publ. House.
- Chadha KL (Ed.). 2002. *Hand book of horticulture*. ICAR.
- Chauhan DVS (Ed.). 1986. *Vegetable production in India*. Ram prasad and Sons.
- Fageria MS, Choudhary BR and Dhaka RS. 2000. *Vegetable crops: production technology*. Vol. II. Kalyani.
- FFTC. *Improved vegetable production in Asia*. Book Series No. 36.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	2	2	1	1	2	1	2	1	2	2
CO-2	1	1	2	1	-	-	1	1	-	1	1
CO-3	2	2	2	1	1	2	-	2	2	1	1
CO-4	2	2	1	1	-	1	1	1	1	-	-
CO-5	2	2	2	1	1	-	1	1	1	-	-
CO-6	1	2	2	1	1	1	-	1	-	1	1
Average	1.7	1.8	1.8	1.0	1.0	1.5	1.0	1.3	1.2	1.2	1.2

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPV C601	Recent Trends in Vegetable Production	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV C602	Credit	3(3+0)
Year/Sem	Elective	L-T-P	3-0-0
Course Name	Advances in Breeding of Vegetable Crops	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> To remember about germplasm conservation, utilization, and center of origin of various vegetable crops To understand genetics of qualitative and quantitative characters and their inheritance To apply advance breeding objectives and procedures including conventional as well as innovative approaches used for development of improved varieties To analyze Seed production technology in different vegetable crops. To evaluate efficient breeding methods for different tuber crops. To formulate high yielding seed production methods for different vegetable crops. 			
UNITS I (Total Topics- 6 and Hrs- 8)			
Advances in Breeding of vegetable <i>Solanaceous crops</i> —Tomato, Brinjal, Hot Peeper, Sweet Pepper, Okra and Potato.			
UNIT II (Total Topics -15 and Hrs-20)			
Advances in Breeding of vegetable Cucurbits and Cole crops.			
UNIT- III (Total Topics -12 and Hrs-14)			
Advances in Breeding of vegetable Legumes and leafy vegetables—Peas and Beans, Amaranth, Palak, Chenopods and Lettuce.			
UNIT-IV (Total Topics -6 and Hrs-8)			
Advances in Breeding of vegetable Root crops and onion—Carrot, Beetroot, Radish, Turnip, Onion.			
UNIT-IV (Total Topics -5 and Hrs-7)			
Advances in Breeding of vegetable Tuber crops—Sweet potato, Tapioca, Elephant foot yam, Colocasia, Dioscorea			
Practical (Experiments- and Hrs -)			
NA			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none"> CO-1: Remember the evolutionary history of important field crops along with their centre of origin, its wild species and wild relatives that can be utilized in breeding. CO-2: Develop the understanding of germplasm conservation, utilization, and centre of origin of various crops, genetics of qualitative and quantitative characters, and their inheritance. CO-3: Apply breeding procedures, and objectives in different crop important for the development of improved varieties. CO-4: Analyz seed production technology in different classes of crop. CO-5: Evaluate effective breeding methods in vegetable crops. CO-6: Formulate the best seed production technique for high yield and quality in different crops. 			
Suggested readings:			
<ul style="list-style-type: none"> Allard RW. 1999. <i>Principle of plant breeding</i>. John Willey and Sons, USA. Basset MJ. (Ed.). 1986. 			

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Breeding vegetable crops. AVI Publ.

- Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. *Plant genetic resources: horticultural crops*. Narosa Publ. House.
- Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable crops: Breeding and seed production*.
- Vol. I. Kalyani.
- Gardner EJ. 1975. *Principles of genetics*. John Wiley and Sons.
- Hayes HK, Immer FR and Smith DC. 1955. *Methods of plant breeding*. McGraw-Hill.
- Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. *Plant Breeding-principles and prospects*. Chapman and Hall.
- Hazra P and Som MG. 2015. *Vegetable science* (Second revised edition), Kalyani publishers, Ludhiana, 598 p
- Hazra P and Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani Publishers, Ludhiana, 459 p
- Kalloo G. 1988. *Vegetable breeding* (Vol. I, II, III). CRC Press, Fl, USA.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	3	1	1	2	1	1	1	1	1	1
CO-2	1	1	2	2	1	2	2	3	1	2	2
CO-3	1	1	1	2	2	2	1	1	3	3	3
CO-4	1	2	1	1	1	2	1	2	1	1	1
CO-5	2	1	2	1	2	1	2	2	1	2	2
CO-6	1	2	1	2	2	1	1	1	2	1	1
Average	1.3	1.6	1.3	1.4	1.6	1.5	1.3	1.3	1.5	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPV C602	Advances in Breeding of Vegetable Crops	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV C603	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Abiotic Stress Management in Vegetable Crops	Course Type	Elective

Course Objectives:

1. To acquaint with stress and its vegetable crops
2. To understand physiological and biochemical factors associated with stress.
3. To apply crop modeling for stress situations
4. To analyze mitigation measures and conservation practices of stress management in vegetable crops.
5. To evaluate biotic and abiotic stress management techniques
6. To judge efficiency of chemical and anti transpirants of different stresses.

UNITS I (Total Topics- 06 and Total Hrs-14)

Environmental stress - its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.

UNIT II (Total Topics- 05 and Total Hrs-10)

Mechanism and measurements - tolerance to drought, water logging, soil salinity, frost and heat stress, in vegetable crops.

UNIT- III (Total Topics- 05 and Total Hrs-10)

Soil-plant-water relations - under different stress conditions in vegetable crops production and their management practices.

UNIT- IV (Total Topics- 03 and Total Hrs-05)

Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

UNIT- V (Total Topics- 04 and Total Hrs-08)

Use of chemicals- techniques of vegetable growing under high and low temperature conditions, use of chemicals and anti-transpirants in alleviation of different stresses.

Practical (Experiments- 08 and Hrs - 16)

Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops; Measurement of tolerance to various stresses in vegetable crops; Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions; Use of chemicals for alleviation of different stresses.

Course Outcomes (COs): After completion of course, students will be able to:

- CO-1: Acquaint with stress and its types in vegetable crops
CO-2: Understand physiological and biochemical factors associated with stress.
CO-3: Apply crop modeling for stress situations
CO-4: Analyz mitigation measures and conservation practices of stress management in vegetable crops.
CO-5: Evaluate the efficiency of chemical and anti-transpirants in various stresses.
CO-6: Judge efficiency of chemical and anti transpirants of different stresses.

Suggested readings:

- Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural

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crops. Narosa Publ. House.

- Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural crops. Narosa Publ. House.
- Kaloo G and Singh K. 2001. Emerging scenario in vegetable research and development. Research periodicals and book publ. house.
- Narendra T. et al. 2012. Improving crops resistance to abiotic stress. Wiley and Sons.US.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO-6
CO-1	2	3	1	1	2	2	1	1	1	1	1
CO-2	1	2	2	2	1	2	2	3	2	2	2
CO-3	2	1	2	2	2	2	1	2	3	3	3
CO-4	2	2	1	1	1	2	1	2	1	1	1
CO-5	2	2	2	2	2	2	2	2	2	2	2
CO-6	1	2	2	2	2	1	1	2	2	1	1
Average	1.5	2.0	1.5	1.5	1.6	1.7	1.3	2.0	1.6	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPV C603	Abiotic Stress Management in Vegetable Crops	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV C604	Credit	3(2+1)
Year/Sem	Year 1; Semester – I/II	L-T-P	2-0-1
Course Name	Seed Certification, Processing and storage of Vegetable Crops	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember importance of seed technology in agriculture.2. To understand seed production techniques in various field crops.3. To apply methods of seed processing, seed quality, seed storage and marketing.4. To analyze various seed control act, order and tests for confirming status of seed.5. To evaluate seed acts and certification processes.6. To formulate best germination methods for higher germination of crops.			
UNITS I (Total Topics- 8 and Hrs- 11) Seed certification, history, concepts and objectives, seed certification agency, phases of seed certification, Indian Minimum seed Certification standards, Planning and management of seed certification programmes.			
UNIT II (Total Topics -5 and Hrs-7) Principles and procedures of field inspection, seed sampling, testing and granting certification, OECD certification Schemes. Government and Non-Government agencies for seed Certification in India.			
UNIT- III (Total Topics -9 and Hrs-12) Principles of seed processing, Methods of seed drying and cleaning, seed processing plant-Layout and design, seed treatment, seed quality enhancement, packaging and marketing.			
UNIT-IV (Total Topics -10 and Hrs- 13) Principles of Seed Storage, orthodox/ recalcitrant seeds, types of storage (open, bulk, controlled, germplasm, cryopreservation), factors affecting seed longevity in storage (Pre and post-harvest factors).			
UNIT- V (Total Topics -8 and Hrs- 10) Seed aging and deterioration, maintenance of seed viability and vigor during storage, storage methods, storage structures, transportation, and marketing of seeds.			
Practical (Experiment-8; Hrs-16) General procedures of seed certification; Field inspection and standards; Isolation and rouging; Inspection and sampling at harvesting, threshing and processing; Testing physical purity, germination and moisture, grow-out test; Visit to regulatory seed testing and plant quarantine laboratories; Seed processing plants and commercial seed stores.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1 : Remember importance of seed technology in agriculture• CO. 2 : Understand the various seed production techniques for different field crops, the importance of maintenance of purity of crop varieties, and factors causing deterioration of variety.• CO.3: Apply the factors related to genetic and physical purity of seed and its health status of seeds of a variety during seed processing.			

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- CO.4: Analyze different methods of seed certification, field inspection, and seed purity testing
- CO.5: Evaluate the seed acts and certification methods.
- CO.6: Formulate the best germination and seed production techniques of different crops.

Suggested readings:

- Agarwal PK and Anuradha V. 2018. *Fundamentals of seed science and technology*. Brilliant publications, New Delhi.
- Basra AS. 2000. *Hybrid seed production in vegetables*. CRC press, Florida, USA.
- Bench ALR and Sanchez RA. 2004. *Handbook of seed physiology*. Food products press, NY/ London.
- Chakraborty SK, Prakash S, Sharma SP and Dadlani M. 2002. *Testing of distinctiveness, uniformity and stability for plant variety protection*. IARI, New Delhi
- Copland LO and McDonald MB. 2004. *Seed science and technology*, Kluwer academic press.
- Fageria MS, Arya PS and Choudhry AK. 2000. *Vegetable crops: breeding and seed production*
Vol 1. Kalyani publishers, New Delhi.
- George RAT. 1999. *Vegetable seed production* (2nd Edition). CAB International.
- Hazra P and Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani publishers, Ludhiana, 459p

Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	1	1	2	1	2	1	2	2	3	3
CO-2	2	3	1	2	1	1	1	3	1	2	2
CO-3	1	1	2	1	2	1	3	1	3	1	1
CO-4	1	2	1	1	2	1	1	2	3	2	2
CO-5	2	1	2	1	1	1	2	1	1	1	1
CO-6	1	2	2	1	2	2	2	1	2	1	1
Average	1.6	1.6	1.5	1.3	1.5	1.3	1.6	1.6	2	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPV C604	Seed Certification, Processing and storage of Vegetable Crops	2	0	1	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV C605	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Breeding for Special Traits in Vegetable Crops	Course Type	Elective
Course Objectives: <ol style="list-style-type: none"> 1. To acquaint with Important nutrient constituents in vegetables. 2. To understand genetic and genomic resources for improving quality traits. 3. To apply breeding strategies for developing varieties with improved nutrition. 4. To analyze breeding methods suitable for regional and national level. 5. To evaluate molecular and biotechnological approaches in breeding suitable cultivars 6. To judge advance breeding methods in vegetable crops. 			
UNITS I (Total Topics- 07 and Total Hrs-15) Block I Important nutrient constituents in vegetables and their role in human diet. Genetics of nutrients. Genetic and genomic resources for improving quality traits in vegetables, breeding strategies for developing varieties with improved nutrition for market and industrial purposes. Molecular and biotechnological approaches in breeding suitable cultivars of different crops for micronutrients and color content. Brassica group, carrot and beetroot.,			
UNIT II (Total Topics- 07 and Total Hrs-15) Tomato, brinjal, peppers and potato. Green leafy vegetables, Legume crops and okra.			
UNIT- III (Total Topics- 07 and Total Hrs-15) Cucurbitaceous vegetable crops and edible Alliums.			
UNIT- IV (Total Topics- 07 and Total Hrs-15) Biofortification in vegetable crops, genetic engineering for improvement of quality traits in vegetable crops, bioavailability of dietary nutrients from improved vegetable crops and impact on micronutrient malnutrition, achievements and future prospects in breeding for quality traits in vegetables.			
Practical (Experiments- and Hrs -) NA			
Course Outcomes (COs): After completion of course, students will be able to: CO.1: Explain stress and its types in vegetable crops CO.2: Understand physiological and biochemical factors associated with stress. CO.3: Apply crop modeling for stress situations CO.4: Analyz mitigation measures and conservation practices of stress management in vegetable crops. CO.5: Evaluate the efficiency of chemical and anti-transpirants in various stresses. CO.6: Judge advance breeding methods in vegetable crops.			
Suggested readings: <ul style="list-style-type: none"> • Hazra P and Som MG. 2016. Vegetable seed production and hybrid technology (Second revised edition), Kalyani Publishers, Ludhiana, 459p. • Kalloo G. 1998. Vegetable breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency. • Kumar JC and Dhaliwal MS. 1990. Techniques of developing hybrids in vegetable crops. Agro Botanical Publ. 			

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- Paroda RS and Kalloo G. (Eds.). 1995. Vegetable research with special reference to hybrid technology in Asia-Pacific Region. FAO.
- Peter KV and Hazra P. (Eds). 2012. Hand book of vegetables. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
- Simmonds NW. 1978. Principles of crop improvement. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publishers, New Delhi.
- Swarup V. 1976. Breeding procedure for cross-pollinated vegetable crops. ICAR.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -5	PSO -6
CO-1	1	3	-	1	1	1	2	1	-	3	3	3
CO-2	1	2	1	-	1	1	2	2	1	1	1	1
CO-3	-	1	-	1	-	-	2	1	1	1	1	1
CO-4	1	2	2	1	1	1	-	-	-	-	-	-
CO-5	1	1	1	1	-	1	1	1	1	1	1	1
CO-6	1	1	1	-	1	1	1	-	1	1	1	1
Average	1.0	1.7	1.2	1.0	1.0	1.0	1.6	1.2	1.0	1.4	1.4	1.4

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPV C605	Breeding for Special Traits in Vegetable Crops	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV C606	Credit	3(3+0)
Year/Sem	Elective	L-T-P	3-0-0
Course Name	Biodiversity and Conservation of Vegetable Crops	Course Type	Elective

Course Objectives:

1. To remember about germplasm conservation, utilization, and centre of origin of various vegetable crops.
2. To understand in situ and ex situ conservation and importance in Biodiversity.
3. To apply major intellectual property rights regulatory horticulture
4. To analyse Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity.
5. To evaluate GIS application in horticultural mapping and spatial analyses of field data.
6. To formulate high yielding GI tagged varieties of vegetables in India.

UNITS I (Total Topics- 8 and Hrs- 11)

General aspects: issues, goals and current status: Biodiversity and conservation; issues and goals-needs and challenges; present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/ database of vegetable crops in India

UNIT II (Total Topics -13 and Hrs-16)

Germplasm conservation: collection, maintenance and characterization: Exploration and collection of germplasm; sampling frequencies; size and forms of fruit and nut germplasm collections; active and base collections. Germplasm conservation- in situ and ex situ strategies, on farm conservation; problem of recalcitrance- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

UNIT- III (Total Topics -20 and Hrs-25)

Regulatory horticulture: Germplasm exchange, quarantine and intellectual property rights germplasm exchange, quarantine and intellectual property rights regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged varieties of vegetable in India.

Practical (Experiment-8; Hrs-16)

Documentation of germplasm- maintenance of passport data and other records of accessions; Field exploration trips and sampling procedures; Exercise on ex situ conservation – cold storage, pollen/ seed storage; Cryopreservation; Visits to national gene bank and other centers of PGR activities; Detection of genetic constitution of germplasm; Germplasm characterization using a standardized DUS test protocol; Special tests with biochemical and molecular markers.

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Remember about germplasm conservation, utilization and centre of origin of various vegetable crops.
- CO.2: Understand in situ and ex situ conservation and importance in Biodiversity.
- CO 3: Apply major intellectual property rights regulatory horticulture

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- CO.4: Analyse Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity.
- CO 5. Evaluate GIS application in horticultural mapping and spatial analyses of field data
- CO 6: Formulate high yielding GI tagged fruit varieties in India.

Suggested readings:

- Dhillon BS, Tyagi RK, Lal A and Saxena S. 2004. Plant genetic resource management. – horticultural crops. Narosa publishing house, New Delhi.
- Engles JM, Ramanath RV, Brown AHD and Jackson MT. 2002. Managing plant genetic resources, CABI, Wallingford, UK.
- Hancock J. 2012. Plant evolution and the origin of crops species. CAB International.
- Jackson M, Ford-Lloyd B and Parry M. 2014, Plant genetic resources and climate change. CABI, Wallingford, UK
- Moore JN and Ballington JR. 1991. Genetic resources of temperate Fruit and nut crops. ISHS, Belgium.
- Peter KV. 2008. Biodiversity of horticultural crops. Vol. II. Daya Publ. House, Delhi. Peter KV. 2011. Biodiversity in horticultural crops. Vol.III. Daya Publ. House, Delhi.
- Rajasekharan PE, Rao V and Ramanatha V. 2019. Conservation and utilization of horticultural genetic resources. Springer.
- Rana JC and Verma VD. 2011. Genetic resources of temperate minor fruits (indigenous and exotic). NBPGR, New Delhi.
- Sthapit et al. 2016. Tropical fruit tree diversity (good practices for in situ and ex situ conservation).

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -5
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPV C606	Biodiversity and Conservation of Vegetable Crops	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV C607	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-2
Course Name	Biotechnological Approaches in Vegetable Crops	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> 1. To acquaint with Importance and scope of biotechnology in vegetables. 2. To understand somaclonal variation and different cultures in improving quality traits 3. To apply blotting and marker technology in vegetable improvement. 4. To analyze advanced plant genetic engineering techniques in fast breeding. 5. To evaluate next generation sequencing in different vegetable crops. 6. To judge genome editing technology in future advancement of olericulture. 			
UNITS I (Total Topics- 08 and Total Hrs-08)			
Importance and scope of biotechnology – in vegetable crop improvement. In-vitro culture, micropropagation, anther culture, pollen culture, ovule culture, embryo culture, endosperm culture.			
UNIT II (Total Topics- 07 and Total Hrs-10)			
Somatic embryogenesis – somaclonal variation and synthetic seed production, protoplast isolation, culture, manipulation and fusion. Somatic hybrids and cybrids and their application in vegetable improvement programme.			
UNIT- III (Total Topics- 06 and Total Hrs-08)			
Blotting techniques, DNA finger printing – Molecular markers/ DNA based markers and role. RFLP, AFLP, RAPD, SSR, SNPs, DNA probes. QTL mapping. MAS and its application in vegetable crop improvement. Allele mining by TILLING and Eco-TILLING.			
UNIT- IV (Total Topics- 07 and Total Hrs-10)			
Plant genetic engineering – Scope and importance, Concepts of cisgenesis, intragenesis and transgenesis. Gene cloning, direct and indirect methods of gene transfer. Role of RNAi based gene silencing in vegetable crop improvement. Biosafety issue, regulatory issues for commercial approval.			
UNIT- V (Total Topics- 08 and Total Hrs-13)			
Concepts and methods of next generation sequencing (NGS)- Genome sequencing, transcriptomics, proteomics, metabolomics. Genome editing (ZFN, TALENS and CRISPER).			
Crops			
Solanaceous crops, cole crops, cucurbitaceous crops, root vegetables, garden pea, onion, potato and leafy vegetables			
Practical (Experiments- and Hrs -) NA			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none"> • CO.1: Acquaint with Importance and scope of biotechnology in vegetables. • CO.2: Understand somaclonal variation and different cultures in improving quality traits • CO.3: Apply blotting and marker technology in vegetable improvement. • CO.4: Analyz advance plant genetic engineering techniques in fast breeding. • CO.5: Evaluate the next generation sequencing in different vegetable crops. • CO.6: Judge genome editing technology in future advancement of olericulture. 			

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Suggested readings:

- Bajaj YPS. (Ed.). 1987. Biotechnology in agriculture and forestry. Vol. XIX. Hitech and Micropropagation. Springer.
- Chadha KL, Ravindran PN and Sahijram L. (Eds.). 2000. Biotechnology of horticulture and plantation crops. Malhotra Publ. House.
- Keshavachandran R and Peter KV. 2008. Plant biotechnology; tissue culture and gene transfer. Orient and Longman, USA.
- Prasad S. 1999. Impact of plant biotechnology on horticulture. 2nd Ed. Agro Botanica.
- Skoog Y and Miller CO. 1957. Chemical regulation of growth and formation in plant tissue cultured in-vitro. Attidel. II Symp. On biotechnology action of growth substance.
- Vasil TK, Vasi M, While DNR and Bery HR. 1979. Somatic hybridization and genetic manipulation in plants, plant regulation and world agriculture. Planum Press.
- Debnath M. 2005. Tools and techniques of biotechnology. Pointer publication, New Delhi.
- Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK and Mohanadas S. 2001. Biotechnology of horticultural crops. Vols. I-III. NayaProkash.
- Rout GR and Peter KV. 2018. Genetic engineering of horticultural crops. Academic Press Elsevier, USA.
- Skoog Y and Miller CO. 1957. Chemical regulation of growth and formation in plant tissue cultured in-vitro. Attidel. II Symp. On biotechnology action of growth substance.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO - 2	PSO - 3	PSO - 4	PSO - 5	PSO - 6
CO-1	1	3	3	1	1	1	2	1	2	3	3
CO-2	1	2	1	2	1	1	2	2	1	1	1
CO-3	2	1	2	1	2	2	2	1	1	1	1
CO-4	1	2	2	1	1	1	1	2	1	1	1
CO-5	1	1	1	1	3	1	1	1	1	1	1
CO-6	1	1	1	3	1	1	1	1	1	1	1
Average	1.3	1.7	1.4	1.3	1.3	1.1	1.6	1.1	1.2	1.1	1.1

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			

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DPV C607	Biotechnological Approaches in Vegetable Crops	2	0	0	30	20	-	50	100	2(2+0)
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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV C607	Credit	3 (2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Principles of Aquaponics	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> To introduce the basics, scope, and significance of aquaculture and hydroponics. To compare aquaculture with agriculture and fisheries with soil-based farming. To study plant nutrition, root growth, and control of disorders and diseases. To understand the role of fertilizers, nutrients, and impurities in plant growth. To study various soilless culture media and hydroponic growing techniques. To study plant varieties, propagation methods, and hydroponic greenhouse techniques. 			
UNIT I (Total Topics-07 and Hrs-13)			
History, definition, scope and significance of aquaculture, comparison of aquaculture with agriculture and commercial fisheries. Aquaculture – Global and Indian Scenario. Methods and classification of aquaculture practices. History; Present status of Hydroponics; Comparison with soil-based culture; Present applications; Developments			
UNIT II (Total Topics – 03 and Hrs-05)			
Plant composition; Essential mineral elements; Root morphology in soil and soilless culture; Nutritional disorders in plants; Disease infestations and control.			
UNIT- III (Total Topics – 06 and Hrs- 08)			
Inorganic salts (fertilizers); Macronutrients; Micronutrients; Formulating, monitoring, and analyzing; Impurities; Media requirements; Types; Water culture; Gravel culture; Sand culture; Sawdust and bark culture; Rock wool culture; Perlite, Vermiculture and Pumice.			
UNIT-IV (Total Topics – 03 and Hrs-04)			
Plant varieties; Planting schedules; Seeding and propagation; Transplanting; Hydroponic greenhouse technology.			
Practical (Total Experiments – 08 and Hrs- 16)			
Identification and classification of major aquaculture systems and components, Aquaculture vs Agriculture and Fisheries, Study of water quality parameters: pH, EC, DO, TDS, and temperature, Preparation of a hydroponic nutrient solution: Macronutrients and Micronutrients, Media preparation and comparison: Cocopeat, perlite, vermiculite, sand, rockwool, etc. Study of plant propagation methods: seeding, transplanting, and vegetative methods.			
Course Outcomes (CO): After completion of the course, the students will be able to			
<ul style="list-style-type: none"> CO1: Describe the history, scope, and importance of aquaculture. CO2: Differentiate aquaculture from agriculture and fisheries, and compare hydroponics with soil-based farming. CO3: Identify and explain essential nutrients, root behaviors, and common plant nutritional disorders and diseases. CO4: Understanding of fertilizer types, nutrient roles, and methods to monitor and analyze impurities. CO5: Classify different soilless media and evaluate their suitability for hydroponic practices. CO6: Prepare plan and execute planting schedules, propagation methods, and transplanting techniques in a hydroponic greenhouse setup. 			
Suggested readings:			
<ul style="list-style-type: none"> Jhingran, V.G. (1991). Fish and Fisheries of India Publisher: Hindustan Publishing Corporation 			

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- Stickney, R.R. (2009). Aquaculture: An Introductory Text (2nd Edition), Publisher: CABI
- Boyd, C.E. (1990). Water Quality in Ponds for Aquaculture Publisher: Auburn University
- Pillay, T.V.R. (1993). Aquaculture: Principles and Practices Publisher: Wiley-Blackwell
- Halwart, M., Soto, D., & Arthur, J.R. (2007). Aquaculture in the Ecosystem Publisher: Springer

Articulated Attainment

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	1	2	1	-	-	1	2	2	2	2
CO2	3	2	2	1	2	2	-	-	2	2	2	2	2
CO3	3	2	2	2	3	2	-	-	2	2	2	2	2
CO4	3	2	2	2	3	2	-	-	2	2	2	2	2
CO5	3	2	2	2	3	2	-	-	3	3	2	3	3
CO6	3	2	2	2	3	2	-	1	3	3	2	3	3
Average	3.0	2.0	1.8	1.8	2.7	1.8	-	1.0	2.2	2.3	2.00	2.3	2.3

Evaluation Scheme

Course Code	Course Title	Periods per week			Progressive Assessment/ Quiz/ Assignment	Practical	Internal Theory (Mid-Term)	External Theory (End Term)	Total	Credit (Theory + Practical)
		L	T	P						
DPV C 608	Principles of Aquaponics	2	0	1	20	20	20	40	100	3 (2+1)

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Minor Course (Gradiual Course)

Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV M601	Credit	3(3+0)
Year/Sem	Elective	L-T-P	3-0-0
Course Name	Innovative Approaches in Fruit Breeding	Course Type	Elective

Course Objectives:

1. To remember various contributions of plant breeding methods in fruit crops.
2. To understand genetics of qualitative and quantitative characters, population genetics.
3. To apply breeding techniques and biotechnological tools for development of fruit cultivars.
4. To analyze various inheritance pattern and incompatibility systems in fruit crops.
5. To evaluate various fast track breeding methods such as molecular breeding and transgenic breeding.
6. To assemble appropriate variety of fruit crops suitable for cultivation.

UNITS I (Total Topics- 6 and Hrs- 8)

Introduction, Current Trends and Status: Modern trends in fruit breeding –with major emphasis on precocity, low tree volume, suitability for mechanization, health benefits, etc.

UNIT II (Total Topics -7 and Hrs-10)

Genetic Mechanisms: Inheritance Patterns and Breeding Systems: Genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits.

UNIT- III (Total Topics -10 and Hrs-10)

Breeding for Specific Traits: Plant Architecture, Stress Tolerance and Fruit Quality: Recent advances in crop improvement efforts- wider adaptation, plant architecture, amenability to mechanization, fruit quality attributes, stress tolerance crop specific traits; use of apomixis, gene introgression and wide hybridization (alien genes).

UNIT- III (Total Topics -15 and Hrs-18)

Fast-Track Breeding: Transgenics, Markers and Genomics: Molecular and transgenic approaches in improvement of selected fruit crops; fast track breeding – marker assisted selection and breeding (MAS and MAB), use of genomics and gene editing technologies. Crops: Mango, banana, guava, papaya, Citrus, grapes, pomegranate, litchi, apple, pear, strawberry, kiwifruit, plums, peaches, apricot, cherries, nectarines, nut crops.

Practical: NA

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Remember various contribution of plant breeding methods in fruit crops.
- CO.2: Understand of genetics of qualitative and quantitative characters, population genetics.
- CO.3: Apply breeding techniques and biotechnological tools for development of crop varieties.
- CO.4: Analyz various inheritance pattern and incompatibility systems in fruit crops.

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- CO.5: Evaluate f various fast track breeding methods such as molecular breeding and transgenic breeding.
- CO.6: Assemble of appropriate variety of fruit crops suitable for cultivation.

Suggested readings:

- Al-Khayari J, Jain SN and Johnson DV. 2018. *Advances in Plant Breeding Strategies. Vol. 3: Fruits.* Springer.
- Badenes S and Byrne DH. 2012. *Fruit Breeding.* Springer.
- Hancock JF. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics.* Springer. Kole C and Abbott AG. 2012. *Genetics, Genomics and Breeding of Stone fruits.* CRC.
- Kole, C. 2011. *Wild Crops Relatives: Genomics and Breeding Resources: Tropical and Subtropical Fruits.* Springer-Verlag.
- Kole C. 2011. *Wild Crops Relatives: Genomics and Breeding Resource: Temperate Fruits.* Springer -Verlag.
- Jain SN and Priyadarshan PM. 2009. *Breeding Plantation and Tree Crops: Tropical Species; Temperate Species.* Springer -Verlag.
- Janick J and Moore JN, 1996. *Fruit Breeding. Vols.I-III.* John Wiley & Sons, USA. Orton T. 2019. *Methods in Fruit Breeding.* Elsevier.
- Singh SK, Patel VB, Goswami AK, Prakash J and Kumar C. 2019. *Breeding of Perennial Horticultural Crops.* Biotech Books. Delhi.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	3	-	1	1	1	2	1	-	3	3
CO-2	1	2	1	-	1	1	2	2	1	1	1
CO-3	-	1	-	1	-	-	2	1	1	1	1
CO-4	1	2	2	1	1	1	-	-	-	-	-
CO-5	1	1	1	1	-	1	1	1	1	1	1
CO-6	1	1	1	-	1	1	1	-	1	1	1
Average	1.0	1.7	1.2	1.0	1.0	1.0	1.6	1.2	1.0	1.4	1.4

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPV M601	Innovative Approaches in Fruit Breeding	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV M602	Credit	3(3+0)
Year/Sem	Elective	L-T-P	3-0-0
Course Name	Modern Trends in Fruit Production	Course Type	Elective
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To become acquainted with general concepts and current scenario of fruit production. 2. To understand propagation, planting Systems and crop regulation technologies of fruits. 3. To demonstrate the advance propagation methods of fruit production. 4. To organize the decision support systems for precision farming of common fruits. 5. To review the physical and chemical factors that regulate the fruit production. 6. To formulate recent trends of production technologies of tropical, subtropical, and temperate fruits. 			
<p>UNIT I (Total Topics- 19 and Total Hrs-45)</p> <p>Block-1 (Topics-3 and Hrs-9): Introduction- General Concepts and Current Scenario: National and International scenario, national problems.</p> <p>Block-2 (Topics-8 and Hrs-18): Advanced Technologies: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation – root stocks, planting systems, High density planting, crop modeling, Precision farming, decision support systems – aspects of crop regulation- physical and chemical regulation.</p> <p>Block-3 (Topics-8 and Hrs-18): Management Practices: Overcoming Stress and Integrated Approaches: Effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Physiological disorders, Total quality management (TQM).</p> <p>Crop: Mango, Banana, Grapes, Citrus, Papaya, Litchi, Guava, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherry, Almond, Walnut, Pecan, Strawberry, Kiwifruit.</p>			
<p>UNIT II (Total Topics - and Hrs-) – Not Applicable</p>			
<p>UNIT- III (Total Topics - and Hrs-) – Not Applicable</p>			
<p>UNIT-IV (Total Topics - and Hrs-) – Not Applicable</p>			
<p>Practical (Experiments- and Hrs -) – Not Applicable</p>			
<p>Course Outcomes (COs): After completion of course, students will be able to:</p> <ul style="list-style-type: none"> • CO.1: Acquaint with general concepts and current scenario of fruit production. • CO.2: Understand propagation, planting Systems and crop regulation technologies of fruits. • CO.3: Demonstrate the advance propagation methods of fruit production. • CO.4: Organize the decision support systems for precision farming of common fruits. • CO.5: Review the physical and chemical factors that regulate the fruit production. • CO.6: Formulate recent trends of production technologies of tropical, subtropical, and temperate fruits. 			
<p>Suggested readings:</p> <ul style="list-style-type: none"> • Bartholomew DP, Paull RE and Rohrbach KG. eds. 2002. The Pineapple: Botany, Production, and Uses. CAB International. • Bose TK, Mitra SK and Sanyol D. Eds. 2002. Fruits of India – Tropical and Sub- Tropical. 3rd Ed. Vols. I, II. Naya Udyog, Kolkata, India. 			

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- Dhillon WS and Bhatt ZA. 2011. Fruit Tree Physiology. Narendra Publishing House, New Delhi.
- Dhillon WS. 2013. Fruit Production in India. Narendra Publishing House, New Delhi.
- Gowen S. 1995. Bananas and Plantains. Chapman & Hall Publication, US.
- Litz RE. ed. 2009. The Mango: Botany, Production and Uses. CAB International.
- Peter KV. 2016. Innovations in Horticulture. NIPA, New Delhi.
- Robinson JC and Saúco VG. 2010. Bananas and Plantains (Vol. 19). CAB International.
- Sharma RR and Krishna H. 2014. Fruit Production: Major Fruits. Daya Publishing House, Delhi.
- Singh S, Shivankar VJ, Srivastava AK and Singh IP. 2004. Advances in Citriculture. Jagminder Book Agency, New Delhi.

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	3	1	1	2	1	1	1	1	1	1
CO-2	1	1	2	2	1	2	2	3	1	2	2
CO-3	1	1	1	2	2	2	1	1	3	3	3
CO-4	1	2	1	1	1	2	1	2	1	1	1
CO-5	2	1	2	1	2	1	2	2	1	2	2
CO-6	1	2	1	2	2	1	1	1	2	1	1
Average	1.3	1.6	1.3	1.4	1.6	1.5	1.3	1.3	1.5	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPV M602	Modern Trends in Fruit Production	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV M603	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-2
Course Name	Recent Developments in Growth Regulation	Course Type	Elective
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To acquaint with recent trends in growth and development in fruit culture. 2. To understand importance of propagation and planting systems. 3. To apply recent technologies in stress management of fruit production. 4. To analyse different intercultural operations in increasing productivity per unit area. 5. To evaluate and manage physiological disorders of various fruits. 6. To judge the Total quality management (TQM) of different fruit crops. 			
<p>UNIT I (Total Topics- 19 and Total Hrs-45)</p> <p>Block-1 (Topics-3 and Hrs-9): Introduction-General Concepts and Current Scenario: National and International scenario, national problems.</p> <p>Block-2 (Topics-8 and Hrs-18): Advanced Technologies: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation – root stocks, planting systems, High density planting, crop modeling, Precision farming, decision support systems – aspects of crop regulation-physical and chemical regulation.</p> <p>Block-3 (Topics-8 and Hrs-18): Management Practices: Overcoming Stress and Integrated Approaches: Effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Physiological disorders, Total quality management (TQM).</p> <p>Crop: Mango, Banana, Grapes, Citrus, Papaya, Litchi, Guava, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherry, Almond, Walnut, Pecan, Strawberry, Kiwifruit.</p>			
<p>UNIT II (Total Topics -5 and Hrs-7) Mango, Banana, Citrus and Papaya</p>			
<p>UNIT- III (Total Topics -6 and Hrs-8) Guava, Sapota and Jackfruit</p>			
<p>UNIT-IV (Total Topics -15 and Hrs- 10) Pineapple, Annonas and Avocado UNIT V: Aonla, Pomegranate, Phalsa and Ber, minor fruits of tropics.</p>			
<p>Practical (Experiments-08 and Hrs-16) Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical and arid zone orchards, Project preparation for establishing commercial orchards.</p>			
<p>Course Outcomes (COs): After completion of course, students will be able to:</p> <ul style="list-style-type: none"> • CO.1: Acquaint with recent trends in growth and development in fruit culture. • CO.2: Understand importance of propagation and planting systems. • CO.3: Apply recent technologies in stress management of fruit production. • CO.4: Analyse different intercultural operations in increasing productivity per unit area. • CO.5: Evaluate and manage physiological disorders of various fruits. 			

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- CO.6: Judge the Total quality management (TQM) of different fruit crops.

Suggested readings:

- Hiwale S. 2015. *Sustainable Horticulture in Semiarid Drylands*. Springer.
- Krishna H and Sharma RR. 2017. *Fruit Production – Minor Fruits*. Daya Publishing House, Delhi.
- More T A, Singh RS, Bhargava R and Sharma BD. 2012. *Arid Horticulture for Nutrition and Livelihood*. Agrotech Publishing Academy, Udaipur (Rajasthan).
- Pareek OP, Sharma S and Arora RK. 2007. *Underutilised Edible Fruits and Nuts*, IPGRI, Rome.
- Peter K.V. 2010. *Underutilized and Underexploited Horticultural Crops*. NIPA, New Delhi.
- Saroj PL, Dhandar DG and Vashishta BB. 2004. *Advances in Arid Horticulture*, Vol.-1 Present Status. IBDC, Lucknow.
- Saroj P L and Awasthi OP. 2005. *Advances in Arid Horticulture*, Vol: II: *Production Technology of Arid and Semiarid Fruits*. IBDC, Lucknow.
- Sontakke MB. 2014. *Production and Management of Fruit crops in Arid/ Drylands*. Agrotech Publishing Academy, Udaipur (Rajasthan).

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	2	2	1	1	2	1	2	1	2	2
CO-2	1	1	2	1	-	-	1	1	-	1	1
CO-3	2	2	2	1	1	2	-	2	2	1	1
CO-4	2	2	1	1	-	1	1	1	1	-	-
CO-5	2	2	2	1	1	-	1	1	1	-	-
CO-6	1	2	2	1	1	1	-	1	-	1	1
Average	1.7	1.8	1.8	1.0	1.0	1.5	1.0	1.3	1.2	1.2	1.2

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPV M603	Recent Developments in Growth Regulation	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph. D (Hort) Vegetable Science	Programme Code	
Course Code	DPV M606	Credit	2(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Abiotic Stress Management in Fruit Crops	Course Type	Elective

Course Objectives:

1. To acquaint with stress and its types in fruit crops
2. To understand physiological and biochemical factors associated with stress.
3. To apply crop modeling for stress situations
4. To analyse mitigation measures and conservation practices of stress management in fruit crops.
5. To evaluate biotic and abiotic stress management techniques in relation to green house and methane emissions.
6. To construct and enhance water use efficiency and sustainability indices.

UNITS I (Total Topics- 6 and Hrs- 12)

Introduction: Basic Aspects and Principles: Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.). Pollution – increased level of CO₂, industrial wastes, impact of stress in fruit crop production, stress indices, physiological and biochemical factors associated with stress, fruit crops suitable for different stress situations.

UNIT II (Total Topics -8 and Hrs-16)

Stress Impact: Assessment, Physiology and Performance: Crop modeling for stress situations, cropping systems, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stresses and their impact on crop growth and productivity.

UNIT- III (Total Topics -12 and Hrs-18)

Stress Management: Mitigation Measures and Conservation Practices: Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers. Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, stability and sustainability indices.

Practical (Experiments-07 and Hrs - 15)

Seed treatment/ hardening practices; Container seedling production; Analysis of soil moisture estimates (FC, ASM, PWP); Analysis of plant stress factors, RWC, chlorophyll fluorescence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate, etc. under varied stress situations; Biological efficiencies, WUE, solar energy conversion and efficiency; Crop growth sustainability indices and economics of stress management; Visit to orchards and watershed locations

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Acquaint with stress and its types in fruit crops
- CO.2: Understand physiological and biochemical factors associated with stress.
- CO.3: Apply crop modeling for stress situations
- CO.4: Analyze mitigation measures and conservation practices of stress management in fruit crops.

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- CO.5: Evaluate biotic and abiotic stress management techniques in relation to green house and methane emissions.
- CO.6: Construct and enhance water use efficiency and sustainability indices.

Suggested readings:

- Blumm A. 1988. Plant Breeding for Stress Environments. CRC Publication, USA. Christiansen,
- MN and Lewis CF. 1982. Breeding Plants for Less Favourable Environments. Wiley International Science, USA.
- Kanayama Y and Kochetor. 2015. Abiotic Stress Biology in Horticultural Plants. Springer.
- Kramer PJ. 1980. Drought Stress and the Origin of Adaptation. In: Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons, USA.
- Maloo SR. 2003. Abiotic Stress and Crop Productivity. Agrotech Publ. Academy, India.
- Nickell LG. 1983. Plant Growth Regulating Chemicals. CRC Publication, USA.
- Rao NKS, Shivashankar KS and Laxman RH. 2016. Abiotic Stress Physiology of Horticultural Crops. Springer.
- Turner NC and Kramer PJ. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons, USA.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	3	1	1	2	2	1	1	1	1	1
CO-2	1	2	2	2	1	2	2	3	2	2	2
CO-3	2	1	2	2	2	2	1	2	3	3	3
CO-4	2	2	1	1	1	2	1	2	1	1	1
CO-5	2	2	2	2	2	2	2	2	2	2	2
CO-6	1	2	2	2	2	1	1	2	2	1	1
Average	1.5	2.0	1.5	1.5	1.6	1.7	1.3	2.0	1.6	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPV M606	Abiotic Stress Management in Fruit Crops	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPF M607	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Biodiversity and Conservation of Fruit Crops.	Course Type	Elective

Course Objectives:

1. To remember about germplasm conservation, utilization and centre of origin of various vegetable crops.
2. To understand in situ and ex situ conservation and importance in Biodiversity.
3. To apply for major intellectual property rights regulatory horticulture
4. To analyze Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity.
5. To evaluate GIS applications in horticultural mapping and spatial analyses of field data
6. To formulate high yielding GI tagged fruit varieties in India.

UNITS I (Total Topics- 10 and Hrs- 15)

General Aspects: Issues, Goals and Current Status: Biodiversity and conservation; issues and goals- needs and challenges; present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/ database of fruit crops in India.

Biotechnological interventions in conservation of fruits.

UNIT II (Total Topics -13 and Hrs-16)

Germplasm Conservation: Collection, Maintenance and Characterization: Exploration and collection of germplasm; sampling frequencies; size and forms of fruit and nut germplasm collections; active and base collections. Germplasm conservation- *in situ* and *ex situ* strategies, on farm conservation; problem of recalcitrancy- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

UNIT- III (Total Topics -20 and Hrs-25)

Regulatory Horticulture: Germplasm EXchange, Quarantine and Intellectual Property Rights: Regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged fruit varieties in India.

Practical (Experiment-8; Hrs-16)

Documentation of germplasm- maintenance of passport data and other records; accessions; Field exploration trips and sampling procedures; Exercise on *ex situ* conservation – cold storage, pollen/ seed storage; Cryopreservation; Visits to National Gene Bank and other centers of PGR activities; Detection of genetic constitution of germplasm; Germplasm characterization using a standardized DUS test protocol; Special tests with biochemical and molecular markers (2).

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1 Remember about germplasm conservation, utilization and centre of origin of various vegetable crops.
- CO.2. Understand in situ and ex situ conservation and importance in Biodiversity.
- CO.3. Apply major intellectual property rights regulatory horticulture

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- CO.4. Analyze Breeder's rights, Farmer's rights, GIS and documentation of local biodiversity.
- CO.5. Evaluate GIS application in horticultural mapping and spatial analyses of field data
- CO.6. Formulate high yielding GI tagged fruit varieties in India.

Suggested readings:

- Engles JM, Ramanath RV, Brown AHD and Jackson MT. 2002. *Managing Plant Genetic Resources*, CABI, Wallingford, UK.
- Frankel OH and Hawkes JG. 1975. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press, USA.
- Hancock J. 2012. *Plant Evolution and the Origin of Crops Species*. CAB International. Jackson M, Ford-Lloyd B and Parry M. 2014. *Plant Genetic Resources and Climate Change*. CABI, Wallingford, UK.
- Moore JN and Ballington Jr, JR. 1991. *Genetic Resources of Temperate Fruit and Nut Crops*. ISHS, Belgium.
- Peter KV. 2008. *Biodiversity of Horticultural Crops*. Vol. II. Daya Publ. House, Delhi. Peter KV. 2011. *Biodiversity in Horticultural Crops*. Vol. III. Daya Publ. House, Delhi.
- Rana JC and Verma VD. 2011. *Genetic Resources of Temperate Minor Fruits (Indigenous and Exotic)*. NBPGR, New Delhi.
- Rajasekharan PE, Rao V and Ramanatha V. 2019. *Conservation and Utilization of Horticultural Genetic Resources*. Springer.
- Sthapit B, et al. 2016. *Tropical Fruit Tree Diversity (Good Practices for in situ and ex situ conservation)*. Bioversity International. Routledge, Taylor and Francis Group.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPV M607	Biodiversity and Conservation of Fruit Crops.	2	0	1	20	20	20	40	100	3(2+1)

5th BOS/2025-26

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Supporting courses (Compulsory for all students) (Gradiual courses)

Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV S601	Credit	3(3+0)
Year/Sem	Year 1; Semester – I	L-T-P	2-0-0
Course Name	Research Methodology in Horticulture	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To Equip the Students with the Concept and Methodology of Research.2. To provide knowledge about type of research, preparation of reports and thesis, designing of Research using Scientific Methods.3. To develop the ability to apply principles and procedure for data analysis and interpretation of results.4. To analyze various sampling methods and probability of research analysis.5. To evaluate interpretations and significance of report writing.6. To develop the ability to create appropriate hypothesis, select experimental design and presentation of results after analysis of data.			
UNIT I (Total Topics- 7 and Hrs-12) <p>Introduction to Research: Definition, Nature and significance, Role and Objectives; Types of Research: exploratory, descriptive, experimental and diagnostic research, social and legal research and traditional, analytical, empirical & fundamental research, Doctrinal and non-doctrinal research methods; Various Research Designs; Scientific Research Process: Overview, Problem identification and formulation of research statement.</p>			
UNIT II (Total Topics- 7 and Hrs- 12) <p>Data Collection: sources, primary and secondary methods, significance of Primary and Secondary Data, questionnaire Vs. schedules; Data Processing: Editing, Coding Organization and Presentation; Attitude Measurement and scaling: Measurement Scales, Sources of Errors in Measurement, Techniques of Developing Measurement Tools, Classification and Testing (Reliability, Verification and Validity) Scales, Designing Questionnaires and Interviews.</p>			
UNIT- III (Total Topics- 5 and Hrs- 10) <p>Sampling, Sampling Methods, Sampling Plans, Sampling Error, Sampling Distributions: Theory and Design of Sample Survey, Census Vs Sample Enumerations, Objectives and Principles of Sampling, Types of Sampling, Sampling and Non-Sampling Errors, Concept of Permutation, Combination & Probability for research analysis.</p>			
UNIT-IV(Total Topics- 5 and Hrs- 10) <p>Interpretations and Report Writing: Meaning of Interpretation, Techniques of Interpretation, Precautions in Interpretation, Significance of Report Writing, Steps in Report Writing, Layout of Report and Precautions in Writing Research Reports. Limitations of RM: Ethics in Research, Philosophical Issues in Research.</p>			
Practical)- NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Acquire in-depth knowledge of the fundamentals, theories, and principles related to research, and apply this knowledge to conduct research studies in the chosen area of interest.			

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- CO2: Identify, formulate, and critically investigate research problems by applying research-oriented knowledge, and analyze relevant data to propose appropriate alternative solutions.
- CO3: Apply acquired knowledge and skills to think creatively and innovatively while conducting research and drawing meaningful conclusions.
- CO4: Apply parametric and non-parametric statistical tests to verify hypotheses and suggest innovative solutions to the research problem under investigation.
- CO5: Evaluate the interpretation, significance, and structure of scientific report writing.
- CO6: Create appropriate hypotheses, select suitable experimental designs, analyze data, and effectively present the results.

Suggested readings:

1. William G. Zikmund, "Business Research Methods", Orlando: Dryden Press.
2. C. William Emory and Cooper R. Donald, "Business Research Methods", Boston, Irwin.
3. Fred N Kerlinger, "Foundations of Behavioural Research", New Delhi: Surjeet Publications.
4. Naresh Malhotra, Marketing Research: An Applied Orientation, Pearson publication David Nachmias and Chava Nachmias, "Research Methods in the Social Sciences", New York: St.Marlia's Press.
5. Bhattacharya, D. K. (2004) Research Methodology, New Delhi, Excel Books

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPV S601	Research Methodology in Horticulture	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV S602	Credit	1(1+0)
Year/Sem	Year 1; Semester – I	L-T-P	1-0-0
Course Name	Computer & Stats Application in Research	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To appraise computational skills for research application.2. To assess statistical methods for research analysis.3. To create skills in methods of collection of any type of data, classification of data, presentation of data, analysis of data, descriptive statistics, parametric and non-parametric tests, etc.4. To analyze statistical calculations and their validation.5. To justify the decision in the reference of data analysis, formation and Analysis of data.6. To create ANOVA through different methods and their interpretation.			
UNIT I (Total Topics- 7 and Hrs-12) <p>Characteristics of Computers, Evolution of computers, computer memory, computer generations, Basic computer organization; System software, Application software, introduction to operating system, single user, multi-user, multitasking single tasking, application of computer for business and research, MS-windows, Linux .Application of Internet in research: INFLIBNET, Use of Internet, sights (DOAJ), Use of E Journals, Use of E library, use of EBSCO HOST online database of Academic Libraries. Subject/field specific tools on www.freeware.com</p>			
UNIT II(Total Topics- 7 and Hrs- 12) <p>Computer Application in Research, Basic concept of Computer, Use of Internet for Research Purpose: E-mail, WWW, Web browsing, technical skills, drawing inferences from data, Research publishing tools-MS Word, Adobe acrobat, Graphics tool-MS Excel, Presentation tool-MS Power, Data Analysis Software and Analysis Techniques point. Creating presentation and adding effects, Introduction to Data analysis software-SPSS: Definition, objectives and features, data analysis using SPSS.</p>			
UNIT- III (Total Topics- 5 and Hrs- 10) <p>Statistical methods for research application in analysis of data, Measurement in Research , data interpretation, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), std deviation, Measures of Relationship, Simple Regression Analysis, Correlation and Regression, Partial Correlation.</p>			
UNIT-IV(Total Topics- 5 and Hrs- 10) <p>Statistical Tools-Hypothesis and Hypothesis Testing: Parametric & Non-Parametric Tests, Important Parametric Tests ,Hypothesis Testing of Correlation Coefficients ,U Test, Chi Square Test, ,T-Test. Analysis of Variance (ANOVA) , The Basic Principle of ANOVA ,ANOVA Technique, Setting up Analysis of Variance Table, Short-cut Method for One-way ANOVA, Coding Method, Two-way ANOVA .</p>			
Practical- NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Remember the basic terms used in data collection, classification, presentation, and analysis, including descriptive statistics and parametric and non-parametric tests.• CO2: Understand the use of various formulas, principles, and statistical methods applied in			

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agricultural sciences.

- CO3: Apply appropriate skills in collecting, classifying, presenting, and analyzing different types of data using descriptive statistics, parametric, and non-parametric tests.
- CO4: Analyze statistical calculations and validate the results obtained.
- CO5: Evaluate datasets using suitable statistical tests for meaningful interpretation.
- CO6: Create ANOVA tables using different methods and interpret the results effectively.

Suggested readings:

- C. R. Kothari, "Research Methodology: Methods and techniques", New Delhi: Vishwa Prakashan.
- Brymann, Alan and Carmer, D. (1995) Qualitative data analysis for social scientist, New York, Routledge Publication.
- Jain, Satish: "Introduction to Computer Science and basic Programming." BPB Publications, New Delhi, 1990. • Rajaraman, V., "Fundamental of Computers", Prentice Hall of India, New Delhi, 1996.
- Hogg, R.V.& Craig, T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
- [\(PDF\) Statistical Methods and their Applications \(researchgate.net\)](#)
- [Welcome to Web Agri Stat Package \(icar.gov.in\)](#)
- [\(PDF\) BASIC STATISTICAL TECHNIQUES IN RESEARCH \(researchgate.net\)](#)
- [Statistical Methods & Applications | Home \(springer.com\)](#)
- [Statistical Methodology - Journal - Elsevier](#)

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPV S602	Computer & Stats Application in Research	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV S603	Credit	1(1+0)
Year/Sem	Year 1; Semester – I	L-T-P	1-0-0
Course Name	Research& Publication Ethics	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To acquaint with knowledge about basics of Agricultural Research and research ethics2. To understand research ethics including research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards, and problems in research ethics.3. To apply research ethics in collection and interpretation of data.4. To analyze the major publication ethics to be followed during research.5. To evaluate violation of publication ethics, authorship and contributor ship6. To develop ability to identify different predatory publishers and journals.			
UNIT I (Total Topics- 2 and Hrs-8) <ol style="list-style-type: none">1. Introduction to philosophy: definition, nature and scope, concept, branches2. Ethics: definition, moral philosophy, nature of moral judgments and reactions			
UNIT II (Total Topics- 5 and Hrs- 5) <ol style="list-style-type: none">1. Ethics with respect to science and research2. Intellectual honesty and research integrity3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)4. Redundant publications: duplicate and overlapping publications, salami slicing5. Selective reporting and misrepresentation of data			
UNIT- III (Total Topics-7 and Hrs-7) <ol style="list-style-type: none">1. Publication ethics: definition, introduction and importance2. Best practices/ standards setting initiatives and guidelines: COPE, WAME, etc.3. Conflicts of interest.4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types5. Violation of publication ethics, authorship and contributor ship6. Identification of publication misconduct, complaints and appeals7. Predatory publishers and journals			
UNIT- IV (Total Topics-4and Hrs-4) Practice Open Access Publishing <ol style="list-style-type: none">1. Open access publications and initiatives2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies3. Software tool to identify predatory publications developed by SPPU4. Journal finder/ Journal suggestion tools viz. JANE, Elsevier Journal finder, Springer Journal Suggester, etc.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Recognize the fundamentals of the philosophy of science and ethics, research integrity, publication ethics, and theories of research ethics.• CO2: Familiarize with major issues related to research ethics, research integrity, scientific			

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misconduct, and data misinterpretation.

- CO3: Analyze best practices in scholarly publishing, understand publication ethics, and identify predatory publishers and journals.
- CO4: Demonstrate the use of plagiarism-detection tools, open-source research tools, citation databases, and research metrics.
- CO5: Evaluate credible and scholarly publications published in reputed peer-reviewed journals.
- CO6: Create ethically sound research publications suitable for high-impact, peer-reviewed journals.

Suggested readings:

Research and Publication Ethics, Dr Sumanta Dutta, Bharti Publications, 2021

Research and Publication Ethics, Dr Santosh kumar Yadav, Anne Publications, 2020

- Kumar, R. 2014. Research Methodology: A Step-by-Step Guide for Beginners. 4th Edition. SAGE Publications Ltd.
- Parikh, M.N, Gogtay, N. 2009. ABC of Research Methodology and Applied Biostatistics. Jaypee Publishers, New Delhi.
- [Library & Information Science Research | Journal | ScienceDirect.com by Elsevier](#)
- [\(PDF\) Library and Information Science Research \(researchgate.net\)](#)
- [Research Journal of Library Sciences Introduction :ISCA](#)
- [Research Ethics: Definition, Principles and Advantages - Public Health Notes](#)
- [What Is Ethics in Research & Why Is It Important? - by David B. Resnik, J.D., Ph.D. \(nih.gov\)](#)
- [The Journal of Ethics | Home \(springer.com\)](#)

Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPV S603	Research & Publication Ethics	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV S691	Credit	1(0+1)
Year/Sem	Year 1; Semester – I/II	L-T-P	0-0-1
Course Name	Doctoral Seminar- I	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscripts/article and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPV S691	Doctoral Seminar -I	0	0	2	-	-	100	-	100	1(0+1)

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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV S692	Credit	1(0+1)
Year/Sem	Year I; Semester – I/II	L-T-P	0-0-1
Course Name	Doctoral Seminar -II	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscripts/article and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPV S692	Doctoral Seminar -II	0	0	2	-	-	100	-	100	1(0+1)

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Doctoral Research Work

Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPV C699	Credit	75(0+75)
Year/Sem	Not Applicable	L-T-P	Not Applicable
Course Name	Doctoral Research	Course Type	Compulsory
Course Objectives:			
<ol style="list-style-type: none">1. To develop a comprehensive understanding of research philosophies, theories, and types of scientific inquiry in agricultural sciences.2. To identify research gaps through systematic literature review and formulate appropriate research problems, objectives, and hypotheses.3. To apply suitable research methodologies, experimental designs, and sampling techniques relevant to agricultural research.4. To enhance skills in data collection, statistical analysis, and interpretation using advanced analytical tools.5. To strengthen scientific writing, academic communication, and referencing skills for research publications and proposals.6. To promote ethical research practices, scientific integrity, and responsible conduct in agricultural research.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs-)			
Synopsis, Research Work & Thesis writing provides the students an excellent opportunity to develop analytical research and entrepreneurial skills, and knowledge through meaningful hands on experience, confidence in their ability to design and investigate the things.			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none">• CO1: Recall and describe fundamental research concepts, methodologies, and statistical tools used in agricultural research.• CO2: Explain research processes, interpret scientific literature, and summarize research gaps in agriculture.• CO3: Apply suitable research designs, data collection methods, and sampling strategies in field, laboratory, and socio-economic studies.• CO4: Analyze research data, identify trends and relationships, and interpret results using appropriate statistical techniques.• CO5: Evaluate the quality, rigor, and validity of research findings and assess scientific articles using standardized evaluation criteria.• CO6: Develop an original research proposal, formulate hypotheses, design experimental models, and produce publishable scientific writing.			
Suggested readings:			
Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee			

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Publisher, New Delhi.

Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	3	3	3	3	3	3	3	3	3
CO-2	3	3	3	3	3	3	3	3	3	3	3
CO-3	3	3	3	3	3	3	3	3	3	3	3
CO-4	3	3	3	3	3	3	3	3	3	3	3
CO-5	3	3	3	3	3	3	3	3	3	3	3
CO-6	3	3	3	3	3	3	3	3	3	3	3
Average	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPV C699	Doctoral Research	N A	N A	N A	NA	NA	NA	NA	NA	75(0+75)

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Detailed Syllabus of Ph.D. (Hort.) Fruit Science

Major courses (Gradual courses)

Programme Name	Ph. D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF C601	Credit	3(3+0)
Year/Sem	Year 1; Semester – I	L-T-P	3-0-0
Course Name	Innovative Approaches in Fruit Breeding	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember various contributions of plant breeding methods in fruit crops.2. To understand genetics of qualitative and quantitative characters, population genetics.3. To apply breeding techniques and biotechnological tools for development of fruit cultivars.4. To analyze various inheritance pattern and incompatibility systems in fruit crops.5. To evaluate various fast track breeding methods such as molecular breeding and transgenic breeding.6. To assemble appropriate variety of fruit crops suitable for cultivation.			
UNITS I (Total Topics- 6 and Hrs- 8) Introduction, Current Trends and Status: Modern trends in fruit breeding –with major emphasis on precocity, low tree volume, suitability for mechanization, health benefits, etc.			
UNIT II (Total Topics -7 and Hrs-10) Genetic Mechanisms: Inheritance Patterns and Breeding Systems: Genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits.			
UNIT- III (Total Topics -10 and Hrs-10) Breeding for Specific Traits: Plant Architecture, Stress Tolerance and Fruit Quality: Recent advances in crop improvement efforts- wider adaptation, plant architecture, amenability to mechanization, fruit quality attributes, stress tolerance crop specific traits; use of apomixis, gene introgression and wide hybridization (alien genes).			
UNIT- III (Total Topics -15 and Hrs-18) Fast-Track Breeding: Transgenics, Markers and Genomics: Molecular and transgenic approaches in improvement of selected fruit crops; fast track breeding –marker assisted selection and breeding (MAS and MAB), use of genomics and gene editing technologies. Crops: Mango, banana, guava, papaya, Citrus, grapes, pomegranate, litchi, apple, pear, strawberry, kiwifruit, plums, peaches, apricot, cherries, nectarines, nut crops.			
Practical: NA			

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Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Remembering various contributions of plant breeding methods in fruit crops.
- CO.2: Understand of genetics of qualitative and quantitative characters, population genetics.
- CO.3: Apply breeding techniques and biotechnological tools for development of crop varieties.
- CO.4: Analyzing various inheritance pattern and incompatibility systems in fruit crops.
- CO.5: Evaluation of various fast track breeding methods such as molecular breeding and transgenic breeding.
- CO.6: Assemblage of appropriate variety of fruit crops suitable for cultivation.

Suggested readings:

- Al-Khayari J, Jain S N and Johnson D V. 2018. *Advances in Plant Breeding Strategies. Vol.3: Fruits*. Springer.
- Badenes S and Byrne D H. 2012. *Fruit Breeding*. Springer.
- Hancock J F. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics*. Springer. Kole C and Abbott A G. 2012. *Genetics, Genomics and Breeding of Stone fruits*. CRC.
- Kole, C. 2011. *Wild Crops Relatives: Genomics and Breeding Resources: Tropical and Subtropical Fruits*. Springer-Verlag.
- Kole C. 2011. *Wild Crops Relatives: Genomics and Breeding Resource: Temperate Fruits*. Springer -Verlag.
- Jain S N and Priyadarshan P M. 2009. *Breeding Plantation and Tree Crops: Tropical Species; Temperate Species*. Springer-Verlag.
- Janick J and Moore J N, 1996. *Fruit Breeding*. Vols. I-III. John Wiley & Sons, USA. Orton T. 2019. *Methods in Fruit Breeding*. Elsevier.
- Singh S K, Patel V B, Goswami A K, Prakash J and Kumar C. 2019. *Breeding of Perennial Horticultural Crops*. Biotech Books. Delhi.

Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	3	-	1	1	1	2	1	-	3	3
CO-2	1	2	1	-	1	1	2	2	1	1	1
CO-3	-	1	-	1	-	-	2	1	1	1	1
CO-4	1	2	2	1	1	1	-	-	-	-	-
CO-5	1	1	1	1	-	1	1	1	1	1	1
CO-6	1	1	1	-	1	1	1	-	1	1	1
Average	1.0	1.7	1.2	1.0	1.0	1.0	1.6	1.2	1.0	1.4	1.4

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CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPF C601	Innovative Approaches in Fruit Breeding	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph. D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF C604	Credit	3(2+1)
Year/Sem	Year 1/II	L-T-P	1-0-1
Course Name	Advanced Laboratory Techniques	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To remember various technical aspects and safety procedures of laboratories.2. To understand the different types of solutions prepared in labs.3. To apply breeding techniques and biotechnological tools for breeding techniques.4. To analyze various Destructive and Non-destructive Analysis Methods5. To evaluate various Application of nuclear techniques in harvested produce.6. To assemble sensory analysis techniques.			
UNITS I (Total Topics- 6 and Hrs- 8) General Aspects Unit 1: Safety Measures and Laboratory Maintenance: Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce. Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity			
UNIT II (Total Topics -7 and Hrs-10) Genetic Mechanisms: Inheritance Patterns and Breeding Systems: Genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits.			
UNIT- III (Total Topics -10 and Hrs-10) Destructive and Non-destructive Analysis Methods: Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops. Chromatographic and Microscopic Analysis: Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultrafiltration. Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in horticultural produce.			
UNIT- III (Total Topics -15 and Hrs-18) Sensory Analysis: Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC). Sensory analysis techniques, control of test rooms, products and panel.			
Practical: (Total Topics -10 and Hrs-15) Determination of moisture, relative water content and physiological loss in weight, Determination of biochemical components in horticultural produce, Calibration and standardization of instruments, Textural properties of harvested produce, Determination of starch index, Specific gravity for determination of maturity assessment, and pH of produce, Detection of adulterations in fresh as well as processed products, Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugars and starch, Estimation of rate of ethylene evolution using gas chromatograph (GC), Use of advanced microscopes (fluorescent, scanning electron microscope, phase contrast, etc.).			
Course Outcomes (COs): After completion of course, students will be able to:			

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- CO.1: Remember various technical aspects and safety procedures of laboratories.
- CO.2: To understand different types of solutions prepared in labs.
- CO.3: To apply breeding techniques and biotechnological tools for breeding techniques.
- CO.4: To analyze various Destructive and Non-destructive Analysis Methods
- CO.5: To evaluate various Application of nuclear techniques in harvested produce.
- CO.6: To assemble sensory analysis techniques.

Suggested Readings

- AOAC International. 2003. Official Methods of Analysis of AOAC International. 17th Ed. Gaithersburg, MD, USA, Association of Analytical Communities, USA.
- Clifton M and Pomeranz Y. 1988. Food Analysis-Laboratory Experiments. AVI Publication, USA.
- Leo ML. 2004. Handbook of Food Analysis. 2nd Ed. Vols. I-III, USA.
- Linskens HF and Jackson JF. 1995. Fruit Analysis. Springer.
- Pomrenz Y and Meloan CE. 1996. Food Analysis – Theory and Practice. CBS, USA.
- Ranganna S. 2001. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata-McGraw-Hill, New Delhi.
- Thompson AK. 1995. Post Harvest Technology of Fruits and Vegetables. Blackwell Sciences. USA.

Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	3	-	1	1	1	2	1	-	3	3
CO-2	1	2	1	-	1	1	2	2	1	1	1
CO-3	-	1	-	1	-	-	2	1	1	1	1
CO-4	1	2	2	1	1	1	-	-	-	-	-
CO-5	1	1	1	1	-	1	1	1	1	1	1
CO-6	1	1	1	-	1	1	1	-	1	1	1
Average	1.0	1.7	1.2	1.0	1.0	1.0	1.6	1.2	1.0	1.4	1.4

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPF C604	Advanced Laboratory Techniques	2	0	1	20	20	20	50	100	3(2+1)

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Programme Name	Ph. D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF C605	Credit	2(2+0)
Year/Sem	Year 1/II	L-T-P	2-0-0
Course Name	Arid and Dryland Fruit Production	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To remember basic concepts of arid and dryland fruits.2. To understand different recent advances in propagation and high density planting.3. To apply Stress Mitigation and Integrated approaches to mitigate stress.4. To analyze various total quality management of arid fruit crops.5. To evaluate various production techniques of arid fruits.6. To assemble current view of minor fruit crops.			
UNITS I (Total Topics- 6 and Hrs- 8) Block 1: Introduction: General Concepts and Current Scenario: Characteristics features and major constraints of the arid and dryland region, distinguishing features of the fruit species trees for adaptation in adapting to the region, nutritional and pharmaceutical importance, national problems.			
UNIT II (Total Topics -7 and Hrs-10) Block 2: Advanced Technologies: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation – root stocks, planting systems, High density planting, crop modelling, Precision farming, decision support systems – aspects of crop regulation- physical and chemical regulation, effects on physiology and development, influence of stress factors			
UNIT- III (Total Topics -10 and Hrs-10) Stress Mitigation and Integrated Approaches: Strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, total quality management (TQM) – Current topics. Crops Aonla, Annonas, ber, bael, jamun, date palm, cactus pear, khejri, kair, pilu, lasoda, manila, tamarind, monkey jack, mahua, khirni, amra, seabuckthorn, chilgoza, cafel, rhododendron, box myrtle, chironji, phalsa, karonda, woodapple, paniala and other minor fruits of regional importance			
Practical: (Total Topics - and Hrs-): Not Applicable			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1: Remember basic concepts of arid and dryland fruits.• CO.2: Understand different recent advances in propagation and high density planting.• CO.3: Apply Stress Mitigation and Integrated approaches to mitigate stress.• CO-4: Analyze various total quality management of arid fruit crops.• CO-5: Evaluate various production techniques of arid fruits.• CO-6: To assemble current view of minor fruit crops.			
Suggested Readings <ul style="list-style-type: none">• Hiwale S. 2015. Sustainable Horticulture in Semiarid Drylands. Springer.• Krishna H and Sharma RR. 2017. Fruit Production – Minor Fruits. Daya Publishing House, Delhi.• More T A, Singh RS, Bhargava R and Sharma BD. 2012. Arid Horticulture for Nutrition and Livelihood. Agrotech Publishing Academy, Udaipur (Rajasthan).• Pareek OP, Sharma S and Arora RK. 2007. Underutilised Edible Fruits and Nuts, IPGRI, Rome.• Peter K.V. 2010. Underutilized and Underexploited Horticultural Crops. NIPA, New Delhi.			

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- Saroj PL, Dhandar DG and Vashishta BB. 2004. Advances in Arid Horticulture, Vol.-1 Present Status. IBDC, Lucknow.
- Saroj P L and Awasthi OP. 2005. Advances in Arid Horticulture, Vol: II: Production Technology of Arid and Semi-arid Fruits. IBDC, Lucknow.
- Sontakke MB. 2014. Production and Management of Fruit crops in Arid/ Drylands. Agrotech Publishing Academy, Udaipur (Rajasthan).

Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	3	-	1	1	1	2	1	-	3	3
CO-2	1	2	1	-	1	1	2	2	1	1	1
CO-3	-	1	-	1	-	-	2	1	1	1	1
CO-4	1	2	2	1	1	1	-	-	-	-	-
CO-5	1	1	1	1	-	1	1	1	1	1	1
CO-6	1	1	1	-	1	1	1	-	1	1	1
Average	1.0	1.7	1.2	1.0	1.0	1.0	1.6	1.2	1.0	1.4	1.4

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPF C605	Arid and Dryland Fruit Production	2	0	1	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF C602	Credit	3(3+0)
Year/Sem	1/ II	L-T-P	3-0-0
Course Name	Modern Trends in Fruit Production	Course Type	Compulsory
Course Objectives:			
<ol style="list-style-type: none"> To acquaint with general concepts and current scenario of fruit production. To understand propagation, planting Systems and crop regulation technologies of fruits. To demonstrate the advance propagation methods of fruit production. To organize the decision support systems for precision farming of common fruits. To review the physical and chemical factors that regulates fruit production. To formulate recent trends of production technologies of tropical, subtropical, and temperate fruits. 			
UNIT I (Total Topics- 19 and Total Hrs-45)			
Block-1 (Topics-3 and Hrs-9): Introduction- General Concepts and Current Scenario: National and International scenario, national problems.			
Block-2 (Topics-8 and Hrs-18): Advanced Technologies: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation – root stocks, planting systems, High density planting, crop modeling, Precision farming, decision support systems – aspects of crop regulation- physical and chemical regulation.			
Block-3 (Topics-8 and Hrs-18): Management Practices: Overcoming Stress and Integrated Approaches: Effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Physiological disorders, Total quality management (TQM).			
UNIT II (Total Topics 07- and Hrs-10) – Mango, Banana, Grapes, Citrus, Papaya, Litchi, Guava,			
UNIT- III (Total Topics -07 and Hrs-10) – Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherry			
UNIT-IV (Total Topics – 05 and Hrs-09) – Almond, Walnut, Pecan, Strawberry, Kiwifruit.			
Practical (Experiments- and Hrs -) Not Applicable			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none"> CO-1: Acquaint with general concepts and current scenario of fruit production. CO-2: Understand propagation, planting Systems and crop regulation technologies of fruits. CO-3: Demonstrate the advance propagation methods of fruit production. CO-4: Organize the decision support systems for precision farming of common fruits. CO-5: Review the physical and chemical factors that regulate the fruit production. CO-6: Formulate recent trends of production technologies of tropical, subtropical, and temperate fruits. 			
Suggested readings:			
<ul style="list-style-type: none"> Bartholomew D. P., Paul, R. E. and Rohrbach, K.G. eds. 2002. The Pineapple: Botany, Production, and Uses. CAB International. Bose T K, Mitra SK and Sanyol D. Eds. 2002. Fruits of India – Tropical and Sub- Tropical. 3rdEd. Vols. I, II. Naya Udyog, Kolkata, India. Dhillon WS and Bhatt ZA. 2011. Fruit Tree Physiology. Narendra Publishing House, New Delhi. 			

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Arcadia Grant, P.O. Chandanwari, Premnagar, Dehradun, Uttarakhand

- Dhillon WS. 2013. Fruit Production in India. Narendra Publishing House, New Delhi.
- Gowen S. 1995. Bananas and Plantains. Chapman & Hall Publication, US.
- Litz RE. ed. 2009. The Mango: Botany, Production and Uses. CAB International.
- Peter KV. 2016. Innovations in Horticulture. NIPA, New Delhi.
- Robinson J C and Saúco V G. 2010. Bananas and Plantains (Vol. 19). CAB International.
- Sharma R R and Krishna H. 2014. Fruit Production: Major Fruits. Daya Publishing House, Delhi.
- Singh S, Shivankar VJ, Srivastava AK and Singh IP. 2004. Advances in Citriculture. Jagminder Book Agency, New Delhi.

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	3	1	1	2	1	1	1	1	1	1
CO-2	1	1	2	2	1	2	2	3	1	2	2
CO-3	1	1	1	2	2	2	1	1	3	3	3
CO-4	1	2	1	1	1	2	1	2	1	1	1
CO-5	2	1	2	1	2	1	2	2	1	2	2
CO-6	1	2	1	2	2	1	1	1	2	1	1
Average	1.3	1.6	1.3	1.4	1.6	1.5	1.3	1.3	1.5	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPF C602	Modern Trends in Fruit Production	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF C603	Credit	3(2+1)
Year/Sem	I/II (Elective course)	L-T-P	2-0-1
Course Name	Recent Developments in Growth Regulation	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To acquaint with recent trends in growth and development in fruit culture.2. To understand importance of propagation and planting systems.3. To apply recent technologies in stress management of fruit production.4. To analyze different intercultural operations in increasing productivity per unit area.5. To evaluate and manage physiological disorders of various fruits.6. To judge the Total quality management (TQM) of different fruit crops.			
UNIT I (Total Topics- 19 and Total Hrs-45) Block-1 (Topics-3 and Hrs-9): Introduction- General Concepts and Current Scenario: National and International scenario, national problems. Block-2 (Topics-8 and Hrs-18): Advanced Technologies: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation – root stocks, planting systems, High density planting, crop modeling, Precision farming, decision support systems – aspects of crop regulation-physical and chemical regulation. Block-3(Topics-8 and Hrs-18): Management Practices: Overcoming Stress and Integrated Approaches: Effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Physiological disorders, Total quality management (TQM). Crop: Mango, Banana, Grapes, Citrus, Papaya, Litchi, Guava, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherry, Almond, Walnut, Pecan, Strawberry, Kiwifruit.			
UNIT II (Total Topics -5 and Hrs-7) Mango, Banana, Citrus and Papaya			
UNIT- III (Total Topics -6 and Hrs-8) Guava, Sapota and Jackfruit			
UNIT-IV (Total Topics -15 and Hrs- 10) Pineapple, Annonas and Avocado UNIT V: Aonla, Pomegranate, Phalsa and Ber, minor fruits of tropics.			
Practical (Experiments-08 and Hrs-16) Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical and arid zone orchards, Project preparation for establishing commercial orchards.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1: Acquaint with recent trends in growth and development in fruit culture.• CO.2: Understand importance of propagation and planting systems.			

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- CO.3: Apply recent technologies in stress management of fruit production.
- CO.4: Analyze different intercultural operations in increasing productivity per unit area.
- CO.5: Evaluate and manage physiological disorders of various fruits.
- CO.6: Judge the Total quality management (TQM) of different fruit crops.

Suggested readings:

- Hiwale S. 2015. *Sustainable Horticulture in Semiarid Drylands*. Springer.
- Krishna H and Sharma RR. 2017. *Fruit Production – Minor Fruits*. Daya Publishing House, Delhi.
- More T A, Singh RS, Bhargava R and Sharma BD. 2012. *Arid Horticulture for Nutrition and Livelihood*. Agrotech Publishing Academy, Udaipur (Rajasthan).
- Pareek OP, Sharma S and Arora RK. 2007. *Underutilized Edible Fruits and Nuts*, IPGRI, Rome.
- Peter K.V. 2010. *Underutilized and Underexploited Horticultural Crops*. NIPA, New Delhi.
- Saroj PL, Dhandar DG and Vashishta BB. 2004. *Advances in Arid Horticulture*, Vol.-1 *Present Status*. IBDC, Lucknow.
- Saroj P L and Awasthi OP. 2005. *Advances in Arid Horticulture*, Vol: II: *Production Technology of Arid and Semiarid Fruits*. IBDC, Lucknow.
- Sontakke MB. 2014. *Production and Management of Fruit crops in Arid/ Drylands*. Agrotech Publishing Academy, Udaipur (Rajasthan).

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	2	2	1	1	2	1	2	1	2	2
CO-2	1	1	2	1	-	-	1	1	-	1	1
CO-3	2	2	2	1	1	2	-	2	2	1	1
CO-4	2	2	1	1	-	1	1	1	1	-	-
CO-5	2	2	2	1	1	-	1	1	1	-	-
CO-6	1	2	2	1	1	1	-	1	-	1	1
Average	1.7	1.8	1.8	1.0	1.0	1.5	1.0	1.3	1.2	1.2	1.2

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPF C603	Recent Developments in Growth Regulation	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph. D. (Hort.) Fruit Science	Programme Code	
Course Code	FSC 606	Credit	2(2+1)
Year/Sem	1/ I/II (Elective course)	L-T-P	2-0-1
Course Name	Abiotic Stress Management in Fruit Crops	Course Type	Elective
<p>Course Objectives:</p> <ol style="list-style-type: none"> To become acquainted with stress and its types in fruit crops To understand physiological and biochemical factors associated with stress. To apply crop modeling for stress situations To analyze mitigation measures and conservation practices of stress management in fruit crops. To evaluate biotic and abiotic stress management techniques in relation to green house and methane emissions. To construct and enhance water use efficiency and sustainability indices. 			
<p>UNITS I (Total Topics- 6 and Hrs- 12) Introduction: Basic Aspects and Principles: Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.). Pollution – increased level of CO₂, industrial wastes, impact of stress in fruit crop production, stress indices, physiological and biochemical factors associated with stress, fruit crops suitable for different stress situations.</p>			
<p>UNIT II (Total Topics -8 and Hrs-16) Stress Impact: Assessment, Physiology and Performance: Crop modeling for stress situations, cropping systems, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stresses and their impact on crop growth and productivity.</p>			
<p>UNIT- III (Total Topics -12 and Hrs-18) Stress Management: Mitigation Measures and Conservation Practices: Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers. Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, stability and sustainability indices.</p>			
<p>Practical (Experiments-07 and Hrs - 15) Seed treatment/ hardening practices; Container seedling production; Analysis of soil moisture estimates (FC, ASM, PWP); Analysis of plant stress factors, RWC, chlorophyll fluorescence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate, etc. under varied stress situations; Biological efficiencies, WUE, solar energy conversion and efficiency; Crop growth sustainability indices and economics of stress management; Visit to orchards and watershed locations</p>			
<p>Course Outcomes (COs): After completion of course, students will be able to:</p> <ul style="list-style-type: none"> CO-1: Acquaint with stress and its types in fruit crops CO-2: Understand physiological and biochemical factors associated with stress. CO-3: Apply crop modeling for stress situations CO-4: Analyze mitigation measures and conservation practices of stress management in fruit 			

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crops.

- CO-5: Evaluate biotic and abiotic stress management techniques in relation to green house and methane emissions.
- CO.6: Construct and enhance water use efficiency and sustainability indices.

Suggested readings:

- Blumm A. 1988. Plant Breeding for Stress Environments. CRC Publication, USA. Christiansen,
- MN and Lewis CF. 1982. Breeding Plants for Less Favourable Environments. Wiley International Science, USA.
- Kanayama Y and Kochetor. 2015. Abiotic Stress Biology in Horticultural Plants. Springer.
- Kramer PJ. 1980. Drought Stress and the Origin of Adaptation. In: Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons, USA.
- Maloo SR. 2003. Abiotic Stress and Crop Productivity. Agrotech Publ. Academy, India.
- Nickell LG. 1983. Plant Growth Regulating Chemicals. CRC Publication, USA.
- Rao NKS, Shivashankar KS and Laxman RH. 2016. Abiotic Stress Physiology of Horticultural Crops. Springer.
- Turner NC and Kramer PJ. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons, USA.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	3	1	1	2	2	1	1	1	1	1
CO-2	1	2	2	2	1	2	2	3	2	2	2
CO-3	2	1	2	2	2	2	1	2	3	3	3
CO-4	2	2	1	1	1	2	1	2	1	1	1
CO-5	2	2	2	2	2	2	2	2	2	2	2
CO-6	1	2	2	2	2	1	1	2	2	1	1
Average	1.5	2.0	1.5	1.5	1.6	1.7	1.3	2.0	1.6	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPF C606	Abiotic Stress Management in Fruit Crops	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF C607	Credit	3(2+1)
Year/Sem	Year 1; Semester – I/II (Elective course)	L-T-P	2-0-1
Course Name	Biodiversity and Conservation of Fruit Crops	Course Type	Elective

Course Objectives:

1. To remember about germplasm conservation, utilization and centre of origin of various vegetable crops.
2. To understand in situ and ex situ conservation and importance in Biodiversity.
3. To apply major intellectual property rights regulatory horticulture
4. To analyze Breeder's rights, Farmer's rights, PPV & FR Act. GIS and documentation of local biodiversity.
5. To evaluate GIS application in horticultural mapping and spatial analyses of field data
6. To formulate high yielding GI tagged fruit varieties in India.

UNITS I (Total Topics- 10 and Hrs- 15)

General Aspects: Issues, Goals and Current Status: Biodiversity and conservation; issues and goals-needs and challenges; present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/database of fruit crops in India. Biotechnological interventions in conservation of fruits.

UNIT II (Total Topics -13 and Hrs-16)

Germplasm Conservation: Collection, Maintenance and Characterization: Exploration and collection of germplasm; sampling frequencies; size and forms of fruit and nut germplasm collections; active and base collections. Germplasm conservation- *in situ* and *ex situ* strategies, on farm conservation; problem of recalcitrancy-cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

UNIT- III (Total Topics -20 and Hrs-25)

Regulatory Horticulture: Germplasm EXchange, Quarantine and Intellectual Property Rights: Regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phyto-sanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged fruit varieties in India.

Practical (Experiment-8; Hrs-16)

Documentation of germplasm-maintenance of passport data and other records; accessions; Field exploration trips and sampling procedures; Exercise on *ex situ* conservation-cold storage, pollen/seed storage; Cryopreservation; Visits to National Gene Bank and other centers of PGR activities; Detection of genetic constitution of germplasm; Germplasm characterization using a standardized DUS test protocol; Special tests with biochemical and molecular markers.

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Remember germplasm conservation, utilization and centre of origin of various vegetable crops.
- CO.2: Understand in situ and ex situ conservation and importance in Biodiversity.

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- CO.3. Apply major intellectual property rights regulatory horticulture
- CO.4: Analyze Breeder's rights, Farmer's rights, GIS and documentation of local biodiversity.
- CO.5: Evaluate GIS application in horticultural mapping and spatial analyses of field data
- CO.6: Formulate high yielding GI tagged fruit varieties in India.

Suggested readings:

- Engles JM, Ramanath RV, Brown A H D and Jackson MT. 2002. *Managing Plant Genetic Resources*, CABI, Wallingford, UK.
- Frankel O H and Hawkes J G. 1975. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press, USA.
- Hancock J. 2012. *Plant Evolution and the Origin of Crops Species*. CAB International.
- Jackson M, Ford-Lloyd B and Parry M. 2014. *Plant Genetic Resources and Climate Change*. CABI, Wallingford, UK.
- Moore J N and Ballington Jr ,J R. 1991. *Genetic Resources of Temperate Fruit and Nut Crops*. ISHS, Belgium.
- Peter K V. 2008. *Biodiversity of Horticultural Crops*. Vol. II. Daya Publ. House, Delhi. Peter K V. 2011. *Biodiversity in Horticultural Crops*. Vol.III. Daya Publ. House, Delhi.
- Rana JC and Verma VD. 2011. *Genetic Resources of Temperate Minor Fruits (Indigenous and Exotic)*. NBPGR, NewDelhi.
- Rajasekharan P E, Rao VandRamanatha V. 2019. *Conservation and Utilization of Horticultural Genetic Resources*. Springer.
- Sthapit B,. 2016. *Tropical Fruit Tree Diversity (Good Practices for insitu and exsitu conservation)*. Bioversity International. Routledge, Taylor and Francis Group.
- Virchow D. 2012. *Conservation of Genetic Resources*, Springer Verlag, Berlin.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			

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DPF C607	Biodiversity and Conservation of Fruit Crops.	2	0	1	20	20	20	40	100	3(2+1)
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Programme Name	Ph.D. (Hort.) Vegetable Science	Programme Code	
Course Code	DPF C608	Credit	2(2+0)
Year/Sem	Elective course	L-T-P	2-0-0
Course Name	Smart Fruit Production	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none">1. To explore the successful application of AI systems in fruit farming and horticultural practices.2. To understand the principles and uses of remote sensing, DGPS, and wireless-based irrigation networks in optimizing fruit production and nursery management.3. To demonstrate the methods of remote sensing, DGPS, and wireless-based irrigation networks in optimizing fruit production and nursery management.4. To analyze the role of mechanization, automation, and robotics in enhancing efficiency and productivity in fruit farming.5. To evaluate how cutting-edge technologies such as AI, GIS, nanotechnology, and robotics can be integrated into traditional fruit farming practices.6. To encourage critical thinking and innovation in addressing issues related to crop monitoring, stress management, nutrient delivery, and automated farming systems.			
UNITS I (Total Topics- 08 and Total Hrs-08)			
Importance and Overview: Introduction and importance; concepts and applications of artificial intelligence systems; case studies in horticulture			
UNIT II (Total Topics- 07 and Total Hrs-10)			
GIS, Sensors and Wireless Systems: Application of sensors in fruit production, crop monitoring – crop load and stress incidence forecast modules, remote sensing, Geographical Information System (GIS), Differential Geo-Positioning System (DGPS) hi-tech nursery production of fruit crops under protected conditions, ultra modern wireless based drip irrigation network.			
UNIT- III (Total Topics- 06 and Total Hrs-08)			
Concepts and Methods: Nanotechnology for smart nutrient delivery in fruit farming, concepts and methods, practical utility, nano-fertilizers, nano-herbicides; nano-pesticides			
UNIT- IV (Total Topics- 07 and Total Hrs-10)			
Mechanization, Automation and Robotics: Production systems amenable to automation and mechanization; automated protected structures (turn- key systems); hydroponics, aeroponics, bioreactors for large scale plant multiplication; Use of drones and robotics in fruit growing – robotic planters, sprayers, shakers, harvesters, stackers, etc. Visit to Hi-tech facilities.			
Practical (Experiments- and Hrs -) NA			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none">• CO.1: Explore the successful application of AI systems in fruit farming and horticultural practices.• CO.2: Understand the principles and uses of remote sensing, DGPS, and wireless-based irrigation networks in optimizing fruit production and nursery management.• CO.3: Demonstrate the methods of remote sensing, DGPS, and wireless-based irrigation networks in optimizing fruit production and nursery management.			

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- CO.4: Analyze the role of mechanization, automation, and robotics in enhancing efficiency and productivity in fruit farming.
- CO.5: Evaluate how cutting-edge technologies such as AI, GIS, nanotechnology, and robotics can be integrated into traditional fruit farming practices.
- CO.6: Encourage critical thinking and innovation in addressing issues related to crop monitoring, stress management, nutrient delivery, and automated farming systems.

Suggested readings:

- Chadha et al. 2017. Doubling Farmers Incomes through Horticulture. Daya Publishing House, New Delhi.
- Chadha et al. 2019. Shaping the Future of Horticulture. Kruger Brentt Publishers, UK.
- Hewett EW. 2013. Automation, Mechanization and Robotics in Horticulture. In: Workshop on Emerging Postharvest Technologies. UC, Davis, USA.
- Peter KV. 2016. Innovations in Horticulture. NIPA, New Delhi.
- Prasad S, Singh D and Bhardwaj RL. 2012. Hi-Tech Horticulture. Agrobios (India).
- Tyagi, S. 2019. Hi- Tech Horticulture. Vols. 1 to 7. NIPA, New Delhi. Zhang Q. 2017.
- Automation in Tree Fruit production – Principles and Practice. CABI.
- <http://horticulture.ucdavis.edu>- Innovative Technology for Horticultural Department.

Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	1	3	3	1	1	1	2	1	2	3	3
CO-2	1	2	1	2	1	1	2	2	1	1	1
CO-3	2	1	2	1	2	2	2	1	1	1	1
CO-4	1	2	2	1	1	1	1	2	1	1	1
CO-5	1	1	1	1	3	1	1	1	1	1	1
CO-6	1	1	1	3	1	1	1	1	1	1	1
Average	1.3	1.7	1.4	1.3	1.3	1.1	1.6	1.1	1.2	1.1	1.1

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			

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DPF C608	Smart Fruit Production	2	0	0	30	-	20	50	100	2(2+0)
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Minor courses (Gradual courses)

Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF M601	Credit	3(3+0)
Year/Sem	Elective	L-T-P	3-0-0
Course Name	Recent Trends in Vegetable Production	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To Familiarize with the production technology of vegetables and spices with recent trends and technologies.2. To acquaint with the new system of planting and application of fertilizers adopted in production technology of vegetables and spices.3. To develop skills to production seeds from existing vegetables crops.4. To identify the various types of problems related to biotic and abiotic stress occurred during the cultivation of vegetables and spices crops.5. To classify and cultivate the crop based on their basic requirement for cultivation.6. To judge the harvesting time and techniques of various vegetable and spices crops, storage conditions.			
UNITS I (Total Topics- 5 and Hrs- 6) Recent trends in vegetable production Solanaceous crops: Tomato, brinjal, chilli, sweet pepper and potato.			
UNIT II (Total Topics -5 and Hrs-7) Recent trends in vegetable production. Cole crops: Cabbage, cauliflower and knol-khol, sprouting broccoli.			
UNIT- III (Total Topics -6 and Hrs-8) Recent trends in vegetable production. Okra, onion, peas and beans, amaranth and drumstick.			
UNIT-IV (Total Topics -15 and Hrs- 10) Recent trends in vegetable production. Root crops Carrot, beet root, turnip and radish and cucurbits.			
UNIT- V (Total Topics -5 and Hrs- 7) Recent trends in vegetable production. Tuber crops: Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• VSC-601 CO-1: Familiarized with the production technology of vegetables and spices with recent trends and technologies.• VSC-601 CO-2 Acquaint with the new system of planting and application of fertilizers adopted in production technology of vegetables and spices.• VSC-601 CO-3 Develop skills to production seeds from existing vegetables crops.• VSC-601 CO-4 Identify the various types of problems related to biotic and abiotic stress occurred during the cultivation of vegetables and spices crops.• VSC-601 CO-5 Classify and cultivate the crop on the basis of their basic requirement for cultivation.• VSC-601 CO-6 Judge harvesting time and techniques of various vegetable and spices crops with proper storage system.			
Suggested readings:			

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Arcadia Grant, P.O. Chandanwari, Premnagar, Dehradun, Uttarakhand

- Bose TK and Som NG. 1986. *Vegetable crops of India*. Nayapokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy V Aand Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya Udyog.
- Brewster JL. 1994. *Onions and other vegetable alliums*. CABI.
- Chadha KL and Kalloo G (Eds.). 1993-94. *Advances in Horticulture* Vols. V-X. Malhotra Publ. House.
- Chadha KL (Ed.). 2002. *Hand book of horticulture*. ICAR.
- Chauhan DVS (Ed.). 1986. *Vegetable production in India*. Ramprasad and Sons.
- Fageria MS, Choudhary B R and Dhaka RS. 2000. *Vegetable crops: production technology*. Vol. II. Kalyani.
- FFTC. *Improved vegetable production in Asia*. Book Series No.36.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -5
CO-1	2	2	2	1	1	2	1	2	1	2	2
CO-2	1	1	2	1	-	-	1	1	-	1	1
CO-3	2	2	2	1	1	2	-	2	2	1	1
CO-4	2	2	1	1	-	1	1	1	1	-	-
CO-5	2	2	2	1	1	-	1	1	1	-	-
CO-6	1	2	2	1	1	1	-	1	-	1	1
Average	1.7	1.8	1.8	1.0	1.0	1.5	1.0	1.3	1.2	1.2	1.2

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPF M 601	Recent Trends in Vegetable Production	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF M602	Credit	3(3+0)
Year/Sem	Elective	L-T-P	3-0-0
Course Name	Advances in Breeding of Vegetable Crops	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> To remember about germplasm conservation, utilization, and center of origin of various vegetable crops To understand genetics of qualitative and quantitative characters and their inheritance To apply advance breeding objectives and procedures including conventional as well as innovative approaches used for development of improved varieties To analyze Seed production technology in different vegetable crops. To evaluate efficient breeding methods for different tuber crops. To formulate high yielding seed production methods for different vegetable crops. 			
UNITS I (Total Topics- 6 and Hrs- 8)			
Advances in Breeding of vegetable <i>Solanaceous crops</i> —Tomato, Brinjal, Hot Peeper, Sweet Pepper, Okra and Potato.			
UNIT II (Total Topics -15 and Hrs-20)			
Advances in Breeding of vegetable Cucurbits and Cole crops.			
UNIT- III (Total Topics -12 and Hrs-14)			
Advances in Breeding of vegetable Legumes and leafy vegetables—Peas and Beans, Amaranth, Palak, Chenopodium and Lettuce.			
UNIT-IV (Total Topics -6 and Hrs-8)			
Advances in Breeding of vegetable Root crops and onion—Carrot, Beet root, Radish, Turnip, Onion.			
UNIT-IV (Total Topics -5 and Hrs-7)			
Advances in Breeding of vegetable Tuber crops—Sweet potato, Tapioca, Elephant foot yam, Colocasia, Dioscorea			
Practical (Experiments- and Hrs -)			
NA			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none"> CO.1: Remembering the evolutionary history of important field crops along with their centre of origin, its wild species and wild relatives that can be utilized in breeding. CO.2: Develop the understanding of germplasm conservation, utilization, and centre of origin of various crops, genetics of qualitative and quantitative characters, and their inheritance. CO.3: Applying breeding procedures, and objectives in different crop important for the development of improved varieties. CO.4: Analyzing seed production technology in different classes of crop. CO.5: Evaluating effective breeding methods in vegetable crops. CO.6: Formulation of best seed production technique for high yield and quality in different crops. 			
Suggested readings:			
<ul style="list-style-type: none"> Allard RW. 1999. <i>Principle of plant breeding</i>. John Willey and Sons, USA. Basset MJ.(Ed.).1986.Breedingvegetablecrops.AVIPubl. 			

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- DhillonBS, Tyagi RK, SaXenaS and Randhawa GJ.2005. *Plant genetic resources: horticultural crops*. Narosa Publ. House.
- Fageria MS,Arya P Sand Choudhary AK.2000.*Vegetable crops:Breeding and seed production*.
- Vol.I.Kalyani.
- Gardner EJ.1975.*Principles of genetics*. John Wiley and Sons.
- Hayes HK, Immer FR and Smith DC. 1955.*Methods of plant breeding*. McGraw-Hill.
- Hayward MD, Bosemark NO and RomagosaI .(Eds.).1993 .*PlantBreeding-principles and prospects*. Chapman and Hall.
- Hazra Pand Som MG.2015.*Vegetable science* (Second revise dedition),Kalyani publishers, Ludhiana,598p
- Hazra Pand Som MG.2016 .*Vegetables production and hybridtechnology* (Second revisededition),Kalyani Publishers,Ludhiana,459p

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	3	1	1	2	1	1	1	1	1	1
CO-2	1	1	2	2	1	2	2	3	1	2	2
CO-3	1	1	1	2	2	2	1	1	3	3	3
CO-4	1	2	1	1	1	2	1	2	1	1	1
CO-5	2	1	2	1	2	1	2	2	1	2	2
CO-6	1	2	1	2	2	1	1	1	2	1	1
Average	1.3	1.6	1.3	1.4	1.6	1.5	1.3	1.3	1.5	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPF C602	Advances in Breeding of Vegetable Crops	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF M603	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Abiotic Stress Management in Vegetable Crops	Course Type	Elective

Course Objectives:

1. To acquaint with stress and its vegetable crops
2. To understand physiological and biochemical factors associated with stress.
3. To apply crop modeling for stress situations
4. To analyze mitigation measures and conservation practices of stress management in vegetable crops.
5. To evaluate biotic and abiotic stress management techniques
6. To judge efficiency of chemical and anti transpirants of different stresses.

UNITS I (Total Topics- 06 and Total Hrs-14)

Environmental stress—its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.

UNIT II (Total Topics- 05 and Total Hrs-10)

Mechanism and measurements—tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

UNIT- III (Total Topics- 05 and Total Hrs-10)

Soil-plant-water relations—under different stress conditions in vegetable crops production and their management practices.

UNIT- IV (Total Topics- 03 and Total Hrs-05)

Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

UNIT- V (Total Topics- 04 and Total Hrs-08)

Use of chemicals—techniques of vegetable growing under high and low temperature conditions, use of chemicals and anti-transpirants in alleviation of different stresses.

Practical (Experiments- 08 and Hrs - 16)

Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops; Measurement of tolerance to various stresses in vegetable crops; Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions; Use of chemicals for alleviation of different stresses.

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Acquaint with stress and its types in vegetable crops
- CO.2: Understanding physiological and biochemical factors associated with stress.
- CO.3: Applying crop modeling for stress situations
- CO.4: Analyzing mitigation measures and conservation practices of stress management in vegetable crops.
- CO.5: Evaluation of efficiency of chemical and anti-transpirants in various stresses.
- CO.6: Judge efficiency of chemical and anti transpirants of different stresses.

Suggested readings:

- Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural

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crops. Narosa Publ. House.

- Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural crops. Narosa Publ. House.
- Kaloo G and Singh K. 2001. Emerging scenario in vegetable research and development. Research periodicals and book publ. house.
- Narendra T. et al. 2012. Improving crops resistance to abiotic stress. Wiley and Sons.US.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO-6
CO-1	2	3	1	1	2	2	1	1	1	1	1
CO-2	1	2	2	2	1	2	2	3	2	2	2
CO-3	2	1	2	2	2	2	1	2	3	3	3
CO-4	2	2	1	1	1	2	1	2	1	1	1
CO-5	2	2	2	2	2	2	2	2	2	2	2
CO-6	1	2	2	2	2	1	1	2	2	1	1
Average	1.5	2.0	1.5	1.5	1.6	1.7	1.3	2.0	1.6	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPF M603	Abiotic Stress Management in Vegetable Crops	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF M604	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Seed Certification, Processing and storage of Vegetable Crops	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To remember importance of seed technology in agriculture.2. To understand seed production techniques in various field crops.3. To apply methods of seed processing, seed quality, seed storage and marketing.4. To analyze various seed control act, order and tests for confirming status of seed.5. To evaluate seed acts and certification processes.6. To formulate best germination methods for higher germination of crops.			
UNITS I (Total Topics- 8 and Hrs- 11) Seed certification, history, concepts and objectives, seed certification agency, phases of seed certification, Indian Minimum seed Certification standards, Planning and management of seed certification programmes.			
UNIT II(Total Topics -5 and Hrs-7) Principles and procedures of field inspection, seed sampling, testing and granting certification, OECD certification Schemes.			
UNIT- III (Total Topics -9 and Hrs-12) Principles of seed processing, Methods of seed drying and cleaning, seed processing plant-Lay-out and design, seed treatment, seed quality enhancement, packaging and marketing.			
UNIT-IV (Total Topics -10 and Hrs- 13) Principles of Seed Storage, orthodox/ recalcitrant seeds, types of storage (open,bulk,controlled,germplasm,cryopreservation),factors affecting seed longevity instorage (Pre and postharvest factors).			
UNIT- V (Total Topics -8 and Hrs- 10) Seed aging and deterioration, maintenance of seed viability and vigor during storage, storage methods, storage structures,transportation and marketing of seeds.			
Practical (Experiment-8; Hrs-16) General procedures of seed certification; Field in section and standards; Isolation and rouging; Inspection and sampling at harvesting, threshing and processing; Testing physical purity, germination and moisture, grow - outtest; Visitto regulatory seed testing and plant quarantine laboratories; Seed processing plants and commercial seeds tores.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO-1 : Remembering importance of seed technology in agriculture• CO-2 : Understanding of various seed production techniques for different field crops, the importance of maintenance of purity of crop varieties, and factors causing deterioration of variety.• CO-3: Applying the factors related to genetic and physical purity of seed and its health status of seeds of a variety during seed processing.• CO-4: Analyzing different methods of seed certification, field inspection, and seed purity testing• CO-5: Evaluation of seed acts and certification methods.			

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- CO-6: Formulation of best germination and seed production techniques of different crops.

Suggested readings:

- Agarwal PK and Anuradha V.2018. *Fundamentals of seed science and technology*. Brilliant publications, New Delhi.
- Basra AS.2000. *Hybrid seed production in vegetables*. CRC press, Florida, USA.
- Bench AL R and Sanchez RA. 2004. *Hand book of seed physiology*. Food products press, NY/London.
- Chakraborty SK, Prakash S, Sharma SP and Dadlani M.2002. *Testing of distinctiveness, uniformity and stability for plant variety protection*. IARI, New Delhi
- Vol1. Kalyani publishers, New Delhi.
- George RAT.1999. *Vegetable seed production* (2nd Edition). CAB International.
- Hazra Pand Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani publishers, Ludhiana, 459p

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	1	1	2	1	2	1	2	2	3	3
CO-2	2	3	1	2	1	1	1	3	1	2	2
CO-3	1	1	2	1	2	1	3	1	3	1	1
CO-4	1	2	1	1	2	1	1	2	3	2	2
CO-5	2	1	2	1	1	1	2	1	1	1	1
CO-6	1	2	2	1	2	2	2	1	2	1	1
Average	1.6	1.6	1.5	1.3	1.5	1.3	1.6	1.6	2	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPF M 604	Seed Certification, Processing and storage of Vegetable Crops	2	0	1	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF M606	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Biodiversity and Conservation of Vegetable Crops	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none">1. To remember general aspects of biodiversity and conservation.2. To understand germplasm conservation and their importance in vegetable production3. To apply methods of regulatory horticulture in conservation of vegetable crops.4. To analyze various seed control acts, order and tests for confirming status of seed.5. To evaluate IPRs, Breeder's rights and Farmer's rights6. To assemble GIS and its application in conservation.			
UNITS I (Total Topics- 8 and Hrs- 11)			
General aspects: issues, goals and current status: Biodiversity and conservation; issues and goals-needs and challenges; present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/ database of fruit crops in India			
UNIT II(Total Topics -5 and Hrs-7)			
Germplasm conservation: collection, maintenance and characterization: Exploration and collection of germplasm; sampling frequencies; size and forms of fruit and nut germplasm collections; active and base collections. Germplasm conservation- in situ and ex situ strategies, on farm conservation; problem of recalcitrance- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.			
UNIT- III (Total Topics -9 and Hrs-12)			
Regulatory horticulture: Germplasm exchange, quarantine and intellectual property rights germplasm exchange, quarantine and intellectual property rights regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPVandFR Act. GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged fruit varieties in India			
Practical (Experiment-8; Hrs-16)			
Documentation of germplasm- maintenance of passport data and other records of accessions; Field exploration trips and sampling procedures; Exercise on ex situ conservation – cold storage, pollen/ seed storage Cryopreservation; Visits to national gene bank and other centers of PGR activities; Detection of genetic constitution of germplasm; Germplasm characterization using a standardised DUS test protocol; Special tests with biochemical and molecular markers.			
Course Outcomes (COs): After completion of course, students will be able to:			
CO.1: Remember general aspects of biodiversity and conservation.			
CO.2: Understand germplasm conservation and their importance in vegetable production			
CO.3: Apply methods of regulatory horticulture in conservation of vegetable crops.			

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CO.4: Analyze various seed control act, order and tests for confirming status of seed.

CO.5: Evaluate IPRs, Breeder's rights and Farmer's rights

CO.6: Assemble about GIS and its application in conservation

Suggested readings:

- Dhillon BS, Tyagi RK, Lal A and Saxena S. 2004. Plant genetic resource management. – horticultural crops. Narosa publishing house, New Delhi.
- Engles JM, Ramanath RV, Brown AHD and Jackson MT. 2002. Managing plant genetic resources, CABI, Wallingford, UK.
- Frankel OH and Hawkes JG. 1975. Crop genetic resources for today and tomorrow. Cambridge University Press, USA.
- Hancock J. 2012. Plant evolution and the origin of crops species. CAB International.
- Jackson M, Ford-Lloyd B and Parry M. 2014, Plant genetic resources and climate change. CABI, Wallingford, UK
- Moore JN and Ballington JR. 1991. Genetic resources of temperate Fruit and nut crops. ISHS, Belgium.
- Peter KV. 2008. Biodiversity of horticultural crops. Vol. II. Daya Publ. House, Delhi.
- Peter KV. 2011. Biodiversity in horticultural crops. Vol.III. Daya Publ. House, Delhi.
- Rajasekharan PE, Rao V and Ramanatha V. 2019. Conservation and utilization of horticultural genetic resources. Springer.
- Rana JC and Verma VD. 2011. Genetic resources of temperate minor fruits (indigenous and exotic). NBPGR, New Delhi.
- Sthapit et al. 2016. Tropical fruit tree diversity (good practices for in situ and ex situ conservation). Bioversity international. routledge, Taylor and Francis Group.
- Virchow D. 2012. Conservation of genetic resources, Springer Verlag, Berlin

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	1	1	2	1	2	1	2	2	3	3
CO-2	2	3	1	2	1	1	1	3	1	2	2
CO-3	1	1	2	1	2	1	3	1	3	1	1
CO-4	1	2	1	1	2	1	1	2	3	2	2
CO-5	2	1	2	1	1	1	2	1	1	1	1
CO-6	1	2	2	1	2	2	2	1	2	1	1
Average	1.6	1.6	1.5	1.3	1.5	1.3	1.6	1.6	2	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			

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DPF M605	Biodiversity and Conservation of Vegetable Crops	2	0	1	20	20	20	40	100	3(2+1)
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Supporting courses (Compulsory for all students) (Gradiual courses)

Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF S601	Credit	3(3+0)
Year/Sem	Year 1; Semester – I	L-T-P	3-0-0
Course Name	Research Methodology in Horticulture	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To Equip the Students with the Concept and Methodology of Research.2. To provide knowledge about type of research, preparation of reports and thesis, designing of Research using Scientific Methods.3. To develop the ability to apply principles and procedure for data analysis and interpretation of results.4. To analyze various sampling methods and probability of research analysis.5. To evaluate interpretations and significance of report writing.6. To develop the ability to create appropriate hypothesis, select experimental design and presentation of results after analysis of data.			
UNIT I (Total Topics- 7 and Hrs-12) <p>Introduction to Research: Definition, Nature and significance, Role and Objectives; Types of Research: exploratory, descriptive, experimental and diagnostic research, social and legal research and traditional, analytical, empirical & fundamental research, Doctrinal and non-doctrinal research methods; Various Research Designs; Scientific Research Process: Overview, Problem identification and formulation of research statement.</p>			
UNIT II(Total Topics- 7 and Hrs- 12) <p>Data Collection: sources, primary and secondary methods, significance of Primary and Secondary Data, questionnaire Vs. schedules; Data Processing: Editing, Coding Organization and Presentation; Attitude Measurement and scaling: Measurement Scales, Sources of Errors in Measurement, Techniques of Developing Measurement Tools, Classification and Testing (Reliability, Verification and Validity) Scales, Designing Questionnaires and Interviews.</p>			
UNIT- III (Total Topics- 5 and Hrs- 10) <p>Sampling, Sampling Methods, Sampling Plans, Sampling Error, Sampling Distributions: Theory and Design of Sample Survey, Census Vs Sample Enumerations, Objectives and Principles of Sampling, Types of Sampling, Sampling and Non-Sampling Errors, Concept of Permutation, Combination & Probability for research analysis.</p>			
UNIT-IV(Total Topics- 5 and Hrs- 10) <p>Interpretations and Report Writing: Meaning of Interpretation, Techniques of Interpretation, Precautions in Interpretation, Significance of Report Writing, Steps in Report Writing, Layout of Report and Precautions in Writing Research Reports. Limitations of RM: Ethics in Research, Philosophical Issues in Research.</p>			
Practical)- NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Acquire in-depth knowledge of the fundamentals, theories, and principles related to research, and apply this knowledge to conduct research studies in the chosen area of interest.• CO2: Identify, formulate, and critically investigate research problems by applying research-			

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oriented knowledge, and analyze relevant data to propose appropriate alternative solutions.

- CO3: Apply acquired knowledge and skills to think creatively and innovatively while conducting research and drawing meaningful conclusions.
- CO4: Apply parametric and non-parametric statistical tests to verify hypotheses and suggest innovative solutions to the research problem under investigation.
- CO5: Evaluate the interpretation, significance, and structure of scientific report writing.
- CO6: Create appropriate hypotheses, select suitable experimental designs, analyze data, and effectively present the results.

Suggested readings:

- William G. Zikmund, "Business Research Methods", Orlando: Dryden Press.
- C. William Emory and Cooper R. Donald, "Business Research Methods", Boston, Irwin.
- Fred N Kerlinger, "Foundations of Behavioural Research", New Delhi: Surjeet Publications.
- Naresh Malhotra, Marketing Research: An Applied Orientation, Pearson publication David Nachmias and Chava Nachmias, "Research Methods in the Social Sciences", New York: St.Marlia's Press.
- Bhattacharya, D. K. (2004) Research Methodology, New Delhi, Excel Books

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPF S601	Research Methodology in Horticulture	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF S602	Credit	1(1+0)
Year/Sem	Year 1; Semester – I	L-T-P	1-0-0
Course Name	Computer & Stats Application in Research	Course Type	Compulsory

Course Objectives:

1. To appraise computational skills for research application.
2. To assess statistical methods for research analysis.
3. To create skills in methods of collection of any type of data, classification of data, presentation of data, analysis of data, descriptive statistics, parametric and non-parametric tests, etc.
4. To analyze statistical calculations and their validation.
5. To justify the decision in the reference of data analysis, formation and Analysis of data.
6. To create ANOVA through different methods and their interpretation.

UNIT I (Total Topics- 7 and Hrs-12)

Characteristics of Computers, Evolution of computers, computer memory, computer generations, Basic computer organization; System software, Application software, introduction to operating system, single user, multi-user, multitasking single tasking, application of computer for business and research, MS-windows, Linux .Application of Internet in research: INFLIBNET, Use of Internet, sights (DOAJ), Use of E Journals, Use of E library, use of EBSCO HOST online database of Academic Libraries. Subject/field specific tools on www.freeware.com

UNIT II (Total Topics- 7 and Hrs- 12)

Computer Application in Research, Basic concept of Computer, Use of Internet for Research Purpose: E-mail, WWW, Web browsing, technical skills, drawing inferences from data, Research publishing tools-MS Word, Adobe acrobat, Graphics tool-MS Excel, Presentation tool-MS Power, Data Analysis Software and Analysis Techniques point. Creating presentation and adding effects, Introduction to Data analysis software-SPSS: Definition, objectives and features, data analysis using SPSS.

UNIT- III (Total Topics- 5 and Hrs- 10)

Statistical methods for research application in analysis of data, Measurement in Research , data interpretation, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), std deviation, Measures of Relationship, Simple Regression Analysis, Correlation and Regression, Partial Correlation.

UNIT-IV (Total Topics- 5 and Hrs- 10)

Statistical Tools-Hypothesis and Hypothesis Testing: Parametric & Non-Parametric Tests, Important Parametric Tests, Hypothesis Testing of Correlation Coefficients, U Test, Chi Square Test, ,T-Test. Analysis of Variance (ANOVA) , The Basic Principle of ANOVA, ANOVA Technique, Setting up Analysis of Variance Table, Short-cut Method for One-way ANOVA, Coding Method, Two-way ANOVA.

Practical- NA

Course Outcomes (COs): After completion of course, students will be able to:

- CO1: Remember the basic terms used in data collection, classification, presentation, and analysis, including descriptive statistics and parametric and non-parametric tests.
- CO2: Understand the use of various formulas, principles, and statistical methods applied in

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agricultural sciences.

- CO3: Apply appropriate skills in collecting, classifying, presenting, and analyzing different types of data using descriptive statistics, parametric, and non-parametric tests.
- CO4: Analyze statistical calculations and validate the results obtained.
- CO5: Evaluate datasets using suitable statistical tests for meaningful interpretation.
- CO6: Create ANOVA tables using different methods and interpret the results effectively.

Suggested readings:

- C. R. Kothari, "Research Methodology: Methods and techniques", New Delhi: Vishwa Prakashan.
- Brymann, Alan and Carmer, D. (1995) Qualitative data analysis for social scientist, New York, Routledge Publication.
- Jain, Satish: "Introduction to Computer Science and basic Programming." BPB Publications, New Delhi, 1990. • Rajaraman, V., "Fundamental of Computers", Prentice Hall of India, New Delhi, 1996.
- Hogg, R.V.& Craig, T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
- [\(PDF\) Statistical Methods and their Applications \(researchgate.net\)](#)
- [Welcome to Web Agri Stat Package \(icar.gov.in\)](#)
- [\(PDF\) BASIC STATISTICAL TECHNIQUES IN RESEARCH \(researchgate.net\)](#)
- [Statistical Methods & Applications | Home \(springer.com\)](#)
- [Statistical Methodology - Journal - Elsevier](#)

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPF S602	Computer Stats & Application in Research	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF S603	Credit	1(1+0)
Year/Sem	Year 1; Semester – I	L-T-P	1-0-0
Course Name	Research & Publication Ethics	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To acquaint with knowledge about basics of Agricultural Research and research ethics2. To understand research ethics including research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards, and problems in research ethics.3. To apply research ethics in collection and interpretation of data.4. To analyze the major publication ethics to be followed during research.5. To evaluate violation of publication ethics, authorship and contributor ship6. To develop ability to identify different predatory publishers and journals.			
UNIT I (Total Topics- 2 and Hrs-8) <ol style="list-style-type: none">1. Introduction to philosophy: definition, nature and scope, concept, branches2. Ethics: definition, moral philosophy, nature of moral judgments and reactions			
UNIT II (Total Topics- 5 and Hrs- 5) <ol style="list-style-type: none">1. Ethics with respect to science and research2. Intellectual honesty and research integrity3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)4. Redundant publications: duplicate and overlapping publications, salami slicing5. Selective reporting and misrepresentation of data			
UNIT- III (Total Topics-7 and Hrs-7) <ol style="list-style-type: none">1. Publication ethics: definition, introduction and importance2. Best practices/ standards setting initiatives and guidelines: COPE, WAME, etc.3. Conflicts of interest.4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types5. Violation of publication ethics, authorship and contributor ship6. Identification of publication misconduct, complaints and appeals7. Predatory publishers and journals			
UNIT- IV (Total Topics-4and Hrs-4) Practice Open Access Publishing <ol style="list-style-type: none">1. Open access publications and initiatives2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies3. Software tool to identify predatory publications developed by SPPU4. Journal finder/ Journal suggestion tools viz. JANE, Elsevier Journal finder, Springer Journal Suggester, etc.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Recognize the fundamentals of the philosophy of science and ethics, research integrity, publication ethics, and theories of research ethics.• CO2: Familiarize with major issues related to research ethics, research integrity, scientific misconduct, and data misinterpretation.			

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- CO3: Analyze best practices in scholarly publishing, understand publication ethics, and identify predatory publishers and journals.
- CO4: Demonstrate the use of plagiarism-detection tools, open-source research tools, citation databases, and research metrics.
- CO5: Evaluate credible and scholarly publications published in reputed peer-reviewed journals.
- CO6: Create ethically sound research publications suitable for high-impact, peer-reviewed journals.

Suggested readings:

Research and Publication Ethics, Dr Sumanta Dutta, Bharti Publications, 2021

Research and Publication Ethics, Dr Santosh kumar Yadav, Anne Publications, 2020

- Kumar, R. 2014. Research Methodology: A Step-by-Step Guide for Beginners. 4th Edition. SAGE Publications Ltd.
- Parikh, M.N, Gogtay, N. 2009. ABC of Research Methodology and Applied Biostatistics. Jaypee Publishers, New Delhi.
- [Library & Information Science Research | Journal | ScienceDirect.com by Elsevier](#)
- [\(PDF\) Library and Information Science Research \(researchgate.net\)](#)
- [Research Journal of Library Sciences Introduction :ISCA](#)
- [Research Ethics: Definition, Principles and Advantages - Public Health Notes](#)
- [What Is Ethics in Research & Why Is It Important? - by David B. Resnik, J.D., Ph.D. \(nih.gov\)](#)
- [The Journal of Ethics | Home \(springer.com\)](#)

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPF S603	Research & Publication Ethics	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF C691	Credit	1(0+1)
Year/Sem	Year 1; Semester – I	L-T-P	0-0-1
Course Name	Doctoral Seminar-I	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscripts/article and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPF C691	Doctoral Seminar - I	0	0	2	-	-	100	-	100	1(0+1)

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Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	DPF C692	Credit	1(0+1)
Year/Sem	Year I; Semester – II	L-T-P	0-0-1
Course Name	Doctoral Seminar-II	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscripts/article and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPF C692	Doctoral Seminar -II	0	0	2	-	-	100	-	100	1(0+1)

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Doctoral Research Work

Programme Name	Ph.D. (Hort.) Fruit Science	Programme Code	
Course Code	FSF C699	Credit	75(0+75)
Year/Sem	Not Applicable	L-T-P	Not Applicable
Course Name	Doctoral Research (Compulsory Course)	Course Type	Compulsory

Course Objectives:

1. To develop a comprehensive understanding of research philosophies, theories, and types of scientific inquiry in agricultural/horticultural sciences.
2. To identify research gaps through systematic literature review and formulate appropriate research problems, objectives, and hypotheses.
3. To apply suitable research methodologies, experimental designs, and sampling techniques relevant to agricultural research.
4. To enhance skills in data collection, statistical analysis, and interpretation using advanced analytical tools.
5. To strengthen scientific writing, academic communication, and referencing skills for research publications and proposals.
6. To promote ethical research practices, scientific integrity, and responsible conduct in agricultural research.

UNIT I (Total Topics- and Hrs-) NA

UNIT II (Total Topics - and Hrs-) NA

UNIT- III (Total Topics - and Hrs-) NA

UNIT-IV (Total Topics - and Hrs-) NA

Practical (Hrs-)

Synopsis, Research Work & Thesis writing provides the students an excellent opportunity to develop analytical research and entrepreneurial skills, and knowledge through meaningful hands on experience, confidence in their ability to design and investigate the things.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1: Recall and describe fundamental research concepts, methodologies, and statistical tools used in agricultural/horticultural research.
- CO2: Explain research processes, interpret scientific literature, and summarize research gaps in agriculture.
- CO3: Apply suitable research designs, data collection methods, and sampling strategies in field, laboratory, and socio-economic studies.
- CO4: Analyze research data, identify trends and relationships, and interpret results using appropriate statistical techniques.
- CO5: Evaluate the quality, rigor, and validity of research findings and assess scientific articles using standardized evaluation criteria.
- CO6: Develop an original research proposal, formulate hypotheses, design experimental models, and produce publishable scientific writing.

Suggested readings:

Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee

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Publisher, New Delhi.

Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	3	3	3	3	3	3	3	3	3
CO-2	3	3	3	3	3	3	3	3	3	3	3
CO-3	3	3	3	3	3	3	3	3	3	3	3
CO-4	3	3	3	3	3	3	3	3	3	3	3
CO-5	3	3	3	3	3	3	3	3	3	3	3
CO-6	3	3	3	3	3	3	3	3	3	3	3
Average	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPF C699	Doctoral Research	N A	N A	N A	NA	NA	NA	NA	NA	75(0+75)

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Detailed Syllabus of Ph.D. Entomology/ Ph.D. Plant Pathology

Major courses (Gradual courses) of Ph.D. Entomology/Minor courses (Gradual courses) of Ph.D. Plant Pathology

Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C601 (Major)/ DPP M601 (Minor)	Credit	3(1+2)
Year/Sem	Year 1; Semester – I	L-T-P	1-0-2
Course Name	Insect Phylogeny and Systematics	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To impart the knowledge about different terms of phylogeny & systematics, phenograms, cladograms, Phylocode, etc.2. To understand the concepts of taxonomic hierarchy, study taxonomic characters, variations, intra-specific phenotypic plasticity.3. To apply multivariate analysis techniques for clustering specimens into different taxa, and development of phenograms.4. To develop ability to differentiate various insect species based on their morphological and molecular characters.5. To evaluation of diversity of insects over geological times on the basis of fossil evidences.6. To prepare taxonomic keys, phylogenetic tree for specific groups and write papers and reviews.			
UNIT I (Total Topics- 5 and Hrs- 8) <p>Detailed study of three schools of classification- numerical, evolutionary and cladistics. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts, speciation processes and evidences. Zoogeography.</p>			
UNIT II (Total Topics - 3 and Hrs- 6) <p>Study of different views on the evolution of insects- alternative phylogenies of insects: Kukalova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times.</p>			
UNIT- III (Total Topics - 6 and Hrs- 10) <p>Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN; scientific ethics. Nomenclature and documentation protocols and procedures; report preparation on new species; deposition of holotypes, paratypes, and insect specimens as a whole in national and international repositories – requirements and procedures.</p>			
UNIT-IV (Total Topics - 4 and Hrs- 6) <p>Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, works on revision of taxa, monographs, and check lists, faunal volumes etc. Websites related to insect taxonomy and databases. Molecular taxonomy, barcoding species and the progress made in molecular systematics.</p>			
Practical (Experiments- 6 and Hrs - 14) <p>Collection, curation and study of one taxon of insects- literature search, compilation of a checklist,</p>			

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study of characters, development of character table, and construction of taxonomic keys for the selected group; Development of descriptions, photographing, writing diagrams, and preparation of specimens for “type like” preservation, Submission of the collections made of the group; Multivariate analysis techniques for clustering specimens into different taxa, and development of phenograms; Rooting and character polarization for developing cladograms and use of computer programmes to develop cladograms.

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Impart the knowledge about different terms of phylogeny & systematics, phenograms, cladograms, Phylocode etc.
- CO.2: Understand the concepts of taxonomic hierarchy, study taxonomic characters, variations, intra-specific phenotypic plasticity.
- CO.3: Apply multivariate analysis techniques for clustering specimens into different taxa, and development of phenograms.
- CO.4: Develop ability to differentiate various insect species on the basis of morphological and molecular characters.
- CO.5: Evaluate of diversity of insects over geological times on the basis of fossil evidence.
- CO.6: Prepare taxonomic keys, phylogenetic tree for specific groups and write papers and reviews.

Suggested Readings:

- CSIRO 1990. *The Insects of Australia: A Text Book for Students and Researchers*. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.
- Dakeshott J and Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer-Verlag, Berlin.
- Freeman S and Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi. Hennig W. 1960. *Phylogenetic Systematics*. Urbana Univ. Illinois Press, USA.
- Hoy MA. 2003. *Insect Molecular Genetics: An Introduction to Principles and Applications*. 2nd Ed. Academic Press, New York.
- Mayr E and Ashlock PD. 1991. *Principles of Systematic Zoology*. 2nd Ed. McGraw Hill, New York.
- Mayr E. 1969. *Principles of Systematic Zoology*. McGraw-Hill, New York.
- Quicke DLJ. 1993. *Principles and Techniques of Contemporary Taxonomy*. Blackie Academic and Professional, London.
- Ross HH. 1974. *Biological Systematics*. Addison Wesley Publ. Co., London.
- Wiley EO. 1981. *Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists*. Columbia Univ. Press, USA.

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Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	1	-	-	-	2	3	1	-	-	-
CO-2	1	-	-	-	1	2	-	-	-	1	1
CO-3	2	2	2	2	1	3	2	1	1	1	1
CO-4	1	-	-	2	1	2	2	3	1	2	2
CO-5	1	-	-	2	1	2	2	3	1	2	2
CO-6	1	-	-	2	1	2	2	3	1	2	2
Average	1.5	1.5	2.0	2.0	1.0	2.3	2.3	1.7	1.0	1.3	1.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPE C601 (Major)/ DPP M601 (Minor)	Insect Phylogeny and Systematics	1	0	4	20	20	20	40	100	3(1+2)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C602 (Major) / DPP M602 (Minor)	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Insect Physiology and Nutrition	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To impart knowledge about physiology and biochemistry of insects.2. To understand about detailed physiology of various secretory and excretory systems, moulting process, chitin synthesis, physiology of digestion, transmission of nerve impulses, nutrition of insects, pheromones, etc.3. To use the semio-chemicals, auditory stimuli and visual signals in pest management.4. To analyze the qualitative and quantitative profile of bio-molecules: practicing analytical techniques for analysis of free amino acids of haemolymph.5. To evaluate and count of insect haemocytes.6. To prepare the semi-synthetic, synthetic and natural diets for different groups of insects.			
UNIT I (Total Topics- 4 and Hrs- 8) <p>Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, hardening of cuticle.</p>			
UNIT II (Total Topics - 10 and Hrs- 15) <p>Digestive enzymes, digestive physiology in phytophagous, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endo-symbionts in insect nutrition, nutritional effects on growth and development; physiology of excretion and osmoregulation, water conservation mechanisms.</p>			
UNIT- III (Total Topics - 4 and Hrs- 5) <p>Detailed physiology of nervous system, transmission of nerve impulses, neuro- transmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semio-chemicals in insect life, toxins and defense mechanisms.</p>			
UNIT-IV (Total Topics -3 and Hrs- 3) <p>Endocrine system and insect hormones, physiology of insect growth and development- metamorphosis, polymorphism and diapause. Insect behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.</p>			
Practical (Experiments-8 and Hrs -16) <p>Preparation of synthetic diets for different groups of insects; Rearing of insects on synthetic, semi-synthetic and natural diets; Determination of co-efficient of utilization; Qualitative and quantitative profile of bio-molecules: practicing analytical techniques for analysis of free amino acids of haemolymph; Zymogram analyses of amylase; Determination of chitin in insect cuticle; Examination and count of insect haemocytes.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Impart knowledge about physiology and biochemistry of insects.• CO.2: Understand about detailed physiology of various secretory and excretory systems, moulting process, chitin synthesis, physiology of digestion, transmission of nerve impulses, nutrition of insects, pheromones, etc.			

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- CO.3: Use of semio-chemicals, auditory stimuli and visual signals in pest management.
- CO.4: Analyze the qualitative and quantitative profile of bio-molecules: practicing analytical techniques for analysis of free amino acids of haemolymph.
- CO.5: Evaluate and count of insect haemocytes.
- CO.6: Prepare semi-synthetic, synthetic and natural diets for different groups of insects.

Suggested readings:

- Ananthkrishnan TN. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. Oxford and IBH, New Delhi.
- Bernays EA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman and Hall, London.
- Kerkut GA and Gilbert LI. 1985. *Insect Physiology, Biochemistry and Pharmacology*. Vols. I- XIII. Pergamon Press, Oxford, New York.
- Muraleedharan K. 1997. *Recent Advances in Insect Endocrinology*. Association for Advancement of Entomology, Trivandrum, Kerala.
- Rockstein, M. 1978. *Biochemistry of Insects*, Academic Press.
- Simpson, SJ. 2007. *Advances in Insect Physiology*, Vol. 33, Academic Press (Elsevier), London, UK.

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	1	-	-	-	-	1	2	1	-	1	1
CO-2	1	2	-	-	-	3	3	1	-	2	2
CO-3	1	1	-	2	-	2	-	1	-	1	1
CO-4	1	2	-	-	1	2	1	2	2	2	2
CO-5	1	1	-	2	-	2	-	1	-	1	1
CO-6	1	2	-	-	-	3	3	1	-	2	2
Average	1.0	1.6	1.0	2.0	1.0	2.2	2.3	1.2	2.0	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Mid term Theory Examination	Assignment	Practical Examination			
DPE C602 (Major) / DPP M602 (Minor)	Insect Physiology and Nutrition	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C603 (Major)/ DPP M603 (Minor)	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Insect Ecology and Diversity	Course Type	Elective

Course Objectives:

1. To acquaint knowledge about insect ecology and diversity.
2. To understand the characterization of distribution of insects, evolution of insect diversity and role of phytophagy, principles of population genetics, Hardy Weinberg Law, Biodiversity and Conservation.
3. To demonstrate the genetic drift and collection of data under field conditions.
4. To calculate algorithms for crop modelling, allelic and phenotypic frequencies – calculation of changes under selection and rates of evolution under selection.
5. To select the various reproductive strategies – timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict.
6. To prepare the life tables and their analyses, assessment of resource size by female insects, reproductive effort and fitness.

UNIT I (Total Topics- 5 and Hrs- 8)

Characterization of distribution of insects- Indices of Dispersion, Taylor's Power law. Island Biogeography. Population dynamics- Life tables, Leslie Matrix, Stable age distribution, Population projections. Predator-Prey Models- Lotka-Volterra and Nicholson-Bailey Model. Crop Modeling- an introduction.

UNIT II (Total Topics - 9 and Hrs- 12)

Insect Plant Interactions. Fig-fig wasp mutualism and a quantitative view of types of associations. Role of insects in the environment. Adaptations to terrestrial habitats. Evolution of insect diversity and role of phytophagy as an adaptive zone for increased diversity of insects. Evolution of resource harvesting organs, resilience of insect taxa and the sustenance of insect diversity- role of plants. Herbivory, pollination, predation, parasitism. Modes of insect-plant interaction, tri-trophic interactions. Evolution of herbivory, monophagy vs polyphagy. Role of plant secondary metabolites. Meaning of stress- plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defenses. Host seeking behavior of parasitoids.

UNIT- III (Total Topics - 8 and Hrs- 10)

Biodiversity and Conservation- RET species, Ecological Indicators. Principles of Population genetics, Hardy Weinberg Law, Computation of Allelic and Phenotypic frequencies, Fitness under selection, Rates of Evolution under selection. Foraging Ecology- Optimal foraging theory, Marginal Value Theorem, and Patch departure rules, central place foraging, Mean-variance relationship and foraging by pollinators, Nutritional Ecology.

UNIT-IV (Total Topics - 1 and Hrs- 2)

Reproductive ecology- Sexual selection, Mating systems, Reproductive strategies – timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict. Agro-ecological vs Natural Ecosystems – Characterisation, Pest Control as applied ecology- case studies.

Practical (Experiments – 7 and Hrs - 14)

Methods of data collection under field conditions; Assessment of distribution parameters, Taylor's power law, Iwao's patchiness index, Index of Dispersion, etc.; Calculation of sample sizes by different methods;

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Fitting Poisson and Negative Binomial distributions and working out the data transformation methods; Hardy-Weinberg Law, Computation of Allelic and Phenotypic Frequencies – Calculation of changes under selection, Demonstration of genetic drift; Assessment of Patch Departure rules. Assessment of Resource size by female insects using a suitable insect model, fruit flies/ *Goniozus*/ Female Bruchids, etc.; A test of reproductive effort and fitness; Construction of Life tables and application of Leslie Matrix – population projections, Stable age distribution; Exercises in development of Algorithms for crop modeling

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Acquaint with knowledge about insect ecology and diversity.
- CO.2: Understand about the characterization of distribution of insects, evolution of insect diversity and role of phytophagy, principles of population genetics, Hardy Weinberg Law, Biodiversity and Conservation.
- CO.3: Explain the genetic drift and collection of data under field condition.
- CO.4: Calculate algorithms for crop modelling, allelic and phenotypic frequencies – calculation of changes under selection and rates of evolution under selection.
- CO.5: Select the various reproductive strategies – timing, egg number, reproductive effort, and sibling rivalry and parent-offspring conflict.
- CO.6: Prepare the life tables and their analyses, assessment of resource size by female insects, reproductive effort and fitness.

Suggested Readings:

- Barbosa P and Letourneau DK. (Eds.). 1988. *Novel Aspects of Insect-Plant Interactions*. Wiley, London.
- Elizabeth BA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman and Hall, New York.
- Freeman S and Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.
- Gotelli NJ and Ellison AM. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Sunderland, MA.
- Gotelli NJ. 2001. *A Primer of Ecology*. 3rd Ed., Sinauer Associates, Sunderland, MA, USA.
- Krebs C. 1998. *Ecological Methodology*. 2nd Ed. Benjamin-Cummings Publ. Co., New York.
- Krebs CJ. 2001 *Ecology: The Experimental Analysis of Distribution and Abundance*. 5th Ed. Benjamin-Cummings Publ. Co., New York.
- Magurran AE. 1988. *Ecological Diversity and its Measurement*. Princeton University Press, Princeton.
- Real LA and Brown JH. (Eds.). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, USA.
- Southwood TRE and Henderson PA. 2000. *Ecological Methods*. 3rd Ed. Wiley Blackwell, London.
- Strong DR, Lawton JH and Southwood R. 1984. *Insects on Plants: Community Patterns and Mechanism*. Harward University Press, Harward.
- Wratten SD and Fry GLA. 1980. *Field and Laboratory Exercises in Ecology*. Arnold Publ., London.

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Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO - 2	PSO - 3	PSO - 4	PSO - 5	PSO - 6
CO-1	2	1	1	1	-	2	3	2	-	2	2
CO-2	1	2	-	3	-	2	3	2	-	1	1
CO-3	3	2	1	1	-	2	1	2	2	2	2
CO-4	1	1	1	1	1	3	1	2	1	2	2
CO-5	3	2	1	1	-	2	1	2	2	2	2
CO-6	1	1	1	1	1	3	1	2	1	2	2
Average	1.8	1.5	1.0	1.3	1.0	2.3	1.7	2.0	1.5	1.8	1.8

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPE C603 (Major)/ DPP M603 (Minor)	Insect Ecology and Diversity	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C604 (Major) / DPP M604 (Minor)	Credit	2(1+1)
Year/Sem	Elective	L-T-P	1-0-1
Course Name	Insect Behavior	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To impart the knowledge about ethology and communication pattern in insects.2. To understand the concepts of super-normal stimuli and behavioral manipulation as potential tool in pest management.3. To use physical cues in host selection in a phytophagous insect, chemical and odor cues in host selection in phytophagous insect.4. To develop ability to differentiate olfactory and auditory signals in inter- and intra-specific communication5. To develop ability to evaluate different types of traps against fruit flies with respect to signals6. To develop semio-chemicals to analyze different behavioral mechanisms in insects.			
UNIT I (Total Topics- 5 and Hrs- 8) <p>Defining Behaviour- Concept of umwelt, instinct, fixed action patterns, imprinting, complex behavior, inducted behavior, learnt behavior and motivation. History of Ethology- development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behavior- Proximate and Ultimate approaches, behavioral traits under natural selection, genetic control of behavior and behavioural polymorphism.</p>			
UNIT II (Total Topics - 3 and Hrs- 6) <p>Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.</p>			
UNIT- III (Total Topics - 6 and Hrs- 10) <p>Reproductive behavior- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behavior- kin selection, parental manipulation and mutualism; Self organization and insect behavior.</p>			
UNIT-IV (Total Topics - 4 and Hrs- 6) <p>Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behavior, pollination behavior, co-evolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio- chemicals, auditory stimuli and visual signals in pest management.</p>			
Practical (Experiments- 6 and Hrs - 14) <p>Quantitative methods in sampling behavior; Training bees to artificial feeders; Sensory adaptation and habituation in a fly or butterfly model, physical cues used in host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect (DBM or gram pod borer), colour discrimination in honey bee or butterfly model, learning and memory in bees, role of self-organization in resource tracking by honeybees; Evaluation of different types of traps against fruit flies with respect to signals; Use of honey bees/ <i>Helicoverpa armigera</i> to understand behavioural polymorphism with respect to learning and response to pheromone mixtures, respectively.</p>			

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Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Explain about ethology and communication pattern in insects.
- CO.2: Understand the concepts of super-normal stimuli and behavioural manipulation as potential tools in pest management.
- CO.3: Use physical cues in host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect.
- CO.4: Differentiate olfactory and auditory signals in inter- and intra-specific communication
- CO.5: Evaluate different types of traps against fruit flies with respect to signals
- CO.6: Develop semio-chemicals to analyse different behavioural mechanisms in insects.

Suggested Readings:

- Ananthkrishnan TN. (Ed.). 1994. Functional Dynamics of Phytophagous Insects. Oxford and IBH, New Delhi.
- Awasthi VB. 2001. Principles of Insect Behaviour. Scientific Publ., Jodhpur.
- Bernays EA and Chapman RF. 1994. Host-Plant Selection by Phytophagous Insects. Chapman and Hall, London.
- Brown LB. 1999. The Experimental Analysis of Insect Behaviour. Springer, Berlin.
- Krebs JR and Davies NB. 1993. An Introduction to Behavioural Ecology. 3rd Ed. Chapman and Hall, London.
- Manning A and Dawkins MS. 1992. An Introduction to Animal Behaviour. Cambridge University Press, USA.
- Mathews RW and Mathews JR. 1978. Insect Behaviour. A Wiley-InterScience Publ. John Wiley and Sons, New York.

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Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	1	-	-	-	2	3	1	-	-	-
CO-2	1	-	-	-	1	2	-	-	-	1	1
CO-3	2	2	2	2	1	3	2	1	1	1	1
CO-4	1	-	-	2	1	2	2	3	1	2	2
CO-5	2	2	2	2	1	3	2	1	1	1	1
CO-6	1	-	-	2	1	2	2	3	1	2	2
Average	1.5	1.7	2.0	2.0	1.0	2.3	2.2	1.8	1.0	1.4	1.4

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Mid term Theory Examination	Assignment	Practical Examination			
DPE C604 (Major) / DPP M604 (Minor)	Insect Behavior	1	0	2	20	20	20	40	100	2(1+1)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C605 (Major)/ DPP M605 (Minor)	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Bio-inputs for Pest Management	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To educate about the natural enemies of insect pests.2. To understand the mass production of bio-pesticides.3. To develop skills in uses of equipment and regulation the factors for breeding of bio-control agents.4. To implement the genetically engineered microbes and parasitoids in biological control of pathogens.5. To analyze the conditions favors the augmentation, survivorship, conservation, and ecological manipulation of bio-control agents.6. To assemble the resources for establishment of large-scale production of bio-control agents.			
UNIT I (Total Topics- 6 and Hrs - 6) Scope of classical biological control and augmentative bio-control; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of bio-agents <i>vis-à-vis</i> target pest populations.			
UNIT II (Total Topics - 10 and Hrs- 8) Bio-inputs: mass production of bio-pesticides, mass culturing techniques of bio- agents, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.			
UNIT- III (Total Topics - 7 and Hrs- 10) Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, large-scale production of bio-control agents, bankable project preparation.			
UNIT-IV (Total Topics - 6 and Hrs- 6) Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in bio-control agents for introgressing and for progeny selections, breeding techniques of bio-control agents.			
Practical (Total Topics - 8 and Hrs- 16) Mass rearing and release of some commonly occurring indigenous natural enemies; Assessment of role of natural enemies in reducing pest populations; Testing side effects of pesticides on natural enemies; Effect of semio-chemicals on natural enemies, breeding of various bio-control agents, performance of efficiency analyses on target pests; Project document preparation for establishing a viable mass-production unit/ insectary; Observation of feeding behavior acts of predatory bugs/ beetles.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Explain about the natural enemies of insect pests.• CO.2: Understand the mass production of bio-pesticides.• CO.3: Develop skills in uses of equipment and regulation the factors for breeding of bio-control			

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agents.

- CO.4: Implement the genetically engineered microbes and parasitoids in biological control of pathogens.
- CO.5: Analyze the evaluate the conditions favors the augmentation, survivorship, conservation, and ecological manipulation of bio-control agents.
- CO.6: Assemble the resources for establishment of large-scale production of bio-control agents.

Suggested Readings:

- Burges HD and Hussey NW. (Eds.). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.
- Coppel HC and James WM. 1977. *Biological Insect Pest Suppression*. Springer Verlag, Berlin.
- De Bach P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman and Hall, London.
- Dhaliwal, GS and Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publishers, New Delhi.
- Gerson H and Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual*. Chapman and Hall, New York.
- Huffakar CB and Messenger PS. 1976. *Theory and Practices of Biological Control*. Academic Press, London.

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO-6
CO-1	1	-	-	-	2	2	3	1	3	2	2
CO-2	-	-	-	-	-	1	1	-	1	-	-
CO-3	2	2	1	-	2	2	3	1	3	1	1
CO-4	2	3	1	-	2	2	3	1	3	1	1
CO-5	2	3	1	-	2	2	3	1	3	1	1
CO-6	1	-	-	-	2	2	3	1	3	2	2
Average	1.6	2.7	1.0	-	2.0	1.8	2.7	1.0	2.7	1.4	1.4

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPE C605 (Major)/ DPP M605 (Minor)	Bio-inputs for Pest Management	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C606 (Major) / DPP M606 (Minor)	Credit	3(2+1)
Year/Sem	Year 1; Semester – II	L-T-P	2-0-1
Course Name	Insect Toxicology and Residues	Course Type	Compulsory
Objectives of the Course:			
<ol style="list-style-type: none">1. To acquaint with scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.2. To classify the insecticides based on mode of entry, mode of action and chemical nature.3. To implement biological techniques for detection of insecticide resistance in insects.4. To analyze factors affecting toxicity of insecticides and their mode of action of newer insecticide.5. To calculate maximum residue limits (MRLs) of insecticides and their significance and environmental implications.6. To develop skills to safe use of insecticides; diagnosis and treatment of insecticide poisoning.			
UNIT I (Total Topics- 8 and Hrs- 9) Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides. Modes of action of newer insecticide molecules; developments in bio-rational approaches; SPLAT; RNAi technology for pest management.			
UNIT II (Total Topics - 7 and Hrs- 7) Biochemical and physiological target sites of insecticides in insects; developments in bio-rationals, bio-pesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.			
UNIT- III (Total Topics - 3 and Hrs- 2) Joint action of insecticides; activation, synergism and potentiation.			
UNIT-IV (Total Topics - 8 and Hrs- 5) Problems associated with pesticide use in agriculture: pesticide resistance; resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects. Case study on pest resurgence in India.			
Unit V (Total Topics - 9 and Hrs- 7) Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; bound and conjugated residues, effect on soil fertility; insecticide laws and standards, and good agricultural practices.			
Practical (Total Topics - 10 and Hrs- 20) Residue sampling, extraction, clean-up and estimation of insecticide residues by various methods; Calculations and interpretation of data; Biochemical and biological techniques for detection of insecticide resistance in insects; Preparation of EC formulation using neem oil.			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none">• CO1: Acquaint with scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.• CO.2: Classify the insecticides based on mode of entry, mode of action and chemical nature.• CO.3: Implement various techniques for detection of insecticide resistance in insects.• CO.4: Analyze factors affecting toxicity of insecticides and their mode of action of newer			

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insecticide.

- CO.5: Calculate maximum residue limits (MRLs) of insecticides and their significance and environmental implications.
- CO.6: Develop skills to safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Suggested readings:

- Busvine JR. 1971. *A Critical Review on the Techniques for Testing Insecticides*. CABI, London. Dhaliwal GS and Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publishers, New Delhi.
- Hayes WJ and Laws ER. 1991. *Handbook of Pesticide Toxicology*. Academic Press, New York.
- Ishaaya I and Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action*. Narosa Publ. House, New Delhi.
- Matsumura F. 1985. *Toxicology of Insecticides*. Plenum Press, New York.
- O' Brien RD. 1974. *Insecticides Action and Metabolism*. Academic Press, New York.
- Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. *Insecticides in Agriculture and Environment*.
- Narosa Publ. House, New Delhi.
- Prakash A and Rao J. 1997. *Botanical Pesticides in Agriculture*. Lewis Publ., New York.

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	-	-	-	3	-	-	-	-	-	-
CO-2	1	-	-	-	3	-	-	-	-	-	-
CO-3	1	-	-	-	3	-	-	-	-	-	-
CO-4	1	-	-	-	3	-	-	-	-	-	-
CO-5	1	-	-	-	3	-	-	-	-	-	-
CO-6	1	-	-	-	3	-	-	-	-	-	-
Average	1.0	-	-	-	3.0	-	-	-	-	-	-

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPE C606 (Major) / DPP M606 (Minor)	Insect Toxicology and Residues	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C607 (Major) / DPP M607 (Minor)	Credit	2(1+1)
Year/Sem	Elective	L-T-P	1-0-1
Course Name	Plant Resistance to Insects	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none">1. To educate about recent advances in resistance of plants to insects and acquaint with the techniques for assessment and evaluation of resistance in crop plants.2. To understand the concept of plant resistance and its significance in agriculture.3. To apply techniques to overcome challenges related to the breakdown of resistance in crop varieties.4. To analyze the relationship between assembly of plant species, gene pool, and the development of resistance.5. To evaluate the behavior of insect sources in relation to host plant factors and its impact on plant resistance.6. To determine antixenosis index, antibiosis index, tolerance index, and plant resistance index.			
UNIT I (Total Topics- 6 and Hrs - 6)			
Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species – gene pool; insect sources – behaviour in relation to host plant factors.			
UNIT II (Total Topics - 10 and Hrs- 8)			
Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oxidase pathways, salicylic acid pathways; effects of induced resistance; exogenous application of elicitors.			
UNIT- III (Total Topics - 7 and Hrs- 10)			
Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; marker aided selection in resistance breeding.			
UNIT-IV (Total Topics - 6 and Hrs- 6)			
Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.			
Practical (Total Topics - 4 and Hrs- 16)			
Understanding mechanisms of resistance for orientation, feeding, oviposition, etc., allelochemical bases of insect resistance; Macro culturing of test insects like aphids, leaf/ plant hoppers, mites and stored grain pests; Field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries; Determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none">• CO1: Explain the recent advances in resistance of plants to insects and acquaint with the			

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techniques for assessment and evaluation of resistance in crop plants.

- CO.2: Understand the concept of plant resistance and its significance in agriculture.
- CO.3: Apply techniques to overcome challenges related to the breakdown of resistance in crop varieties.
- CO.4: Analyze the relationship between assembly of plant species, gene pool, and the development of resistance.
- CO.5: Evaluate the behavior of insect sources in relation to host plant factors and its impact on plant resistance.
- CO.6: Determine antixenosis index, antibiosis index, tolerance index, and plant resistance index.

Suggested Readings:

- Panda N. 1979. Principles of Host Plant Resistance to Insects. Allenheld, Osum and Co., New York.
- Rosenthal GA and Janzen DH. (Eds.). 1979. Herbivores – their Interactions with Secondary Plant Metabolites. Vol. I, II. Academic Press, New York.
- Sadasivam S and Thayumanavan B. 2003. Molecular Host Plant Resistance to Pests. Marcel Dekker, New York.
- Smith CM, Khan ZR and Pathak MD. 1994. Techniques for Evaluating Insect Resistance in Crop Plants. CRC Press, Boca Raton, Florida.

Journals

- Molecular Plant-Microbe Interactions: Link: [Molecular Plant-Microbe Interactions](#)
- Annual Review of Entomology: Link: [Annual Review of Entomology](#)
- Plant Biotechnology Journal: Link: [Plant Biotechnology Journal](#)

Websites

- National Bureau of Agricultural Insect Resources (NBAIR): <http://www.nbair.res.in/>
- National Centre for Integrated Pest Management (NCIPM): <https://www.ncipm.org.in/>
- Indian Society of Plant Protection (ISPP): <https://www.ispponline.org/>
- National Bureau of Plant Genetic Resources (NBPGR): <http://www.nbpgr.ernet.in/>

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO-6
CO-1	1	-	-	-	2	2	3	1	3	2	2
CO-2	-	-	-	-	-	1	1	-	1	-	-
CO-3	2	2	1	-	2	2	3	1	3	1	1
CO-4	2	3	1	-	2	2	3	1	3	1	1
CO-5	2	3	1	-	2	2	3	1	3	1	1
CO-6	1	-	-	-	2	2	3	1	3	2	2
Average	1.6	2.7	1.0	-	2.0	1.8	2.7	1.0	2.7	1.4	1.4

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CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPE C607 (Major) / DPP M607 (Minor)	Plant Resistance to Insects	2	0	2	20	20	20	40	100	2(1+1)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	ENT-609 (Major) / DPP M609 (Minor)	Credit	2(1+1)
Year/Sem	Elective	L-T-P	1-0-1
Course Name	Molecular Entomology	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> To acquaint with basic knowledge about molecular biology and its techniques. To develop understanding of DNA-based diagnostics, genetic improvement of inebriate tolerance of natural enemies. To develop skills in isolation of DNA/ RNA; Purity determinations, purification of total DNA from animal tissues; Base pair estimation. To develop ability to DNA-based diagnostics, insect immune systems in comparison to vertebrates. To develop ability to select the marker genes for sex identification. To develop resistance management strategies in transgenic crops by using recombinant technology. 			
UNIT I (Total Topics - 2 and Hrs - 2)			
Introduction to molecular biology; 1-0 techniques used in molecular biology.			
UNIT II (Total Topics - 10 and Hrs- 12)			
DNA and RNA analysis in insects-transcription and translocation mechanisms. DNA recombinant technology, identification of genes/ nucleotide sequences for characters of interest. Genetic improvement of natural enemies. Cell lines, genetic engineering in baculoviruses, Bt and entomopathogenic fungi.			
UNIT- III (Total Topics - 10 and Hrs- 5)			
Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, St toxins and venoms, chitinase, CPTI; lectins and proteases. Transgenic plants for pest resistance and diseases.			
UNIT-IV (Total Topics - 4 and Hrs-2)			
Insect gene transformation; biotechnology in relation to silkworms and honey bees; introduction of lectin genes for pest suppression; DNA finger printing for taxonomy and phylogeny. Genetic improvement of inebriate tolerance of natural enemies.			
UNIT-V (Total Topics - 4 and Hrs-2)			
DNA-based diagnostics; insect immune systems in comparison to vertebrates; molecular basis of metamorphosis; Sf transgenic technology and implications; molecular biology of baculoviruses; insecticide resistance. Resistance management strategies in transgenic crops.			
Practical (Experiments- 8 and Hrs -16)			
Isolation of DNA/ RNA; Purity determinations, purification of total DNA from animal tissues; Base pair estimation. Agarose gel electrophoresis; Quantitative enzyme profile of alimentary canal; restriction mapping of DNA; demonstration of PCR, RFLP and RAPD techniques.			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none"> CO1: Explain basics of molecular biology and its techniques. CO.2: Understand the DNA-based diagnostics, genetic improvement of inebriate tolerance of natural enemies. 			

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- CO.3: Develop skills in isolation of DNA/ RNA; Purity determinations, purification of total DNA from animal tissues; Base pair estimation.
- CO.4: Develop ability to demonstration of PCR, RFLP and RAPD techniques.
- CO.5: Select the marker genes for sex identification.
- CO.6: Develop resistance management strategies in transgenic crops by using recombinant technology.

Suggested readings:

- Bhattacharya TK, Kumar P and Sharma A. 2007. Animal Biotechnology. 1st Ed., Kalyani Publication, New Delhi.
- Hagedon HH, Hilderbrand JG, Kidwell MG and Law JH. 1990. Molecular Insect Science. Plenum Press, New York.
- Hoy MA. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2nd Ed. Academic Press, New York.
- Oakeshott J and Whitten MA. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer Verlag.
- Rechcigl JE and Rechcigl NA. 1998. Biological and Biotechnological Control of Insect Pests. Lewis Publ., North Carolina.
- Roy U and Saxena V. 2007. A Handbook of Genetic Engineering. 1st Ed., Kalyani Publishers, New Delhi.
- Singh BD. 2008. Biotechnology (Expanding Horizons). Kalyani Publishers, New Delhi. Singh P. 2007. Introductory to Biotechnology. 2nd Ed. Kalyani Publishers, New Delhi.

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	2	1	2	-	3	1	1	-	2	2
CO-2	-	-	-	-	-	3	-	-	-	1	1
CO-3	-	-	-	-	-	2	-	-	-	-	-
CO-4	1	1	1	-	-	2	2	1	3	2	2
CO-5	2	2	1	2	-	3	1	1	-	2	2
CO-6	1	1	1	-	-	2	2	1	3	2	2
Average	1.5	1.5	1.0	2.0	-	2.5	1.5	1.0	3.0	1.8	1.8

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Mid-term Theory Examination	Assignment	Practical Examination			
ENT-609 (Major) / DPP M609 (Minor)	Molecular Entomology	1	0	2	20	20	20	40	100	2(1+1)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C610 (Major) / DPP M610 (Minor)	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Integrated Pest Management	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> To educate about the concepts, tools and principles of Integrated Pest and Disease Management. To develop understanding of the role of IPM in sustainable agriculture as the future of modern plant protection in pest and disease control strategy. To develop skills in methods of detection and diagnosis of insect pest and diseases and application of different pest and disease control techniques. To develop skills for analyzing the agricultural ecosystem, level of pest damage, Pest risk and timing of different pest control tactics to manage the pest population effectively. To evaluate economic injury level and economic threshold level for timely application of control measures for pest management. To design crop model for implementing IPM system. 			
UNIT I (Total Topics - 6 and Hrs- 5)			
Principles of sampling and surveillance, database management and computer programming; simulation techniques, system analysis and modeling.			
UNIT II (Total Topics - 2 and Hrs- 5)			
Study of case histories of national and international programmes, their implementation, adoption and criticism; global trade and risk of invasive pests; updating knowledge on insect outbreaks and their management.			
UNIT- III (Total Topics - 7 and Hrs- 14)			
Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes; application of IPM to farmers' real time situation.			
UNIT-IV (Total Topics - 8 and Hrs- 6)			
Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management. Case study on IPM in Uttarakhand.			
Practical (Experiments – 00 and Hrs - 00)			
NA			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none"> CO1: Explain about the concepts, tools and principles of Integrated Pest and Disease Management. CO.2: Understand the role of IPM in sustainable agriculture as the future of modern plant protection in pest and disease control strategy. CO.3: Skills in methods of detection and diagnosis of insect pest and diseases and application of different pest and disease control techniques. CO.4: Analyzing the agricultural ecosystem, level of pest damage, Pest risk and timing of different pest control tactics to manage the pest population effectively. CO.5: Evaluate economic injury level and economic threshold level for timely application of control 			

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measures for pest management.

- CO.6: Design crop model for implementing IPM system.

Suggested readings:

- Dhaliwal GS and Arora R. 2003. *Integrated Pest Management – Concepts and Approaches*. Kalyani Publishers, New Delhi.
- Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publishers, New Delhi.
- Flint MC and Bosch RV. 1981. *Introduction to Integrated Pest Management*. Springer, Berlin. Koul O and Cuperus GW. 2007. *Ecologically Based Integrated Pest Management*. CABI, London. Koul O, Dhaliwal GS and Curperus GW. 2004. *Integrated Pest Management –Potential, Constraints and Challenges*. CABI, London.
- Maredia KM, Dakouo D and Mota-Sanchez D. 2003. *Integrated Pest Management in the Global Arena*. CABI, London.
- Metcalf RL and Luckman WH. 1982. *Introduction to Insect Pest Management*. John Wiley and Sons, New York.
- Norris RF, Caswell-Chen EP and Kogan M. 2002. *Concepts in Integrated Pest Management*. Prentice Hall, New Delhi.
- Pedigo RL. 1996. *Entomology and Pest Management*. Prentice Hall, New Delhi. Subramanyam B and Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products*. Marcel Dekker, New York.

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	1	1	1	1	-	3	1	3	2	3	3
CO-2	1	-	-	-	-	2	2	1	-	2	2
CO-3	1	1	-	-	-	2	1	2	3	2	2
CO-4	1	1	-	-	-	2	1	2	3	2	2
CO-5	1	1	1	1	-	3	1	3	2	3	3
CO-6	1	-	-	-	-	2	2	1	-	2	2
Average	1.0	1.0	1.0	1.0	-	2.3	1.3	2.0	2.7	2.3	2.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPE C610 (Major) / DPP M610 (Minor)	Integrated Pest Management	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C 612 (Major)/ DPP M612 (Minor)	Credit	3 (2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Insect Farming Technology	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To acquaint with rearing technology of Insects.2. To understand the nutrients available in different insects.3. To develop skills to use of different tools in insect rearing.4. To develop ability to analyze efficient insects for rearing and mass production.5. To evaluate insect species to use in various industries like poultry, fishery, livestock etc.6. To develop rearing methods efficient production of important insects.			
Unit. I: (Total Topics-9 and Hours-12) Introduction; Importance of Insect farming in Agriculture. Mass-Produced insect Species and their respective applications, Insects for Food and Feed, Insects for Medicinal Use; Principals of Feed Production for Insect, Manufacture of Insect Feed.			
Unit. II:(Total Topics- 6 and Hours- 10) Nutritional Requirements for Farmed Insects; Insect Mass Rearing Equipment and Mechanization, Production and Operation Management, Rearing Area, Feeding and Watering; Separation and Sorting Room and Product Traceability & control software.			
Unit. III: (Total Topics - 4 and Hours- 4) Production Techniques by Species; Mealworm Production Technologies, Black Soldier Fly, <i>Hermetia illucens</i> , Housefly, <i>Musca domestica</i> , crickets and Wax worm Production.			
Unit. IV: (Total Topics- 3 and Hours- 4) Environmental Control for Efficient Production of Insects. Current opportunities & challenges in Insect farming.			
Practical: (Experiments 8 & Hours-16) Identification and handling of economically important farmed insect species such as mealworms, black soldier flies, crickets, houseflies, and wax worms, focusing on recognizing their developmental stages. Preparation of insect feed using agro-waste and locally available by-products, feed manufacturing techniques like mixing, fermenting, and pelletizing. Practical demonstrates the setup and functioning of insect mass-rearing equipment, including trays, containers, and environmental control devices. Design a model layout for an insect farming unit, including rearing, sorting, and processing zones. Rearing techniques for mealworms, involving substrate preparation and life cycle observation. Explores black soldier fly larval rearing, substrate management, and larval harvesting. Cricket farming, emphasizing enclosure design, feeding, and humidity regulation.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO. 1. Acquaint with rearing technology of Insects.• CO. 2. Understand the nutrients available in different insects.• CO.3. Develop skills to use of different tools in insect rearing.• CO. 4. Analyze efficient insects for rearing and mass production.• CO. 5. Evaluate insect species to use in various industries like poultry, fishery, livestock etc.• CO. 6. Develop rearing methods efficient production of important insects.			

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Suggested readings:

Textbook

- Ortiz, J.A. & Torres Ruiz, Alejandro & Morales-Ramos, Juan & Thomas, M. & Rojas, M.G. & Tomberlin, Jeffery & Yi, L. & Han, R. & Giroud, L. & Jullien, R.L. 2016. Insect Mass Production Technologies. 10.1016/B978-0-12-802856-8.00006-5.
- Halloran, A.; Flore, R.; Vantomme, P. Roos, N. 2018. Edible insects in sustainable Food System (1st Edition).

Articulated Attainment

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	1	2	1	-	-	1	2	2	2	2
CO2	3	2	2	1	2	2	-	-	2	2	2	2	2
CO3	3	2	2	2	3	2	-	-	2	2	2	2	2
CO4	3	2	2	2	3	2	-	-	2	2	2	2	2
CO5	3	2	2	2	3	2	-	-	3	3	2	3	3
CO6	3	2	2	2	3	2	-	1	3	3	2	3	3
Average	3.0	2.0	1.83	1.83	2.67	1.83	-	1.0	2.17	2.33	2.00	2.33	2.33

Evaluation Scheme

Course Code	Course Title	Periods per week			Progressive Assessment/ Quiz/ Assignment	Practical	Internal Theory (Mid-Term)	External Theory (End Term)	Total	Credit (Theory + Practical)
		L	T	P						
DPE C 612/ DPP M612	Insect Farming Technology	2	0	1	20	20	20	40	100	3 (2+1)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C611 (Major)/ DPP M611 (Minor)	Credit	3 (2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Modern Technologies in Beekeeping	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To identify major honeybee species and their distribution.2. To explain the components and use of modern hives and tools.3. To apply techniques for colony division, uniting, and honey extraction.4. To analyze colony performance and identify signs of disease or pest infestation.5. To evaluate honey quality, processing methods, and product standards.6. To design packaging, branding, and marketing strategies for bee products.			
Unit. I: (Total Topics-3 and Hours-6) <p>Importance of beekeeping in agriculture and livelihoods. Species of honey bees and their distribution (<i>Apis mellifera</i>, <i>A. cerana</i>, <i>A. dorsata</i>, <i>A. florea</i>). Bee colony structure: queen, workers, drones, and their roles.</p>			
Unit. II:(Total Topics- 6 and Hours- 9) <p>Components of Langstroth hive and accessories: smokers, hive tools, feeders, queen excluders. Protective gear and handling tools. Hive placement and apiary site selection. Seasonal management and feeding techniques. Artificial swarming, colony division and uniting. Queen rearing methods and importance.</p>			
Unit. III: (Total Topics - 4 and Hours- 4) <p>Modern honey extraction, processing, and storage methods. Quality standards, grading, and value-added products (wax, royal jelly, propolis). Packaging, labeling, and marketing strategies.</p>			
Unit. IV: (Total Topics- 3 and Hours- 5) <p>Pests and diseases of bees (Varroa mite, brood diseases). Disease prevention and integrated management practices. Scope of commercial and migratory beekeeping, government schemes.</p>			
Practical: (Experiments 7 & Hours-16) <p>Identification of bee species and study of bee colony structure. Handling of beekeeping tools and hive components. Installation and seasonal inspection of modern hives. Observation of brood stages and colony strength. Techniques of colony division and uniting. Honey extraction, filtration, and bottling. Preparation of wax foundation sheets. Identification of common pests/diseases and control measures. Visit to a model apiary/commercial beekeeping unit.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO. 1. Identify major honeybee species (<i>Apis mellifera</i>, <i>A. cerana</i>, <i>A. dorsata</i>, <i>A. florea</i>) and their distribution.• CO. 2. Explain the components and use of modern hives and tools.• CO. 3. Apply techniques for colony division, uniting, and honey extraction.• CO. 4. Analyse colony performance and identify signs of disease or pest infestation.• CO. 5. Evaluate honey quality, processing methods, and product standards.• CO. 6. Design packaging, branding, and marketing strategies for bee products.			

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Suggested readings:

- Handbook of Beekeeping" – R.K. Tewari and Veer Singh
- Apiculture" – M.C. S. Nair
- Modern Beekeeping: Theory and Practice" – M.S. Khurana

Articulated Attainment

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	1	-	1	1	1	-	2
CO2	3	2	1	1	1	-	-	1	1	1	1
CO3	3	2	1	1	2	-	1	1	1	-	1
CO4	3	2	2	1	1	1	-	1	2	2	2
CO5	3	2	2	1	1	-	1	1	1	-	1
CO6	3	2	2	1	1	1	-	1	1	1	1
Average	3.0	2.2	1.7	1.0	1.2	1.0	1.0	1.0	1.2	1.3	1.3

Evaluation Scheme

Course Code	Course Title	Periods per week			Progressive Assessment/ Quiz/ Assignment	Practical	Internal Theory (Mid-Term)	External Theory (End Term)	Total	Credit (Theory + Practical)
		L	T	P						
DPE C 611/ DPP M611	Modern technologies in Beekeeping	2	0	1	20	20	20	40	100	3 (2+1)

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Major courses (Gradual courses) of Ph.D. Plant Pathology/Minor courses (Gradual courses) of Ph.D. Entomology

Programme Name	Ph.D. Plant Pathology/Ph.D. Entomology	Programme Code	
Course Code	DPP C601 (Major)/ DPE M601 (Minor)	Credit	3(2+1)
Year/Sem	Year-1; Semester-I	L-T-P	2-0-1
Course Name	Advances in Mycology	Course Type	Compulsory for Major
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To educate fundamentals, concepts, relationship and classification of fungi are studied. 2. To develop the understanding about morphological and biology of fungi in the laboratory. 3. To apply the different techniques for identification and preservation of fungi. 4. To examine the morphological and reproductive structure of fungi. 5. To evaluate the chemicals for preserve and manage of fungal pathogen. 6. To demonstrate the morphological structures and disease samples in lab 			
<p>UNIT I (Total Topics - 6 and Hrs- 5) 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.</p>			
<p>UNIT II (Total Topics - 2 and Hrs- 5) 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.</p>			
<p>UNIT- III (Total Topics - 7 and Hrs- 14) 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.</p>			
<p>UNIT-IV (Total Topics - 8 and Hrs- 6) Genetic Improvement of Fungal strains. Fungal biotechnology. Fungi mediated synthesis of nano particles – characterization process and application. Mycotoxins problems and its management</p>			
<p>Practical (Experiments – 6 and Hrs - 12) Isolation, purification and identification of cultures, spores and mating type determination; Study of conidiogenesis-Phialides, porospores, arthospores; Study of fruiting bodies in Ascomycotina; Identification of fungi up to species level; Study of hyphal anastomosis; Morphology of representative plant pathogenic genera form different groups of fungi; Molecular characterization of fungi.</p>			
<p>Course Outcomes (COs): After completion of course, students will be able to:</p> <ul style="list-style-type: none"> • CO1: Gain knowledge of the fundamentals, concepts, relationships, and classification of fungi. • CO2: Understand the morphology and biology of fungi through laboratory observations. • CO3: Apply appropriate techniques for the identification and preservation of fungi. • CO4: Examine the morphological and reproductive structures of fungi using laboratory methods. 			

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- CO5: Evaluate chemicals and methods used for the preservation and management of fungal pathogens.
- CO6: Reveal the morphological structures of fungi and diagnose disease samples in the laboratory.

Suggested readings:

- 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.

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	1	1	1	-	3	1	3	2	3	3
CO-2	1	-	-	-	-	2	2	1	-	2	2
CO-3	1	1	-	-	-	2	1	2	3	2	2
CO-4	1	1	-	-	-	2	1	2	3	2	2
CO-5	1	1	1	1	-	3	1	3	2	3	3
CO-6	1	1	-	-	-	2	1	2	3	2	2
Average	1.0	1.0	1.0	1.0	-	2.3	1.2	2.2	2.6	2.3	2.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPP C601 (Major)/ DPE M601 (Minor)	Advances in Mycology	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Plant Pathology/Ph.D. Entomology	Programme Code	
Course Code	DPP C602 (Major)/ DPE M602 (Minor)	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Advances in Plant Virology	Course Type	Elective

Objectives of the Course:

1. To educate about the viruses and their morphology, replication, vectors transmit viruses, detection techniques, and new developments in plant virology.
2. To understand the cytological effects by viruses in infected plant cells, mechanisms leading to the evolution of new viruses, principles of immunology and serology, PCR technology used in virology.
3. To use the new techniques like tissue culture for production of virus-free planting materials.
4. To examine the viruses from different specimens using Immunological, serological, biotechnological and bioinformatics assays.
5. To exhibit the state of viral infection plant diseases caused by virus based on results of various assays.
6. To assemble the minimum requirements for advanced techniques and new developments in plant virology.

Unit I: (Total Topics – 6 and Hrs-10)

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 (Total Topics -11 and Hrs-8):

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 (Total Topics -6 and Hrs-6):

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 noncoding regions), replication, transcription and translational strategies of pararetroviruses, geminiviruses, tobamo-, poty-, bromo, cucumo, ilar, tospoviruses, satellite viruses and satellite RNA.

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Unit IV (Total Topics – 6 and Hrs-6):

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.

Practical (Total Experiments – 10 and Hrs-22)

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 Plant Protection–Plant Pathology 237 (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).

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Educate about the viruses and its morphology, replication, vectors transmit viruses, detection techniques, and new developments in plant virology.
- CO.2: Understand the cytological effects by viruses in infected plant cells, mechanisms leading to the evolution of new viruses, principles of immunology and serology, PCR technology used in virology.
- CO.3: Use the new techniques like tissue culture for production of virus-free planting materials.
- CO.4: Examine the viruses from different specimens using Immunological, serological, biotechnological and bioinformatics assays.
- CO.5: Exhibit the state of viral infection plant diseases caused by virus based on results of various assays.
- CO.6: Assemble the minimum requirements for advanced techniques and new developments in plant virology.

Suggested readings:

- 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.
- Thresh JM. 2006. Advances in Virus Research. Academic Press, New York.

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Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	-	1	-	-	1	2	1	1	1	1
CO-2	2	-	-	-	-	-	1	-	-	-	1
CO-3	2	1	1	-	-	2	1	1	1	1	1
CO-4	2	-	1	-	-	1	1	-	1	1	1
CO-5	2	-	-	1	-	1	1	1	-	1	1
CO-6	2	1	-	-	-	1	-	1	2	1	1
Average	2.0	1.0	1.0	1.0	-	1.2	1.2	1.0	1.3	1.0	1.0

Course Code	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPP C602 (Major)/ DPE M602 (Minor)	Insecticide Toxicology and Residues	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Plant Pathology/Ph.D. Entomology	Programme Code	
Course Code	DPP C603 (Major)/ DPE M603 (Minor)	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Advances in Plant Pathogenic Prokaryotes	Course Type	Elective
Objectives of the Course: <ol style="list-style-type: none">1. To acquaint with general features of plant pathogenic prokaryotes and bacteriophages.2. To understand the demonstrate the taxonomy and identification of phytopathogenic prokarya.3. To demonstrate bacterial genetics and its importance in pathogenicity.4. To differentiate and examine the pathogenicity factors of soft rot, necrosis, wilt, canker, etc.5. To evaluate the molecular mechanism of virulence and pathogenesis.6. To organize endophytes, PGPR, Phylloplane bacteria in disease management in crops.			
Unit I: <p>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).</p>			
Unit II: <p>Current trends in taxonomy and identification of phytopathogenic prokarya: 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.</p>			
Unit III: <p>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.</p>			
Unit IV: <p>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</p>			

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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.

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

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Acquaint with general features of plant pathogenic prokaryotes and bacteriophages.
- CO.2: Understand and demonstrate the taxonomy and identification of phytopathogenic prokaryotes.
- CO.3: Show the bacterial genetics and its importance in pathogenicity.
- CO.4: Differentiate and examine the pathogenicity factors of soft rot, necrosis, wilt, canker, etc.
- CO.5: Evaluate the molecular mechanism of virulence and pathogenesis.
- CO.6: Organize the endophytes, PGPR, Phylloplane bacteria in disease management in crops.

Suggested readings:

- 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.
- Sigeo 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.

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Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	-	1	-	-	1	2	1	1	1	1
CO-2	2	-	-	-	-	-	1	-	-	-	1
CO-3	2	1	1	-	-	2	1	1	1	1	1
CO-4	2	-	1	-	-	1	1	-	1	1	1
CO-5	2	-	-	1	-	1	1	1	-	1	1
CO-6	2	1	-	-	-	1	-	1	2	1	1
Average	2.0	1.0	1.0	1.0	-	1.2	1.2	1.0	1.3	1.0	1.0

Course code	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Mid term Theory Examination	Assignment	Practical Examination			
DPP C603 (Major)/ DPE M603 (Minor)	Advances in Plant Pathogenic Prokaryotes	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Plant Pathology/Ph.D. Entomology	Programme Code	
Course Code	DPP C604 (Major)/ DPE M604 (Minor)	Credit	3(2+1)
Year/Sem	I/I or II	L-T-P	2-0-1
Course Name	Molecular Basis of Host-pathogen Interaction	Course Type	Compulsory for Major

Objectives of the Course:

1. To acquaint with the concepts of molecular biology and biotechnology in relation to host plant-pathogen interactions.
2. To understand the plant-microbe interactions and the development of disease-resistant plants.
3. To demonstrate interpret the host immune system, pathogen recognition and establishment inside hosts, and signal transduction processes.
4. To examine the molecular genetics, imaging, and analytical chemistry tools for studying plants, and microbes.
5. To evaluate the molecular processes of underlying host-pathogen interactions for fungi, bacteria, viruses, and nematodes.
6. To utilize the biotechnological tools and approaches for developing disease-resistant plants.

Unit I (Lectures - 5; Hrs. -5):

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 (Lectures - 10; Hrs. -5):

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 (Lectures - 16; Hrs. - 10):

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 (Lectures - 11; Hrs. - 10):

Pathogen population genetics and durability, viruses vs cellular pathogens. Gene deployment,

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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.

Practical (Experiment- 8; Hrs. - 16)

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.

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1: Acquaint with the concepts of molecular biology and biotechnology in relation to host plant- pathogen interactions.
- CO.2: Understand the plant-microbe interactions and the development of disease-resistant plants.
- CO.3: Interpret the host immune system, pathogen recognition and establishment inside hosts, and signal transduction processes.
- CO.4: Examine the molecular genetics, imaging, and analytical chemistry tools for studying plants, and microbes.
- CO.5: Evaluate the molecular processes of underlying host-pathogen interactions for fungi, bacteria, viruses, and nematodes.
- CO.6: Utilize the biotechnological tools and approaches for developing disease-resistant plants.

Suggested readings:

- 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.
- 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.
- Sigeo 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.

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Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	-	1	-	-	1	2	1	1	1	1
CO-2	2	-	-	-	-	-	1	-	-	-	1
CO-3	2	1	1	-	-	2	1	1	1	1	1
CO-4	2	-	1	-	-	1	1	-	1	1	1
CO-5	2	-	-	1	-	1	1	1	-	1	1
CO-6	2	1	-	-	-	1	-	1	2	1	1
Average	2.0	1.0	1.0	1.0	-	1.2	1.2	1.0	1.3	1.0	1.0

Course CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPP C604 (Major)/ DPE M604 (Minor)	Molecular Basis of Host-pathogen Interaction	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Plant Pathology/Ph.D. Entomology	Programme Code	
Course Code	DPP C605 (Major)/ DPE M605 (Minor)	Credit	1(1+0)
Year/Sem	Elective	L-T-P	1-0-0
Course Name	Principles and Procedures of Certification	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To acquaint with certification procedures of seed and planting material.2. To understand the international scenario of certification and role of ISTA, EPPO, OECD, etc. in certification and quality control.3. To develop skills to apply ecological based IPM to farmers' real time situation.4. To examine genetic identity, physical purity, germination percentage, seed health etc.5. To evaluate quality of various seed/ planting material before certification.6. To prepare highly equipped laboratory for seed/plant material testing.			
UNIT I (Total Topics - 6 and Hrs- 5) <p>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</p>			
UNIT II (Total Topics - 2 and Hrs- 5) <p>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.</p>			
Practical (Experiments – NA and Hrs - NA) NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1: Acquaint with certification procedures of seed and planting material.• CO.2: Understand the International scenario of certification and role of ISTA, EPPO, OECD, etc. in certification and quality control.• CO.3: Develop skills to apply ecological based IPM to farmers' real time situation.• CO.4: Examine genetic identity, physical purity, germination percentage, seed health etc.• CO.5: Evaluate quality of various seed/ planting material before certification.• CO.6: Develop highly equipped laboratory for seed/plant material testing.			
Suggested readings: <ul style="list-style-type: none">• 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			

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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>

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	1	1	1	-	3	1	3	2	3	3
CO-2	1	-	-	-	-	2	2	1	-	2	2
CO-3	1	1	-	-	-	2	1	2	3	2	2
CO-4	1	1	-	-	-	2	1	2	3	2	2
CO-5	1	-	-	-	-	2	2	1	-	2	2
CO-6	1	1	-	-	-	2	1	2	3	2	2
Average	1.0	1.0	1.0	1.0	-	2.3	1.3	2.0	2.7	2.3	2.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPP C605 (Major)/ DPE M605 (Minor)	Principles and procedures of Certification	2	0	2	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. Plant Pathology/Ph.D. Entomology	Programme Code	
Course Code	DPP C606 (Major)/ DPE M606 (Minor)	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Plant Biosecurity and Biosafety	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none">1. To define the terms quarantine, Invasive Alien Species, biowarfare, Emerging/ resurgence of pests.2. To understand the concept of biosecurity and its importance.3. To develop skills to use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity.4. To analyze pest risk and its assessment by using GIS & GPS systems.5. To examine invasive species, emerging/ resurgence of pests and diseases quality of various seed/ planting material before certification.6. To develop strategies for combating risks and costs associated with agro-terrorism event, mitigation planning, and integrated approach for biosecurity.			
UNIT I (Total Topics - 8 and Hrs- 8)			
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 (Total Topics - 15 and Hrs- 12)			
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 (Total Topics - 15 and Hrs- 12)			
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.			
Practical (Experiments – and Hrs -) - NA			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none">• CO.1: Define the terms quarantine, Invasive Alien Species, biowarfare, Emerging/ resurgence of pests.• CO.2: Understand the concept of biosecurity and its importance.• CO.3: Develop skills to use of Global Positioning System (GPS) and Geographic Information system (GIS) for plant biosecurity.• CO.4: Analyze pest risk and its assessment by using GIS & GPS systems.• CO.5: Examine invasive species, emerging/ resurgence of pests and diseases quality of various seed/ planting material before certification.• CO.6: Prepare strategies for combating risks and costs associated with agro-terrorism event, mitigation planning, integrated approach for biosecurity.			

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Suggested Readings:

- 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. e-Resources.
- <http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.sht ml>
- 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
- www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm
- www.affa.gov.au/biosecurityaustralia
- <http://www.fao.org/biosecurity/CFIA>.
- www.daff.gov.au/ba

Articulated attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	1	1	1	-	3	1	3	2	3	3
CO-2	1	-	-	-	-	2	2	1	-	2	2
CO-3	1	1	-	-	-	2	1	2	3	2	2
CO-4	1	1	-	-	-	2	1	2	3	2	2
CO-5	1	1	-	-	-	2	1	2	3	2	2
CO-6	1	1	-	-	-	2	1	2	3	2	2
Average	1.0	1.0	1.0	1.0	-	2.3	1.3	2.0	2.7	2.3	2.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPP C606 (Major)/ DPE M606 (Minor)	Plant biosecurity and biosafety of Certification	2	0	2	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Plant Pathology/Ph.D. Entomology	Programme Code	
Course Code	DPP C607 (Major)/ DPE M607 (Minor)	Credit	2(1+1)
Year/Sem	Elective	L-T-P	1-0-1
Course Name	Plant Health Diagnostics and Management	Course Type	Elective

Course Objectives:

1. To educate the basic concepts and importance of plant health clinics, including the identification of beneficial microbes and the principles of disease management in crops.
2. To understand the processes for screening and identifying causal agents of plant diseases, including microbes, nematodes, mites, and nutritional imbalances.
3. To demonstrate the identification of symptoms and management strategies for plant parasitic nematodes affecting major crops, including root knot and ear-cockle diseases.
4. To analyze molecular diagnostic approaches for identifying viral, bacterial, and fungal diseases in plants using ITS region sequencing, barcoding, and BLAST search techniques.
5. To evaluate different genetic engineering methods and gene transfer techniques for developing disease-resistant plants.
6. To develop practical skills in disease diagnostics, nematode sampling and extraction, and the use of tissue culture and gene transfer techniques to produce disease-resistant plants.

UNIT I (Total Topics - 5 and Hrs -3)

Introduction to the plant health clinic: concept, importance, infrastructure etc. Identification of important beneficial microbes and others of economic importance. Principles of disease management. Host range, bio-ecology and integrated management of different diseases of field crops and horticultural crops.

UNIT II (Total Topics - 4 and Hrs -4)

Screening of damaged material for establishing the identity of causal agent viz.; microbe, nematode, mites, competitive plant as well as nutritional, imbalances in plant nutrients or any other physiological disorders.

UNIT- III (Total Topics - 3 and Hrs -3)

Important Plant parasitic nematodes and their symptoms produced on major field, fruit, ornamental and plantation crops. Damage caused by important nematodes causing root knot, ear-cockle and other diseases in different crops and their management.

UNIT-IV (Total Topics - 4 and Hrs. -3)

Molecular approaches for viral, bacterial and fungal diseases with regards to diagnostics (Identification using ITS region, Barcoding, BLAST search etc.) and management.

UNIT-V (Total Topics - 2 and Hrs. -2)

Development of disease resistance plants using genetic engineering approaches, different methods of gene transfer

Practical (Total Topics - 12 and Hrs. -24)

Collection and Identification of symptoms caused by important pathogens; Assessment of damage caused by pathogens in crops plants; Disease diagnostic kit and related basic facilities; Methods of sampling and extraction of nematodes from soil and plant parts; Nematicides and their application methods; Screening of infected materials to find out the identity of common diseases in crops; Collection and Identification of symptoms caused by common diseases in

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crops; DNA isolation and sequencing through ITS for identification of fungal pathogens; DNA isolation and sequencing through ITS for identification of bacterial pathogens; Isolation and purification for identification of viral diseases; Development of disease resistance plants using tissue culture technique; Development of disease resistance plants using gene transfer techniques.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1: Understand the basic concepts and importance of plant health clinics, including the identification of beneficial microbes and the principles of disease management in crops.
- CO2: Understand the processes involved in screening and identifying causal agents of plant diseases, including microbes, nematodes, mites, and nutritional disorders.
- CO3: Demonstrate the identification of symptoms and management strategies for plant-parasitic nematodes affecting major crops, such as root-knot and ear-cockle diseases.
- CO4: Analyze molecular diagnostic approaches for identifying viral, bacterial, and fungal plant diseases using ITS region sequencing, DNA barcoding, and BLAST search techniques.
- CO5: Evaluate various genetic engineering methods and gene transfer techniques for developing disease-resistant plants.
- CO6: Develop practical skills in disease diagnostics, nematode sampling and extraction, and the application of tissue culture and gene-transfer techniques to produce disease-resistant plants.

Suggested readings:

- Dhananjaya Pratap Singh and Ratna Prabha 2020. Microbial Interventions in Agriculture and Environment: Volume 3: Soil and Crop Health Management. Springer Publications.
- Awasthi L.P. 2016. Recent Advances in the Diagnosis and Management of Plant Diseases. Springer Publications.
- Balaji Aglave. 2021. Handbook of Plant Disease Identification and Management. CRC Press.
- Richard A. Sikora, Johan Desaegeer and Molendijk L.P.G. 2021. Integrated Nematode Management: State-of-the-Art and Visions for the Future. CABI Publications.
- Parvatha P. Reddy. 2021. Nematode Diseases of Crops and their Management. Springer Verlag, Singapore.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	2	2	1	2	1	2	2	1	2	-
CO-2	1	1	-	1	1	1	1	1	1	1	1
CO-3	1	2	2	1	1	1	1	2	2	1	3
CO-4	1	2	1	-	1	1	1	1	1	1	1
CO-5	1	1	1	2	1	1	2	1	2	1	1
CO-6	1	1	-	-	1	1	1	1	3	1	-
Average	1.0	1.5	1.5	1.3	1.2	1.0	1.3	1.3	1.7	1.2	1.5

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CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPP C607 (Major)/ DPE M607 (Minor)	Plant Health Diagnostics and Management	1	0	1	20	20	20	40	100	2(1+1)

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Programme Name	Ph.D. Plant Pathology/Ph.D. Entomology	Programme Code	
Course Code	DPP C608 (Major)/ DPE M608 (Minor)	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Modern Technologies in Mushroom Cultivation	Course Type	Elective

Course Objectives:

1. To provide advanced knowledge of mushroom biology, genetics, and physiology relevant to high-tech cultivation.
2. To understand the modern technologies such as controlled-environment systems, IoT-based monitoring, and automated production in mushroom farming.
3. To analyze substrate composition, environmental parameters, and cultivation systems for enhanced mushroom productivity and quality.
4. To diagnose mushroom diseases using classical and molecular diagnostic tools and apply integrated disease management strategies.
5. To evaluate innovations, sustainability concerns, and techno-economic feasibility of modern mushroom cultivation technologies.
6. To design novel cultivation methods, diagnostic tools, and value-added mushroom products through research-based approaches.

UNIT I (Total Topics - 8 and Hrs - 7)

History and evolution of mushroom cultivation; Advanced classification and taxonomy of edible and medicinal mushrooms; Mushroom biology, morphology and reproductive strategies; Physiology of mushroom growth and development; Mushroom biodiversity and conservation; Domestication and breeding of mushrooms; Genetic improvement approaches including hybridization and molecular techniques; Overview of global and Indian mushroom industries and emerging trends.

UNIT II (Total Topics - 8 and Hrs - 7)

Advanced spawn production technologies; Liquid spawn, grain spawn and plug spawn systems; Substrate selection, processing and sterilization; Nutritional optimization of substrates using supplements and additives; Use of IoT and automation in climate control; Precision management of temperature, humidity, CO₂ and airflow; Modern cultivation systems including vertical farms, bag technology and shelf culture; Environmental sustainability and waste reutilization in mushroom farming.

UNIT- III (Total Topics – 8 and Hrs - 8)

Major fungal, bacterial, viral and nematode diseases of mushrooms; Modern molecular diagnostics including PCR, qPCR and LAMP assays; Disease surveillance using biosensors and imaging tools; Integrated disease management strategies; Mycoparasites and their exploitation; Hygiene, sanitation and biosecurity in mushroom units; Post-harvest handling, grading and packaging; Quality standards, certification and food safety regulations.

UNIT-IV (Total Topics - 8 and Hrs. - 8)

Robotics and AI-assisted mushroom cultivation; Automated monitoring systems and smart mushroom units; Novel substrates and industrial by-products for mushroom farming; Functional mushrooms and nutraceutical development; Processing and value addition: powders, extracts and fortified foods; Business models and supply chains for mushroom enterprises; Economics and

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feasibility of modern mushroom technologies; Research advances and opportunities in mushroom biotechnology.

Practical (Total Topics - 12 and Hrs. -24)

Isolation and identification of mushroom cultures; Preparation of mother culture, grain spawn and liquid spawn; Substrate preparation, sterilization and supplementation; Operation of climate-controlled mushroom cropping rooms; Monitoring temperature, humidity, CO₂ and airflow using sensors; Disease diagnosis using microscopy and molecular tools; Assessment of contamination and hygiene indicators; Evaluation of yield and biological efficiency; Post-harvest processing and value addition techniques; Visit to commercial high-tech mushroom farms and research facilities.

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1. Describe advanced knowledge of mushroom biology, genetics, and physiology relevant to high-tech cultivation.
- CO.2. Understand modern technologies such as controlled-environment systems, IoT-based monitoring, and automated production in mushroom farming.
- CO.3. Analyze substrate composition, environmental parameters, and cultivation systems for enhanced mushroom productivity and quality.
- CO.4. Diagnose mushroom diseases using classical and molecular diagnostic tools and apply integrated disease management strategies.
- CO.5. Evaluate innovations, sustainability concerns, and techno-economic feasibility of modern mushroom cultivation technologies.
- CO.6. Design novel cultivation methods, diagnostic tools, and value-added mushroom products through research-based approaches.

Suggested readings:

- Chang, S. T., & Hayes, W. A. (2013). *The biology and cultivation of edible mushrooms*. Academic Press.
- Giri, S., & Prasad, A. (2021). *Mushroom cultivation: Modern techniques and applications*. Springer.
- Sánchez, C. (2010). Cultivation of *Pleurotus ostreatus* and other edible mushrooms. *Applied Microbiology and Biotechnology*, 85(5), 1321–1337.
- Miles, P. G., & Chang, S. T. (2004). *Mushrooms: Cultivation, nutritional value, medicinal effect, and environmental impact* (2nd ed.). CRC Press.
- Royse, D. J., Baars, J., & Tan, Q. (2017). *Edible and medicinal mushrooms: Technology and applications*. Wiley-Blackwell.
- Singh, M., Pandey, R., & Upadhyay, R. C. (2011). *Mushroom production technology*. ICAR-DMR.
- Zied, D. C., & Pardo-Giménez, A. (Eds.). (2017). *Edible and medicinal mushrooms: Technology and applications*. Wiley.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	2	2	1	2	1	2	2	1	2	-
CO-2	1	1	-	1	1	1	1	1	1	1	1
CO-3	1	2	2	1	1	1	1	2	2	1	3

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CO-4	1	2	1	-	1	1	1	1	1	1	1
CO-5	1	1	1	2	1	1	2	1	2	1	1
CO-6	1	1	-	-	1	1	1	1	3	1	-
Average	1.0	1.5	1.5	1.3	1.2	1.0	1.3	1.3	1.7	1.2	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPP C608 (Major)/ DPE M608 (Minor)	Modern Technologies in Mushroom Cultivation	2	0	1	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Plant Pathology/Ph.D. Entomology	Programme Code	
Course Code	DPP C609 (Major)/ DPE M609 (Minor)	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Advanced Bacterial Phytopathology and Disease Management	Course Type	Elective

Course Objectives:

1. To describe bacterial morphology, physiology, virulence systems, and host-pathogen interactions.
2. To utilize molecular, immunological, and genomic tools for detection and identification of phytopathogenic bacteria.
3. To examine host–bacterial interactions, virulence factors, and disease epidemiology under diverse environmental conditions.
4. To implement advanced diagnostic, surveillance, and integrated bacterial disease management strategies.
5. To assess modern approaches such as biocontrol, bacteriophage therapy, and genome editing for bacterial disease management.
6. To develop innovative research designs, diagnostic tools, and management strategies for emerging and re-emerging bacterial plant diseases.

UNIT I (Total Topics - 5 and Hrs - 7)

History and evolution of bacterial plant pathology; Modern bacterial taxonomy and phylogenetics; Virulence factors and pathogenicity determinants including secretion systems; Bacterial colonization, survival and biofilm formation; Quorum sensing and cell–cell communication in plant-associated bacteria; Host–bacterial interaction biology and recognition mechanisms; Emerging and re-emerging bacterial pathogens; Advances in bacterial genome sequencing and comparative genomics.

UNIT II (Total Topics - 8 and Hrs - 7)

Classical methods for isolation, purification and identification of plant pathogenic bacteria; Biochemical and physiological characterization including Biolog and API systems; Serological tools including ELISA, immunofluorescence and lateral-flow assays; Molecular diagnostics including PCR, qPCR, multiplex PCR and LAMP; DNA barcoding and multilocus sequence analysis (MLSA); Whole genome sequencing and metagenomics-based diagnostics; Biosensors and nano-based pathogen detection; Digital and automated diagnostic platforms.

UNIT- III (Total Topics - 8 and Hrs - 8)

Disease cycles and survival strategies of bacterial pathogens; Environmental factors influencing bacterial epidemiology; Population biology and molecular epidemiology of bacterial diseases; Phytobiome concepts and bacterial community dynamics; Mechanisms of host resistance against bacterial pathogens; Effector biology and plant immune responses; Systems biology approaches for bacterial disease modeling; Climate change impacts on bacterial disease emergence and severity.

UNIT-IV (Total Topics - 8 and Hrs. - 8)

Chemical, cultural and biological management strategies for bacterial diseases; Antibiotic resistance, alternatives and stewardship in plant pathology; Use of bacteriophages and phage cocktails in disease management; CRISPR-based genome editing and interference strategies;

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Biological control using endophytes, rhizobacteria and bacteriocins; Nanotechnology for disease detection and suppression; Integrated disease management (IDM) and decision support tools; Policy, quarantine and biosafety issues in bacterial plant pathology.

Practical (Total Topics - 10 and Hrs. - 20)

Isolation and purification of bacterial plant pathogens; Gram staining, motility testing and biochemical characterization; Serological assays including ELISA and immunofluorescence; Molecular detection using PCR, qPCR and LAMP; DNA extraction, gel electrophoresis and sequencing sample preparation; Pathogenicity testing and fulfillment of Koch's postulates; Antibiotic sensitivity and resistance profiling; Microscopy of bacterial structures and biofilms; Screening of biocontrol agents against bacterial pathogens; Field visit to disease surveillance sites and advanced diagnostic laboratories.

Course Outcomes (COs): After completion of course, students will be able to:

- CO.1. Describe bacterial morphology, physiology, virulence systems, and host-pathogen interactions.
- CO.2. Apply molecular, biochemical, and serological techniques for detection, identification, and characterization of bacterial pathogens.
- CO.3. Analyze disease cycles, virulence mechanisms, and epidemiological patterns using scientific data.
- CO.4. Perform advanced diagnostic assays and design appropriate disease management interventions.
- CO.5. Evaluate biosafety, biosecurity, and sustainability of contemporary bacterial disease management practices.
- CO.6. Propose novel experiments, molecular diagnostic tools, and integrated management strategies for bacterial plant diseases.

Suggested readings:

- Agrios, G. N. (2005). *Plant pathology* (5th ed.). Elsevier Academic Press.
- Schumann, G. L., & D'Arcy, C. J. (2010). *Essential plant pathology* (2nd ed.). APS Press.
- Young, J. M., Takikawa, Y., Gardan, L., & Stead, D. E. (2016). *Guide to plant pathogenic bacteria* (3rd ed.). CABI.
- Jacobs, J. M., Babujee, L., & Meng, Q. (2015). Comparative and functional genomics of plant pathogenic bacteria. *Annual Review of Phytopathology*, 53, 249–272.
- Waldron, P. R., & Creason, A. L. (2019). Advances in molecular diagnostics for plant pathogenic bacteria. *Phytopathology*, 109(1), 6–19.
- Schaad, N. W., Jones, J. B., & Chun, W. (2001). *Laboratory guide for identification of plant pathogenic bacteria* (3rd ed.). APS Press.
- Dow, J. M., & Daniels, M. J. (2000). Bacterial diseases of plants. In A. Slusarenko, R. Fraser, & R. van Loon (Eds.), *Mechanisms of plant defense responses* (pp. 161–197). Springer.

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	2	2	1	2	1	2	2	1	2	-
CO-2	1	1	-	1	1	1	1	1	1	1	1
CO-3	1	2	2	1	1	1	1	2	2	1	3
CO-4	1	2	1	-	1	1	1	1	1	1	1
CO-5	1	1	1	2	1	1	2	1	2	1	1
CO-6	1	1	-	-	1	1	1	1	3	1	-
Average	1.0	1.5	1.5	1.3	1.2	1.0	1.3	1.3	1.7	1.2	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPP C609 (Major)/ DPE M609 (Minor)	Advanced Bacterial Phytopathology and Disease Management	2	0	1	20	20	20	40	100	3(2+1)

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Supporting Courses (Compulsory for students of all disciplines of Agriculture) (Gradual courses)

Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE S601/ DPP S601	Credit	3(3+0)
Year/Sem	Year -1; Semester-I	L-T-P	3-0-0
Course Name	Research Methodology in Entomology/ Research Methodology in Plant Pathology	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To Equip the Students with the Concept and Methodology of Research.2. To provide knowledge about types of research, preparation of reports and thesis, designing of Research using Scientific Methods.3. To develop the ability to apply principles and procedure for data analysis and interpretation of results.4. To analyze various sampling methods and probability of research analysis.5. To evaluate interpretations and significance of report writing.6. To develop the ability to create appropriate hypothesis, select experimental design and presentation of results after analysis of data.			
UNIT I (Total Topics- 7 and Hrs-12) Introduction to Research: Definition, Nature and significance, Role and Objectives; Types of Research: exploratory, descriptive, experimental and diagnostic research, social and legal research and traditional, analytical, empirical & fundamental research, Doctrinal and non-doctrinal research methods; Various Research Designs; Scientific Research Process: Overview, Problem identification and formulation of research statement.			
UNIT II (Total Topics- 7 and Hrs- 12) Data Collection: sources, primary and secondary methods, significance of Primary and Secondary Data, questionnaire Vs. schedules; Data Processing: Editing, Coding Organization and Presentation; Attitude Measurement and scaling: Measurement Scales, Sources of Errors in Measurement, Techniques of Developing Measurement Tools, Classification and Testing (Reliability, Verification and Validity) Scales, Designing Questionnaires and Interviews.			
UNIT- III (Total Topics- 5 and Hrs- 10) Sampling, Sampling Methods, Sampling Plans, Sampling Error, Sampling Distributions: Theory and Design of Sample Survey, Census Vs Sample Enumerations, Objectives and Principles of Sampling, Types of Sampling, Sampling and Non-Sampling Errors, Concept of Permutation, Combination & Probability for research analysis.			
UNIT-IV(Total Topics- 5 and Hrs- 10) Interpretations and Report Writing: Meaning of Interpretation, Techniques of Interpretation, Precautions in Interpretation, Significance of Report Writing, Steps in Report Writing, Layout of Report and Precautions in Writing Research Reports. Limitations of RM: Ethics in Research, Philosophical Issues in Research.			
Practical)- NA			

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Course Outcomes (COs): After completion of course, students will be able to:

- CO1: Acquire in-depth knowledge of the fundamentals, theories, and principles related to research, and apply this knowledge to conduct research studies in the chosen area of interest.
- CO2: Identify, formulate, and critically investigate research problems by applying research-oriented knowledge, and analyze relevant data to propose appropriate alternative solutions.
- CO3: Apply acquired knowledge and skills to think creatively and innovatively while conducting research and drawing meaningful conclusions.
- CO4: Apply parametric and non-parametric statistical tests to verify hypotheses and suggest innovative solutions to the research problem under investigation.
- CO5: Evaluate the interpretation, significance, and structure of scientific report writing.
- CO6: Create appropriate hypotheses, select suitable experimental designs, analyze data, and effectively present the results.

Suggested readings:

- William G. Zikmund, "Business Research Methods", Orlando: Dryden Press.
- C. William Emory and Cooper R. Donald, "Business Research Methods", Boston, Irwin.
- Fred N Kerlinger, "Foundations of Behavioural Research", New Delhi: Surjeet Publications.
- Naresh Malhotra, Marketing Research: An Applied Orientation, Pearson publication David Nachmias and Chava Nachmias, "Research Methods in the Social Sciences", New York: St. Marlia's Press.
- Bhattacharya, D. K. (2004) Research Methodology, New Delhi, Excel Books

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPE S601/ DPP S601	Research Methodology in Entomology	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE S602/ DPP S602	Credit	1(1+0)
Year/Sem	Year -1; Semester-I	L-T-P	1-0-0
Course Name	Computer & Stats Application in Research	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To appraise computational skills for research application.2. To assess statistical methods for research analysis.3. To create skills in methods of collection of any type of data, classification of data, presentation of data, analysis of data, descriptive statistics, parametric and non-parametric tests, etc.4. To analyse statistical calculations and their validation.5. To justify the decision in the reference of data analysis, formation and Analysis of data.6. To create ANOVA through different methods and their interpretation.			
UNIT I (Total Topics- 7 and Hrs-12) <p>Characteristics of Computers, Evolution of computers, computer memory, computer generations, Basic computer organization; System software, Application software, introduction to operating system, single user, multi-user, multitasking single tasking, application of computer for business and research, MS-windows, Linux .Application of Internet in research: INFLIBNET, Use of Internet, sights (DOAJ), Use of E Journals, Use of E library, use of EBSCO HOST online database of Academic Libraries. Subject/field specific tools on www.freeware.com</p>			
UNIT II(Total Topics- 7 and Hrs- 12) <p>Computer Application in Research,. Basic concept of Computer, Use of Internet for Research Purpose: E-mail, WWW, Web browsing, technical skills, drawing inferences from data, Research publishing tools-MS Word, Adobe acrobat, Graphics tool-MS Excel, Presentation tool-MS Power, Data Analysis Software and Analysis Techniques point. Creating presentation and adding effects, Introduction to Data analysis software-SPSS: Definition, objectives and features, data analysis using SPSS.</p>			
UNIT- III (Total Topics- 5 and Hrs- 10) <p>Statistical methods for research application in analysis of data, Measurement in Research , data interpretation, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), std deviation, Measures of Relationship, Simple Regression Analysis, Correlation and Regression, Partial Correlation.</p>			
UNIT-IV(Total Topics- 5 and Hrs- 10) <p>Statistical Tools-Hypothesis and Hypothesis Testing: Parametric & Non-Parametric Tests, Important Parametric Tests, Hypothesis Testing of Correlation Coefficients, U Test, Chi Square Test, T-Test. Analysis of Variance (ANOVA) , The Basic Principle of ANOVA, ANOVA Technique, Setting up Analysis of Variance Table, Short-cut Method for One-way ANOVA, Coding Method, Two-way ANOVA .</p>			
Practical- NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Remember the basic terms used in data collection, classification, presentation, and analysis, including descriptive statistics and parametric and non-parametric tests.			

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- CO2: Understand the use of various formulas, principles, and statistical methods applied in agricultural sciences.
- CO3: Apply appropriate skills in collecting, classifying, presenting, and analyzing different types of data using descriptive statistics, parametric, and non-parametric tests.
- CO4: Analyze statistical calculations and validate the results obtained.
- CO5: Evaluate datasets using suitable statistical tests for meaningful interpretation.
- CO6: Create ANOVA tables using different methods and interpret the results effectively.

Suggested readings:

- C. R. Kothari, "Research Methodology: Methods and techniques", New Delhi: Vishwa Prakashan.
- Brymann, Alan and Carmer, D. (1995) Qualitative data analysis for social scientist, New York, Routledge Publication.
- Jain, Satish: "Introduction to Computer Science and basic Programming." BPB Publications, New Delhi, 1990. • Rajaraman, V., "Fundamental of Computers", Prentice Hall of India, New Delhi, 1996.
- Hogg, R.V.& Craig, T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
- [\(PDF\) Statistical Methods and their Applications \(researchgate.net\)](#)
- [Welcome to Web Agri Stat Package \(icar.gov.in\)](#)
- [\(PDF\) BASIC STATISTICAL TECHNIQUES IN RESEARCH \(researchgate.net\)](#)
- [Statistical Methods & Applications | Home \(springer.com\)](#)
- [Statistical Methodology - Journal - Elsevier](#)

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPE S602/ DPP S602	Computer & Stats Application in Research	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE S603/DPP S603	Credit	1(1+0)
Year/Sem	Year -1; Semester-I	L-T-P	1-0-0
Course Name	Research & Publication Ethics	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To acquaint with knowledge about basics of Agricultural Research and research ethics2. To understand research ethics including research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards, and problems in research ethics.3. To apply research ethics in collection and interpretation of data.4. To analyze the major publication ethics to be followed during research.5. To evaluate violation of publication ethics, authorship and contributor ship6. To develop ability to identify different predatory publishers and journals.			
UNIT I (Total Topics- 2 and Hrs-8) Introduction to philosophy: definition, nature and scope, concept, branches; Ethics: definition, moral philosophy, nature of moral judgments and reactions			
UNIT II (Total Topics- 5 and Hrs- 5) Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP); Redundant publications: duplicate and overlapping publications, salami slicing; Selective reporting and misrepresentation of data			
UNIT- III (Total Topics-7 and Hrs-7) Publication ethics: definition, introduction and importance; Best practices/ standards setting initiatives and guidelines: COPE, WAME, etc.; Conflicts of interest; Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types; Violation of publication ethics, authorship and contributor ship; Identification of publication misconduct, complaints and appeals; Predatory publishers and journals			
UNIT- IV (Total Topics-4and Hrs-4) Open access publications and initiatives; SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies; Software tool to identify predatory publications developed by SPPU; Journal finder/ Journal suggestion tools viz. JANE, Elsevier Journal finder, Springer Journal Suggester, etc.			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Recognize the fundamentals of the philosophy of science and ethics, research integrity, publication ethics, and theories of research ethics.• CO2: Familiarize with major issues related to research ethics, research integrity, scientific misconduct, and data misinterpretation.• CO3: Analyze best practices in scholarly publishing, understand publication ethics, and identify predatory publishers and journals.• CO4: Demonstrate the use of plagiarism-detection tools, open-source research tools, citation databases, and research metrics.• CO5: Evaluate credible and scholarly publications published in reputed peer-reviewed journals.• CO6: Create ethically sound research publications suitable for high-impact, peer-reviewed journals.			

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Suggested readings:

- Research and Publication Ethics, Dr Sumanta Dutta, Bharti Publications, 2021
- Research and Publication Ethics, Dr Santosh Kumar Yadav, Anne Publications, 2020
- Kumar, R. 2014. Research Methodology: A Step-by-Step Guide for Beginners. 4th Edition. SAGE Publications Ltd.
- Parikh, M.N, Gogtay, N. 2009. ABC of Research Methodology and Applied Biostatistics. Jaypee Publishers, New Delhi.
- <https://www.sciencedirect.com/journal/library-and-information-science-research>
- <https://www.researchgate.net/publication/306097844> Library and Information Science Research
- <http://isca.in/RJLS/>
- <https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm>
- <https://www.springer.com/journal/10892>

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPE S603/DP P S603	Research & Publication Ethics	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C691/ DPP C691	Credit	1(0+1)
Year/Sem	Year 1; Semester – I	L-T-P	0-0-2
Course Name	Doctoral Seminar – I (Compulsory Course)	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscripts/articles and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPE C691/ PDPP C691	Doctoral Seminar -I	0	0	2	-	-	100	-	100	1(0+1)

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Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C692/ PDPP C692	Credit	1(0+1)
Year/Sem	Year 1; Semester – II	L-T-P	0-0-1
Course Name	Doctoral Seminar-II (Compulsory Course)	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscripts/article and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPE C692/ PDPP C692	Doctoral Seminar - II	0	0	2	-	-	100	-	100	1(0+1)

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Doctoral Research Work

Programme Name	Ph.D. Entomology/ Ph.D. Plant Pathology	Programme Code	
Course Code	DPE C699/ DPP C699	Credit	75(0+75)
Year/Sem	Not Applicable	L-T-P	Not Applicable
Course Name	Doctoral Research	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To develop a comprehensive understanding of research philosophies, theories, and types of scientific inquiry in agricultural and related sciences.2. To identify research gaps through systematic literature review and formulate appropriate research problems, objectives, and hypotheses.3. To apply suitable research methodologies, experimental designs, and sampling techniques relevant to agricultural research.4. To enhance skills in data collection, statistical analysis, and interpretation using advanced analytical tools.5. To strengthen scientific writing, academic communication, and referencing skills for research publications and proposals.6. To promote ethical research practices, scientific integrity, and responsible conduct in agricultural research.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs-) <p>Synopsis, Research Work & Thesis writing provides the students an excellent opportunity to develop analytical research and entrepreneurial skills, and knowledge through meaningful hands on experience, confidence in their ability to design and investigate the things.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Recall and describe fundamental research concepts, methodologies, and statistical tools used in agricultural and related research.• CO2: Explain research processes, interpret scientific literature, and summarize research gaps in agriculture.• CO3: Apply suitable research designs, data collection methods, and sampling strategies in field, laboratory, and socio-economic studies.• CO4: Analyze research data, identify trends and relationships, and interpret results using appropriate statistical techniques.• CO5: Evaluate the quality, rigor, and validity of research findings and assess scientific articles using standardized evaluation criteria.• CO6: Develop an original research proposal, formulate hypotheses, design experimental models, and produce publishable scientific writing.			
Suggested readings:			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	3	3	3	3	3	3	3	3	3
CO-2	3	3	3	3	3	3	3	3	3	3	3
CO-3	3	3	3	3	3	3	3	3	3	3	3
CO-4	3	3	3	3	3	3	3	3	3	3	3
CO-5	3	3	3	3	3	3	3	3	3	3	3
CO-6	3	3	3	3	3	3	3	3	3	3	3
Average	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPE C699/ DPP C699	Doctoral Research	N A	N A	N A	NA	NA	NA	NA	NA	75(0+75)

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Detailed Syllabus of Ph.D. Genetics & Plant Breeding

List of Major Courses

Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C601	Credit	3(3+0)
Year/Sem	1/I	L-T-P	3-0-0
Course Name	Advances in Plant Breeding Systems	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To recall and describe fundamental concepts of crop reproductive biology, gene regulation, and floral organ development.2. To explain and differentiate classical, pre- and post-Mendelian, and modern breeding methodologies.3. To apply molecular, transgenic, and advanced breeding tools (e.g., doubled haploid, shuttle, and speed breeding) for crop improvement.4. To analyze and evaluate population improvement and selection methods, including recurrent, convergent, and reciprocal recurrent selection.5. To evaluate and integrate molecular marker-assisted selection, gene pyramiding, and utilization of exotic germplasm for trait enhancement and genetic diversity management.6. To design and implement breeding strategies for climate resilience, stress tolerance, and bio-fortification.			
UNIT I (Total Topics - 17 and Hrs - 15) <p>Advances in reproductive biology of crops; Genes governing the whorls formation and various models proposed; Pollen pistil interaction: biochemical and molecular basis, environmental factors governing anthesis and bottlenecks for gene transfer. Plant Breeding methodologies: Classic versus modern; Overview of Pre and Post Mendelian breeding methods in self- and cross-pollinated crops; Molecular and transgenic breeding approaches; doubled haploid breeding, shuttle breeding, forward and reverse breeding, speed breeding, participatory plant breeding, breeding for organic situations.</p>			
UNIT II (Total Topics – 13 and Hrs - 10) <p>Principles and procedures in the formation of a complex population; Genetic basis of population improvement in crop plants; Recurrent selection methods in self- and cross-pollinated crops and their modifications; Convergent selection, divergent selection; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection; Selection in clonally propagated crops – Assumptions and realities. Choice of molecular markers for plant breeding efficiency, fingerprinting and genetic diversity assessment, application of MAS for selection of qualitative and quantitative traits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exotic germplasm, introgression libraries.</p>			
UNIT- III (Total Topics – 17 and Hrs - 15) <p>Genetic resources: primary, secondary, tertiary and alien trans gene pool; Molecular and</p>			

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biochemical basis of self-incompatibility and male sterility, nucleocytoplasmic interactions with special reference to male sterility – genetic, biochemical and molecular bases. Genetic engineering technologies to create male sterility, prospects and problems, use of self-incompatibility and sterility in plant breeding – case studies; Fertility restoration in male sterile lines and restorer diversification programs; Conversion of agronomically ideal genotypes into male sterile: Concepts and breeding strategies; Case studies - Generating new cyto-nuclear interaction system for diversification of male sterile; Stability of male sterile lines – Environmental influence on sterility, Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding; Temperature sensitive genetic male sterility and its use heterosis breeding; Apomixis and its use in heterosis breeding; Incongruity: Factors influencing incongruity Methods to overcome incongruity mechanisms.

UNIT-IV (Total Topics – 8 and Hrs. - 5)

Breeding for climate change -Improving root systems, abiotic stress tolerance, water use efficiency, flooding and sub-mergence tolerance; Biotic stress tolerance; Nutrient use efficiency, nitrogen fixation and assimilation, greenhouse gases and carbon sequestration; Breeding for bio-fortification.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1. Identify and explain the genetic and molecular mechanisms governing reproductive development, whorl formation, pollen–pistil interaction, and gene transfer.
- CO2. Compare and contrast breeding strategies in self-, cross-, and clonally propagated crops, and interpret their historical evolution and applications.
- CO3. Utilize molecular and biotechnological approaches for accelerating genetic gains and developing improved cultivars.
- CO4. Assess the effectiveness and genetic implications of population improvement strategies for hybrid and clonal crops.
- CO5. Employ molecular tools such as MAS and genomic selection for efficient breeding of qualitative and quantitative traits.
- CO6. Develop climate-smart breeding programs targeting abiotic and biotic stress tolerance, water and nutrient use efficiency, carbon sequestration, and nutritional enhancement.

Suggested readings:

- Agarwal RL. 1996. *Fundamentals of Plant Breeding and Hybrid Seed Production*. Oxford & IBH.
- Allard RW. 1966. *Principles of Plant Breeding*. John Wiley & Sons.
- Briggs FN and Knowles PF. 1967. *Introduction to Plant Breeding*. Reinhold.
- Fehr WR. 1987. *Principles of Cultivar Development: Theory and Technique*. Vol I. Macmillan.
- Hayes HK, Immer FR and Smith DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.
- Kang MS and Priyadarshan PM (Edit.). 2007. *Breeding Major Food Staples*. Blackwell Publishing.
- Kole C. 2013. *Genomics and Breeding for Climate-Resilient Crops*. Springer. Volume 2-Target Traits.
- Mandal AK, Ganguli PK and Banerji SP. 1995. *Advances in Plant Breeding*. Vol. I, II. CBS.

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- Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.
- Sharma JR. 1994. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.
- Simmonds NW. 1979. *Principles of Crop Improvement*. Longman.
- Singh BD. 1997. *Plant Breeding: Principles and Methods*. 5th Ed., Kalyani Publishers, New Delhi.
- Singh P. 1996. *Essentials of Plant Breeding*. Kalyani Publishers, New Delhi.
- Welsh JR. 1981. *Fundamentals of Plant Genetic and Breeding*. John Wiley.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	1	1	1	-	3	1	3	2	3	3
CO-2	1	-	-	-	-	2	2	1	-	2	2
CO-3	1	1	-	-	-	2	1	2	3	2	2
CO-4	1	1	-	-	-	2	1	2	3	2	2
CO-5	1	1	1	1	-	3	1	3	2	3	3
CO-6	1	1	-	-	-	2	1	2	3	2	2
Average	1.0	1.0	1.0	1.0	-	2.3	1.2	2.2	2.6	2.3	2.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPG C601	Advances in Plant Breeding Systems		0		30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C602	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Advances in Biometrical Genetics	Course Type	Elective
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To recall and describe the basic principles of continuous variation, quantitative inheritance, and genetic parameters involved in complex traits. 2. To explain and analyze components of mean, gene effects (additive, dominance, epistasis), and their estimation through generation mean analysis. 3. To apply biometrical techniques for estimating genetic variances, heritability, and combining ability using appropriate mating designs and models. 4. To evaluate $G \times E$ interactions, genotype stability, and adaptability through advanced stability analysis models (AMMI, PCA, Biplots). 5. To integrate and interpret linkage mapping, QTL mapping, and marker-assisted selection for genetic dissection of quantitative traits. 6. To design and execute biometrical analyses using advanced statistical and computational software for quantitative genetic studies. 			
<p>UNIT I (Total Topics – 6 and Hrs - 5) Continuous variation-evolutionary studies; Genetic principles of continuous variation, Qualitative and quantitative techniques-differences, population types, approaches; various types of metrics, F₂, F and mixed; Selection of parents Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes.</p>			
<p>UNIT II (Total Topics – 6 and Hrs - 5) Components of mean- Additive effect, breeding value, coefficient of gene dispersion, dominance; Simple scaling test, expectation of mean of character in various types of families in coupling and dispersed phase; Epistasis- Specification, weighted and un-weighted joint scaling test; Effect of linkage to generation mean, specification of mean to $G \times E$ interaction.</p>			
<p>UNIT- III (Total Topics – 12 and Hrs - 10) Component of variances-advantages, variances of different generations, balance sheet of variance; estimation of parameters-weighted and unweighted, least square analysis; random mating population; experimental population-BIPs, NCD-I, II, III, Triple test cross for random mating population and inbreds; Estimates of linkage and non-allelic interactions; Combining ability analysis, Hayman's Approach. $G \times E$ Interaction, stability and adaptability; Advanced models in stability analysis Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Merits and limitation of different stability analysis methods; Analysis and selection of genotypes; Methods and steps to select the best model - Biplots and mapping genotypes.</p>			
<p>UNIT-IV (Total Topics – 8 and Hrs. - 10) Construction of saturated linkage maps, concept of framework map development; QTLs-different types of markers and mapping populations, linkage maps, mapping Strategies for QTL mapping - desired populations, statistical methods; MAGIC populations, Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on markers - simultaneous selection</p>			

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based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods; Use of advanced software packages for biometrical analysis, interpretation of analysed data.

Practical (Total Topics – 8 and Hrs. - 16)

• Generation mean analysis: ABC scaling test and Joint scaling test- Analysis and interpretation; • Estimation of variance of different filial generations and interpretations; • Diallel analysis: Numerical, graphical and combining ability analysis; Triallel analysis; • NC Designs: Triple test cross analysis; • Stability analysis: Eberhart and Russel model; • AMMI model - Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes; • Construction of linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; • Phenotype and Marker linkage studies; • Use of advanced software in biometrical analysis.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1. Explain the genetic principles of continuous variation and distinguish between qualitative and quantitative inheritance, metrics, and population approaches.
- CO2. Interpret the role of additive and dominance effects, conduct scaling tests, and analyze gene interactions including epistasis and $G \times E$ effects.
- CO3. Perform variance partitioning, use biparental and North Carolina designs, and apply combining ability analysis (Hayman's approach) to identify superior genotypes.
- CO4. Critically assess genotypic performance across environments using stability models and select genotypes based on stability and adaptability parameters.
- CO5. Utilize different marker systems, mapping populations, and statistical models for detecting QTLs and apply MAS strategies for improving breeding efficiency.
- CO6. Develop, analyze, and interpret biometrical data sets using modern software to construct linkage maps, perform QTL analysis, and design marker-based breeding programs.

Suggested readings:

- Bos I and Caligari P. 1995. Selection Methods in Plant Breeding. Chapman & Hall.
- Dabholkar AR.1993. Elements of Biometrical Genetics. Concept Publishing Co. New Delhi.
- Falconer DS and Mackay J. 1996. Introduction to Quantitative Genetics (4 Ed.). ELBS/ Longman, London.
- Mather K and Jinks JL. 1985. Biometrical Genetics (3rd Ed.). Chapman and Hall, London.
- Nandarajan N and Gunasekaran M. 2008. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.
- Roy D. 2000. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi.
- Singh P and Narayanan SS. 1993. Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.
- Singh RK and Choudhary BD. 1987. Biometrical Methods in Quantitative Genetics. Kalyani Publishers, New Delhi.
- Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.
- Wricke G and Weber WE. 1986. Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	2	-	1	-	-	1	2	1	1	1	1
CO-2	2	-	-	-	-	-	1	-	-	-	1
CO-3	2	1	1	-	-	2	1	1	1	1	1
CO-4	2	-	1	-	-	1	1	-	1	1	1
CO-5	2	-	-	1	-	1	1	1	-	1	1
CO-6	2	1	-	-	-	1	-	1	2	1	1
Average	2.0	1.0	1.0	1.0	-	1.2	1.2	1.0	1.3	1.0	1.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPG C602	Advances in Biometrical Genetics	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C603	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Molecular Cytogenetics for Crop Improvement	Course Type	Elective
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To recall and describe the organization and structure of nuclear and organellar genomes, their interactions, and variation in DNA content. 2. To understand and analyze cytogenetic tools and techniques such as karyotyping, chromosome banding, FISH, and GISH for gene mapping. 3. To apply cytogenetical methods for pre-breeding, gene transfer, and structural chromosome studies (duplications, inversions, translocations). 4. To analyze chromosomal aberrations such as trisomics, monosomics, and telocentric chromosomes and their role in genetic mapping. 5. To evaluate the significance of cytogenomics, chromosome sorting, and distant hybridization in crop evolution and breeding. 6. To design cytogenomic-based strategies for polyploid breeding and chromosome engineering for trait improvement. 			
<p>UNIT I (Total Topics – 8 and Hrs - 5) Organization and structure of genome, Genome size, Organization of organellar genomes, Nuclear DNA organization, Nuclear and Cytoplasmic genome interactions and signal transduction; Inheritance and expression of organellar DNA; Variation in DNA content - C value paradox; Sequence complexity – Introns and Exons, Repetitive sequences, Role of repetitive sequence.</p>			
<p>UNIT II (Total Topics – 11 and Hrs - 10) Karyotyping – Chromosome banding and chromosome painting; Tracking introgressions using FISH, GISH, localization and mapping of genes/ genomic segments. Pre-breeding and applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchange genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multiple interchanges-use in producing inbreds, transfer of genes- linked marker methods; Duplication production and use; Inversions and location of genes; B/ A chromosome translocations and gene location.</p>			
<p>UNIT- III (Total Topics – 8 and Hrs - 10) Trisomics- types, production, breeding behavior and location of genes, use of balanced tertiary trisomics in hybrid seed production; Monosomics methods of production, breeding behavior and location of genes; Intervarietal substitutions-allelic and non allelic interactions; Telocentric method of mapping. Cytogenomics: Concept, tools and techniques for crop improvement; Chromosome sorting: Isolation of specific chromosome for development of molecular maps and gene location.</p>			
<p>UNIT-IV (Total Topics – 4 and Hrs. - 5) Role of polyploidy in crop evolution and breeding. Auto- and allopolyploids; Distant hybridization, barriers to interspecific and intergeneric hybridization; Behaviour of interspecific and intergeneric crosses.</p>			
<p>Course Outcomes (COs): After completion of course, students will be able to:</p> <ul style="list-style-type: none"> • CO1. Explain genome organization, C-value paradox, and the role of repetitive, intronic, and 			

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exonic sequences in genome complexity.

- CO2. Demonstrate understanding of cytogenetic mapping techniques and apply them for chromosomal localization of genes and introgressions.
- CO3. Utilize cytogenetic manipulations like balanced lethals, multiple interchanges, and translocations for gene mapping and crop improvement.
- CO4. Interpret chromosomal behavior in abnormal karyotypes and use them for gene localization, hybrid seed production, and gene introgression.
- CO5. Assess the importance of cytogenomic tools and interspecific/intergeneric hybridization in crop improvement and genome analysis.
- CO6. Develop breeding strategies utilizing polyploidy, cytogenetic manipulations, and chromosome-level mapping for enhancing crop traits.

Suggested readings:

- Conger BV. (Ed.). 1981. Cloning Agricultural Plants via in-vitro Techniques. CRC Press.
- Constabel F and Vasil IK. (Eds.). 1988. Cell Culture and Somatic Cell Genetics of Plants. Vol. V. Cell Culture and Phytochemicals in Plant Cell Cultures. Academic Press.
- Gupta P K. 2006. Cytogenetics. Rastogi Publisher
- Lal R and Lal S. (Eds.). 1990. Crop Improvement Utilizing Biotechnology. CRC Press.
- Mantel SH and Smith H. 1983. Plant Biotechnology. Cambridge University Press.
- Sen SK and Giles KL. (Eds.). 1983. Plant Cell Culture in Crop Improvement. Plenum Press.
- Yao-Shan F. 2002. Molecular Cytogenetics: Protocols and Application. Human Press

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	-	1	-	-	1	2	1	1	1	1
CO-2	2	-	-	-	-	-	1	-	-	-	1
CO-3	2	1	1	-	-	2	1	1	1	1	1
CO-4	2	-	1	-	-	1	1	-	1	1	1
CO-5	2	-	-	1	-	1	1	1	-	1	1
CO-6	2	1	-	-	-	1	-	1	2	1	1
Average	2.0	1.0	1.0	1.0	-	1.2	1.2	1.0	1.3	1.0	1.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPG C603	Molecular Cytogenetics for Crop Improvement	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C604	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Plant Genetic Resources, Conservation and Utilization	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To recall and describe the principles of biodiversity conservation and the concept of natural gene banks.2. To understand and analyze in situ conservation strategies for wild species and on-farm agro-biodiversity management.3. To apply ex situ conservation methods for genetic resources in gene banks, repositories, and clonal collections.4. To evaluate in vitro conservation methods for diverse crop species and assess their advantages, limitations, and applications.5. To analyze and apply cryopreservation techniques for long-term storage of plant genetic material.6. To design and develop comprehensive PGR management and utilization strategies integrating germplasm characterization, evaluation, and core collection development.			
UNIT I (Total Topics – 8 and Hrs - 5) <p>Concept of natural reserves and natural gene banks; In situ conservation of wild species in nature reserves: in situ conservation components, factors influencing conservation value, national plan for in situ conservation; in situ conservation of agro-biodiversity on-farm; scientific basis of in situ conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of in situ conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.</p>			
UNIT II (Total Topics – 8 and Hrs - 5) <p>Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, permafrost conservation, guidelines for seed multiplication and exchange to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling, clonal repositories, genetic stability under long term storage condition.</p>			
UNIT- III (Total Topics – 10 and Hrs - 10) <p>In-vitro storage, maintenance of in-vitro culture under different conditions, in-vitro bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/ suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of in-vitro gene bank.</p>			
UNIT-IV (Total Topics – 10 and Hrs. - 10) <p>Cryopreservation- procedure for handling seeds of orthodox and recalcitrant-cryo protectants, desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation/ dehydration techniques, national facilities, achievements, application of cryopreservation in agricultural, horticultural and forestry crops. Problems and prospects; challenges ahead. Concept and procedure for PGR management, germplasm characterization, evaluation and utilization; Concept of core and</p>			

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mini core; collections and registration of plant germplasm.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1. Explain the concept of natural reserves, in situ conservation, and factors influencing the conservation value of biodiversity.
- CO2. Differentiate between nature reserve conservation and on-farm conservation approaches and assess their benefits for farmers and local ecosystems.
- CO3. Implement conservation techniques for orthodox and recalcitrant seeds and maintain genetic stability in long-term storage conditions.
- CO4. Conduct in vitro culture and storage for crops like fruits, tubers, spices, and medicinal plants, and evaluate their effectiveness in genetic conservation.
- CO5. Utilize cryoprotectants, vitrification, encapsulation, and dehydration techniques for safe cryopreservation of orthodox and recalcitrant seeds.
- CO6. Formulate conservation and utilization plans, establish core and mini-core collections, and contribute to effective PGR management at institutional and national levels.

Suggested readings:

- Ellis RH, Roberts EH and White Head J. 1980. A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks. FAO/IBPGR Pl. Genet. Resources News 41-3-18.
- Frankel OH and Hawkes JG. 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press, Cambridge.
- Paroda RS and Arora RK. 1991. Plant Genetic resource Conservation and management, NBPGR, New-Delhi.
- Simmonds NW. 1979. Principles of Crop Improvement, Longman.
- Westwood MN. 1986. Operation Manual for National Clonal Germplasm Repository. Processed Report. USDA-ARS and Oregon State Univ. Oregon, USA.
- Withers LA. 1980. Tissue Culture Storage for Genetic Conservation. IBPGR Tech. Rep. IBPGR, Rome, Italy.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	-	1	-	-	1	2	1	1	1	1
CO-2	2	-	-	-	-	-	1	-	-	-	1
CO-3	2	1	1	-	-	2	1	1	1	1	1
CO-4	2	-	1	-	-	1	1	-	1	1	1
CO-5	2	-	-	1	-	1	1	1	-	1	1
CO-6	2	1	-	-	-	1	-	1	2	1	1
Average	2.0	1.0	1.0	1.0	-	1.2	1.2	1.0	1.3	1.0	1.0

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CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPG C604	Plant Genetic Resources, Conservation and Utilization	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C605	Credit	3(3+0)
Year/Sem	I/II	L-T-P	3-0-0
Course Name	Genomics in Plant Breeding	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To recall and describe the organization, structure, and complexity of plant genomes including nuclear, chloroplast, and mitochondrial genomes.2. To understand the principles and technologies of genome sequencing and genome analysis.3. To apply molecular marker-based and mapping approaches to identify and locate genes and QTLs associated with important traits.4. To analyze functional genomics tools for understanding gene function and regulation.5. To evaluate bioinformatics tools and databases for genome annotation, data management, and gene discovery.6. To design genomics-based breeding and genome editing strategies for trait enhancement using modern tools.			
UNIT I (Total Topics – 8 and Hrs - 15) <p>Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes; Concept of genome size and complexity: C-value paradox, repetitive and unique DNA. Genome sequencing: Principles and techniques of conventional approaches and next generation sequencing including sequencing-by-synthesis/ ligation and single molecule real time (SMRT) technologies; Applications of sequence information: structural, functional and comparative genomics; Plant genome projects: Strategies for genome sequencing including shot gun and clone-by-clone method.</p>			
UNIT II (Total Topics – 6 and Hrs - 10) <p>Molecular maps: Use of molecular markers/ SNPs for development of genetic and physical maps; Linkage and LD-based gene mapping approaches including gene/ QTL mapping, genome wide association studies (GWAS) and association analysis; Integration of genetic and physical map for map-based cloning of economically important genes. Concept of allele mining; Diversity array technology: concepts and applications.</p>			
UNIT- III (Total Topics – 9 and Hrs - 10) <p>Functional genomics: concept of reverse and forward genetics; Use of activation tagging, transposon tagging, insertional mutagenesis, TILLING and ecoTILLING for crop improvement; Genome-wide and gene-specific transcriptomics approaches: serial analysis of gene expression, massively parallel signature sequencing, next generation sequencing, microarray, northern hybridization, RT-PCR, qRT-PCR and molecular beacon.</p>			
UNIT-IV (Total Topics – 9 and Hrs. - 10) <p>Development and management of databases; Applications of bioinformatics tools/ software in genomics for crop improvement. Basic concepts of high-throughput proteomics, metabolomics and phenomics. Recent transgene free genome editing tools such as CRISPR-Cas9 system, TALENS and ZFNs for crop improvement. Cisgenesis and Intragenesis tools as twin sisters for Crop Improvement; Genomics-based plant breeding: Genome-Wide Genetic Diversity Studies, Identification of molecular markers linked to single Genes and QTL, Marker Assisted Selection (Marker Assisted Backcross Selection, Association mapping, Breeding by Design, Genome selection).</p>			

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Course Outcomes (COs): After completion of course, students will be able to:

- CO1. Explain genome size variation, C-value paradox, and structural differences among nuclear and organellar genomes.
- CO2. Distinguish between conventional and next-generation sequencing (NGS) technologies such as Illumina, SOLiD, and SMRT sequencing, and explain their applications in structural, functional, and comparative genomics.
- CO3. Use molecular maps, SNPs, GWAS, and LD-based mapping to detect genes/QTLs, perform allele mining, and utilize diversity array technologies for crop improvement.
- CO4. Employ forward and reverse genetics approaches including activation tagging, TILLING, transcriptomics (RNA-seq, microarray, RT-PCR), and evaluate their utility in functional genomics.
- CO5. Utilize genomic databases and software tools for analyzing genomic, transcriptomic, proteomic, and metabolomic data for crop improvement.
- CO6. Develop breeding programs integrating genome editing (CRISPR-Cas9, TALENs, ZFNs), cisgenesis, intragenesis, and genome-wide selection approaches for precision crop improvement.

Suggested readings:

- Alonso JM, Stepanova AN. 2015. Plant Functional Genomics: Methods and Protocols. Springer.
- Chopra VL, Sharma RP, Bhat SR and Prasanna BM. 2007. Search for New Genes. Academic Foundation, New Delhi.
- Hackett PB, Fuchs JA and Messing JW. 1988. An Introduction to Recombinant DNA Technology-Basic Experiments in Gene and Manipulation. 2nd Ed. Benjamin Publication Co.
- Primose SB and Twyman RM. 2006. Principles of Gene Manipulation and Genomics. 7th Ed. Wiley-Blackwell Publishing.
- Sambrook J and Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Laboratory Press.
- Singh BD. 2005. Biotechnology: Expanding Horizons. Kalyani Publishers, New Delhi.
- Somers DJ, Langridge P, Gustafson JP. 2009. Plant Genomics: Methods and Protocols. Springer.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	1	1	1	-	3	1	3	2	3	3
CO-2	1	-	-	-	-	2	2	1	-	2	2
CO-3	1	1	-	-	-	2	1	2	3	2	2
CO-4	1	1	-	-	-	2	1	2	3	2	2
CO-5	1	-	-	-	-	2	2	1	-	2	2

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CO-6	1	1	-	-	-	2	1	2	3	2	2
Average	1.0	1.0	1.0	1.0	-	2.3	1.3	2.0	2.7	2.3	2.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPG C605	Genomics in Plant Breeding	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C606	Credit	2(2+0)
Year/Sem	Elective	L-T-P	2-0-0
Course Name	Population Genetics	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> 1. To recall and describe the properties and structure of Mendelian populations and factors influencing their genetic constitution. 2. To understand the concept and mathematical basis of Hardy-Weinberg equilibrium and its significance in population genetics. 3. To apply gene and genotypic frequency concepts to evaluate population-level changes under various evolutionary forces. 4. To analyze the effects of multiple alleles, sex linkage, and selection models (including overdominance) on population genetic structure. 5. To evaluate the effects of various mating systems and nonrandom mating on genetic parameters. 6. To design and interpret genetic models explaining population adaptation and polymorphism. 			
UNIT I (Total Topics – 6 and Hrs - 5)			
Population: Properties of population, Mendelian population; Genetic constitution of a population through time, space, age structure, etc.; Frequencies of genes and genotypes; Causes of change: population size, differences in fertility and viability, migration and mutation.			
UNIT II (Total Topics – 5 and Hrs - 5)			
Hardy-Weinberg equilibrium, Hardy-Weinberg law, Proof and applications of the Hardy-Weinberg law, Test of Hardy-Weinberg equilibrium; Mating frequencies: Non-dominance, Codominance, Snyder's ratio, importance and its effect over random mating in succeeding generations.			
UNIT- III (Total Topics – 7 and Hrs - 10)			
Multiple alleles, More than one locus, Sex linked genes; Use of gene and genotypic frequencies evaluation in field population level; Interpretations - Changes of gene frequency, Migration, Mutation, Recurrent and non-recurrent Selection; Balance between selection and mutation; Selection favoring heterozygotes; Overdominance for fitness.			
UNIT-IV (Total Topics – 13 and Hrs. - 10)			
Mating systems, Random mating population, Nonrandom mating: selfing –inbreeding coefficient, panmictic index, sibmating, Assortative mating and disassortative mating; Pedigree populations and close inbreeding, Estimation of linkage disequilibrium, Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops; Gene substitution and average effects; Breeding value- Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis- Adaptive organization of gene pools; Polymorphism- Balanced and Non-balanced polymorphism, heterozygous advantage- Survival of recessive and deleterious alleles in populations.			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none"> • CO1. Define key population genetics terms and explain how population size, fertility, viability, migration, and mutation affect gene and genotype frequencies. • CO2. Demonstrate the Hardy-Weinberg principle, test for equilibrium using real or simulated data, and explain its applications in crop breeding and evolution. 			

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- CO3. Compute and interpret changes in gene frequencies due to selection, mutation, and migration, and explain balance between selection and mutation.
- CO4. Examine the genetic consequences of multilocus interactions and heterozygote advantage in maintaining genetic variation.
- CO5. Assess the influence of selfing, sibmating, assortative/disassortative mating, and inbreeding on genetic variation, linkage disequilibrium, and inbreeding coefficient (F).
- CO6. Develop models to predict population-level outcomes such as genetic drift, co-adapted gene complexes, polymorphism maintenance, and adaptive genetic organization in crops.

Suggested readings:

- Chawla V and Yadava RK. 2006. Principles of Population Genetics – A Practical Manual. Dept. of Genetics, CCS HAU Hisar.
- Falconer DS and Mackay J. 1996. Introduction to Quantitative Genetics. Longman.
- Jain JP, Jain J and Parbhakaran VT. 1992. Genetics of Populations. South Asia Books.
- Li CC. 1955. Population Genetics. The Univ. of Chicago Press.
- Mather K and Jinks JL. 1982. Biometrical Genetics. Chapman & Hall.
- Sorrens D and Doniel G. 2007. Methods in Quantitative Genetics. Series: Statistics for Biology and Health. Likelihood.
- Tomar SS. 1992. Text Book of Population Genetics. Universal Publication

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	1	1	1	-	3	1	3	2	3	3
CO-2	1	-	-	-	-	2	2	1	-	2	2
CO-3	1	1	-	-	-	2	1	2	3	2	2
CO-4	1	1	-	-	-	2	1	2	3	2	2
CO-5	1	1	-	-	-	2	1	2	3	2	2
CO-6	1	1	-	-	-	2	1	2	3	2	2
Average	1.0	1.0	1.0	1.0	-	2.3	1.3	2.0	2.7	2.3	2.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPG C606	Population Genetics	2	0	0	30	20	-	50	100	2(2+0)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C607	Credit	3(3+0)
Year/Sem	Elective	L-T-P	3-0-0
Course Name	Crop Evolution	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To understand the origin and evolution of species and centers of crop diversity.2. To explain the genetic and evolutionary processes involved in domestication and speciation.3. To analyze the mechanisms of genetic differentiation, hybridization, and gene transfer for crop improvement.4. To evaluate the cytogenetic and molecular processes underlying polyploid evolution and stabilization.5. To examine the evolutionary and breeding significance of polyploidy, haploidy, and hybridization in crop improvement.6. To integrate classical and contemporary approaches to design crop evolution and domestication studies.			
UNIT I (Total Topics - 8 and Hrs – 10) <p>Origin and evolution of species; Centres of diversity/ origin, diffused centres; Time and place of domestication; Patterns of evolution and domestication-examples and Case studies; Domestication and uniformity – Characteristics of early domestication and changes – Concept of gene pools and crop evolution; Selection and Genetic drift– Consequences.</p>			
UNIT II (Total Topics – 10 and Hrs - 15) <p>Speciation and domestication–The process of speciation, Reproductive isolation barriers; Genetic differentiation during speciation; Hybridization - speciation and extinction; Exploitation of natural variation: Early attempts to increase variation, Distant hybridization and introgression, Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques; Validation of transferred genes and their expression; Controlled introgressions.</p>			
UNIT- III (Total Topics – 8 and Hrs - 10) <p>Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization – Transgenesis in crop evolution, Multifactorial genome, Intragenomic interaction, Intergenomic interaction, Genome introgression; Methods to study crop evolution - Contemporary Methods, Based on morphological features, Cytogenetic analysis, Allozyme variations and crop evolution, DNA markers, genome analysis and comparative genomics.</p>			
UNIT-IV (Total Topics – 8 and Hrs. - 10) <p>Evolutionary significance of polyploidy, evolution of crop plants through ploidy manipulations; Polyploids: methods, use of autopolyploids; haploidy and DH-method of production and use, allopolyploids; synthesis of new crops; Case studies – Cereals, Pulses, Oilseeds, vegetables, Fibre crops, Plantation crops, Forage crops, Tuber crops, Medicinal Plants.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1. Describe the centers of origin, diffused centers, and time and place of domestication for major crop species.• CO2. Explain reproductive isolation mechanisms, hybridization, introgression, and their roles in crop evolution and species formation.			

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- CO3. Apply knowledge of genetic variation, distant hybridization, and gene transfer tools to enhance genetic diversity in crops.
- CO4. Assess the role of genome organization, transgenesis, and intergenomic interactions in the stabilization and diversification of polyploids.
- CO5. Interpret evolutionary case studies across cereals, pulses, oilseeds, and other crops to evaluate the use of ploidy manipulations and new crop synthesis.
- CO6. Develop evolutionary models or experimental strategies using molecular, cytogenetic, and genomic tools to study and utilize crop evolution for future breeding programs.

Suggested readings:

- Hancock JF. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed. CABI.
- Ladizinsky G. 1999. Evolution and Domestication. Springer.
- Miller AJ. 2007. Crop Plants: Evolution. John Wiley & Sons.
- Smartt J and Simmonds NW. 1995. Evolution of Crop Plants. Blackwell.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	1	2	2	1	2	1	2	2	1	2	-
CO-2	1	1	-	1	1	1	1	1	1	1	1
CO-3	1	2	2	1	1	1	1	2	2	1	3
CO-4	1	2	1	-	1	1	1	1	1	1	1
CO-5	1	1	1	2	1	1	2	1	2	1	1
CO-6	1	1	-	-	1	1	1	1	3	1	-
Average	1.0	1.5	1.5	1.3	1.2	1.0	1.3	1.3	1.7	1.2	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPG C607	Crop Evolution	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C608	Credit	2(1+1)
Year/Sem	Elective	L-T-P	1-0-1
Course Name	Breeding Designer Crops	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> To understand the principles and applications of ideotype breeding and genetic manipulation for crop improvement. To comprehend the physiological basis of crop productivity and efficiency traits. To apply breeding and physiological concepts to develop crops with improved performance under stress and sub-optimal conditions. To analyze genetic and molecular determinants of nutrient composition and specialized metabolites in crops. To evaluate the scope and implications of biopharming in developing crops producing industrial and pharmaceutical compounds. To design experimental approaches to assess and enhance physiological and biochemical traits in crop plants. 			
UNIT I (Total Topics - 3 and Hrs - 2)			
Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds-proteins, vaccines, gums, starch and fats.			
UNIT II (Total Topics – 8 and Hrs - 5)			
Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode; Physiological mechanism of improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement; Breeding for special traits, viz., oil, protein, vitamins, amino acids, etc.; Ecospecific ideotypes, Ideotypes for high and low moisture conditions, low and high input conditions, conversion mechanism of C3 to C4 plants; Determination of genetics of above mentioned traits.			
UNIT- III (Total Topics – 5 and Hrs - 3)			
Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships, effect of suboptimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations.			
UNIT-IV (Total Topics – 6 and Hrs. - 5)			
Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products; Success stories in vaccines, modified sugars, gums and starch through biopharming. Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management.			
Practical (Total Topics - 7 and Hrs. - 14)			
Demonstration of plant responses to stresses through recent techniques; • Water use efficiency, transpiration efficiency, screening techniques under stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence, canopy temperature depression, stomatal conductance, chlorophyll estimation, heat/ drought/ salt shock proteins.			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none"> CO1. Explain the concept of crop ideotypes and describe methods of genetic manipulation 			

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through recombination breeding, genomics, and transgenics.

- CO2. Illustrate physiological mechanisms underlying nutrient use efficiency, water use efficiency, osmotic adjustment, and photosynthetic efficiency.
- CO3. Integrate physiological parameters such as canopy architecture, source-sink dynamics, and stay-green traits for breeding high-yielding and stress-tolerant genotypes.
- CO4. Examine the genetic control of oil, protein, vitamin, and amino acid content, and assess molecular strategies for targeted genetic improvement.
- CO5. Critically evaluate case studies on vaccines, gums, starches, and nutraceuticals produced through biopharming and their biosafety management protocols.
- CO6. Formulate experimental designs and screening methods (e.g., chlorophyll fluorescence, canopy temperature depression, stress protein assays) for evaluating stress responses and physiological efficiency in crops.

Suggested readings:

- Balint A. 1984. *Physiological Genetics of Agricultural Crops*. AK Ademiaikiado.
- Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.
- Pessaraki M. 1995. *Handbook of Plant and Crop Physiology*. Marcel Dekker.
- Taiz L and Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	3	1	1	2	2	1	1	1	1	1
CO-2	1	2	2	2	1	2	2	3	2	2	2
CO-3	2	1	2	2	2	2	1	2	3	3	3
CO-4	2	2	1	1	1	2	1	2	1	1	1
CO-5	2	2	2	2	2	2	2	2	2	2	2
CO-6	1	2	2	2	2	1	1	2	2	1	1
Average	1.5	2.0	1.5	1.5	1.6	1.7	1.3	2.0	1.6	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			

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DPG C608	Breeding Designer Crops	2	0	2	20	20	20	40	100	2(1+1)
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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C609	Credit	1(1+0)
Year/Sem	2/III	L-T-P	1-0-0
Course Name	IPR and Regulatory Mechanism	Course Type	Compulsory
Course Objectives:			
<ol style="list-style-type: none">1. To understand the historical development and global context of the Intellectual Property Rights (IPR) regime.2. To identify and differentiate among various forms of intellectual properties and their relevance in agriculture.3. To interpret the Indian legal framework governing the protection of intellectual property and biodiversity.4. To analyze protectable subject matter in biotechnology and understand ownership, period of protection, and related conventions.5. To evaluate the importance of international treaties and agreements in protecting plant genetic resources and ensuring fair use.6. To develop awareness and competency in managing IPR-related agreements and technology transfer mechanisms.			
UNIT I (Total Topics - 2 and Hrs - 2)			
Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPS and various provisions in TRIPS Agreement;			
UNIT II (Total Topics – 9 and Hrs - 7)			
Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection;			
UNIT- III (Total Topics – 5 and Hrs - 3)			
Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity;			
UNIT-IV (Total Topics – 4 and Hrs. - 3)			
International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none">• CO1. Explain the evolution of IPR, the need for its introduction, and describe major provisions under the TRIPS Agreement.• CO2. Distinguish between patents, copyrights, trademarks, geographical indications, and plant variety protection, and explain their significance in agricultural innovation.• CO3. Analyze the scope and application of Indian legislations such as the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, Biodiversity Act, and other relevant laws.• CO4. Evaluate national and international initiatives such as the Convention on Biological Diversity and National Biodiversity Protection programs in the context of agricultural biotechnology.			

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- CO5. Critically assess the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and its role in global agricultural biodiversity governance.
- CO6. Formulate and interpret licensing, material transfer, and research collaboration agreements for responsible technology dissemination and commercialization.

Suggested readings:

- Erbisch FH and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
- Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
- Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.
- Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	1	3	-	1	1	1	2	1	-	3	3
CO-2	1	2	1	-	1	1	2	2	1	1	1
CO-3	-	1	-	1	-	-	2	1	1	1	1
CO-4	1	2	2	1	1	1	-	-	-	-	-
CO-5	1	1	1	1	-	1	1	1	1	1	1
CO-6	1	1	1	-	1	1	1	-	1	1	1
Average	1.0	1.7	1.2	1.0	1.0	1.0	1.6	1.2	1.0	1.4	1.4

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPG C609	IPR and Regulatory Mechanism	1	0	0	30	20	-	50	100	1(1+0)

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List of Minor courses

Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG M601	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Hybrid Seed Production Technology	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To understand the history, importance, and global scenario of hybrid crop development.2. To comprehend and apply the concept of heterosis and types of hybrids in breeding programs.3. To apply genetic and molecular tools for the development and maintenance of parental lines.4. To analyze the genetic mechanisms of male sterility, self-incompatibility, and synchronization in hybrid breeding.5. To evaluate hybrid seed production techniques across field and horticultural crops.6. To develop hands-on competency in hybrid seed production practices and problem-solving in seed industries.			
UNIT I (Total Topics - 7 and Hrs - 5) <p>Introduction – history – scope – importance of hybrid development – national and international scenario of seed industry – popular public sector hybrids in various crops. Heterosis – definition – expression – types – utilization of heterosis in hybrid development, hybrid vigour and seed vigour.</p>			
UNIT II (Total Topics – 7 and Hrs - 5) <p>Types of hybrids – intra-specific, inter-specific hybrids, single, double, three way cross, top cross hybrids – apomixes; generation system of seed multiplication in different types of hybrids. Development and maintenance of inbred lines – male sterile – maintainer lines – fertility restoration – transgenic hybrids – principles and method of development.</p>			
UNIT- III (Total Topics – 9 and Hrs - 10) <p>Breeding tools – genetic mechanism – male sterility – types: CMS, GMS, CGMS, TGMS, PGMS – barnase and barstar system – pistillateness – self incompatibility. Manual creation of male sterility – emasculation and pollination – gametocides mode of action, mechanism. Synchronization of flowering – problems – methods to achieve synchrony – planting ratio and supplementary pollination methods.</p>			
UNIT-IV (Total Topics – 10 and Hrs. - 10) <p>Techniques of hybrid seed production in major agricultural crops – cereals (wheat, rice), millets (maize, sorghum, bajra), pulses (red gram), oilseeds (sunflower, castor, mustard), cotton and forage crops. Hybrid seed production techniques in horticultural crops – tomato, brinjal, chilli, bhendi, onion, bitter gourd, bottle gourd, ridge gourd, cucumber, melon, cabbage, cauliflower, potato, coconut and papaya.</p>			
Practical (Total Topics - 15 and Hrs. - 30) <ul style="list-style-type: none">• Characteristics features of parental lines and their hybrids;• Floral biology of rice, maize, pearl millet, sunflower, castor and cotton;• Study on floral biology of vegetable crops – solanaceous and other vegetables;• Study on floral biology of cucurbitaceous crops;• Production and maintenance of A, B and R lines;• Practicing planting design and border rows – rice, maize,			

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pearlmillet, sunflower and red gram; brinjal and chillies; • Practicing planting design and border rows in tomato, cotton and cucurbitaceous vegetables; • Manipulation for synchronization – rice, sunflower, pearlmillet and sorghum; • Practicing supplementary pollination – rice and sunflower; • Practicing field inspection in hybrid seed production plot – crops planted in ratio sunflower, pearlmillet, sorghum, etc.; • Practicing field inspection in hybrid seed production field – red gram, castor, cotton, cucurbits and tomato; • Practicing roguing and identification of off-types – pollen shedders – shedding tassel – selfed fruits; • Visit to hybrid seed production fields; • Visit to potato seed production plots; • Determination of cost benefit of hybrid seed production; • Visit to seed Industry and assessing problems and perspectives in hybrid seed

Course Outcomes (COs): After completion of course, students will be able to:

- CO1. Explain the origin, evolution, and significance of hybrid breeding in major crops, and describe global and national advancements in hybrid seed technology.
- CO2. Illustrate types of hybrids (single, double, three-way, interspecific) and explain the mechanisms of heterosis and hybrid vigor in different crops.
- CO3. Demonstrate the process of developing and maintaining inbred, male sterile, maintainer, and restorer lines, and utilize transgenic and apomictic systems in hybrid breeding.
- CO4. Examine various male sterility systems (CMS, GMS, TGMS, PGMS), emasculation and pollination techniques, and evaluate methods to achieve synchrony and effective hybridization.
- CO5. Assess hybrid seed production methods in cereals, pulses, oilseeds, cotton, and vegetable crops, and determine cost-benefit aspects and quality parameters of hybrid seeds.
- CO6. Design and implement hybrid seed production plans, conduct field inspections, manage roguing, and propose solutions to challenges faced in commercial seed production systems.

Suggested readings:

- Agarwal RL. 2012. Seed Technology. 3rd Ed. Oxford & IBH Publishers, New Delhi.
- Basra A. 1999. Heterosis and Hybrid Seed Production in Agronomic Crops. CRC Press., Florida, United States.
- Chhabra AK. 2006. Practical Manual of Floral Biology of Crop Plants. Department of Plant Breeding, CCSHAU, Hisar.
- Dar SH. 2018. Methods of Hybrid Seed Production in Major Crops. Educreation Publishing, Chhattisgarh.
- Frankel R and Galun E. 1977. Pollination Mechanisms, Reproduction and Plant Breeding. Springer Verlag, New York.
- Hebblethwaite PD. 1980. Seed Production. Butterworth Heinemann Ltd., London, UK.
- Joshi AK and Singh BD. 2004. Seed Science and Technology. Kalyani Publishers, New Delhi.
- Krishnan M. 2012. Plant breeding and Hybrid Seed Production. Domin and Publishers & Distributors, New Delhi, India.
- Kulkarni GN. 2011. Principles of Seed Technology. Kalyani Publishers, New Delhi.
- Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios., Jodhpur, India.

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	3	1	1	2	1	1	1	1	1	1
CO-2	1	1	2	2	1	2	2	3	1	2	2
CO-3	1	1	1	2	2	2	1	1	3	3	3
CO-4	1	2	1	1	1	2	1	2	1	1	1
CO-5	2	1	2	1	2	1	2	2	1	2	2
CO-6	1	2	1	2	2	1	1	1	2	1	1
Average	1.3	1.6	1.3	1.4	1.6	1.5	1.3	1.3	1.5	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPG M601	Hybrid Seed Production Technology	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG M602	Credit	2(1+1)
Year/Sem	Elective	L-T-P	1-0-1
Course Name	Physiology and Biochemistry of Seeds	Course Type	Elective

Course Objectives:

1. To understand the physiological and biochemical mechanisms governing seed development and maturation.
2. To comprehend the physiological basis of seed dormancy and its regulation.
3. To apply knowledge of germination physiology to understand biochemical and molecular mechanisms involved in seed germination.
4. To analyze the genetics and physiology of seed viability and germination potential.
5. To evaluate mechanisms and biochemical changes associated with seed deterioration during storage.
6. To develop practical competence in assessing the seed physiological and biochemical parameters related to development, dormancy, germination, and deterioration.

UNIT I (Total Topics – 8 and Hrs - 5)

Seed development and maturation – role of cell organelles – embryogeny translocation of assimilates – synthesis of starch, protein, lipid, secondary metabolites and toxic compounds – possible alteration in metabolic pathway. Development of embryo, endosperm and seed coat – translocation of assimilates and food reserves; desiccation tolerance – mechanism, hypothesis, role of LEA proteins; development of hard seeds – mechanisms and factors.

UNIT II (Total Topics – 5 and Hrs - 3)

Seed dormancy – types – physiology and biochemistry of seed dormancy induction and release – hormonal regulation of seed dormancy – environmental control genetic inheritance and control of dormancy; physiology of orthodox, recalcitrant and intermediate seeds.

UNIT- III (Total Topics – 9 and Hrs - 5)

Seed germination – acquisition of viability and capacity of germination during development – genetics of germination acquisition; types of germination – phases of germination – requirements – imbibition – enzyme activation and hormonal regulation – respiration – mitochondrial activity and ATP synthesis – protein and nucleic acid synthesis – metabolism of starch, protein, lipid – physiology of embryo growth and development.

UNIT-IV (Total Topics - 5 and Hrs. - 2)

Seed deterioration – theories, causes – ultra-structural, cell membrane and functional changes; biochemical changes – enzyme activity, storage reserves and genetic changes; lipid peroxidation – biological effects – free radicals and secondary products.

Practical (Total Topics - 15 and Hrs. - 30)

• Study on the pattern of seed development and maturation; • Study on the structural changes during seed maturation; • Estimation of seed moisture content, fresh and dry weight and acquisition of germination and dormancy; • Estimation of different hormones during seed development and maturation – GA and ABA; • Estimation of phenolic compounds during seed maturity; • Estimation of food reserves accumulation – starch, protein and oil at different stages of maturity; • Study on the pattern of seed development in recalcitrant seeds; • Studying the germination behaviour of

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different type of seeds; • Study on imbibition pattern and soaking injury in seeds; • Estimation of enzymes in dormant and non-dormant seeds; • Estimation of hormones in dormant and non-dormant seeds; • Studying the effect of light and temperature on dormancy; • Study on deterioration pattern of orthodox and recalcitrant seeds; • Estimation of lipid peroxidation product and free fatty acid; • Studying the cytological and chromosomal changes in deteriorated seeds; • Estimation of volatile aldehydes during seed storage and deterioration.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1. Describe the stages of seed development and maturation, the roles of cell organelles, assimilate translocation, and biochemical synthesis of major reserves and secondary metabolites.
- CO2. Explain the types, causes, and biochemical basis of dormancy; analyze hormonal and environmental factors regulating dormancy induction and release in different seed types.
- CO3. Illustrate germination phases, enzymatic and hormonal activities, and metabolic processes (starch, protein, lipid breakdown) associated with embryo growth and seedling establishment.
- CO4. Evaluate genetic control of germination and the acquisition of viability during seed development using physiological and biochemical parameters.
- CO5. Assess causes and consequences of seed deterioration, including lipid peroxidation, enzymatic degradation, and membrane damage leading to loss of seed vigor and viability.
- CO6. Design and perform laboratory experiments to estimate hormones, enzymes, storage compounds, and deterioration indicators to interpret physiological seed quality.

Suggested readings:

- Barton LV. 1961. Seed Preservation and Longevity, (Vol. 1). Leonard Hill, London.
- Baskin C and Baskin JM. 2014. Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination. Academic Press, Cambridge, UK.
- Bewley JD and Black M. 1982. Physiology and Biochemistry of Seeds in Relation to Germination (Vol. I & II). Springer Verlage, Berlin Heidelberg, New York, United States.
- Bewley JD, Bradford KJ, Hilhorst HWM and Nanogaki H. 2013. Seeds: Physiology of Development, Germination and Dormancy. Springer, New York.
- Bradbeer JW. 1988. Seed Dormancy and Germination. Chapman and Hall, New York, USA.
- David R Murray. 1985. Seed Physiology. Volume 2: Germination and Reserve Mobilisation. Academic Press, London, UK.
- Justice OL and Bass LN. 1978. Principles and Practices of Seed Storage. Agriculture Hand Book No. 506, Castle House Publication Ltd., Washington.
- Khan AA. 1977. Physiology and Biochemistry of Seed Dormancy and Germination. North Holland Co, Amsterdam, New York, United States.
- Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios., Jodhpur, India.
- Mayer AM and Mayber AP. 1989. Germination of Seeds. Pergamon Press, Oxford, United Kingdom.
- Ovcharov KE. 1977. Physiological Basis of Seed Germination, Amerind Publishing Co, New Delhi and New York, United States.
- Prakash M. 2011. Seed Physiology of Crops. Satish Serial Publishing house. Azadpur. New Delhi.

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- Roberts EH. 1972. Viability of seeds. Springerlink, New York, USA.
- Vanangamudi K. 2006. Seed Physiology. Associated Publishing Company, New Delhi, India

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	2	2	2	1	1	2	1	2	1	2	2
CO-2	1	1	2	1	-	-	1	1	-	1	1
CO-3	2	2	2	1	1	2	-	2	2	1	1
CO-4	2	2	1	1	-	1	1	1	1	-	-
CO-5	2	2	2	1	1	-	1	1	1	-	-
CO-6	1	2	2	1	1	1	-	1	-	1	1
Average	1.7	1.8	1.8	1.0	1.0	1.5	1.0	1.3	1.2	1.2	1.2

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPG M602	Physiology and Biochemistry of Seeds	1	0	2	20	20	20	40	100	2(1+1)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG M603	Credit	3(2+1)
Year/Sem	Elective	L-T-P	2-0-1
Course Name	Genetic Purity and DUS Testing	Course Type	Elective
Course Objectives:			
<ol style="list-style-type: none"> 1. To understand the concept and importance of genetic purity in seed quality assurance. 2. To learn and apply various laboratory, greenhouse, and field techniques for genetic purity testing. 3. To analyze molecular marker and electrophoretic techniques used in varietal identification. 4. To understand national and international frameworks of plant variety protection and farmers' rights. 5. To acquire knowledge about DUS testing procedures, principles, and characterization of varieties. 6. To evaluate the role of PVP and DUS testing in promoting innovation and protecting biodiversity. 			
UNIT I (Total Topics - 10 and Hrs - 10)			
Genetic purity – importance – factors influencing genetic purity; genetic/ cultivar purity test – objectives – principles – methods; laboratory tests – green house and field plot methods, grow – out test, seed and seedling growth tests; chemical and biochemical methods; anthocyanin pigmentation, secondary compounds, phenol, peroxidase and fluorescence tests – chromatography techniques.			
UNIT II (Total Topics – 10 and Hrs - 10)			
Electrophoretic analysis of proteins and isozymes; DNA finger printing methods RAPD, AFLP, SSR, SNP and other markers; computer based machine vision technique and image analysis for varietal identification.			
Genesis of Plant Variety Protection (PVP); International Union for Protection of New Varieties of Plants (UPOV) and its functions – GATT agreement in relation to plant variety protection; Protection of Plant Varieties and Farmer's Rights (PPV and FR) Act 2001 – objectives, salient features, farmer's rights, breeder's rights, researcher's rights – PPV and FRA Rules 2003.			
UNIT- III (Total Topics – 9 and Hrs - 5)			
Criteria for protection of new varieties of plants; Distinctness, Uniformity and Stability (DUS) testing – principles and procedures, guidelines, sample size, test duration, testing option; varieties of common knowledge – extant variety – essentially derived variety – collection of reference samples – grouping of varieties– example varieties; types and categories of characters – recording observations on characteristics – colour characteristics.			
UNIT-IV (Total Topics – 9 and Hrs. - 5)			
Assessment of DUS characters of major crops based on morphological, biochemical and molecular markers – rice, maize, wheat, barley, black gram, green gram, red gram, cowpea, rajma, sunflower, groundnut, castor, mustard, tomato, brinjal, onion, potato, chilli, bhendi, cucurbits, cole crops, sugarcane, cotton, flower, fruit and tree species; statistical procedure – computer software for DUS testing; guidelines for registration of germplasm – impact of plant variety protection on seed industry growth.			
Practical (Total Topics - 15 and Hrs. - 30)			
Genetic purity assessment based on seed characters; • Genetic purity assessment based on seedling			

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growth tests, anthocyanin pigmentation; • Genetic purity assessment based on secondary compounds, phenol, peroxidase and fluorescence tests; • Chromatography analysis of secondary compounds; • Electrophoretic analysis of seed protein and isozymes; • DNA fingerprinting using PCR techniques; • DUS testing based on morphological descriptors of plant – rice and millets; • DUS testing based on morphological descriptors of plant – pulses and oil seeds; • DUS testing based on morphological descriptors of plant – vegetable crops; • DUS testing based on morphological descriptors of plant – flower, fruit and tree species; • Recording observations and interpretation of data; • Tree method of classification of varieties/ cultivars; • Chemical and biochemical test applicable for DUS testing; • Practical exercise on recording DUS characteristics, statistical analysis and interpretation in major agricultural crops; • Practical exercise on recording DUS characteristics, statistical analysis and interpretation in major horticultural crops; • Visit to DUS test centers.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1. Explain the importance and principles of genetic purity, and identify factors influencing cultivar purity in crop seeds.
- CO2. Conduct and interpret results of seed and seedling tests, grow-out tests, and biochemical tests such as phenol, peroxidase, and fluorescence assays.
- CO3. Evaluate and compare electrophoretic, isozyme, and DNA fingerprinting (RAPD, SSR, AFLP, SNP) methods for variety differentiation and purity analysis.
- CO4. Summarize the genesis and significance of PVP, UPOV, GATT, and PPV&FR Act 2001, and evaluate the implications for breeders, farmers, and researchers.
- CO5. Apply DUS testing guidelines to assess distinctness, uniformity, and stability; interpret data for variety registration and recognition.
- CO6. Critically assess the impact of variety protection on the seed industry and biodiversity conservation; design basic DUS testing protocols for crop species.

Suggested readings:

- Anon. 2016. Manual of Seed Certification Procedures. Directorate of Seed Certification, Coimbatore, Tamil Nadu.
- Chakrabarthi SK. 2010. Seed Production and Quality Control. Kalyani Publishers, New Delhi.
- Choudhary DR. 2009. Guidelines for Storage and Maintenance of Registered Plant Varieties in the National Gene Bank. Published by Protection of Plant Varieties and Farmer's Rights Authority. Ministry of Agriculture, GoI, New Delhi, India.
- ISTA. 2010. Handbook of Variety Testing. International Seed Testing Association, Switzerland.
- Joshi AK and Singh BD. 2004. Seed Science and Technology, Kalyani Publishers, New Delhi, India.
- Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios., Jodhpur, India.
- Mishra DK, Khare D, Bhale, MS and Koutu GK. 2011. Handbook of Seed Certification. Agrobios, Jodhpur, Rajasthan.
- Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. Seed Legislation in India. Agrobios, Jodhpur, Rajasthan.
- Trivedi PC. 2011. Seed Technology and Quality Control. Publications, Jaipur, Rajasthan.

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	3	1	1	2	2	1	1	1	1	1
CO-2	1	2	2	2	1	2	2	3	2	2	2
CO-3	2	1	2	2	2	2	1	2	3	3	3
CO-4	2	2	1	1	1	2	1	2	1	1	1
CO-5	2	2	2	2	2	2	2	2	2	2	2
CO-6	1	2	2	2	2	1	1	2	2	1	1
Average	1.5	2.0	1.5	1.5	1.6	1.7	1.3	2.0	1.6	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPG M603	Genetic Purity and DUS Testing	2	0	2	20	20	20	40	100	3(2+1)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG M604	Credit	2(1+1)
Year/Sem	Elective	L-T-P	1-0-1
Course Name	Advances in Seed Quality Enhancement	Course Type	Elective
Course Objectives: <ol style="list-style-type: none">1. To understand the concept, significance, and principles of seed quality enhancement and its types.2. To study physical enhancement techniques such as grading, coating, pelleting, plasma, and nano-formulations.3. To comprehend physiological enhancement methods including priming, infusion, and hardening for improved stress tolerance.4. To learn about biological seed enhancement using microbial formulations and smart seed concepts.5. To evaluate the influence of enhancement treatments on seedling establishment, crop performance, and storability.6. To integrate and design suitable seed enhancement strategies using advanced technologies for sustainable agriculture.			
UNIT I (Total Topics – 10 and Hrs - 5) <p>Seed quality – importance and enhancement – principles, concept, significance, strategies; types of seed enhancement – physical, physiological and biological enhancement techniques. Physical seed quality enhancement – concept and principles of grading – upgrading magnetic, electromagnetic, irradiation, coating, pelleting, colouring; plasma treatment – thermal and cold plasma – treatment; application of nano formulations concepts – principles – mode of action on improving germination.</p>			
UNIT II (Total Topics – 8 and Hrs - 3) <p>Physiological methods of seed quality enhancement – seed priming – principles, methods, mode of action – physiological, biochemical and molecular mechanism of priming techniques; seed infusion – principles and methods, mode of action imparting abiotic stress tolerance – hardening – principles and methods.</p>			
UNIT- III (Total Topics - 6 and Hrs - 2) <p>Application of biological formulations – bacterial, fungal agents – concepts, formulations and compatibility; methods of application – growth promotion protection – control over pest and disease infection and mode of action; designer/ smart seed – concept, methods, applicability to different crops.</p>			
UNIT-IV (Total Topics – 7 and Hrs. - 5) <p>Effect of different treatments on crop establishment and modulation of seedling growth – crop geometry, phenology and yield improvement; storability of primed, coated and pelleted seeds – pre-storage and mid-storage enhancement techniques hydration-dehydration techniques, moisture equilibrium drying and halogenations principles, methods and application.</p>			
Practical (Total Topics – 16 and Hrs. - 32) <ul style="list-style-type: none">• Physical seed quality up gradation – specific gravity separator, density grading, floatation technique;• Practicing seed pelleting – methods of pelleting for different crop species;• Performing seed coating – polymer, colouring and nano emulsion coating;• Study on the effect of magnetic and			

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electromagnetic seed treatment on seed germination and vigour; • Practicing seed priming – hydro, osmo, halo and solid matrix priming methods; • Nutrient and bio priming and assessing the performance of primed seeds; • Assessing the storability of primed seed; • Study on seed hardening on the performance of seed under abiotic stress; • Preparation of designer/ smart seed for different crops; • Biological seed treatment – biological formulations, bacteria, fungi, protectants and bio fertilizers; • Study on the effect of biological seed treatment on seedling growth and disease incidence; • Estimating the microbial population in biologically treated seeds; • Assessing the storability and vigour potential of treated seeds; • Performing mid-storage seed treatment – hydration-dehydration, moisture equilibrium and drying; • Halogenation of seeds and their effect on seed performances; • Assessing the performance of treated seeds under field condition.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1. Explains the importance and principles of seed quality enhancement and differentiates among physical, physiological, and biological enhancement methods.
- CO2. Applies suitable physical enhancement techniques and interprets their effects on seed germination and vigor.
- CO3. Performs and analyzes physiological enhancement techniques and interprets the underlying biochemical and molecular mechanisms.
- CO4. Evaluates microbial and biological enhancement strategies for growth promotion, disease protection, and development of smart seeds.
- CO5. Assesses the effects of various enhancement methods on seed performance, field establishment, and storage behavior.
- CO6. Designs and integrate advanced physical, physiological, and biological enhancement methods into efficient seed quality management systems.

Suggested readings:

- Bewley JD, Bradford KJ, Hilhorst HWM and Nonogaki H. 2013. Seeds: Physiology of Development, Germination and Dormancy, Third Edition. Springer, New York, United States.
- Doijode SD. 2006. Seed Quality in Vegetable Crops. In: Handbook of Seed Science and Technology.
- Basra AS (Ed.). The Haworth Press, New York, United States. pp. 677–702.
- Filatova I, Azharonok V, Lushkevich V, Zhukovsky A, Gadzhieva G, Spasic K, Zivkovic S, Puac N, Lazovic S, and Malovic G. 2013. Plasma Seeds Treatment as a Promising Technique for Seed Germination Improvement. 31st International Conference on Phenomena in Ionized Gases, Granada, Spain.
- Glick BR. 2012. Plant Growth-Promoting Bacteria: Mechanisms and Applications. Hindawi Publishing Corporation, Scientifica.
- Halmer P. 2003. 'Methods to improve seed performance.' In: Benech-Arnold RL, Sanchez RA (Eds.). Seed Physiology, Applications to Agriculture. Food Product Press, New York, United States.
- Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios., Jodhpur, India.
- McDonald MF and Copeland LO. 2012. Seed Production: Principles and Practices. Springer Science and Business Media., Boston, United States.
- Thomas B, Murphy DJ and Murray BG. 2003. Encyclopedia of Applied Plant Sciences (3

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volume set). Elsevier Science, Netherland.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	1	1	2	1	2	1	2	2	3	3
CO-2	2	3	1	2	1	1	1	3	1	2	2
CO-3	1	1	2	1	2	1	3	1	3	1	1
CO-4	1	2	1	1	2	1	1	2	3	2	2
CO-5	2	1	2	1	1	1	2	1	1	1	1
CO-6	1	2	2	1	2	2	2	1	2	1	1
Average	1.6	1.6	1.5	1.3	1.5	1.3	1.6	1.6	2	1.6	1.6

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPG M604	Advances in Seed Quality Enhancement	1	0	2	20	20	20	40	100	2(1+1)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPA C601	Credit	2(1+1)
Year/Sem	Elective	L-T-P	1-0-1
Course Name	Germplasm Conservation Techniques	Course Type	Elective
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To understand the concept, importance, and need for conservation of biological diversity with emphasis on in-situ approaches. 2. To learn the principles and methods of ex-situ conservation and management of gene banks. 3. To study in-vitro conservation methods for short, medium, and long-term storage of diverse plant genetic resources. 4. To acquire knowledge on cryopreservation principles, techniques, and cryoprotectants for germplasm conservation. 5. To understand gene bank standards, viability monitoring, regeneration, and roles of national and international organizations. 6. To integrate modern conservation techniques and develop sustainable strategies for long-term germplasm security. 			
<p>UNIT I (Total Topics – 7 and Hrs - 3) Biological diversity in India – importance – need for conservation – concept of natural reserves and gene banks; post-exploration handling of germplasm collections, preservation of seed and plant specimens, importance and use of herbaria; in-situ conservation – components – biosphere reserve – natural park; factors influencing conservation; in-situ conservation – national programmes – on farm conservation.</p>			
<p>UNIT II (Total Topics – 7 and Hrs - 3) Ex-situ conservation – components – plant genetic resources conservation in gene banks – national gene banks – gene repositories – seed gene bank – types of collections – base, active and working collections – perma-frost seed conservation guidelines for sending seeds to gene bank; handling of orthodox and recalcitrant seeds for conservation – clonal repositories.</p>			
<p>UNIT- III (Total Topics – 9 and Hrs - 5) Methods of in-vitro conservation – short, medium and long term, concept of active and base in-vitro genebank; in-vitro storage – culture maintenance – problems and perspectives – gene bank maintenance for temperate and tropical fruit crops, spices, tubers, bulbs, medicinal and aromatic plants; conservation of embryos and ovules, meristem, cell/ suspension cultures – protoplast and callus cultures – pollen culture– micro propagation techniques – genetic stability under long term storage.</p>			
<p>UNIT-IV (Total Topics – 10 and Hrs. - 5) Cryopreservation – principle and method – handling of orthodox and recalcitrant seeds for cryopreservation – cryoprotectants – desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation and dehydration techniques; application of cryopreservation techniques for agricultural, horticultural and forest crops. Gene bank standards for various crops – monitoring viability of stored seed samples multiplication and regeneration of stored germplasm materials – National and International organizations – NBPGR and NPGR – roll and functions; Dooms-day safe seed vault – Biodiversity International –</p>			

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conservation guidelines.

Practical (Total Topics – 16 and Hrs. - 32)

• Study on In-situ conservation methods and case studies; • Plant exploration, germplasm collection and documenting passport data; • Ex-situ conservation techniques for long term conservation of germplasm collections; • Preparation and handling of materials, packaging and documentation; • Preparation of seed album and herbarium specimens for ex-situ conservation; • Planning and designing of cold storage units and facilities for gene bank; • Conservation protocols for orthodox seeds; • Study of conservation protocols for recalcitrant seeds; • Conservation techniques for vegetative propagules/ clones; • Cryopreservation techniques – encapsulation, dehydration, freezing, thawing methods; • Cryopreservation of in-vitro cultures – meristem, embryo, cell suspension and pollen cultures; • Study on freezing and vitrification techniques; • Conservation technique of forest tree species; • Study on in-vitro cryo-genebanking and database management; • Visit to national and regional seed gene banks; • Visit to on-farm conservation sites and Botanical Survey of India.

Course Outcomes (COs): After completion of course, students will be able to:

- CO1. Explains the importance of biodiversity conservation and distinguishes components and methods of in-situ conservation.
- CO2. Describes and applies procedures for ex-situ conservation, including seed and clonal repositories and gene bank operations.
- CO3. Analyzes in-vitro conservation and maintenance techniques for different plant categories including fruits, tubers, spices, and medicinal crops.
- CO4. Evaluates various cryopreservation techniques and their applications for agricultural, horticultural, and forest germplasm.
- CO5. Assesses gene bank management standards and formulates conservation strategies involving NBPGR, NPGRI, and Biodiversity International.
- CO6. Designs integrated conservation systems combining in-situ, ex-situ, in-vitro, and cryogenic approaches for safeguarding genetic resources.

Suggested readings:

- Basra AS (Ed.). 1995. Seed Quality: Basic Mechanisms and Agricultural Implications. Food Product Press, USA.
- Brush SB. 1999. Genes in the field: On-farm Conservation of Crop Diversity. Lewis Publishers, Boca Raton, Florida, USA.
- Choudhary DR. 2009. Guidelines for Storage and Maintenance of Registered Plant Varieties in the National Gene Bank. Published by Protection of Plant Varieties and Farmer's Rights Authority. Ministry of Agriculture and Farmers Welfare, GoI, New Delhi.
- Gupta D. 2009. Seeds: Their Conservation Principles and Practices. Sathish Serial Publishing House. New Delhi.
- Jarvis DI, Meyer L, Klemick H, Guarino L, Smale M, Brown AHD, Sadiki M and Sthapit B. 2000. A Training Guide for In-situ Conservation On-farm. Version 1. International Plant Genetic Resources Institute, Rome, Italy.
- Joshi AK and Singh BD. 2004. Seed Science and Technology, Kalyani Publishers, New Delhi.
- Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios., Jodhpur.

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- McDonald MF and Copeland LO. 2012. Seed Production: Principles and Practices. Springer Science and Business Media., Boston, USA.
- Meerabi G and Pullaiah T. 2015. Plant Biodiversity Conservation and Management, Daya Publishing House, Delhi.
- Rao NK, Hanson J, Dulloo ME, Ghosh K, Nowell A and Iarinde M. 2006. Manual of Seed Handling in Genebanks. Bioversity International, Rome.
- Vernoy R, Shrestha P and Sthapit B. 2015. Community Seed Banks: Origins, Evolution and Prospects, Oxford, Routledge, UK.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	2	1	-	-	-	2	3	1	-	-	-
CO-2	1	-	-	-	1	2	-	-	-	1	1
CO-3	2	2	2	2	1	3	2	1	1	1	1
CO-4	1	-	-	2	1	2	2	3	1	2	2
CO-5	2	2	2	2	1	3	2	1	1	1	1
CO-6	1	-	-	2	1	2	2	3	1	2	2
Average	1.5	1.7	2.0	2.0	1.0	2.3	2.2	1.8	1.0	1.4	1.4

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPG M605	Germplasm Conservation Techniques	1	0	2	20	20	20	40	100	2(1+1)

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Supporting Courses (Compulsory for students of all disciplines of Agriculture) (Gradual courses)

Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG S601	Credit	3(3+0)
Year/Sem	Year -1; Semester-I	L-T-P	3-0-0
Course Name	Research Methodology in Genetics & Plant Breeding	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To Equip the Students with the Concept and Methodology of Research.2. To provide knowledge about types of research, preparation of reports and thesis, designing of Research using Scientific Methods.3. To develop the ability to apply principles and procedure for data analysis and interpretation of results.4. To analyze various sampling methods and probability of research analysis.5. To evaluate interpretations and significance of report writing.6. To develop the ability to create appropriate hypothesis, select experimental design and presentation of results after analysis of data.			
UNIT I (Total Topics- 7 and Hrs-12) Introduction to Research: Definition, Nature and significance, Role and Objectives; Types of Research: exploratory, descriptive, experimental and diagnostic research, social and legal research and traditional, analytical, empirical & fundamental research, Doctrinal and non-doctrinal research methods; Various Research Designs; Scientific Research Process: Overview, Problem identification and formulation of research statement.			
UNIT II (Total Topics- 7 and Hrs- 12) Data Collection: sources, primary and secondary methods, significance of Primary and Secondary Data, questionnaire Vs. schedules; Data Processing: Editing, Coding Organization and Presentation; Attitude Measurement and scaling: Measurement Scales, Sources of Errors in Measurement, Techniques of Developing Measurement Tools, Classification and Testing (Reliability, Verification and Validity) Scales, Designing Questionnaires and Interviews.			
UNIT- III (Total Topics- 5 and Hrs- 10) Sampling, Sampling Methods, Sampling Plans, Sampling Error, Sampling Distributions: Theory and Design of Sample Survey, Census Vs Sample Enumerations, Objectives and Principles of Sampling, Types of Sampling, Sampling and Non-Sampling Errors, Concept of Permutation, Combination & Probability for research analysis.			
UNIT-IV(Total Topics- 5 and Hrs- 10) Interpretations and Report Writing: Meaning of Interpretation, Techniques of Interpretation, Precautions in Interpretation, Significance of Report Writing, Steps in Report Writing, Layout of Report and Precautions in Writing Research Reports. Limitations of RM: Ethics in Research, Philosophical Issues in Research.			
Practical)- NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Acquire in-depth knowledge of the fundamentals, theories, and principles related to			

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research, and apply this knowledge to conduct research studies in the chosen area of interest.

- CO2: Identify, formulate, and critically investigate research problems by applying research-oriented knowledge, and analyze relevant data to propose appropriate alternative solutions.
- CO3: Apply acquired knowledge and skills to think creatively and innovatively while conducting research and drawing meaningful conclusions.
- CO4: Apply parametric and non-parametric statistical tests to verify hypotheses and suggest innovative solutions to the research problem under investigation.
- CO5: Evaluate the interpretation, significance, and structure of scientific report writing.
- CO6: Create appropriate hypotheses, select suitable experimental designs, analyze data, and effectively present the results.

Suggested readings:

- William G. Zikmund, "Business Research Methods", Orlando: Dryden Press.
- C. William Emory and Cooper R. Donald, "Business Research Methods", Boston, Irwin.
- Fred N Kerlinger, "Foundations of Behavioural Research", New Delhi: Surjeet Publications.
- Naresh Malhotra, Marketing Research: An Applied Orientation, Pearson publication David Nachmias and Chava Nachmias, "Research Methods in the Social Sciences", New York: St.Marlia's Press.
- Bhattacharya, D. K. (2004) Research Methodology, New Delhi, Excel Books

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO - 2	PSO - 3	PSO - 4	PSO - 5	PSO - 6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPG S601	Research Methodology in Entomology	3	0	0	30	20	-	50	100	3(3+0)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG S602	Credit	1(1+0)
Year/Sem	Year -1; Semester-I	L-T-P	1-0-0
Course Name	Computer & Stats Application in Research	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To appraise computational skills for research application.2. To assess statistical methods for research analysis.3. To create skills in methods of collection of any type of data, classification of data, presentation of data, analysis of data, descriptive statistics, parametric and non-parametric tests, etc.4. To analyse statistical calculations and their validation.5. To justify the decision in the reference of data analysis, formation and Analysis of data.6. To create ANOVA through different methods and their interpretation.			
UNIT I (Total Topics- 7 and Hrs-12) <p>Characteristics of Computers, Evolution of computers, computer memory, computer generations, Basic computer organization; System software, Application software, introduction to operating system, single user, multi-user, multitasking single tasking, application of computer for business and research, MS-windows, Linux .Application of Internet in research: INFLIBNET, Use of Internet, sights (DOAJ), Use of E Journals, Use of E library, use of EBSCO HOST online database of Academic Libraries. Subject/field specific tools on www.freeware.com</p>			
UNIT II(Total Topics- 7 and Hrs- 12) <p>Computer Application in Research, Basic concept of Computer, Use of Internet for Research Purpose: E-mail, WWW, Web browsing, technical skills, drawing inferences from data, Research publishing tools-MS Word, Adobe acrobat, Graphics tool-MS Excel, Presentation tool-MS Power, Data Analysis Software and Analysis Techniques point. Creating presentation and adding effects, Introduction to Data analysis software-SPSS: Definition, objectives and features, data analysis using SPSS.</p>			
UNIT- III (Total Topics- 5 and Hrs- 10) <p>Statistical methods for research application in analysis of data, Measurement in Research , data interpretation, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), std deviation, Measures of Relationship, Simple Regression Analysis, Correlation and Regression, Partial Correlation.</p>			
UNIT-IV(Total Topics- 5 and Hrs- 10) <p>Statistical Tools-Hypothesis and Hypothesis Testing: Parametric & Non-Parametric Tests, Important Parametric Tests ,Hypothesis Testing of Correlation Coefficients ,U Test, Chi Square Test, ,T-Test. Analysis of Variance (ANOVA) , The Basic Principle of ANOVA ,ANOVA Technique, Setting up Analysis of Variance Table, Short-cut Method for One-way ANOVA, Coding Method, Two-way ANOVA .</p>			
Practical- NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Remember the basic terms used in data collection, classification, presentation, and analysis, including descriptive statistics and parametric and non-parametric tests.• CO2: Understand the use of various formulas, principles, and statistical methods applied in			

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agricultural sciences.

- CO3: Apply appropriate skills in collecting, classifying, presenting, and analyzing different types of data using descriptive statistics, parametric, and non-parametric tests.
- CO4: Analyze statistical calculations and validate the results obtained.
- CO5: Evaluate datasets using suitable statistical tests for meaningful interpretation.
- CO6: Create ANOVA tables using different methods and interpret the results effectively.

Suggested readings:

- C. R. Kothari, "Research Methodology: Methods and techniques", New Delhi: Vishwa Prakashan.
- Brymann, Alan and Carmer, D. (1995) Qualitative data analysis for social scientist, New York, Routledge Publication.
- Jain, Satish: "Introduction to Computer Science and basic Programming." BPB Publications, New Delhi, 1990. • Rajaraman, V., "Fundamental of Computers", Prentice Hall of India, New Delhi, 1996.
- Hogg, R.V.& Craig, T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
- [\(PDF\) Statistical Methods and their Applications \(researchgate.net\)](#)
- [Welcome to Web Agri Stat Package \(icar.gov.in\)](#)
- [\(PDF\) BASIC STATISTICAL TECHNIQUES IN RESEARCH \(researchgate.net\)](#)
- [Statistical Methods & Applications | Home \(springer.com\)](#)
- [Statistical Methodology - Journal - Elsevier](#)

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPG S602	Computer & Stats Application in Research	1	0	0	30	20	-	50	100	1(1+0)

5th BOS/2025-26

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(Established vide Uttaranchal University Act, 2012)

(Uttarakhand Act No. 11 of 2013)

Arcadia Grant, P.O. Chandanwari, Premnagar, Dehradun, Uttarakhand

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Arcadia Grant, P.O. Chandanwari, Premnagar, Dehradun, Uttarakhand

Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG S603	Credit	1(1+0)
Year/Sem	Year -1; Semester-I	L-T-P	1-0-0
Course Name	Research & Publication Ethics	Course Type	Compulsory
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To acquaint with knowledge about basics of Agricultural Research and research ethics 2. To understand research ethics including research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards, and problems in research ethics. 3. To apply research ethics in collection and interpretation of data. 4. To analyze the major publication ethics to be followed during research. 5. To evaluate violation of publication ethics, authorship and contributor ship 6. To develop ability to identify different predatory publishers and journals. 			
<p>UNIT I (Total Topics- 2 and Hrs-8) Introduction to philosophy: definition, nature and scope, concept, branches; Ethics: definition, moral philosophy, nature of moral judgments and reactions</p>			
<p>UNIT II (Total Topics- 5 and Hrs- 5) Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconduct: Falsification, Fabrication, and Plagiarism (FFP); Redundant publications: duplicate and overlapping publications, salami slicing; Selective reporting and misrepresentation of data</p>			
<p>UNIT- III (Total Topics-7 and Hrs-7) Publication ethics: definition, introduction and importance; Best practices/ standards setting initiatives and guidelines: COPE, WAME, etc.; Conflicts of interest; Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types; Violation of publication ethics, authorship and contributor ship; Identification of publication misconduct, complaints and appeals; Predatory publishers and journals</p>			
<p>UNIT- IV (Total Topics-4and Hrs-4) Open access publications and initiatives; SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies; Software tool to identify predatory publications developed by SPPU; Journal finder/ Journal suggestion tools viz. JANE, Elsevier Journal finder, Springer Journal Suggester, etc.</p>			
<p>Course Outcomes (COs): After completion of course, students will be able to:</p> <ul style="list-style-type: none"> • CO1: Recognize the fundamentals of the philosophy of science and ethics, research integrity, publication ethics, and theories of research ethics. • CO2: Familiarize with major issues related to research ethics, research integrity, scientific misconduct, and data misinterpretation. • CO3: Analyze best practices in scholarly publishing, understand publication ethics, and identify predatory publishers and journals. • CO4: Demonstrate the use of plagiarism-detection tools, open-source research tools, citation databases, and research metrics. • CO5: Evaluate credible and scholarly publications published in reputed peer-reviewed journals. • CO6: Create ethically sound research publications suitable for high-impact, peer-reviewed 			

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journals.

Suggested readings:

- Research and Publication Ethics, Dr Sumanta Dutta, Bharti Publications, 2021
- Research and Publication Ethics, Dr Santosh Kumar Yadav, Anne Publications, 2020
- Kumar, R. 2014. Research Methodology: A Step-by-Step Guide for Beginners. 4th Edition. SAGE Publications Ltd.
- Parikh, M.N, Gogtay, N. 2009. ABC of Research Methodology and Applied Biostatistics. Jaypee Publishers, New Delhi.
- <https://www.sciencedirect.com/journal/library-and-information-science-research>
- https://www.researchgate.net/publication/306097844_Library_and_Information_Science_Research
- <http://isca.in/RJLS/>
- <https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm>
- <https://www.springer.com/journal/10892>

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPG S603	Research & Publication Ethics	1	0	0	30	20	-	50	100	1(1+0)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C691	Credit	1(0+1)
Year/Sem	Year 1; Semester – I	L-T-P	0-0-1
Course Name	Doctoral Seminar – I (Compulsory Course)	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscripts/article and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPG C691	Doctoral Seminar -I	0	0	2	-	-	100	-	100	1(0+1)

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Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C692	Credit	1(0+1)
Year/Sem	Year 1; Semester – II	L-T-P	0-0-1
Course Name	Doctoral Seminar-II (Compulsory Course)	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To remember scientific terms, concepts, and content preparation, etc.2. To understand procedures of power point presentation.3. To apply usage of photographs and sketches in power point to give valuable information.4. To analyze data incorporation in seminar and its effectiveness.5. To evaluate utilization of different sources of data.6. To develop the skills of preparation of research proposal or synopsis, report, manuscripts/article and publications and use of computer programs etc.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs- 20) <p>A power point presentation on any topic chosen from the courses studied to be prepared and delivered to the group of faculty members/staff and students of department.</p> <p>Essential components of Presentation are: Organization of topic, Presentation of data. Oral presentation, Delivery, language, explanation of figures, Ability to grasp and understand the subject, Depth of understanding the topic.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Know the scientific terminology, key concepts, and content preparation techniques.• CO2: Understand and develop the ability to create effective PowerPoint presentations.• CO3: Apply photographs and sketches in presentations to enhance information delivery.• O4: Analyze the incorporation of data in seminar presentations and assess its effectiveness.• CO5: Evaluate the use of different data sources for preparing presentations and seminars.• CO6: Develop skills in preparing research proposals/synopses, reports, manuscripts, and publications, and in using relevant computer software.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee Publisher, New Delhi.</p>			

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Articulated Attainment

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	1	1	3	2	2	2	1	2	2
CO-2	1	3	1	2	3	2	2	2	1	1	1
CO-3	2	1	2	3	1	1	1	3	2	1	1
CO-4	3	3	1	1	2	1	1	2	1	1	1
CO-5	1	2	2	1	1	2	2	2	1	2	2
CO-6	1	1	1	2	2	2	1	1	1	2	2
Average	1.8	2.1	1.1	1.6	2.0	1.6	1.5	2.0	1.1	1.5	1.5

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
					Internal Examination			End Term Examination	Subject Total	
		L	T	P	Midterm Theory Examination	Assignment	Practical Examination			
DPG C692	Doctoral Seminar -II	0	0	2	-	-	100	-	100	1(0+1)

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Doctoral Research Work

Programme Name	Ph.D. Genetics & Plant Breeding	Programme Code	
Course Code	DPG C699	Credit	75(0+75)
Year/Sem		L-T-P	Not Applicable
Course Name	Doctoral Research	Course Type	Compulsory
Course Objectives: <ol style="list-style-type: none">1. To develop a comprehensive understanding of research philosophies, theories, and types of scientific inquiry in agricultural sciences.2. To identify research gaps through systematic literature review and formulate appropriate research problems, objectives, and hypotheses.3. To apply suitable research methodologies, experimental designs, and sampling techniques relevant to agricultural research.4. To enhance skills in data collection, statistical analysis, and interpretation using advanced analytical tools.5. To strengthen scientific writing, academic communication, and referencing skills for research publications and proposals.6. To promote ethical research practices, scientific integrity, and responsible conduct in agricultural research.			
UNIT I (Total Topics- and Hrs-) NA			
UNIT II (Total Topics - and Hrs-) NA			
UNIT- III (Total Topics - and Hrs-) NA			
UNIT-IV (Total Topics - and Hrs-) NA			
Practical (Hrs-) <p>Synopsis, Research Work & Thesis writing provides the students with an excellent opportunity to develop analytical research and entrepreneurial skills, and knowledge through meaningful hands on experience, confidence in their ability to design and investigate the things.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Recall and describe fundamental research concepts, methodologies, and statistical tools used in agricultural research.• CO2: Explain research processes, interpret scientific literature, and summarize research gaps in agriculture.• CO3: Apply suitable research designs, data collection methods, and sampling strategies in field, laboratory, and socio-economic studies.• CO4: Analyze research data, identify trends and relationships, and interpret results using appropriate statistical techniques.• CO5: Evaluate the quality, rigor, and validity of research findings and assess scientific articles using standardized evaluation criteria.• CO6: Develop an original research proposal, formulate hypotheses, design experimental models, and produce publishable scientific writing.			
Suggested readings: <p>Grover, S. and Ameen, S. 2018. A Primer of Research, Publication and Presentation. Jaypee</p>			

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Publisher, New Delhi.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	3	3	3	3	3	3	3	3	3	3
CO-2	3	3	3	3	3	3	3	3	3	3	3
CO-3	3	3	3	3	3	3	3	3	3	3	3
CO-4	3	3	3	3	3	3	3	3	3	3	3
CO-5	3	3	3	3	3	3	3	3	3	3	3
CO-6	3	3	3	3	3	3	3	3	3	3	3
Average	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
DPE C699	Doctoral Research	N A	N A	N A	NA	NA	NA	NA	NA	75(0+75)

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Non Gradual common Courses for Students of all Disciplines of Agriculture

(To be opted if not in course curriculum of M.Sc. degree Programme of a student)

Course Code	SOA N501	Credit	1(1+0)
Year/Sem	Year I; Semester I/II	L-T-P	1-0-0
Course Name	Intellectual Property Rights and Their Management in Agriculture		
Course Objectives:			
<ol style="list-style-type: none">1. To acquaint the meaning of intellectual property and differentiate it from tangible property.2. To develop understanding of the process of IPR, their eligibility and various treaties and conventions.3. To develop ability to apply Licensing technologies, Material transfer agreements and Research collaboration Agreement.4. To develop the ability to analyze TRIPs and various provisions in TRIPS Agreement, GI, ITK, protection of plant varieties, researcher's right and farmers' right.5. To develop ability to evaluate the ethical and professional issues that arise in the intellectual property law.6. To develop the skill to create patents, copyrights, geographical indications, designs and layout.			
UNIT I (Total Topics- 3 and Hrs - 3)			
Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs.			
UNIT II (Total Topics - 5 and Hrs- 3)			
Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks			
UNIT- III (Total Topics - 6 and Hrs- 4)			
Protection of plant varieties and farmers' rights and bio-diversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture			
UNIT-IV (Total Topics - 4 and Hrs- 3)			
Writing skills of patent and copyright; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.			
Practical (Hrs-) – NA			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none">• CO.1: Acquaint the meaning of intellectual property and differentiate it from tangible property.• CO.2: Understand the process of IPR, their eligibility and various treaties and conventions.• CO.3: Develop ability to apply Licensing technologies, Material transfer agreements and Research collaboration Agreement.• CO.4: Develop the ability to analyze TRIPs and various provisions in TRIPS Agreement, GI,			

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ITK, protection of plant varieties, researcher's right and farmers' right.

- CO.5: Develop ability to evaluate the ethical and professional issues that arise in the intellectual property law.
- CO.6: Develop the skill to create patents, copyrights, geographical indications, designs and layout.

Suggested readings:

- Bilek Debroy, 2004. Intellectual Property Rights, BR World of books, New Delhi.
- Ganguli, P., 2001. Intellectual Property Rights - Unleashing the Knowledge Economy. Tata McGraw Hill, New Delhi.
- Narayanan, R., 2006. Patent Law, Eastern Law House, New Delhi.
- Ramappa, T., 2000. Intellectual Property Rights under WTO - Tasks before India, Wheeler Publishing, New Delhi.
- Link: <https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=ZzUApmBk4i7kYctp+aiP1w==>

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -5	PSO -6
CO-1	1	1	1	1	1	1	1	1	1	1	1	1
CO-2	1	1	1	-	1	1	1	1	1	1	1	1
CO-3	1	1	2	-	1	-	1	1	1	1	1	1
CO-4	1	1	2	-	1	-	1	1	3	1	1	1
CO-5	1	1	1	1	1	-	1	1	1	1	1	1
CO-6	1	1	1	1	1	-	1	1	1	1	1	1
Average	1.0	1.0	1.8	1.0	1.0	1.0	1.0	1.0	1.8	1.0	1.0	1.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
SOA N501	Intellectual Property and Its Management in Agriculture	1	0	0	30	20	-	50	100	1(1+0)

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Course Code	SOA N502	Credit	1(0+1)
Year/Sem	Year I; Semester I/II	L-T-P	0-0-1
Course Name	Technical Writing and Communication Skills		
Course Objectives:			
<ol style="list-style-type: none">1. To educate about the various forms of writings frequently required in a preparation of documents, reports, manuscripts, manual, research paper, and dissertation.2. To develop the understanding of principles and method of effective and professional communication and speech.3. To develop the ability to differentiate among and to use facts, inferences and judgments and editing and proof-reading and organizing information for research communication, report, thesis and other publication.4. To develop the analytical skills in composing the abstracts, content, notation, citation, captions, pagination, bibliography, review of literature, scientific manuscript, research article, review article, etc.5. To able to evaluate the principles and need of technical communication and scientific writing style.6. To able to design the scientific article writing and other professional encrypts.			
UNIT- I (Total Topics - and Hrs -) NA			
UNIT-II (Total Topics - and Hrs -) NA			
UNIT- III (Total Topics - andHrs -) NA			
UNIT-IV (Total Topics - andHrs -) NA			
Practical (Topics- 13 Hrs- 26)			
Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; Type and style of bibliography commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article. Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none">• CO.1: Educate about the various forms of writings frequently required in a preparation of documents, reports, manuscripts, manual, research paper, dissertation etc.• CO.2: Develop the understanding of principles and method of effective and professional communication and speech.• CO.3: Develop the ability to differentiate among and to use facts, inferences and judgments and editing and proof-reading and organizing information for research communication, report, thesis and other publication.• CO.4: Develop the analytical skills in composing the abstracts, content, notation, citation, captions, pagination, bibliography, review of literature, scientific manuscript, research article, review article, etc.			

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- CO.5: Able to evaluate the principles and need of technical communication and scientific writing style.
- CO.6: Able to design the scientific article writing and other professional encrypts.

Suggested readings:

- Gordon, H.M.& Walter, J.A. 1970. Technical Writing. 3rd Ed. Holt, Rinehart & Winston.
- Hornby, A.S. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6thEd. Oxford University Press.
- Joseph, G. 2000. MLA Handbook for writers of Research Papers. 5th Ed. Affiliated EastWest Press.
- Mohan, K. 2005. Speaking English Effectively. MacMillan India.
- Richard, W.S. 1969. Technical Writing. Barnes & Noble.
- Abhishek Sethi, J.& Dhamija, P.V. 2004. Course in Phonetics and Spoken English. 2ndEd. Prentice Hall of India.
- Wren, P.C.& Martin, H. 2006. High School English Grammar and Composition. S. Chand & Co.
- Mohan, K. 2015. Speaking English Effectively. MacMillan India.
- Link: <https://agrimoon.com/comprehension-developing-communication-skills-in-english-pdf-book/>

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	3	2	2	-	2	1	3	2	1	3	3
CO-2	3	2	2	-	1	1	2	2	1	2	2
CO-3	3	1	2	1	1	-	1	1	-	2	2
CO-4	2	1	2	2	2	-	1	1	1	-	-
CO-5	1	1	-	-	-	-	-	1	-	-	-
CO-6	1	-	-	-	1	1	-	-	-	-	-
Average	2.2	1.4	2.0	1.5	1.4	1.0	1.8	1.4	1.0	2.3	2.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
SOA N502	Technical Writing and Communication Skills	0	0	2	30	20	50	-	100	1(0+1)

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Course Code	SOA N503	Credit	1(1+0)
Year/Sem	Year I; Semester I/II	L-T-P	1-0-0
Course Name	Disaster Management		
Course Objectives:			
<ol style="list-style-type: none">1. To educate about different types of natural and manmade disasters and their impact on lives on the earth.2. To understand the standard methods for the mitigation process of natural and manmade disasters.3. To use the necessary precautions of dos and don'ts for a disaster.4. To identify the reasons for different types of natural and manmade disasters at a location.5. To prioritize the elements of disaster response as per immediate needs.6. To make contributions to disaster management activities of government and non-government agencies.			
UNIT I (Total Topics- 13 and Hrs- 5)			
Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Cloudburst and its causes; Case studies of cloudburst in Uttarakhand, Storm and its types, Earthquakes, Landslides, Case study of landslide in Uttarakhand, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion. Individual efforts to mitigate the impacts of climate change and global warming.			
UNIT II (Total Topics - 17 and Hrs- 5)			
Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.			
UNIT- III (Total Topics - 5 and Hrs- 5)			
Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.			
UNIT-IV (Total Topics - and Hrs-) – NA			
Practical – NA			
Course Outcomes (COs): After completion of course, students will be able to:			
<ul style="list-style-type: none">• CO1: Educate about different types of natural and manmade disasters and their impact on lives on the earth.• CO.2: Understand the standard methods for the mitigation process of natural and manmade disasters.• CO.3: Use the necessary precautions of dos and don'ts for a disaster.• CO.4: Identify the reasons for different types of natural and manmade disasters at a location.• CO.5: Prioritize the elements of disaster response as per immediate needs.• CO.6: Make contributions to disaster management activities of government and non-			

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government agencies.

Suggested readings:

- Bharucha, E. 2004. Textbook for Environmental Studies For Undergraduate Courses of Higher Education. UGC, New Delhi and Bharati Vidyapeeth Institute of Environment Education and Research, Pune.
- Gupta, H.K. 2003. Disaster Management. Indian National Science Academy. Orient Blackswan.
- Hodgkinson, P.E. & Stewart, M. 1991. Coping with Catastrophe: A Handbook of Disaster Management. Routledge.
- Sharma, V.K. 2001. Disaster Management. National Centre for Disaster Management, India.
- Sharma P.D. Ecology and Environment. 2017. Thirteenth Edition. Rastogi Publications.
- Rao, M N. & Datta, A.K. 1987. WasteWater treatment. Oxford & IBH Publ. Co. Pvt. Ltd.
- Brunner, R.C., 1989. Hazardous Waste Incineration, McGraw Hill Inc.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -5
CO-1	1	1	1	1	1	1	1	1	1	1	1
CO-2	1	1	1	-	1	1	1	1	1	1	1
CO-3	1	1	2	-	1	-	1	1	1	1	1
CO-4	1	1	2	-	1	-	1	1	3	1	1
CO-5	1	1	1	1	1	-	1	1	1	1	1
CO-6	1	1	1	1	1	-	1	1	1	1	1
Average	1.0	1.0	1.8	1.0	1.0	1.0	1.0	1.0	1.8	1.0	1.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
SOA N503	Disaster Management	1	0	0	30	20	-	50	100	1(1+0)

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Course Code	SOA N504	Credit	1(0+1)
Year/Sem	Year I; Semester I/II	L-T-P	0-0-1
Course Name	Library and Information Services		
Course Objectives: <ol style="list-style-type: none">1. To educate about the basics of library and its services.2. To understand the system and organization of library.3. To use the different sources of information of library.4. To analyses the Intricacies of abstracting and indexing services.5. To select appropriate information and database available online and offline and categorize them.6. To author an abstract, scientific manuscript, report, review, etc. with appropriate citation and bibliography.			
UNIT- I (Total Topics - and Hrs -) NA			
UNIT-II (Total Topics - and Hrs -) NA			
UNIT- III (Total Topics - and Hrs -) NA			
UNIT-IV (Total Topics - and Hrs -) NA			
Practical (Topic- 11, Hrs- 20) <p>Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Scopus index, Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD- ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1: Educate about the basics of library and its services.• CO.2: Understand the system and organization of library.• CO.3: Use the different sources of information of library.• CO.4: Analyses the Intricacies of abstracting and indexing services.• CO.5: Select appropriate information and database available online and offline and categorize them.• CO.6: Author an abstract, scientific manuscript, report, review, etc. with appropriate citation and bibliography.			
Suggested readings: <ul style="list-style-type: none">• Sharma, B.K. and Thakur, U.M., 2013. Library, Information Science & Information Technology: Descriptive Study (2 Vols). YK Publishers, India.• Omesh, A. 2010. Management of Digital Library. Oxford Book Company.• Kumbhar, R. 2014. Library and Information Science Research Methods and Techniques. Universal Prakashan, Pune, India.• Sukula, S. 2014. Introduction to Library & Information Science. EssEss Publications.			

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Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	1	-	-	2	-	1	-	3	-	2	2
CO-2	1	1	1	1	1	1	3	-	3	-	-
CO-3	-	1	3	2	3	3	2	2	-	3	3
CO-4	-	-	2	-	3	2	2	-	2	-	-
CO-5	2	2	1	2	2	2	1	2	1	2	2
CO-6	2	2	1	3	1	3	1	1	1	1	1
Average	1.0	1.0	1.3	1.3	1.3	2.0	1.3	1.3	1.1	1.3	1.3

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
SOA N504	Library and Information Services	0	0	2	30	20	50	-	100	1(0+1)

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Course Code	SOA N505	Credit	1(0+1)
Year/Sem	Year 1; Semester I/II	L-T-P	0-0-1
Course Name	Basic Concepts in Laboratory Techniques		
Course Objectives: <ol style="list-style-type: none">1. To educate about basic rules and regulations of laboratory, use.2. To develop the understanding of principles and methods of handling chemicals and equipment, preparation of solutions, testing samples, etc. in the laboratory.3. To develop the skills to operate laboratory equipment efficiently and safely.4. To develop the skill to analyze handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing.5. To evaluate the preparation of buffers of different strengths and pH values.6. To develop the ability to design appropriate procedure of scientific works in the laboratory in such a way that accuracy of results remains higher.			
UNIT- I (Total Topics - and Hrs -) NA			
UNIT-II (Total Topics - and Hrs -) NA			
UNIT- III (Total Topics - and Hrs -) NA			
UNIT-IV (Total Topics - and Hrs -) NA			
Practical (Experiments- 17 Hrs- 20) <p>Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccumets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro- chemical doses in field and pot applications; Preparation of solutions of acids; Neutralization of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy.</p>			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO.1: Educate about basic rules and regulations of laboratory, use.• CO.2: Develop the understanding of principles and methods of handling chemicals and equipments, preparation of solution, testing samples, etc. in the laboratory.• CO.3: Develop the skills to operate laboratory equipments efficiently and safely.• CO.4: Develops the skill to analyse handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, water bath, oilbath; Electric wiring and earthing.• CO.5. Evaluate the preparation of buffers of different strengths and pH values.• CO.6. Develops the ability to design appropriate procedure of scientific works in the laboratory in such a way that accuracy of results remains higher.			
Suggested readings: <ul style="list-style-type: none">• Furr, A.K. 2000. CRC Hand Book of Laboratory Safety. CRC Press.• Gabb, M.H. & Latchem, W.E. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.			

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- Prescott, L.M., Harley, P. and Klein, A. 2003. Microbiology , 5th Edition, MC. GrawHill, USA.
- Gupta, P.K. 1997. Elements of Biotechnology. Rastogi Publications. Meerut.
- Singh, B.D. 2005. Bio technology, Expanding Horizons. Kalyani Publications, New Delhi.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-5	PSO-6
CO-1	-	-	-	-	-	-	1	-	-	-	-	-
CO-2	-	-	-	-	-	-	-	1	1	2	2	2
CO-3	-	-	-	-	-	-	1	1	1	-	-	-
CO-4	-	-	-	2	-	-	1	-	-	-	-	-
CO-5	-	-	-	-	-	-	1	1	-	-	-	-
CO-6	-	-	-	-	-	-	1	1	-	-	-	-
Average	-	-	-	1.0	-	-	1.0	1.0	1.0	1.0	1.0	1.0

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
SOA N504	Basic Concepts in Laboratory Techniques	0	0	2	30	20	50	-	100	1(0+1)

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Course Code	SOA N506	Credit	1(1+0)
Year/Sem	Year 1; Semester I/II	L-T-P	1-0-0
Course Name	Agricultural Research, Research Ethics and Rural Development Programme		
Course Objectives: <ol style="list-style-type: none">1. To acquaint with knowledge about basics of Agricultural Research, Research Ethics and Rural Development Programmes in India.2. To understand research ethics including research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.3. To apply research ethics in collection and interpretation of data.4. To analyze the major constraints in implementation of rural policies and programmes.5. To evaluate different rural developmental programs, policies and strategies at different levels.6. To formulate analyzed data according to different designs.			
UNIT I (Total Topics - 6 and Hrs - 6) <p>History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centers (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.</p>			
UNIT II (Total Topics - 5 and Hrs- 3) <p>Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.</p>			
UNIT- III (Total Topics - 9 and Hrs- 4) <p>Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, and Voluntary Agencies/Non-Government Organizations.</p>			
UNIT-IV (Total Topics - 1 and Hrs- 2) <p>Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.</p>			
Practical (Total Topics - and Hrs -) NA			
Course Outcomes (COs): After completion of course, students will be able to: <ul style="list-style-type: none">• CO1: Acquaint about basics of Agricultural Research and Research Ethics• CO.2: Understand of research ethics including research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and• CO.3: Apply research ethics in collection and interpretation of data.• CO.4: Analyze the major constraints in implementation of rural policies and Programmes.• CO.5: Evaluate different rural developmental programs, policies and strategies at different levels.			

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- CO.6: Formulate analyzed data according to different designs.

Suggested readings:

- Kumar, R. 2014. Research Methodology: A Step-by-Step Guide for Beginners. 4th Edition. SAGE Publications Ltd.
- Parikh, M.N, Gogtay, N. 2009. ABC of Research Methodology and Applied Biostatistics. Jaypee Publishers, New Delhi.

Articulated Attainment

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO -2	PSO -3	PSO -4	PSO -5	PSO -6
CO-1	2	2	2	1	1	2	1	2	1	2	2
CO-2	1	1	2	1	-	-	1	1	-	1	1
CO-3	2	2	2	1	1	2	-	2	2	1	1
CO-4	2	2	1	1	-	1	1	1	1	-	-
CO-5	2	2	2	1	1	-	1	1	1	-	-
CO-6	1	2	2	1	1	1	-	1	-	1	1
Average	1.7	1.8	1.8	1.0	1.0	1.5	1.0	1.3	1.2	1.2	1.2

CODE	Course Title	Periods per week			Evaluation Scheme					Credit Hours (Theory + Practical)
		L	T	P	Internal Examination			End Term Examination	Subject Total	
					Midterm Theory Examination	Assignment	Practical Examination			
SOA N506	Agriculture Research, Research Ethics and Rural Development Programme	1	0	0	30	20	-	50	100	1(1+0)