Ph.D. (Horticulture) Vegetable Science

PROGRAM SYLLABUS (EMBEDDED WITH COs)

School of Agriculture

ITM University, Gwalior, Madhya Pradesh 474001

SYLLABUS

WITH

EMBEDDED

COURSE OUTCOMES (COs)

Course Code: VSC-601	Course Name: Recent Trends in Vegetable Production	Semester: I

Credits	L	T	P	Max. Marks			Contact Hours (per week)	Independent Study Hours (per week)	Programmes
03	3	0	0	1	0	0	03		**Ph.D. Horticulture (Vegetable Science)**
Curriculum level							• Information based • Critical thinking based • Research based	Student specific course outcome	• Placement • Research • Higher education

Objective: To acquaint with the production technology of vegetable crops.

Course outcomes: After successful completion of the course, the students are expected to

CO-1	Students know the production technology, nutritional and economic importance of vegetable crops.
CO-2	Demonstration of nursery bed preparation and cultural practices of Cole crops and bulb crops.
CO-3	Examine the performance of different varieties of vegetables.
CO-4	Evaluate the performance of various vegetable crops on the basis of plant and fruit morphology.
CO-5	Development of museum for vegetable crops.

T1	Class room Lectures Laboratory/ Field Practicals Student Seminars/ Presentations
T2	ABL activities Field Tours/ Demonstrations Assignments

Assessment tools	
AT1-1	One Midterm Exam
AT1-2	Seminar Presentation and Report
AT1-3	Assignment
AT1-4	Activity Based Learning
AT1-5	Review writing

Course Contents	Module wise details	Assessment tools
CONTENTS	Present status and prospects of vegetable cultivation; nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching; Protected cultivation of vegetables, containerized culture for year round vegetable production; low cost polyhouse; nethouse production; crop modelling, organic gardening; vegetable production for pigments, export and processing of: **UNIT-I:**	Assignment ABL activities Mid term

	Solanaceous crops: Tomato, brinjal, chilli, sweet pepper and potato.	
	UNIT-II: *Cole crops:* Cabbage, cauliflower and knol-khol, sprouting broccoli.	Assignment ABL activities Mid term
	Unit-III: Okra, onion, peas and beans, amaranth and drumstick.	Assignment ABL activities Mid term
	Unit-IV: *Root crops and cucurbits*: Carrot, beet root, turnip and radish and cucurbits	Assignment ABL activities Mid term
	Unit-V: *Tuber crops:* Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.	Assignment ABL activities Mid term

References:	➢ S. Thamburaj. 2014. Text book of vegetable, tuber crops and Spices. ICAR, New Delhi. ➢ B.R.Choudhary 2009.AText book on production technology of vegetables. Kalyani Publishers. Ludhiana. ➢ T.K.Bose. 2002.Vegetable Crops. Nayaprakash. Kolkata ➢ P.Hazra. 2011. Modern Technology in Vegetable Production. New India Publishing Agency. New Delhi. ➢ M.K.Rana, 2008.Olericulture in India. Kalyani Publishers. Ludhiana ➢ P.Hazra. 2006.Vegetable science. Kalyani Publishers .Ludhiana ➢ Bose, T.K. 2003. Vegetable Crops. Nayaudyog publishers, Kolkata. 2002. NayaPrakash, Calcutta. ➢ Prem Singh Arya, 1999. Vegetable Seed Production Principles. Kalyani Publishers, New Delhi. ➢ Choudhery, B., 1990. Vegetables. 8th edition. National Book Trust, New Delhi.
Resources:	LCD, Black/White Board, Laboratory, CRC farm
Assignment/Tutorial:	Students are required to submit prepare lab manual, assignments and ABL activities as a part of their continuous evaluation system.
List of Assignments:	1) List of vegetable crops with their common name, botanical name, family, origin, chromosome number, fruit type and edible portion of fruit. 2) Description of varieties with their characteristics. 3) Various sowing and transplanting methods of vegetable crops. 4) Physiological disorders of Cole and Solanaceous vegetable crops. 5) Various insect-pest and diseases of vegetable crops.
E-Resources:	1. https://www.slideshare.net/UbaidAbdulKhaliq/new-trends-of-vegetable-production 2. https://www.slideshare.net/NIKHILAMBISHMEHTA/recent-techniques-in-vegetable-production-in-india 3. https://www.ijcmas.com/6-8-2017/Aditika,%20et%20al.pdf 4. https://www.curresweb.com/csi/csi/2022/csi.2022.11.4.34.pdf 5. https://iub.edu.pk/uploads/2340/books/1687764253-olericulture-science-of-vegetables-2.pdf

Course Code: VSC-603			Course Name: Abiotic Stress Management in Vegetable Crops				Semester: I
Credits	**L**	**T**	**P**	**Marks**	**Contact Hours (per week)**	**Independent Study Hour (per week)**	**Section (Group)**
3	2	0	1		4		**Ph.D. Horticulture (Vegetable Science)**
Curriculum level					Basic and applied	**Student specific course outcome**	Higher Education Placement Research

Objective: After successful completion of this course, the students are expected to:

Course outcomes: After completion of course, the student will be able to:

CO-1	Describe basic concepts of various methods and technologies used in Abiotic Stress Management in Vegetable Crops
CO-2	Explain the various procedures used for Abiotic Stress Management in Vegetable Crops
CO-3	Utilize the modern concepts and principles for Abiotic Stress Management in Vegetable Crops
CO-4	Investigate the suitability of different methods and technologies for the Abiotic Stress Management in Vegetable Crops
CO-5	Assess the various breeding strategies for Abiotic Stress Management in Vegetable Crops
CO-6	Formulate the breeding strategies for Management of various Abiotic Stress

Teaching Pedagogy:

T1	Activity based learning using different tools Flipped classes teaching model Collaborative learning Socratic method of teaching. Power Point Presentations.
T2	ABL activities Field demonstration of cultivation practices, Assignment Unannounced test Seminars with open discussions Group discussions or debate Quiz

Assessment tools	
AT1-1	Mid term Exams and end term exam
AT1-2	Assignment
AT1-3	Unannounced test
AT1-4	Activity Based Learning
AT1-5	Group discussions or debate
AT1-6	Skill test
AT1-7	Quiz
AT1-8	Extempore (student needs to explain the instant given topic as a teacher to all other students)
AT1-9	Seminar Presentation

Prerequisites	Unit wise contents details	Assessment tools
Course Contents	**Unit-I:** Environmental stress—its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.	Assignment, Quiz , Mid-term examinations
	Unit-II: Mechanism and measurements—tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.	Assignment, Unannounced test Mid and End Term Examinations
	Unit-III: Soil-plant-water relations—under different stress conditions in vegetable crops production and their management practices.	Skill test , Quiz. end term examinations
	Unit-IV: Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.	Group discussions or debate, Assignment, Extempore, End Term Examinations
	Unit-V: Use of chemicals—techniques of vegetable growing under high and low temperature conditions, use of chemicals and antitranspirants in alleviation of different stresses.	Seminar Presentation , Unannounced test, End term examination

Practical Exercise	List of practicals (field/lab exercises)	Assessment tools
	• 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.	
Resources:	LCD, OHP, Black Board, research field, Molecular Biology Laboratory	
Assignment/Tutorial:	Students are required to submit the given assignments and deliver one power point presentation as a part of their continuous evaluation system.	
List of Assignments	1. Application of MAS in Abiotic Stress management 2. Use of PGR in management of Abiotic Stress	

Suggested reading:	**A. Text and Reference books:** Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural crops. Narosa Publ. House. Dwivedi P and Dwivedi RS. 2005. Physiology of abiotic stress in plants. Agrobios. Janick JJ. 1986. Horticultural science. 4th Ed. WH Freeman and Co. Kaloo G and Singh K. 2001. Emerging scenario in vegetable research and development. Research periodicals and book publ. house. Kaloo G. 1994.Vegetable breeding. Vols. I-III. Vedams eBooks. Lerner HR. (Eds.). 1999. Plant responses to environmental stresses. Marcel Decker. Maloo SR. 2003. Abiotic stresses and crop productivity.Agrotech Publ. Academy. Narendra T. et al. 2012. Improving crops resistance to abiotic stress. Wiley and Sons.US. Peter KV and Pradeep Kumar T. 2008. Genetics and breeding of vegetables. (Revised Ed.). ICAR. Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables volume II.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p. Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p. Ram HH. 2001. Vegetable breeding. Kalyani. Rao NK. (Eds.). 2016. Abiotic stress physiology of horticultural crops. Springer publication.
Suggested e-resources (Websites/e-books)	1. https://biosafety.icar.gov.in/wp-content/uploads/2016/10/6_Biology_of_Solanum_lycoperscicum_Tomato.pdf 2. https://iimr.icar.gov.in/wp-content/uploads/2020/12/Biofortified-Varieties-Book_V3_ICAR.pdf 3. https://www.frontiersin.org/articles/10.3389/fpls.2017.01484/full 4. https://blog.ciat.cgiar.org/origin-of-crops/ 5. https://www.frontiersin.org/articles/10.3389/fpls.2022.1008904/full 6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9861506/ 7. http://www.cropwildrelatives.org/fileadmin/templates/cropwildrelatives.org/upload/documents/Wild_relatives_of_crops_plants_in_India_collection_and_conservation_Pandey_2005.pdf

Course Code: GPB-502	Course Name: Principles of Plant Breeding	Semester: I

Credits	L	T	P	Marks	Contact Hours (per week)	Independent Study Hour (per week)	Section (Group)
3	2	0	1		4		**Ph.D. Horticulture (Vegetable Science)**
Curriculum level					• Information based • Critical thinking based Research based	**Student specific course outcome**	Higher Education Placement Research

Objective: To impart the theoretical knowledge and practical skills about plant breeding objectives, modes of reproduction and genetic consequences, breeding methods for crop improvement.

Course outcomes: After completion of course, the student will be able to:

CO-1	Define the basic concept of crop improvement and genetic variation.
CO-2	Describe the various breeding methods, their draw backs and significance.
CO-3	Demonstrate the skill on emasculation, pollination and hybridization.
CO-4	Differentiate the inbred lines and hybrids, composite and synthetic varieties.
CO-5	Problems based on heritability, genetic advances and genetic variations and the role of heterosis, inbreeding depression, heritability and genetic advances in plant breeding.

Teaching Pedagogy:

T1	Activity based learning through field experiments on modeling of SPC's and CPC's Power Point Presentations
T2	ABL activities Assignments Flip Class/Seminar Quiz Field trial

Assessment tools	
AT1-1	Mid term Exams and End term examination
AT1-2	Seminar Presentation
AT1-3	Industrial Visit Report
AT1-4	Quiz
AT1-5	Poster
AT1-6	Activity Based Learning
AT1-7	Flip Class
AT1-8	Spot Identification
AT1-9	Report writing
AT1-10	Field trial
AT1-11	Herbarium
AT1-12	Viva voce

Prerequisites	Unit wise contents details	Assessment tools
Course Contents	**Unit–1** History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants- Centres of Origin-biodiversity and its significance. Plant genetic recourses and its conservation.	Field trial AB L Quiz
	Unit–2 Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction.	Field Trial Report Writing Poster Presentation Mid Term Examination
	Unit–3 Self-incompatibility and male sterility in crop plants and their commercial exploitation. General and specific combining ability; Types of gene actions and implications in plant breeding; Plant introduction and utilization.	Skill test , Quiz. end term examinations
	Unit–4 Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in self-pollinated crops (diallel selective mating approach), Stability model analysis.	Seminar Presentation Industrial Visit Report Quiz
	Unit-5 Breeding methods in cross pollinated crops; Population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter population improvement and development of synthetics and composites; Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds.	Seminar Presentation Review writing Report writing
	Unit-6 Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection. Self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Transgressive breeding.	Seminar Presentation Industrial Visit Report Quiz
	Unit-7 Special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses. Cultivar development- testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.	Field trial ABL Quiz End term examination

Practical Exercise* (Min-8)	List of practicals (field/lab exercises)	Assessment tools
	• Seed treatment/ hardening practices • Floral biology in self and cross pollinated species, selfing and crossing techniques. • Selection methods in segregating populations and evaluation of breeding material • Analysis of variance (ANOVA)	Practical Activity Practical Record Viva voce

	• Estimation of heritability and genetic advance • Maintenance of experimental records; • Learning techniques in hybrid seed production using male-sterility in field crops.	Spot Identification Herbarium File
Resources:	LCD, OHP, Black Board, Horticulture lab and tools, Gardens, and field for demonstration,	
Assignment/ Tutorial:	Students are required to submit the given assignments and deliver one power point presentation as a part of their continuous evaluation system.	
List of Assignments	1. Patterns of Evolution in Crop Plants 2. Mating system sand response to selection 3. Self-incompatibility and male sterility in crop plants. 4. Population breeding in self-pollinated 5. Breeding approaches for improvement of inbreds 6. Special breeding techniques-Mutation breeding 7. Plant breeders' rights and regulations for plant variety protection and farmers rights	
Projects based learning	Attachment to seed production industry	
Suggested reading:	**A. Text and Reference books:** 1. Allard R W. 1981. *Principles of Plant Breeding*. John Wiley & Sons. 2. Chopra VL. 2001. *Breeding Field Crops*. Oxford & IBH. 3. ChopraVL.2004. *Plant Breeding*. Oxford & IBH. 4. Gupta S K. 2005. *Practical Plant Breeding*. Agribios. 5. Pohlman J M & Bothakur D N.1972.*Breeding Asian Field Crops*. Oxford & IBH. 6. Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*.Narosa Publ. House. 7. Sharma JR. 2001. *Principles and Practice of Plant Breeding*. TataMcGraw- Hill. 8. Simmonds NW. 1990. *Principles of Crop Improvement*. English LanguageBook Society. 9. Singh B D.2006. *Plant Breeding*. Kalyani. 10. Singh P. 2002. *Objective Genetics and Plant Breeding*. Kalyani. 11. Singh P. 2006. *Essentials of Plant Breeding*. Kalyani. Singh S & Pawarl S. 2006. *Genetic Bases and Methods of Plant Breeding*. CBS.	
Suggested e-resources (Websites/e-books)	1. "BiomesoftheWorld"-MissouriBotanicalGarden 2. DragonflyWeb Pages 3. Eco-SensorWeb-livedatafromtheNationalBotanicGarden,Irelandwith online tours and elementary-level activities 4. FloraDelaterre,ThePlantDetective -learnaboutmedicinalplantsandlisten to radio audio clips 5. FunFactsaboutFungi 6. JuniorMasterGardener 7. Kid'sValleyWebgarden-K-5pageongrowingplants,understanding flowers, veggies, herbs, shrubs and more 8. Photosynthesis,EnergyandLife-anelementaryschoolsciencesite 9. PlantWatch-partofCanada'sNatureWatchcitizensciencepro grams 10. TheGreatPlantEscape-acleverchapterfor4thand5thgraders,6activities and a teacher's guide 11. TheScienceofGardening -fromtheExploratorium 12. YoungNaturalist'sPage-afocusonplantsof Florida 13. FactMonster-includesscience(!) 14. TheWWWVirtualLibrary:ScienceFairs -searchsciencefairprojects 15. TryScience -agatewaytosciencecentersandonlineactivities GardeningWithChildren-ResourcestoEncourageKidstoPlant	

Course Code: STAT-511	Course Name: Experimental Designs	Semester: I

Credits	L	T	P	Marks	Contact Hours(per week)	Independent StudyHour (per week)	Section (Group)
3	2	0	1		4		**Ph.D. Horticulture (Vegetable Science)**
Curriculum level					Information based Critical thinking based Research based	**Student specificcourse outcome**	Placement Research Higher education

Objective: To educate about concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Course outcomes: After completion of course, the student will be able to:

CO-1	To provide knowledge about the basic concept of designing of field experiment
CO-2	Understand the concept of Factorial experiments, Split plot and strip plot designs
CO-3	To educate about concept of analysis of covariance in basic designs and confounding in factorial experiments
CO-4	To get idea about complete and incomplete block designs and its uses in the field of agriculture
CO-5	Get acquainted with use of different softwares for the statistical analysis of different designs
CO-6	Design various field experiments to overcome different problems in Agriculture for sustainable development

Teaching Pedagogy:

T1	Classroom Lectures/Guest lectures Student Seminars/Presentations
T2	ABL activities Assignments

Assessment tools:	
AT-1	One Midterm Exam
AT-2	Seminar, Presentation
AT-3	Assignment
AT-4	Activity Based Learning

Prerequisites	Unit wise contents details	Assessment tools
	Unit – 1 Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.	Classroom teaching ABL
	Unit – 2 Uniformity trials, size and shape of plots and blocks; Analysis of variance; completely randomized design, randomized block design and Latin square	Assignment Unannounced test Mid Term

	design.	examination
	Unit – 3 Factorial experiments, (symmetrical as well as asymmetrical). Orthogonality and partitioning of degrees of freedom. Concept of confounding.	Quiz Assignment
	Unit – 4 Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.	ABL Assignment Quiz

Practical Exercise*(Min-8)	**List of practicals**	**Assessment tools**
	1. Analysis of data obtained from CRD 2. Analysis of data obtained from RBD 3. Analysis of data obtained from LSD 4. Analysis of factorial experiments without and with confounding 5. Analysis of Split plot Design 6. Analysis of Strip plot design 7. Transformation of data 8. Uniformity Trial data analysis	Practical Activity Practical Record Viva voce

Resources:	LCD, Black/White Board, Computer Lab
Assignment/Tutorial:	Students are required to submit one assignment and attend quiz as a part of their continuous evaluation system.
List of Assignments	1. Examples of different designs 2. Analysis of different designs in Various softwares
Suggested reading:	**A. Textbooks:** 1. Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd. 2. Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer. 3. Federer WT. 1985. Experimental Designs. MacMillan. 4. Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley. 5. Cochran WG and Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley. 6. Montgomery DC. 2012. Design and Analysis of Experiments, 8th Ed. John Wiley. **B. Reference Book:** 1. Gupta, S. C. and Kapoor, V. K. 2007. Fundamentals of Applied Statistics. Sultan Chand and sons. New Delhi 2. Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ. 3. Rangaswamy, R.1995. *A Text Book of Agricultural Statistics*. New Age International Publishing Limited, Hyderabad.
Suggested e-reading:	http://apps.iasri.res.in/ebook/EBADAT/2-Basic%20Statistical%20Techniques/9-Fundamentals%20Of%20Designsf.pdf http://apps.iasri.res.in/ebook/EBADAT/2-Basic%20Statistical%20Techniques/17-factoriallectf.pdf

Course Code: STAT 522 Course Name: Data Analysis Using Statistical Packages Semester: 1Ind

Credits	L	T	P	Marks			Contact Hours (per week)	Independent Study Hour (per week)	Section (Group)
3	2	0	1				4		**Ph.D. Horticulture (Vegetable Science)**
Curriculum level							Information based Critical thinking based Research based	Student specific course outcome	Placement Research Higher education

Objective: To understand different statistical packages like Excel, SPSS, SAS, R, and Python for enhancing practical proficiency in data analysis.

Course outcomes: Through this course students will be able to:

CO-1	To Gain a solid understanding of fundamental statistical concepts and develop skills to explore and visualize data effectively using statistical packages, fostering the ability to identify patterns, trends, and outliers.
CO-2	Develop skills to clean and preprocess raw data effectively and acquire proficiency in conducting statistical inference
CO-3	Learn advanced techniques in multivariate analysis, such as ANOVA and MANOVA, to analyze complex relationships among multiple variables simultaneously.
CO-4	Able to develop the ability to interpret statistical results in the context of the problem domain, translating findings into actionable insights for decision-makers.
CO-5	Gain hands-on experience with popular statistical packages like Excel, SPSS, SAS, R, and Python for enhancing practical proficiency in data analysis.
CO-6	Apply data analysis techniques to real-world scenarios, solving practical problems and making data-driven decisions in the field of Agriculture.

Teaching Pedagogy:

T1	Classroom Lectures/Guest lectures Student Seminars/Presentations
T2	ABL activities Assignments

Assessment tools:	
AT-1	One Midterm Exam
AT-2	Seminar, Presentation
AT-3	Assignment
AT-4	Activity Based Learning

Prerequisites	Module wise details	Assessment tools
Course Contents	Unit – 1 Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.	Classroom teaching ABL
	Unit – 2	Assignment Unannounced test

	Test for normality; Testing of hypothesis using chi-square, t and F statistics and Z-test.	Mid Term examination
	Unit – 3 Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.	Quiz Assignment
	Unit – 4 Analysis of mixed models; Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.	ABL Assignment Quiz
	Unit-V Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.	End term examination ABL Viva Voce

Practical Exercise* (Min-8)	**Course Modules**	**Assessment tools**
	1. Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data 2. Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, one-way analysis of variance 3. Designs for Factorial Experiments, fixed effect models, random effect models, mixed effect models, estimation of variance components 4. Linear regression, Multiple regression, Regression plots 5. Discriminant analysis - fitting of discriminant functions, identification of important variables 6. Factor analysis. Principal component analysis - obtaining principal component.	Practical Activity Practical Record Viva voce
Resources:	LCD, White Board, Computer Lab.	
Assignment/Tutorial	Students are required to submit one assignment and attend quiz as a part of their continuous evaluation system.	
List of Assignments	1. Data analysis using SPSS software. 2. Data analysis using SAS software. 3. Data analysis using R software. 4. Data analysis using Python software.	
ABL	Shot term courses of Python, SPSS, SAS and R Software.	
Suggested reading:	**A.** Textbooks: **1)** Anderson C.W. and Loynes R.M. 1987. The Teaching of Practical Statistics. John Wiley. **2)** Atkinson A.C. 1985. Plots Transformations and Regression. Oxford University Press. **3)** Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. Graphical Methods for Data Analysis. Wadsworth,	

Belmount, California.

4) Chatfield C. 1983. Statistics for Technology. 3rd Ed. Chapman & Hall. Chatfield C. 1995. Problem Solving: A Statistician's Guide. Chapman & Hall.

5) Cleveland W.S. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.

6) Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.

7) Erickson B.H. and Nosanchuk T.A. 1992. Understanding Data. 2nd Ed. Open University Press, Milton Keynes.

8) Snell E.J. and Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman and Hall.

9) Sprent P. 1993. Applied Non-parametric Statistical Methods. 2nd Ed. Chapman & Hall.

10) Tufte ER. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire, Conn.

11) Velleman PF and Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press

Reference books:

1) Rangaswamy, R.1995. *A Text Book of Agricultural Statistics*. New Age International Publishing Limited, Hyderabad.

2) Gupta, S. C. and Kapoor, V. K. 2014. Fundamentals of Mathematical Statistics. Sultan Chand and sons. New Delhi

Course Code: PGS-501	Course Name: Library and Information Services	Semester: I

Credits	L	T	P	Marks	Contact Hours (per week)	Independent Study Hour (per week)	Section (Group)
1	0	0	1		2		**Ph.D. Horticulture (Vegetable Science)**
Curriculum level					Basic, applied and Innovative	**Student specific course outcome**	Higher Education Placement Research Entrepreneurship

Objective: To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Course outcomes: After completion of course, the student will be able to:

CO-1	Describe about the information and knowledge resources
CO-2	Carry out literature survey
CO-3	Apply the modern tools (Internet, OPAC, search engines, etc.) of information search
CO-4	Equip the students/scholars with skills to trace information from libraries efficiently
CO-5	Formulate information search strategies

Teaching Pedagogy:

T1	Activity based learning using different tools Flipped classes teaching model Collaborative learning Socratic method of teaching. Power Point Presentations.
T2	ABL activities Field demonstration of cultivation practices, Assignment Unannounced test Seminars with open discussions Group discussions or debate Quiz

Assessment tools	
AT1-1	Mid-term Exams and end term exam
AT1-2	Assignment
AT1-3	Unannounced test
AT1-4	Activity Based Learning
AT1-5	Group discussions or debate
AT1-6	Skill test
AT1-7	Quiz
AT1-8	Extempore (student needs to explain the instant given topic as a teacher to all other students)
AT1-9	Seminar Presentation

Practical Exercise* (Min-8)	List of practicals (field/lab exercises)	Assessment tools
	1. Introduction to library and its services; 2. Role of libraries in education, research and technology transfer; Classification systems and organization of library; 3. Sources of information- Primary Sources, 4. Secondary Sources and Tertiary Sources; 5. Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc); Tracing information from reference sources; 6. Literature survey; Citation techniques/ Preparation of bibliography; 7. Use of CD-ROM Databases, 8. Online Public Access Catalogue and other computerized library services; 9. Use of Internet including search engines and its resources; E Resources access methods.	Spot Identification Practical Activity Practical Record Attendance Viva voce
Resources:	LCD, Black/White Board, Library	
Assignment/ Tutorial:	Students are required to submit the given assignments and deliver one power point presentation as a part of their continuous evaluation system.	
List of Assignments	1. Application of SCOPUS for scientific profile and scientific writing 2. Application of WoS for scientific profile and scientific writing 3. Application of reference management tools like Mendeley, EndNote, Paperpile *etc*. for scientific writing	
Suggested reading:	**A. Text and Reference books:** 1. James HS. 1994. Handbook for Technical Writing. NTC Business Books. 2. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press. 3. Sethi J &Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India. 4. Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.	
Suggested e-resources (Websites/e-books)	1. https://www.scopus.com/sources.uri?zone=TopNavBar&origin=searchbasic 2. https://mjl.clarivate.com/home	

Course Code: PGS-501	Course Name: Technical Writing and Communications Skill	Semester: I

Credits	L	T	P	Marks	Contact Hours (per week)	Independent Study Hour (per week)	Section (Group)
1	0	0	1		2		**Ph.D. Horticulture (Vegetable Science)**
Curriculum level					• Information based • Critical thinking based • Research based	**Student specific course outcome**	Higher Education Placement Research Entrepreneurship

Objective: To equip the students/ scholars with skills to write dissertations, research papers, etc. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Course outcomes: After completion of course, the student will be able to:

CO-1	Define various aspects of technical writing and communication skills.
CO-2	Translate scientific literatures for effective draft of technical writings.
CO-3	Apply the writing and communication skills at scientific platform.
CO-4	Relate the various scientific works on the given research ideas.
CO-5	Reframe the sentences for effective communication and will be able to articulate in English.
CO-6	Design and draft dissertations, research communication and research reports.

Teaching Pedagogy:

T1	Activity based learning
T2	Assignment Worksheets Report writing Group discussions or debate Quiz

Assessment tools	
AT1-1	Assignment
AT1-2	Worksheet
AT1-3	Quiz
AT1-4	Report Writing
AT1-5	Group Discussion
AT1-6	Review writing
AT1-7	Presentation

Practical Exercise* (Min-8)	List of practicals (field/lab exercises)	Assessment tools
	UNIT-1: Technical Writing - Introduction 1. Various forms of scientific writings- theses, technical	Evaluation will be done to understand the students'

	papers, reviews, manuals, etc. 2. Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion). **UNIT-2: Technical Writing – How to write thesis or a research communication?** 3. Writing of abstracts, summaries, précis, citations etc. 4. Commonly used abbreviations in the theses and research communications. 5. Illustrations, photographs and drawings with suitable captions. 6. Pagination, numbering of tables and illustrations. **UNIT-3: Technical Writing – Referencing, proof reading and writing review article** 7. Writing of numbers and dates in scientific write-ups. 8. Referencing styles in thesis and research communications. 9. Editing and proof-reading. 10. Writing of a review article. **UNIT-4: Communication Skills – verbal and writing** 11. Grammar (Tenses, parts of speech, clauses, punctuation marks). 12. Error analysis (Common errors); Concord; Collocation. 13. Phonetic symbols and transcription. 14. Accentual pattern. 15. Weak forms in connected speech. **UNIT-5: Communication Skills – GD, interview and presentation** 16. Participation in group discussion. 17. Facing an interview. • Presentation of scientific papers.	ability to utilize the skill set learnt. The assessment tools include: Assignment, Presentation, Worksheet, Quiz, Report Writing, Group Discussion, and Review writing.
Resources:	LCD, Black/White Board, Computer Laboratory	
Assignment/ Tutorial:	Students are required to submit the given assignments and deliver one power point presentation as a part of their continuous evaluation system.	
List of Assignments	1. Preparation of preliminary body of thesis/ dissertation. 2. Draft of references in MLA and APA style. 3. Draft of references in Chicago and Harvard style. 4. Draft of references in Harvard and Vancouver style. 5. Draft of references in MLA and Chicago style.	
Suggested reading:	**A. Text and Reference books:** 1. James HS. 1994. Handbook for Technical Writing. NTC Business Books. 2. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press. 3. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India. 4. Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.	

Course Code: PGS-503	Course Name: Intellectual Property and its Management in Agriculture	Semester: I

Credits	L	T	P	Marks	Contact Hours (per week)	Independent Study Hour (per week)	Section (Group)
1	1	0	0		1		**Ph.D. Horticulture (Vegetable Science)**
Curriculum level					Basic, applied and Innovative	**Student specific course outcome**	Higher Education Placement Research Entrepreneurship

Objective: The main objective of this course is to equip students and stakeholders with knowledge of Intellectual Property Rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Course outcomes: After completion of course, the student will be able to:

CO-1	Define various aspects of IPR.
CO-2	Elaborate scope of various types of IPRs in agriculture.
CO-3	Understand the significance of various national and international initiatives for biodiversity protection.
CO-4	Apply the approach of IPRs for protection.
CO-5	Equip the students/scholars with skills to apply for IPR.

Teaching Pedagogy:

T1	Activity based learning using different tools Flipped classes teaching model Collaborative learning Socratic method of teaching. Power Point Presentations.
T2	ABL activities Field demonstration of cultivation practices, Assignment Unannounced test Seminars with open discussions Group discussions or debate Quiz

Assessment tools	
AT1-1	Mid-term Exams and end term exam
AT1-2	Assignment
AT1-3	Unannounced test
AT1-4	Activity Based Learning
AT1-5	Group discussions or debate
AT1-6	Skill test
AT1-7	Quiz
AT1-8	Extempore (student needs to explain the instant given topic as a teacher to all other students)
AT1-9	Seminar Presentation

Prerequisites	Unit wise contents details	Teaching Pedagogy	Assessment tools
Course Contents	**UNIT-I: History of IPR:** Historical perspectives and need for the introduction of Intellectual Property Right regime. TRIPs and various provisions in TRIPS Agreement.	Socratic method, Presentation	Assignment, Quiz , Mid-term examinations
	UNIT II: Introduction to IPR: Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs.Indian Legislations for the protection of various types of Intellectual Properties.	Flipped classes teaching model, Discussions, Field demonstration (ABL)	Assignment, Unannounced test Mid and End Term Examinations
	UNIT III: Fundamentals of IPRs: 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.	Lecture method/ Presentation Field demonstration (ABL)	Skill test , Quiz. end term examinations
	UNIT IV: Protection of IPR: Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection.	Collaborative learning, Lecture method, ABL	Group discussions or debate, Assignment, Extempore, End Term Examinations
	UNIT V: National and International initiatives: National Biodiversity protection initiatives; Convention on Biological Diversity.International Treaty on Plant Genetic Resources for Food and Agriculture.Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.	Flipped classes teaching model, Discussions and Presentation, ABL	Seminar Presentation, Unannounced test, End term examination
Resources:	LCD, Black/White Board, Library		
Assignment/ Tutorial:	Students are required to submit the given assignments and deliver one power point presentation as a part of their continuous evaluation system.		
List of Assignments	1. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000 2. PPV and FR Act 2001, and Rules 2003 3. The Biological Diversity Act, 2002		
Suggested reading:	**A. Text and Reference books:** 1. Erbisch FH and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI. 2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill. 3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies. 4. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation. 5. Rothschild M and Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI. 6. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing 5.Countries: A Compendium on Law and Policies. Daya Publ. House.		
Suggested e-resources (Websites/e-books)	1. https://www.meity.gov.in/writereaddata/files/National_IPR_Policy.pdf 2. https://icar.org.in/sites/default/files/ICAR%20Guidelines%20for%20IPM%20and%20Technology%20Transfer_2018-1.pdf		

Course Code: PGS-504	Course Name: Basic concepts in laboratory techniques	Semester: II

Credits	L	T	P	Marks	Contact Hours (per week)	Independent Study Hour (per week)	Section (Group)
1	0	0	1		2		**Ph.D. Horticulture (Vegetable Science)**
Curriculum level					Basic, applied and Innovative	**Student specific course outcome**	Higher Education Placement Research Entrepreneurship

Objective: To acquaint the students about the basics of commonly used techniques in laboratory.

Course outcomes: After completion of course, the student will be able to:

CO-1	Describe the basic concepts and working principles of common laboratory instruments and techniques
CO-2	Explain the SOPs of various equipment and techniques used in different laboratories
CO-3	Demonstrate the analysis of physiochemical, molecular analysis using different equipment and techniques and solve problems with trouble shooting.
CO-4	Examine the results of various lab analysis with scientific explanation
CO-5	Assess the precision level of laboratory instruments and techniques and find the suitable methods for performing the different lab analyses

Teaching Pedagogy:

T1	Activity based learning using different tools Flipped classes teaching model Collaborative learning Socratic method of teaching. Power Point Presentations.
T2	ABL activities Field demonstration of cultivation practices, Assignment Unannounced test Seminars with open discussions Group discussions or debate Quiz

Assessment tools	
AT1-1	Mid-term Exams and end term exam
AT1-2	Assignment
AT1-3	Unannounced test
AT1-4	Activity Based Learning
AT1-5	Group discussions or debate
AT1-6	Skill test
AT1-7	Quiz
AT1-8	Extempore (student needs to explain the instant given topic as a teacher to all other students)
AT1-9	Seminar Presentation

Practical Exercise* (Min-8)	List of practical's (field/lab exercises)	Assessment tools
	• Safety measures while in Lab; • Handling of chemical substances; • Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; • 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; • Neutralisation 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.	Spot Identification Practical Activity Practical Record Attendance Viva voce
Resources:	Bio-chemistry Laboratory, Departmental laboratories	
Assignment/Tutorial:	Students are required to submit the given assignments and deliver one power point presentation as a part of their continuous evaluation system.	
List of Assignments	1. Principle of working of different lab instruments 2. Sterilization techniques 3. Tissue culture Media composition and preparation	
Suggested reading:	**A. Text and Reference books:** 1. Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press. Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.	
Suggested e-resources (Websites/e-books)	1. https://faculty.ksu.edu.sa/sites/default/files/1_identification_of_the_common_laboratory_glassware_pipettes_and_equipment_.pdf 2.https://ncert.nic.in/ncerts/l/kelm202.pdf 3.https://5.imimg.com/data5/BW/FG/MY-7710909/glass-reaction-cum-distillation-unit.pdf 4.https://www.borosil.com/site/assets/files/2618/labglassware_catalogue_2021.pdf	

Course Code: PGS-505	Course Name: Agricultural research, research ethics and rural development programmes	Semester: II

Credits	L	T	P	Marks	Contact Hours (per week)	Independent Study Hour (per week)	Section (Group)
1	1	0	0		1		**Ph.D. Horticulture (Vegetable Science)**
Curriculum level					Basic, applied and Innovative	**Student specific course outcome**	Higher Education Placement Research Entrepreneurship

Objective: To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Course outcomes: After completion of course, the student will be able to:

CO-1	Define various aspects of agricultural research.
CO-2	Understand the research ethics.
CO-3	Apply the skill for rural development programmes.
CO-4	Relate the functioning of agricultural research systems at national and international levels.
CO-5	Equip the students/scholars with skills to perform research.

Teaching Pedagogy:

T1	Activity based learning using different tools Flipped classes teaching model Collaborative learning Socratic method of teaching. Power Point Presentations.
T2	ABL activities Field demonstration of cultivation practices, Assignment Unannounced test Seminars with open discussions Group discussions or debate Quiz

Assessment tools	
AT1-1	Mid-term Exams and end term exam
AT1-2	Assignment
AT1-3	Unannounced test
AT1-4	Activity Based Learning
AT1-5	Group discussions or debate
AT1-6	Skill test
AT1-7	Quiz
AT1-8	Extempore (student needs to explain the instant given topic as a teacher to all other students)
AT1-9	Seminar Presentation

Prerequisites	Unit wise contents details	Teaching Pedagogy	Assessment tools
Course Contents	**UNIT-I:** Agricultural Research: History of agriculture in brief. Global agricultural research system: need, scope, opportunities. Role in promoting food security, reducing poverty and protecting the environment.	Socratic method, Presentation	Assignment, Quiz, Mid-term examinations
	UNIT II: NARS and CGIAR: National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions. Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (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.	Flipped classes teaching model, Discussions, Field demonstration (ABL)	Assignment, Unannounced test Mid and End Term Examinations
	UNIT III: Research Ethics: Research ethics: research integrity, research safety in laboratories. Welfare of animals used in research, computer ethics. Standards and problems in research ethics.	Lecture method/ Presentation Field demonstration (ABL)	Skill test, Quiz. end term examinations
	UNIT IV: RDP- Concept and policies: 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, Voluntary Agencies/ Non-Governmental Organisations.	Collaborative learning, Lecture method, ABL	Group discussions or debate, Assignment, Extempore, End Term Examinations
	UNIT V: RDP- Evaluation and implementation: Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.	Flipped classes teaching model, Discussions and Presentation, ABL	Seminar Presentation, Unannounced test, End term examination
Resources:	LCD, Black/White Board, Library		
Assignment/ Tutorial:	Students are required to submit the given assignments and deliver one power point presentation as a part of their continuous evaluation system.		
List of Assignments	1. Case studies on NARS 2. Case studies on RDP 3. Case studies on Research ethics		
Suggested reading:	**A. Text and Reference books:** 1. Bhalla GS and Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ. 2. Punia MS. Manual on International Research and Research Ethics. CCS Haryana Agricultural University, Hisar. 3. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ. 4. Singh K. 1998. Rural Development - Principles, Policies and Management. Sage 6.Publ.		
Suggested e-resources (Websites/e-books)	1.https://www.fao.org/3/i1307e/i1307e.pdf 2.https://icar.org.in/files/reports/icar-dare-annual-reports/2013-14/NAIP-13-14.pdf 3.https://icar.org.in/files/advcn.pdf		