

**Department of Plant Physiology**  
**Degree programme Ph.D. programme**

**Courses offer**

<b>Group</b>	<b>Number</b>	<b>Title of Course</b>	<b>Credit</b>
<b>Major</b>	1	PP 601 Functional Genomics and Genes Associated with a few Physiological Processes	2 (2+0)
	2	PP 602 Signal Perceptions and Transduction and Regulation of Physiological Processes	2 (2+0)
	3	PP 603 Molecular Approaches for Improving Physiological Traits	3 (2+1)
	4	PP 604 Techniques in Plant Physiology	3 (1+2)
	5	PP 605 Climate Change and Crop Growth	2 (2+0)
	6	PP 608 Seed Physiology	3 (2+1)
<b>Total</b>			<b>15(11+4)</b>
<b>Seminar</b>	PP 691	Credit Seminar – I & II	<b>2(0+2)</b>
<b>Thesis research</b>	PP 699	Research	<b>45(0+45)</b>
<b>Minor</b>	AGRON-603	Crop Production and System Modeling	3 (2+1)
	AGRON 604	Advances in Crop Growth and Productivity	3 (2+1)
	AGRON 605	Irrigation Management	3 (2+1)
<b>Total</b>			<b>9(6+3)</b>
<b>Supporting</b>	1	STAT 521 Applied Regression Analysis	3(2+1)
	2	STAT 531 Data Analysis Using Statistical Packages	3(2+1)
<b>Total</b>			<b>6 (4+2)</b>
<b>Total credit</b>			<b>77(21+56)</b>
<b>Non-Credit</b>	1.	PGS 501 Library and Information Services	0+1
<b>Compulsory Course</b>	2.	PGS 502 Technical Writing and Communications Skills	0+1
	3.	PGS 503 Intellectual Property and its Management in Agriculture	1+0
	4	PGS 504 Basic Concepts in Laboratory Techniques	0+1
	5	PGS 505 Agril Res. Ethics and Rural Dev. Programs	1+0
	6	PGS 506 Disaster Management	1+0
	7	-	Human value and Professional Ethics
<b>Total</b>			<b>8(4+4)</b>

**Department of Plant Physiology**  
**Degree programme Ph.D. programme**  
**Semester wise distribution of Course**

Course	Course Title	Code	Credits
<b>Semester- I</b>			
<b>Major</b>	Signal Perceptions and Transduction And Regulation of Physiological Processes	PP 602	2 (2+0)
	Molecular Approaches for Improving Physiological Traits	PP 603	3 (2+1)
	Climate Change and Crop Growth	PP 605	2 (2+0)
<b>Minor</b>	Crop Production and System Modeling	AGRON-603	3 (2+1)
<b>Supporting</b>	Applied Regression Analysis	STAT 521	3 (2+1)
<b>Compulsory NC</b>	Library Information Services	PGS 501	1(0+1)
	Intellectual Property Rights and its management	PGS 503	1(1+0)
	Basic concepts in Laboratory Techniques	PGS 504	1(0+1)
	Human Value and Professional Ethics	-	2(1+1)
<b>Semester- II</b>			
<b>Major</b>	Functional Genomics and Genes Associated with a few Physiological Processes	PP 601	2 (2+0)
	Techniques in Plant Physiology	PP 604	3 (1+2)
	Seed Physiology	PP 608	3 (2+1)
<b>Minor</b>	Advances in Crop Growth and Productivity	AGRON 604	3 (2+1)
	Irrigation Management	AGRON 605	3 (2+1)
<b>Supporting</b>	Data Analysis Using Statistical Packages	STAT 531	3 (2+1)
<b>Compulsory NC</b>	Technical Writing and Communication Skill	PGS 502	1(1+0)
	Agricultural Research Ethics and Rural Development Programme	PGS 505	1(1+0)
	Disaster Management	PGS 506	1(1+0)
<b>Semester- III</b>			
	Written and Oral Comprehensive Examination		NC
	Doctoral Research	PP 699	10 (0+10)
	Doctoral Seminar	PP 691	2(0+2)
<b>Semester- IV</b>			
	Doctoral Research	PP 699	10 (0+10)
<b>Semester- V</b>			
	Doctoral Research	PP 699	10 (0+10)
<b>Semester- VI</b>			
	Doctoral Research	PP 699	15 (0+15)

**Objective**                      To impart knowledge about physiological process of plant at molecular level.

**Theory**

**UNIT I**                      Gene discovery Finding Genes in Complex Plant System, Constructing Gene-Enriched Plant Genomic Libraries, In Silico Prediction of plant Gene Function, Quantitative Trait Locus Analysis as a Gene Discovery Tool.

**UNIT II**                      Genetic tools for plant development- Understanding the importance of mutants in unraveling the physiological processes – T-DNA insertion mutants, Gain in function Transposon mutagens, Transposition, Physical and Chemical mutagenesis, Gene and Enhancer Traps for Gene Discovery, High- Throughput TAIL-PCR as a Tool to identify DNA Flanking insertions, High-Throughput TILLING for functional Genomics.

**UNIT III**                      Gene knock out approaches Antisense technology, Virus induced gene silencing (VIGS), Custom Knock-outs with Haripin RNA-mediated Gene Silencing and other silencing tools, Complementation studies, DNA micro arrays.

**UNIT IV**                      Gene Over expression approaches Vector Construction for Gene Overexpression as a tool to Elucidate Gene Function; Transient expression, Transgenics.

**UNIT V**                      Proteomics Networking of Biotechnology for interpreting gene functions. Yeast two hybrid systems to study protein –protein interaction to study gene functions, Proteomics as a Functional Genomics Tool, Crystallographic and NMR approaches to determine protein structures.

**UNIT VI**                      Functional characterization of genes associated with important cellular processes influencing crop growth and development.

**UNIT VII**                      Case studies of genes controlling photosynthesis, respiration, photorespiration, fatty acid biosynthesis, nutrient uptake, flowering, seed protein quality and quantity.

**Suggested Readings**

Agrawal, Gand Rakwal R Plant Proteomics Panima Book Distributors

Leister, D Plant functional Genomics, Panima Book Distributors

Primrose SB & Twyman RM Principle of Genome Analysis and Genomics, Panima Book Distributors

Staya & Pratik Genomics and Genetic Engineering, New India Publishing Agency

**Objective**      To impart the knowledge about signaling of hormones and regulation of physiological processes.

**Theory**

**UNIT I**      General aspects Introduction to signaling-Long range (Diffusible) signaling and short range (contact) signaling. Components of signaling- Upstream components receptor and ligands concept-types of ligands and its relevance-receptor kinases-Two component sensing system. Downstream components G. proteins-second messengers-Cyclic AMP, adenylate cyclase cascade, cyclic GMP, calcium-calmodulin-Kinases-Effector molecules (transcription factor).

**UNIT II**      Hormone signaling Hormone binding receptors-Transduction process. Effector molecules and gene expression.

**UNIT III**      Specific signaling pathways of Auxins, Cytokinin, Gibberellins, Ethylene, ABA, Brassinosteroids which leads to formative effects. The cross talk in the signaling of different hormones-significance of studies with hormone action mutants.

**UNIT IV**      Light signaling Perception of light-pigments involved-activation of phytochrome/cryptochrome (study of mutants). Light signal transduction- Multiple signaling cascades-identification of signaling components through mutant analysis-changes in gene expression.

**UNIT V**      Abiotic stress signaling Sensing of environmental factors (Temperature- Osmotic-Ionic stress) Activation of specific molecules and secondary messengers-Activation of Down stream components-leading to stress gene expression. Case studies with different abiotic stresses.

**UNIT VI**      Cross talk between signaling pathways.

**UNIT VII**      Signal perception and transduction in plant defense responses Role of salicylic acid and active oxygen species.

**UNIT VIII**      Signaling cascade during leaf senescence, abscission, flowering and tuberisation

**UNIT IX**      Transcription factor as signaling regulatory tools for improving growth processes-Case studies Tbi- lateral branch development, Shi 4- grain shattering, GA1- Dwarfing.MADS, KNOX- flowering development, HAT 4- Shade development, AP2-EREBP- biotic/abiotic stresses.

**Suggested Readings**

Annual Review of Plant Physiology and Plant Molecular Biology

Buchanan, B Grussen, W Jones, R (Eds) Biochemistry and Molecular Biology of Plants American Society of Plant Physiology, USA

Pfannschmidt, T Plant Signal Transduction Methods and Protocols Humana Press

Selected articles from various journals.

**PP 603**                      **Molecular Approaches for Improving Physiological Traits**                      **2+1**

**Objective**                      To impart knowledge to improve the physiological traits using molecular approaches.

**Theory**

**UNIT I**                      Importance of Molecular Breeding for complex multi-gene controlled physiological traits and its relevance in augmenting trait based breeding. Physiological traits with relevance to growth, development, abiotic stress tolerance, nutrient acquisition, Approaches for accurate phenotyping of large germplasm accessions and/or mapping populations.

**UNIT II**                      The advantages of "Trait based" breeding approaches. Concept of segregation, independent assortment and linkage. The concept of molecular markers, various types of Dominant and Co-dominant marker systems.

**UNIT III**                      Relevance and development of mapping populations and genetic analysis using marker systems. Advantages of association mapping and the concept of linkage, LD decay and population structure.

**UNIT IV**                      Statistical analysis to assess the variance in phenotypic traits and molecular data. Assessment of genetic parameters such as heritability, genetic advance etc.

**UNIT V**                      Strategies for QTL introgression and Marker Assisted Selection (MAS). Map based cloning of novel genes and alleles. Allele mining

**UNIT VI**                      Transgenic approach in improving physiological processes- Introduction to GMOs and application in crop improvement; gene mining, sequence structure & function analysis using bioinformatics tools, identification of candidate genes for various physiological process associated with specific traits (such as stress tolerance) and their potential benefits in transgenic crops.

**UNIT VII**                      Cloning full-length candidate genes, stress inducible promoters, strategies to clone and characterize and make constructs for specific crops, gene stacking strategies, tissue specific expression and functional validation of genes.

**UNIT VIII**                      Transformation of crop plants-*Agrobacterium* and use of other organisms for transformation-particle gun transformation and other methods.

**UNIT IX**                      Selection of transformants- molecular analysis on the basis of qRT-PCR, Southern, Northern analysis and immunoassays; estimation of copy number. Concept of desirable number of independent events.

**UNIT X**                      Evaluation of transgenics on basis of empirical/physiological/biochemical process under specific conditions on the basis of gene function. Generation of T1 populations, event characterization and generation of molecular data as per the regulatory requirements.

**UNIT XI**                      Issues related to Biosafety and Registration of Transgenic Agricultural Organisms, methods to detect GMOs from agricultural products.

## Practical

- Phenotyping approaches for the different physiological traits.
- Genotyping options using gene-scan systems.
- Development of SSR, SNP and SCAR markers, resolution of polymorphism on agarose gels and PAGE, genotyping using a DNA sequencing machine, scoring of gels and assessment of polymorphisms.
- Statistical approaches to assess genetic variability, heritability and other parameters. Phylogenetic analysis, Principal component analysis and construction of dendrograms.
- Construction of Linkage map, QTL maps, population structure, LD decay etc leading to identification of QTLs, Bioinformatics – sequence analysis, structure analysis.
- Molecular biology - genomic/plasmid DNA isolation, RNA isolation. Full-length gene cloning, vector construction with specific promoter, gene stacking & transient assays. Transformation in model system, Crop transformation - *Agrobacterium* mediated transformation (in planta & invitro), particle-gun transformation.
- Evaluation of transgenics – semiquantitative & quantitative RT-PCR, southern blot, northern blot, western blot and ELISA, biochemical/physiological assay based on the function of gene & testing LOD.

## Suggested Readings

Hipkins, MF & Baku, NR Photosynthesis Energy Transduction A practical Approach  
Selected articles from various journals.

**PP 604                      Techniques in Plant Physiology                      1+2**

**Objective**                      To impart recent practical training to study various physiological processes in plants.

**Theory**

**UNIT I**                      Recent experimental techniques to study various physiological processes, Photosynthetic gas exchange measurements, light and CO<sub>2</sub> response curves-determination of relative limitations to photosynthesis; chlorophyll fluorescence measurements.

**UNIT II**                      Estimation of water use efficiency at whole plant and single leaf level. Use of stable isotopes to understand physiological processes.

**UNIT III**                      Radio isotopes in plant biology.

**UNIT IV**                      Tools and techniques (molecular and biochemical) to study physiological processes and to screen & assess stress responses in plants, such as (a) DNA & RNA isolation, cDNA synthesis & library construction, semiquantitative & quantitative RT-PCR, northern blot, immunoassays; (b) techniques for defined physiological processes.

**UNIT V**                      Methods to phenotype germplasm for specific physiological traits.

**UNIT VI**                      Quantification of mineral nutrients using advanced instruments like AAS, & ICP.

**UNIT VII**                      Techniques in plant transformation & analysis of transgenic plants

**UNIT VIII**                      Molecular markers- genetic distance and mapping population concept of linkage maps and identification of QTLs.

**UNIT IX**                      Instrumentation Acquaintance of the operation of specific instruments important in physiological research like Mass spec., phosphor-imager, DNA sequencer, spectro-fluorometer, oxygen electrode, etc.

**Practical**

- Photosynthetic gas exchange measurements, light and CO<sub>2</sub> response curves-determination of relative limitations to photosynthesis.
- Chlorophyll fluorescence measurements. Estimation of water use efficiency at whole plant and single leaf level.
- Use of stable and radioactive isotopes to understand physiological processes.
- DNA & RNA isolation, cDNA synthesis & library construction, semiquantitative & quantitative RT-PCR, northern blot, immunoassays.
- Techniques for defined physiological processes.
- Quantification of mineral nutrients using advanced instruments like AAS.

**Suggested Readings**

Dhopte MA & Manuel Livera M. 1986. Useful Techniques for Plant Scientists. Forum for Plant Physiologists, R. D. G., Aloka.

**PP 605**                      **Climate Change and Crop Growth**                      **2+0**

**Objective**                      To impart knowledge about climate change and its implication to crop growth.

**Theory**

**UNIT I**                      History and evidences of climate change and its implications. Effect of climate change on monsoons, hydrological cycle and water availability.

**UNIT II**                      Natural and anthropogenic activities and agricultural practices on GHG production, Monitoring of greenhouse gases and their influence on global warming and climate change, Ozone depletion leading to increased ionizing radiations and its implications on crop growth.

**UNIT III**                      Long-term and short-term projections of climate change effects on natural vegetations and ecosystems, crop-pest interaction, area shift, food production and supply.

**UNIT IV**                      Approaches to mitigate climate change through studies on plant responses.

**UNIT V**                      Direct and indirect effects of climate change on plant processes – phenology, net carbon assimilation, water relations, grain development and quality, nutrient acquisition and yield.

**UNIT VI**                      Conventional and biotechnological approaches to improve the crop adaptation to climate change. Relevance of “Genome wide mutants” to identify genes/processes for improved adaptation to changing environments

**UNIT VII**                      International conventions and global initiatives on Carbon sequestration, carbon trading.

### **Suggested Readings**

Abrol YP & Gadgil S. (Eds.). 1999. Rice in a Changing Climate.

Reddy KR & Hodges HF. 2000. Climate Change and Global Crop Productivity. CABI.

Watson RT, Zinyowera MC & Moss RH. 1998. The Regional Impacts of Climate Change - an Assessment of Vulnerability. Cambridge Univ. Press. 98



**Objective**

To apprise students regarding seed germination, dormancy and physiological processes involved in regulation of seed development

**Theory****UNIT I**

Seed and fruit development, seed and fruit abortion, proximate mechanism of seed and fruit abortion. Hereditary and environmental effect on seed development. Gene imprints and seed development.

**UNIT II**

Importance of seeds, seed structure and function, physiological and biochemical changes, environmental influences, physiology of seed and fruit development; seed and fruit abortion and means to overcome it; proximate mechanisms of seed and fruit abortion.

**UNIT III**

Structure of seeds and their storage resources, seed developmental patterns and source of assimilates for seed development.

**UNIT IV**

Pathway of movement of assimilates in developing grains of monocots and dicots, Chemical composition of seeds, Storage of carbohydrates, proteins and fats in seeds and their biosynthesis.

**UNIT V**

Seed respiration, mitochondrial activity, Seed ageing, Mobilization of stored resource in seeds, Chemistry of oxidation of starch, proteins and fats, Utilization of breakdown products by embryonic axis.

**UNIT VI**

Control processes in mobilization of stored resources, Role of embryonic axes, Gibberlin and  $\alpha$ -amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, Role of LEA proteins.

**UNIT VII**

Seed viability, Physiology of and means to prolong seed viability, Seed vigour concept, importance, measurement; invigoration methods and physiological basis of it, Seed dormancy, types and regulation, Means to overcome seed dormancy.

**Practical**

- Determination of seed storage proteins, Sink drawing ability of ovules, empty ovule technique, Alpha-amylase activity in germinating seeds.
- Role of GA in inducing amylase activity. Role of embryo in GA induced amylase activity, Protease and lipase activity in germinating seeds.
- Seed viability test and accelerated ageing test.
- Seed hardening/osmotic priming of seeds, seed respiration rates, seed viability losses through membrane leakage studies.

**Suggested Readings**

Bewley JD & Black M. 1985. Seed Physiology of Development and Germination. Plenum Publ.  
 Copeland LO & McDonald MB. Principles of Seed Sciences and Technology. Burgers Publ. Co.  
 Srivastav L M. Plant Growth and Development - Hormones and Environment, Academic Press. 101

**AGRON 603      Crop Production and System Modeling      (2+1)**

**Objective**      To familiarize the students about systems approach and to stimulate yields and growth of several crops under varied soil and weather conditions with different management practices and their optimization.

**Theory**

**UNIT I**      Systems classification; flow charts, modeling techniques and methods of integration-state, rates and driving variables, feedbacks and relational diagrams.

**UNIT II**      Elementary models for crop growth based on basic methods of classical growth analysis.

**UNIT III**      Crop modeling methods for crop-weather interaction, climate change and variability components.

**UNIT IV**      Potential production: leaf and canopy CO<sub>2</sub> assimilation, respiration, dry matter accumulation, crop phenology and dry matter distribution and development in different crops.

**UNIT V**      Production by moisture availability, potential evapotranspiration, water balance of the soil, and production with nutrient and moisture limitations.

**Practical**

- Simulation of elementary models for crop growth
- Simulation of potential production
- Simulation with limitations of water and nutrient management options
- Sensitivity analysis using different climatic years and crop management practices

**Suggested Readings**

Gordan G. 1992. System Simulation. 2nd Ed. Prentice Hall.

Kropff MJ & Vann Laar HH. (Ed.). 1993. Modelling Crop Weed Interactions.

Mathews RB, Kriff MJ, bachelet D and Vaanlaar HH. EDn. 1993. Modelling the Impact of Climate Change on Rice Production in Asia. CABI.

Penning de Vries FWT & Van Laar HH. (Eds.). 1982. Simulation of Plant Growth and Crop Production. Wageningen Centre for Agricultural Publications and Documentation, Netherlands.

Ritchie JT & Hanks J. 1991. Modelling Plant and Soil Systems. American Society of Agronomy, Madison.

Zeigler BP. 1976. Theory of Modeling and Simulation. John Wiley & Sons.

**AGRON 604      Advances in Crop Growth and Productivity      (2+1)**

**Objective**      To study the physiology of vegetative growth in relation to productive of different crops in various environments

**Theory**

**UNIT I**      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.

**UNIT II**      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.

**UNIT III**      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.

**UNIT IV**      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.

**Practical**

- Field measurement of root-shoot relationship in crops at different growth stages
- Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc
- 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 etc in intercropping
- Senescence and abscission indices
- Analysis of productivity trend in irrigated areas
- Analysis of productivity trend in un-irrigated areas.

**Suggested Readings**

Chopra VL & Paroda RS. 1984. Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants. Oxford and IBH.

Delvin RM & Vitham FH. 1986. Plant Physiology. CBS Publ.

Evans LT. 1996. Crop Evolution, Adaptation and Yield. Cambridge Univ. Press.

Gupta US. (Ed.). 1995. Production and Improvement of Crops for Drylands. Oxford & IBH.

Kramer PJ & Boyer JS. 1995. Water Relations of Plant and Soils. Academic Press.

Mukherjee S & Ghosh AK. 1996. Plant Physiology. Tata McGraw Hill.

Narwal SS, Politycka B & Goswami CL. 2007. Plant Physiology Research Methods. Scientific Publishers.

**AGRON 605      Irrigation Management      (2+1)**

**Objective**      To teach students about optimization of irrigation in different crops under variable agroclimatic conditions

**Theory**

**UNIT I**      Water resources of India, irrigation projects; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

**UNIT II**      Soil-plant-water relationships, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

**UNIT III**      Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

**UNIT IV**      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.

**UNIT V**      Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

**UNIT VI**      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.

**Practical**

- Determination of water infiltration characteristics and water holding capacity of soil profiles
- Moisture extraction pattern of crops
- Consumptive use, water requirement of a given cropping pattern for optimum/variable productivity
- Crop planning at the farm and project level
- Agronomic evaluation of irrigation projects, case studies

**Suggested Readings**

FAO. 1984. Irrigation Practice and Water Management. Oxford & IBH.  
Michael AM. 1978. Irrigation Theory and Practices. Vikas Publ.  
Mishra RR & 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 Publ.  
Sankara Reddy GH & Yellamananda Reddy 1995. Efficient Use of Irrigation Water Kalyani Publ.  
Gupta US. (Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH.  
Singh SS. 2006. Principles and Practices of Agronomy. Kalyani Publication

**STAT 521**      **Applied Regression Analysis**      **2+1**

**Objective**      The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multi-collinearity and heteroscedasticity.

**Theory**

**UNIT I**      Introduction to correlation analysis and its measures; Correlation from grouped data, Biserial correlation, Rank correlation; Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

**UNIT II**      Problem of correlated errors; Auto correlation; Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multicollinearity; Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

**UNIT III**      Examining the multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation; regression approach applied to analysis of variance in one way classification.

**UNIT IV**      Heteroscedastic models, Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

**Practical**

- Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses; Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection; Handling of correlated errors, multicollinearity; Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

**Suggested Readings**

Draper NR & Smith H. 1998. Applied Regression Analysis. 3<sup>rd</sup> Ed. John Wiley.  
Ezekiel M. 1963. Methods of Correlation and Regression Analysis. John Wiley.  
Kleinbaum DG, Kupper LL, Muller KE & Nizam A. 1998. Applied Regression Analysis and Multivariable Methods. Duxbury Press.  
Koutsoyiannis A. 1978. Theory of Econometrics. MacMillan.  
Kutner MH, Nachtsheim CJ & Neter J. 2004. Applied Linear Regression Models. 4<sup>th</sup> Ed. With Student CD. McGraw Hill.

**STAT 531**      **Data Analysis using Statistical Packages**      **2+1**

**Objective**      This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students a hands on experience in the analysis of their research data. This course is useful to all disciplines.

**Theory**

**UNIT I**      Use of Software packages for Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

**UNIT II**      Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, t and F statistics.

**UNIT III**      Concept of analysis of variance and covariance of data for single factor, multi-factor, one-way and multi-classified experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

**UNIT IV**      Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression.

**UNIT V**      Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Time series data; Spatial analysis; Neural networks.

**Practical**

- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data. Robust Estimation, Testing linearity and normality assumption, Estimation of trimmed means etc., Cross tabulation of data including its statistics, cell display and table format and means for different sub-classifications; Fitting and testing the goodness of fit of probability distributions; 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, contrast and its testing, pairwise comparisons; Multiway classified analysis of variance - cross-classification, nested classification, factorial set up, fixed effect models, random effect models, mixed effect models, estimation of variance components; Generalized linear models - analysis of unbalanced data sets, testing and significance of contrasts, Estimation of variance components in unbalanced data sets - maximum likelihood, ANOVA, REML, MINQUE; Bivariate and partial correlation, Distances-to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models-curve estimation models, examination of residuals; Discriminant analysis-fitting of discriminant functions, identification of important variables, Factor analysis. Principal component analysis - obtaining principal component, spectral composition; Analysis of time series data - fitting of ARIMA models, working out moving averages. Spatial analysis; Neural networks.

## Suggested Readings

- Anderson CW & Loynes RM. 1987. The Teaching of Practical Statistics. John Wiley.
- Atkinson AC. 1985. Plots Transformations and Regression. Oxford University Press.
- Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmont, California.
- Chatfield C & Collins AJ. 1980. Introduction to Multivariate Analysis. Chapman & Hall.
- Chatfield C. 1983. Statistics for Technology. 3<sup>rd</sup> Ed. Chapman & Hall.
- Chatfield C. 1995. Problem Solving A Statistician's Guide. Chapman & Hall.
- Cleveland WS. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.
- Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.
- Erickson BH & Nosanchuk TA. 1992. Understanding Data. 2<sup>nd</sup> Ed. Open University Press, Milton Keynes.
- Snell EJ & Simpson HR. 1991. Applied Statistics A Handbook of GENSTAT Analyses. Chapman & Hall.
- Sprent P. 1993. Applied Non-parametric Statistical Methods. 2<sup>nd</sup> Ed. Chapman & Hall.
- Tufte ER. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire, Conn.
- Velleman PF & Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.
- Weisberg S. 1985. Applied Linear Regression. John Wiley.
- Wetherill GB. 1982. Elementary Statistical Methods. Chapman & Hall.
- Wetherill GB. 1986. Regression Analysis with Applications. Chapman & Hall.
- Learning Statistics <http://freestatistics.altervista.org/en/learning.php>.
- Free Statistical Softwares <http://freestatistics.altervista.org/en/stat.php>.
- Statistics Glossary [http://www.cas.lancs.ac.uk/glossary\\_v1.1/main.html](http://www.cas.lancs.ac.uk/glossary_v1.1/main.html).
- Course on Experimental design  
<http://www.stat.sc.edu/~grego/course/stat706/>.
- Design Resources Server [www.iasri.res.in/design](http://www.iasri.res.in/design).
- Analysis of Data Design Resources Server.  
<http://www.iasri.res.in/design/Analysis%20of%20data/Analysis%20of%20Data.html>.

<b>PGS 501</b>	<b>Library and Information Services</b>	<b>1(0+1)</b>
<b>Objective</b>	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.	
<b>Practical</b>	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 (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; ere sources access methods.	
<b>PGS 504</b>	<b>Basic Concepts in Laboratory Techniques</b>	<b>1(0+1)</b>
<b>Objective</b>	To acquaint the students about the basics of commonly used techniques in laboratory.	
<b>Practical</b>	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; 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, sand bath, water bath, oil bath; 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	

### **Suggested Readings**

Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.

Gabb MH & Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.



**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.

**Theory**

**UNIT I** 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 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.

**UNIT II** Research ethics research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

**UNIT III** 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. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

**Suggested Readings**

Bhalla GS & Singh G. 2001. Indian Agriculture- Four Decades of Development. Sage Publ.

Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. Rural Development Strategies and Role of Institutions- Issues, Innovations and Initiatives.

Singh K.. 1998. Rural Development Principles, Policies and Management. Sage Publ.

**Objective** To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building.

**Theory**

**UNIT I** Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change Global warming, Sea Level rise, Ozone Depletion

**UNIT II** 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** 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.

**Suggested Readings**

Gupta HK. 2003. Disaster Management. Indian National Science Academy. Orient Blackswan.

Hodgkinson PE & Stewart M. 1991. Coping with Catastrophe A Handbook of Disaster Management. Routledge.

Sharma VK. 2001. Disaster Management. National Centre for Disaster Management, India.

**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).

**Practical**

- **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.; 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.

**Suggested Readings**

- Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India. Collins' Cobuild English Dictionary. 1995.
- Harper Collins. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed. Holt, Rinehart & Winston.
- Hornby AS. 2000. Comp.Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press. James HS. 1994. Handbook for Technical Writing. NTC Business Books.
- Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
- Mohan K. 2005. Speaking English Effectively. MacMillan India. Richard WS. 1969. Technical Writing.
- Barnes & Noble. Robert C. (Ed.). 2005. Spoken English Flourish Your Language.
- Abhishek. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2<sup>nd</sup>Ed. Prentice Hall of India.
- Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

### 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.

### Theory

- 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; 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; 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; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

### Suggested Readings

- Erbisch FH & 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. Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
- Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries A Compendium on Law and Policies. Daya Publ. House.
- The Indian Acts - Patents Act, 1970 and amendments;
- Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.