Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya,
Chitrakoot, Satna (M.P.)
Statute No. 9, Faculty Board of Studies, Section-15 (3)
For Ph.D. in Biochemistry

Minutes of the Meeting

The meeting of the Board of Studies for Ph.D. in Biochemistry programme is held on 25.03.2023 at 11.00 A.M. in the Dean office, faculty of Agriculture. The committee for Board of Studies of Ph. D. in Biochemistry constituted as follow :-

S.N.	Name of the Members	Designation & Address	Committee position	Signature
1.	Dr. D. P. Rai	Dean, Faculty of Agriculture	Chairman	
2.	Prof. Veeru Prakash,	Head ,Deptt. of Biochemistry and Biochemical Engg.,SHUATS, Naini, Prayagraj(U.P.)	External Expert	
3.	Dr. Pawan. Sirothia	Asso.Prof. (Soil Sci.) Head, Deptt. of NRM	Member	
4.	Dr. U.S. Mishra	Associate Prof. (Soil Sci.) Deptt. of NRM	Member	
5.	Dr. K. K. Singh	Prof. (Ag. Ext.) Head, Deptt. of Transfer Technology	Member	
6	Dr. H.S. Kushwaha	Prof.(Agronomy)	Member	
7	Dr. S.S. Gautam	Associate Prof. (Agril. Statistics)	Member	
8	Dr. Y.K. Singh	Associate Prof. Deptt. of Transfer Technology	Member	
9	Dr. S. S. Singh	Asst. Prof. (Horticulture)	Member	
10	Dr. S.P. Mishra	Asso.Prof. (Ag. Bioch.) Head, Deptt. Of Crop Sciences	Member Secretary	25/3/2023

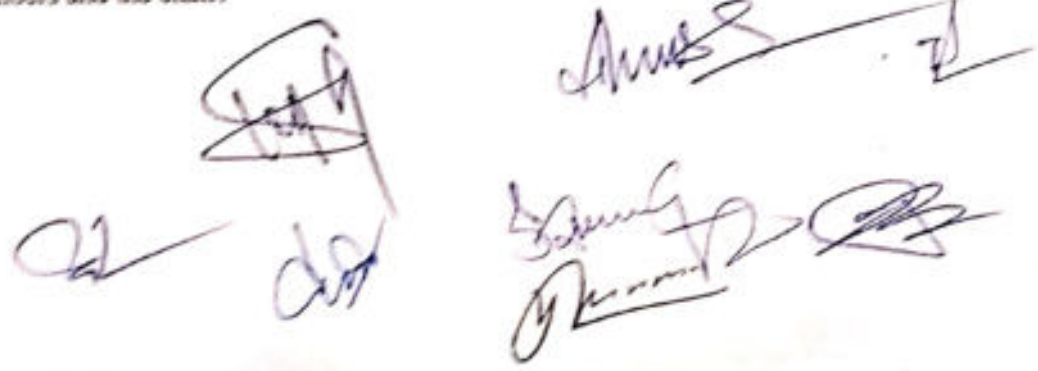
The Following issued were discussed:

1. Implementation of new course structure:
   The ICAR has revised and restructured Doctoral syllabi in various disciplines of agriculture and allied sciences with the view to equip the students to gain knowledge enhance their employability and skill sets towards entrepreneurship and global competitiveness. It is heartening to note that to comply various provisions of National Education Policy- 2020 due care have taken following flexible, multi-disciplinary and holistic approach while developing the syllabus and academic regulations. Further, the

Teaching Assistantship has been introduced to provide experience to the Ph.D. Scholars on teaching, evaluation and other related academic matters. This is an important part of doctoral training all over the world and it is expected to enrich the students.

1. All the Committee Members discussed on the name of course and suggested that, the name of Degree should be Ph.D. in Biochemistry as per the BSMA ICAR has revised restructured Doctoral on the basis of National Education Policy-2020 as per the ICAR rule.
2. The Course Curriculum of Ph. D in Biochemistry as per the ICAR has revised restructured Doctoral on the basis of National Education Policy-2020 as per the ICAR accreditation committee report was discussed and courses proposed was critically examined. The committee members also discussed thoroughly semester wise breakup of the courses. The valuable advice of the members have been incorporated in the light of course breakup as per prescribed by the BSMA ICAR has revised restructured Doctoral on the basis of National Education Policy-2020 as per the ICAR accreditation committee report. The Syllabus of Ph.D in Biochemistry courses and approved the courses and their contents.
3. All the members interacted and finally agreed for 102 credit load and same courses have been approved by the committee as given in Appendix I
4. The course curriculum will be applicable from academic session of 2022-23 Ph.D in Biochemistry and onward.
5. For Ph.D in Biochemistry programme, the registration date of commencement of first semester (date of fee deposition) is to be considered for calculating time period of degree programme.
6. The RDC (Research Development Committee) of Ph. D in Biochemistry programme is to be conducted at the end of first Semester of Ph.D. degree programme.
7. Ph.D. in Biochemistry programme is to be offered abiding the rules/norms as it is stated in I.C.A.R.

The meeting ended with a vote of thanks to the esteemed external members, faculty members and the chair.



Faculty of Agriculture, Department of Crop Sciences,

Ph.D. Programme in Biochemistry

Semester wise course breakup

Credit Distribution of Ph.D. In Biochemistry

S.N.	Course	Credits
1	Major Courses	12
2	Minor Courses	07
3	Supporting Courses	06
4	Seminar	02
5	Thesis Research	75
	Total	102

Semester wise course breakup

Semester I

S.N.	Course No.	Course Title	Credits
Major Courses			
1	Biochem 601	Advanced Enzymology	3(2+1)
2	Biochem 602	Advanced Molecular Biology	3(3+0)
Minor Courses			
3	SOIL 602	Modern Concept in Soil Fertility	2(2+0)
Supporting Courses			
4	STAT -604	Advance Statistical Methods	3(2+1)
		Total Credit	**11 (9+2)**

Semester II

S.N.	Course No.	Name of the course	Credits
Major Courses			
1	Biochem 603	Biochemistry of Biotic and Abiotic Stresses	3(3+0)
2	Biochemistry 607	Application of Techniques in Biochemistry	3(1+2)
Minor Courses			
3	Biochem 604	Frontier Topics in Biochemistry	2(2+0)
4	VSC 607	Biotechnologial Approaches in Vegetable Crops	3(2+1)
Supporting Courses			
6	STAT - 612	Advanced Design of Experiments	3(2+1)
		Total Credit	**14(10+4)**

Semester III

S.N.	Course No.	Course Title	Credits
1.	Biochem 691	Doctoral Seminar	1(0+1)
2.	Biochem 699	Doctoral Research	25(0+25)
		Total Credit	**26(0+26)**

Semester IV

S.N.	Course No.	Course Title	Credits
1.	Biochem- 692	Doctoral Seminar	1(0+1)
2.	Biochem- 699	Doctoral Research	25(0+25)
		Total Credit	**26 (0+26)**

Semester V

S.N.	Course No.	Course Title	Credits
1.	Biochem 699	Doctoral Research	25(0+25)
		Total Credit	**25 (0+25)**

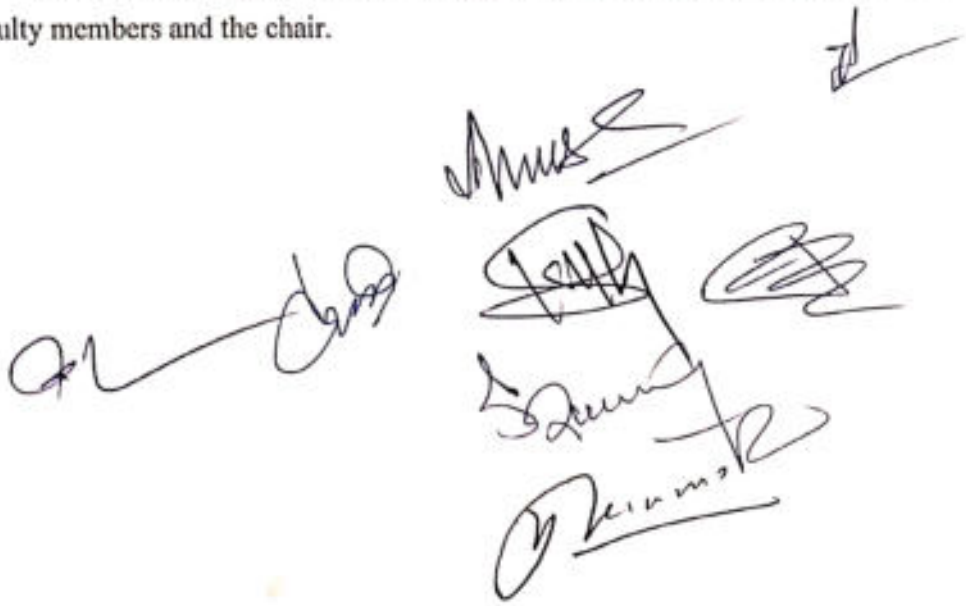
Semester VI

S.N.	Course No.	Course Title	Credits
1.	Thesis writing and submission		
		I,II,III,IV,V & VI Semester Total Credit	**102 (19+83)**

Note:

1. Curricula research may be given in any semester as per according to need.
2. For calculating time period of Ph.D. in Biochemistry degree, registration date of commencement of first semester (date of fee deposition) is to be considered for the degree programme.
3. The RDC (Research Development Committee) of Ph.D. in Biochemistry programme is to be conducted at the end of first Semester of Ph.D. degree programme.
4. Written comprehensive viz. Major and Minor Exam is to be conducted with completion of major and minor courses respectively, by Major Supervisor/Guide. The students must have cleared (60 % passing marks) Major and Minor courses offered for the degree programme.
5. Oral comprehensive exam is to be conducted in coordination of Supervisor and Advisory committee by external examiner after completion of written comprehensive.

The meeting ended with a vote of thanks to the esteemed external members, Faculty members and the chair.



- Chang, Y-C.(ed). 2019. *Microbial Biodegradation of Xenobiotic Compounds*. CRC Press
- Costas Ioannides (ed). 2002. Enzyme Systems that Metabolise Drugs and Other Xenobiotics. WILEY
- Lee, P., , Aizawa, H., Gan, L., Prakash, C. And Zhong, D. 2014. *Handbook of Metabolic Pathways of Xenobiotics*. WILEY
- Emerson, M. L. 2012. Xenobiotics: *New Research*. Nova Science
- Shamaan, N. A. 2008.*Biochemistry of xenobiotics : towards a healty lifestyle and safe environment*.PenerbitUniversiti Putra Malaysia.

Ph.D. Syllabus

CODE	COURSE TITLE	CREDITS
BIOCHEM 601*	ADVANCED ENZYMOLOGY	2+1
BIOCHEM 602	ADVANCED MOLECULAR BIOLOGY	3+0
BIOCHEM 603	BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES	3+0
BIOCHEM 604	FRONTIER TOPICS IN BIOCHEMISTRY	2+0
BIOCHEM 605	CONCEPTS AND APLICATION OF OMICS IN BIOLOGICAL SCIENCE	3+0
BIOCHEM 606	BIOMEMBRANES	2+0
BIOCHEM 607*	APPLICATION OF TECHNIQUES IN BIOCHEMISTRY	1+2
BIOCHEM 691	DOCTORAL SEMINAR I	1+0
BIOCHEM 692	DOCTORAL SEMINAR II	1+0
BIOCHEM 699	DOCTORAL RESEARCH	75

*Core course

Credit: 2+1

Course Code: BIOCHEM 601*

Title: ADVANCED ENZYMOLOGY

WHY THIS COURSE?

The course will make the students able to make a conceptual analysis of the enzymatic reaction mechanism and know the principles of the application of enzymes in analytical biochemistry, and some industrial applications.

AIM OF THE COURSE

To provide advanced knowledge about the structure of enzymes, mechanism, kinetics and regulation of enzymatic reactions and use of enzymes as biosensors.

No.	Blocks	Units
1.	**Enzymology and enzyme engineering**	1. Enzyme catalysis and specificity
		2. Enzyme kinetics
		3. Enzyme mechanism and regulation
		4. Industrial enzymology

LEARNING OUTCOMES

After completing the course students will understand the mode of action of enzymes, mechanisms of enzymatic catalysis and also possible applications of enzymes in various technological processes.

BLOCK 1:ENZYMOLOGY AND ENZYME ENGINEERING

Unit 1: Enzyme catalysis and specificity(Seven lectures)

Theory of enzymatic catalysis, Specificity and editing mechanisms, concept of active site and enzyme substrate complex, active site mapping, factors associated with catalytic efficiency, mechanism of enzyme reactions,detection of intermediates in enzymatic reactions.

Unit 2: Enzyme kinetics(Seven lectures)

Transition state theory, Arrhenius equation, Determination of energy of activation, effect of pH and temperature on enzyme kinetics, pre-steady state and steady state kinetics, single substrate kinetics, allosteric enzymes and mixed inhibition, substrate and product inhibition, numerical exercises.

Unit 3: Enzyme mechanism and regulation(Seven lectures)

Mechanism determination by radioisotope exchange, role of enzymes in regulation of metabolism, bifunctional enzymes, pseudoenzyme and enzyme promiscuity, extremozymes, catalytic nucleic acids (ribozymes, catalytic DNA).

Unit 4: Industrial enzymology(Seven lectures)

Advantages and disadvantages of biocatalysis in technology driven processes, stabilization and regeneration of enzyme systems used in biotechnology, protein engineering of enzymes, creation of chimeric, bifunctional, immobilization of enzymes, semisynthetic enzymes and their use as industrial biocatalysts, and their practical significance, modern information technologies in enzyme engineering.

PRACTICALS

1. Purification and characterization of some model enzymes (peroxidise, α-amylase, lipase)
2. Study kinetics of inhibited and un inhibited enzyme catalysed reactions
3. Determination of Km values of single substrate reactions
4. Determination of enzyme activity by coupled assay
5. Electrophoretic separation of isozymes
6. Enzyme immobilization.

TEACHING METHODS / ACTIVITIES

- Classroom lectures (oral + audio-visual)
- Assignment (Reading/Writing)
- Oral presentation by students on specified topics
- Class room quiz
- Case study

RESOURCES

- Aehle, W. 2007. *Enzymes in Industry. Production and Application.* (Third, Completely Revised Edition). WILEY-VCH Verlag GmbH & Co. KGaA
- Buchholz, K., Bornscheuer, U., Kasche, V. 2012. *Biocatalysts and Enzyme Technology*. UK: Wiley-VCH Verlag GmbH

99

- Fessner, W. and Anthonsen, T. 2009. *Modern Biocatalysis*. Germany: Wiley-VCH Verlag GmbH
- Frey, P.A. and Hegeman,, A.D. 2007. *Enzymatic Reaction Mechanisms*. Oxford University Press
- Young Je Yoo, Yan Feng, Yong-Hwan Kim, Camila Flor J. Yagonia. 2017. *Fundamentals of Enzyme Engineering*. Springer

Credit: 3+0

Course Code: BIOCHEM 602

Title: ADVANCED MOLECULAR BIOLOGY

WHY THIS COURSE?

To impart knowledge on genome organization and analysis, gene expression and its regulation and modern techniques for genome.

AIM OF THE COURSE

To provide latest information on structure and organisation of genetic materials; genes, their expression in plants and biochemical approaches employed in genetic engineering.

No.	Blocks	Units
1.	**Genome organisation and manipulation**	1. Concepts of gene and genome
		2. Regulation of gene expression
		3. Techniques in genome analysis
		4. Techniques for gene transfer and genome manipulation
		5. Aspects of molecular breeding

LEARNING OUTCOMES

On completion of this course, studentswill get an insight into the genome structure, its organization and means for its manipulation for applications in areas such as human and animal health, agriculture, and the environment.

BLOCK 1:GENOME ORGANISATION AND MANIPULATION

Unit 1: Concepts of gene and genome(Five lectures)

Genes, their relationship with chromosomes, gene number hypothesis; Genome – definition, variation and organization in plants and animals, structure of organelle genomes; concept of epigenome, genome size and genome evolution.

Unit 2: Regulation of gene expression(Six lectures)

Prokaryotic and eukaryotic gene regulation, transcriptional and posttranscriptional regulation; regulation at genome level, role of histones, riboswitches.

Unit 3: Techniques in genome analysis(Six lectures)

Genome sequencing technologies, Sanger sequencing, next generation sequencing, nanopore sequencing; genome mapping – genetic map construction, physical mapping.

Unit 4: Techniques for gene transfer and genome manipulation(Six lectures)

Methods of gene isolation and transfer in plants and animals, agrobacterium mediated and direct transfer of genes in plants and animals; gene silencing technologies: virus induced gene silencing, RNA interface; genome editing -TALENs, CRISPR/cas, ZFN and their application, site directed mutagenesis,Application of genetic engineering in different fields, gene therapy.

Unit 5: Aspects of molecular breeding(Five lectures)

Genome browsing, primer design, marker application for breeding, application of MAS in case studies. Bioethics and bio safety guidelines, IPR in recombinant DNA research

TEACHING METHODS / ACTIVITIES

- Classroom lectures (oral + audio-visual)
- Assignment (Reading/Writing)
- Oral presentation by students on specified topics
- Class room quiz
- Case study

RESOURCES

- Brown, T. A. 2018. *Genomes 4*. Garland Science
- Rippe, K. 2011. *Genome Organization and Function in the Cell Nucleus*. Wiley-VCH Verlag
- Primrose, S. B. and Twyman, R.2006. *Principle of Gene Manipulation and Genomics*. 7th edition. Blackwell Publishing
- Christopher Howe. 2007. *Gene Cloning and Manipulation*. 2nd edition. Cambridge University Press
- S. Mohan Jain, D S Brar.(eds.). 2009. *Molecular Techniques in Crop Improvement*. 2nd edition. Springer
- Boopathi, N. M. 2013. Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits. Springer
- Brown, T. A. 2010. *Gene Cloning and DNA Analysis. An Introduction*. Wiley-Blackwell
- Singh, K. K. 2015. *Biotechnology and Intellectual Property Rights. Legal and Social Implications*. Springer

Credit: 3+0

Course Code: BIOCHEM 603

Title: BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES

WHY THIS COURSE?

Plants are constantly confronted to both abiotic and biotic stresses that seriously reduce their productivity. Plant responses to these stresses involve numerous physiological, biochemical, molecular, and cellular adaptations. This course will help to have an insight into the mechanism underlying the stress tolerance and to elucidate the molecular basis of stress adaptation.

AIM OF THE COURSE

To impart knowledge on biochemistry of biotic and abiotic stresses in plants.

No.	Blocks	Units

1.	**Biochemistry of biotic and abiotic stresses**	1. Plant-pathogen interaction and disease development
		2. Biochemistry of plant defence mechanisms
		3. Plant host-virus interaction
		4. Biochemical basis of abiotic stresses
		5. Tolerance against biotic and abiotic stress

LEARNING OUTCOMES

Upon completion of the course, students will get the suite of molecular and cellular processes that are triggered by plant stress responses.

BLOCK 1:BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES

Unit 1: Plant-pathogen interaction and disease development(Four lectures)

Molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants.

Unit 2: Biochemistry of plant defence mechanisms(Seven lectures)

Role of secondary metabolites, Plant defence response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance, pathogen derived resistance

Unit 3: Plant host-virus interaction(Four lectures)

Plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viroids.

Unit 4: Biochemical basis of abiotic stresses(Seven lectures)

Biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavy metals, air and water pollutants, synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses; stress adaptation

Unit 5: Tolerance against stress(Six lectures)

Reactive oxygen species and biotic and abiotic stress, antioxidants, enzymes of defense system. Role of calcium, nitric oxide and salicylic acid in plant development. Molecular strategies for imparting tolerance against biotic and abiotic stress.

TEACHING METHODS / ACTIVITIES

- Classroom lectures (oral + audio-visual)
- Assignment (Reading/Writing)
- Oral presentation by students on specified topics
- Class room quiz
- Case study

RESOURCES

- Buchanan, Bob B., Gruisem, W. and Jones, R. 2015. Biochemistry and molecular biology of plants, 2nd edition, Wiley Blackwell
- Dresselhaus, T. and Hückelhoven, R. (Eds.) 2019. *Biotic and Abiotic Stress Responses in Crop Plants.* MDPI. https://doi.org/10.3390/agronomy8110267
- Rout, G. R. and Das, A. B. 2013. *Molecular Stress Physiology of Plants*. Springer. DOI 10.1007/978-81-322-0807-5
- Shanker, A. K. and Shanker, C. (Eds.) 2016. *Abiotic and Biotic Stress in Plants - Recent Advances and Future Perspectives.* InTech. http://dx.doi.org/10.5772/60477
- Ramakrishna, A. and Gill, S. S. 2018. Metabolic Adaptations in Plants During Abiotic Stress. CRC Press
- Khan, M. I. R. and Khan, N. A. (Eds.). 2017. *Reactive Oxygen Species and Antioxidant Systems in Plants: Role and Regulation under Abiotic Stress*. Springer
- Smirnoff, N. (ed.) 2005. Antioxidants and reactive oxygen species in plants, Blackwell

Credit: 2+0

Course Code: BIOCHEM 604

Title: FRONTIER TOPICS IN BIOCHEMISTRY

WHY THIS COURSE?

To update the students to the recent developments in various fields of biochemistry.

AIM OF THE COURSE

To acquaint the students with the advanced developments in the field of biochemistry and to inculcate the habit of searching and reading the topics of current importance.

No.	Blocks	Units
1.	**Frontier topics in Biochemistry**	**There will be 8 Units related to different areas in Biochemistry**

LEARNING OUTCOMES

Students will build up the habit of searching and studying the topics of current importance and the recent developments in the field of biochemistry.

BLOCK 1: FRONTIER TOPICS IN BIOCHEMISTRY

Unit 1: Latest development in metabolic nutrition.

Unit 2: Latest development in environmental and industrial biochemistry.

Unit 3: Latest development in molecular biology techniques.

Unit 4: Latest development in metabolic engineering.

Unit 5: Latest development in regulation of gene expression.

Unit 6: Latest development in biotic and abiotic stress response in plants.

Unit 7: Latest development in protein chemistry.

Unit 8: Topics related to recent approaches concerning application of biochemical tools and techniques

- Shinitzky, M. 2008. *Biomembranes: Structural and Functional Aspects.* VCH. DOI:10.1002/9783527616114
- Berk, A., Kaiser, C. A., Lodish, H., Amon, A., Ploegh, H., Bretscher, A., Krieger, M. And Martin, K. C. 2016. *Molecular Cell Biology.* Macmillan Learning
- Stillwell, W. 2013. *An Introduction to Biological Membrane: From Bilayers to Rafts.* Elsevier
- Yeagle, P. 2016. *The Membranes of Cell.* 3rd edition. Academic Press

Credit: 1+2

Course Code: BIOCHEM 607*

Title: APPLICATION OF TECHNIQUES IN BIOCHEMISTRY

WHY THIS COURSE?

This course will provide the students the theoretical basis of various separation techniques and their application with practical experience in the use of different biochemical and molecular biology techniques.

AIM OF THE COURSE

To train students the application ofcuttingedge laboratory techniques in research in biochemistry and molecular biology.

No.	Blocks	Units
1.	**Application of techniques in Biochemistry**	1. Isolation, purification and analysis of metabolites
		2. Electrophoretic separation
		3. Application of centrifugation
		4. Enzyme techniques
		5. Molecular biology and immunochemical techniques

LEARNING OUTCOMES

This course will help the students in acquiring the laboratory skills required for success in experimental biochemistry and molecular biology.

BLOCK 1:APPLICATION OF TECHNIQUES IN BIOCHEMISTRY

Unit 1: Isolation, purification and analysis of metabolites(Three lectures)

Isolation and purification of important metabolites from microbial/plant/animal source, Applications of paper, thin layer and gas liquid chromatography, PAGE, FPLC and HPLC in the separation of biomolecules. Determination of molecular weight of protein using PAGE/ gel filtration method

Unit 2: Electrophoretic separation(Three lectures)

Electrophoretic separation of protein, Experiments on DNA: Isolation, agarose gel electrophoresis and restriction analysis of DNA. Techniques in DNA-protein and protein-protein interaction.

Unit 3: Application of centrifugation(Two lectures)

Isolation of chloroplast and mitochondria by differential centrifugation and their purification by density gradient centrifugation.

Unit 4: Enzyme techniques(three lectures)

Isolation, purification and characterization of enzymes, isozymic analysis and enzyme immobilization

Unit 5: Molecular biology and immunochemical techniques(Three lectures)

Application of PCR, yeast 2 hybrid system, Antigen-Antibody interaction, ELISA, Chromatin immunoprecipitation, gel based and gel free proteasome tools.

TEACHING METHODS / ACTIVITIES

- Classroom lectures (oral + audio-visual)
- Demonstration and hands on training
- Exposure visit to institutions equipped with modern facilities

25/3/2022

- Kaiser, K. 2011. *Analytical Techniques in Biochemistry and Molecular Biology*. Springer
- Wilson, K. and Walker, J. 2010. *Principles and Techniques of Biochemistry and Molecular Biology*. 7th Edition. Cambridge University Press
- Hegyi, G., Kardon, J., Kovács, M., Miklósi-Csizmadia, A., Nyitray, L. Pál, G. Radnai, L., Rusznyák, A. and Venekei, I. 2011. *Introduction to Practical Biochemistry*. Eötvös Loránd University

Journals

- Annual Review of Biochemistry
- Annual Review of Genetics
- Annual Review of Plant Physiology and Plant Molecular Biology
- Biochemical and Biophysical Research Communications
- Biochemical Journal
- Biochim. Biophys. Acta
- Cell
- Current Science
- Federation of European Biochemical Society
- Food Chemistry
- Indian Journal of Experimental Biology
- Journal of Agriculture and Food Chemistry
- Journal of Biological Chemistry
- Journal of Immunology
- Journal of Molecular Modelling
- Journal of Plant Biochemistry and Biotechnology
- Nature
- Physiologia Plantarum
- Plant Physiology
- Plant Science
- Planta
- Proceedings of National Academy of Sciences, USA

- Protein Science
- RNA
- Science
- Scientific American
- Trends in Biochemical Sciences
- Trends in Biotechnology
- Trends in Plant Sciences

25/3/2023

I. Course Title : Modern Concept in Soil Fertility
II. Course Code : Soil 602
III. Credit Hours : 2+0

Ph.D. Minor Syllabus.

IV. Aim of the course

To provide knowledge of modern concepts of soil fertility and nutrient use in crop production.

V. Theory

Unit I

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

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

Chemical equilibria (including solid-solution equilbria) involving nutrientions in soils, particularly in submerged soils; Kinetic studies of nutrients in soils.

Unit IV

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

Unit V

Modernconcepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

Unit VI

Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Unit VII

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.

VI. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

VIII. Suggested Reading

- Barber SA. 1995. *Soil Nutrient Bioavailability*. John Wiley & Sons.
- 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*. Crosby 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.

Glover MD. 1984. *Gene cloning: the mechanics of DNA manipulation*. Chapman and Hall.
Gordon H and Rubsell S. 1980. *Hormones and cell culture*. Alt Book Publ.
Kesavachandran R. 2007. *Recent trends in biotechnology of horticultural crops*. New India Publ. Agency.
Kesavachandran R and Peter KV. 2008. *Plant biotechnology, tissue culture and gene transfer*. Orient and Longman, USA.
Kesavachandran R. 2007. *Recent trends in biotechnology of horticultural crops*. New India Publication Agency. New Delhi.
Pamposulas NJ. (Ed.). 1981. *Genetic engineering in plant sciences*. Praeger Publ.
Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK and Mohanadas S. 2001. *Biotechnology of horticultural crops*. Vols I-III. Naya Prokash.
Pierik RLM. 1987. *In vitro culture of higher plants*. Martinus Nijhoff Publ.
Prasad S. 1989. *Impact of plant biotechnology on horticulture*. 2nd Ed. Agro Botanica.
Rout GR and Peter KV. 2010. *Genetic engineering of horticultural crops*. Academic Press Elsevier, USA.
Sharma R. 2000. *Plant tissue culture*. Campus Books.
Singh BD. 2010. *Biotechnology: expanding horizons*. Kalyani Publishers, New Delhi.
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, White DNR and Berg HR. 1979. *Somatic hybridization and genetic manipulation in plants, plant regulation and world agriculture*. Plenum Press.

Course Title : **Advanced Laboratory Techniques for Vegetable Crops**
Course Code : **VSC 608**
Credit Hours : **(1+2)**

Why this course ?

Accurate quality analysis of vegetables warrants stringent measurement protocols besides requisite instruments/ tools and laboratory facilities. Consequently, a specialized course is designed for imparting basic and applied training on physical and biochemical assessment of the vegetable produce.

Aim of the course

To familiarize with the laboratory techniques for analysis of vegetable crops.

The organisation of the course is as under:

No.	Blocks	Units
1	Advanced laboratory techniques for vegetable crops	I Safety measures and laboratory maintenance II Qualitative and quantitative analysis destructive and non destructive analysis methods III Chromatographic and microscopic analysis IV Sensory analysis

Theory

Unit I

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

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 underutilized)*. NBPGR, New Delhi.
Schapt 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. 2013. *Conservation of genetic resources*. Springer Verlag, Berlin

I. Course Title : **Biotechnological Approaches in Vegetable Crops**
II. Course Code : **VSC 607**
III. Credit Hours : **(2+1)**

IV. Why this course ?

Biotechnology is a rapidly developing area of contemporary science. It can bring new ideas, improved tools and novel approaches to the solution of some persistent, seemingly intractable problems in vegetable production. Given the pressing need to enhance and stabilize the vegetable production in response to mounting population pressures and increasing awareness, there is an urgent need to explore novel technologies that will break traditional barriers.

V. Aim of the course

To impart latest knowledge in biotechnical advancement in vegetable crops

The course is organised as follows:-

No.	Blocks	Units
1	Biotechnological approaches in vegetable crops	I Importance and scope of Biotechnology II Somatic embryogenesis III Blotting techniques, DNA finger printing. IV Plant genetic engineering V Concepts and methods of next generation sequencing (NGS)

VI. Theory

Unit I

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

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

Marker 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

Plant genetic engineering – Scope and importance. Concepts of oligenesis, integrenesis and cointegrenesis. Gene cloning. Direct and indirect methods of gene transfer. Role of RNAi based gene silencing in vegetable crop improvement. Bio-safety issue, regulatory issues for commercial approval.

Unit V

Concepts and methods of next generation sequencing (NGS). Genome sequencing, transcriptomics, proteomics, metabolomics. Genome editing (ZFN, TALENS and CRISPR).

Crops

Solanaceous crops, cole crops, cucurbitaceous crops, root vegetables, garden pea, okra, potato and leafy vegetables.

II. Practical

- *Micropropagation, Pollen, Ovule and Embryo culture. Synthetic seed production (2).*
- *In-vitro mutation induction, in-vitro rooting – hardening at primary and secondary nurseries (3).*
- *DNA isolation from economic vegetable crop varieties – Quantification and amplification (2).*
- *DNA and Protein profiling – molecular markers, PCR Handling (2).*
- *Vectors for cloning and particle bombardment (3).*
- *DNA fingerprinting of flower crop varieties (3).*
- *Project preparation for establishment of low, medium and high cost Tissue culture laboratories (1).*

III. Teaching Methods/ Activities

- *Class room lectures*
- *Laboratory, field practicals*
- *Student seminars/ presentations*
- *Field tours/ demonstrations*
- *Assignments*

IV. Learning outcome

The student would be expected to learn

- *Different biotechnological tools*
- *NGS, genetic engineering*

V. Suggested Reading

Bajaj YPS (Ed.) 1987. Biotechnology in agriculture and forestry. Vol. III. Wheat and Monocotyledons. Springer.

Chadha KL, Ravindran PN and Sahijram L. (Eds.) 2008. Biotechnology of horticulture and plantation crops. Malhotra Publ. House.

Debnath M. 2010. Tools and techniques of Biotechnology. Pointer publication, New Delhi.

components for unbalanced data and advanced techniques for analysis of data in agriculture.

V. Theory

Unit I

Gauss Markoff set up, Gauss Markoff's theorem, Rao's unified theory of linear estimation, test of hypothesis in linear models, Analysis of variance, partitioning of degrees of freedom, Restricted least squares, Special cases of one and two way classifications (including Proportionate cell frequencies and proportion, cross and nested classifications).

Unit II

Analysis of covariance, Variance components models, estimation of variance components from unbalanced data, Unified theory of least squares, MINQUE, MIVQUE, Mixed models, LAB, LASSO.

VI. Suggested Reading

- Bapat, R. B. (2012). *Linear Algebra and Linear Models*. Springer Verlag.
- Graybill, F. A. (1976). *Theory and Application of the Linear Model*. Duxbury, North Scituate.
- Joshi, D. D. (2007). *Linear Estimation and Design of Experiments*. Wiley Eastern.
- Rao, C. R. (2001). *Linear Inference and its Applications*. Wiley Eastern.
- Searle, S. R. (1992). *Variance Components*. John Wiley.
- Searle, S. R. (1971). *Linear Models*. John Wiley.
- Silvey, S. D. (1969). *The Linear Hypothesis: A General Theory*. Griffin, Charles and Co. Ltd.
- Shuffe, H. (1959). *Analysis of Variance*. John Wiley.

I. Course Title : **Advanced Statistical Methods**

II. Course Code : **STAT 604**

III. Credit Hours : **2+1**

IV. Aim of the course

This is an advanced course in Statistical Methods that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject in agricultural sciences.

V. Theory

Unit I

Truncated and compound distributions. Fitting of orthogonal polynomials. Poissonian curves Categorical data analysis - loglinear models, Association between attributes. Variance stabilizingtransformations.

Unit II

Sampling distribution of correlation coefficient, regression coefficient, correlation ratio, intra class correlation coefficient.

Unit III

Non-central t, χ^2 and F distributions. Distributions of quadratic forms. Cochran's theorem. Tests for normality. Large sample tests. Tests of significance based on t, χ^2 and F distributions. Order statistics, distribution of r^{th} order statistics, joint

Unit II
Subjective Prior distribution of a parameter; Posterior Distribution of parameters using Bayes Theorem

Unit III
Informative and non-informative priors for Location and scale; Conjugate families -Discrete and Continuous and interpretation of Hyper-parameters of conjugates

Unit IV
Non-informative, improper and invariant priors for location and scale and in general settings.

Unit V
Bayesian Point Estimation – squared error loss, absolute error loss etc. Bayesian Interval Estimation – Credible Interval, interpretation and comparison with frequentist confidence Intervals

Unit VI
Bayesian Hypothesis Testing - Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem. Prior odds, Posterior odds, Bayes factor for various types of testing hypothesis problems

Unit VII
Bayesian Prediction; Numerical and Monte-Carlo Integrations

Unit VIII
Applications of Bayesian Inference - Bayesian Data Analysis

Suggested Reading

- Berger, J.O. 1985. *Statistical Decision Theory and Bayesian Analysis*, Springer Verlag.
- Box, G.P. and Tiao, G.C. 1992. *Bayesian Inference in StatisticalAnalysis*,Addison – Wesley
- Pilon C.D. 2015. *Bayesian Methods for Hackers: Probabilistic Programming and Bayesian Inference* (Addison-Wesley Data and Analytics)

Course Title : Advanced Design of Experiments
Course Code : STAT 612
Credit Hours : 2+1

Aim of the course
This is an advanced course in Design of Experiments that aims at describing some advanced level topics for students who wish to pursue research in Design of Experiments. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Theory

Unit I
General properties and analysis of block designs. Balancing criteria. *m*- associate PBIB designs, and their association schemes including lattice designs - properties and construction, Designs for test treatment – control(s) comparisons; Nested block designs, Mating designs.Structurally Incomplete block designs

Unit II

General properties and analysis of two-way heterogeneity designs, Youden type designs, generalized Youden designs, Pseudo Youdendesigns., Designs for two sets of treatments.

Unit III

Balanced factorial experiments - characterization and analysis (symmetrical and asymmetrical factorials). Factorial experiments with extra treatment(s). Orthogonal arrays. Mixed orthogonal arrays, balanced arrays, Fractional replication, Resolution plans. Regular and irregular fractions.

Unit IV

Response surface designs - Symmetrical and asymmetrical factorials, Response optimization and slope estimation, Blocking, Canonical analysis and ridge analysis, CCD, Box-Jenkins, Experiments with mixtures: design and analysis. Experiments with qualitative cum quantitative factors.

Unit V

Optimality criteria and optimality of designs, robustness of designs against loss of data, outliers, etc. Diagnostics in design of experiments.

II. Practical

Analysis of block designs, Analysis of Latin square type designs, group divisible designs, triangular designs, lattice designs. Analysis of fractional replications of factorial experiments, analysis of asymmetrical factorials and block designs with factorial structure. Analysis of second order response surface designs.

II. Suggested Reading

- Chakraborti M.C. 1962. *Mathematics of Design and Analysis of Experiments*. Asia Publ.House
- Dean A.M. and Voss D. 1999. *Design and Analysis of Experiments*.
- pringer. Dey A and Mukerjee R. 1999. *Fractional Factorial Plans*. John Wiley.
- Dey A 1986. *Theory of Block Designs*. Wiley Eastern.
- Hall M Jr. 1986. *Combinatorial Theory*. John Wiley.
- Hedayat A.S., Sloane N.J.A. and Stufken J. 1999. *Orthogonal Arrays: Theory and Applications*. Springer.
- John J.A. and Quenouille M.H. 1977. *Experiments: Design and Analysis*. Charles and Griffin.
- Khuri A.I. and Cornell J.A. 1996. *Response Surface Designs and Analysis*. 2nd Ed. Marcel Dekker.
- Montgomery D.C. 2005. *Design and Analysis of Experiments*. John Wiley.
- Ogawa J. 1974. *Statistical Theory of the Analysis of Experimental Designs*. Marcel Dekker.
- Parsad R, Gupta V.K., Batra P.K., Satpati S.K. and Biswas P. 2007. *Monograph on n-designs*. IASRI, New Delhi.
- Raghavarao D. 1971. *Construction and Combinatorial Problems in Design of Experiments*. John Wiley.
- Shah K.R. and Sinha B.K. 1989. *Theory of Optimal Designs. Lecture notes in Statistics*. Vol. 54. Springer.
- Sharma M.K. 2012. *Design and Analysis of Experiments*. Kindle Ed. 1st Ed.
- Street A.P. and Street D.J. 1987. *Combinatorics of Experimental Designs* Oxford Science Publ.
- Design Resources Server: www.drs.icar.gov.in.