Department of Natural Resource Management
Faculty of Agriculture
Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, M.P.

Credit Distribution of Ph.D. (Agronomy)

S.N.	Course	Credits
(I)	**Course work**	
1	Major Subject	13
2	Minor Subject	07
3	Supporting subjects	06
4	Seminar	02
5	Thesis research	75
	Total	103

Semester wise course breakup

Semester I

S.N	Code	Name of the course	Credits
Major courses			
1	AGRON 601	Current trends in Agronomy	3(3+0)
2	AGRON 602	Recent trends in crop growth and productivity	3(2+1)
3	AGRON 603	Irrigation management	3(2+1)
Minor courses			
4	SOIL 602	Modern concept in soil fertility	2(2+0)
5	SOIL 603	Physical Chemistry of Soil	2(2+0)
Supporting courses			
6	STAT 604	Advance statistical method	3(2+1)
		Total	**16(13+3)**

Semester II

S.N	Code	Name of the course	Credits
Major courses			
1	AGRON 604	Recent trends in weed management	2(2+0)
2	AGRON 608	Research and publication ethics	2(2+0)
Minor courses			
3	SOIL 608	Clay Mineralogy	3(2+1)
Supporting courses			
5	STAT 612	Advanced Design of Experiments	3(2+1)
		Total	**10(08+2)**

Semester III

S.N.	Course No.	Course Title	Credits
1	AGRON 691	Doctoral seminar	1+0
2	AGRON 699	Doctoral research	0+25
3		Written comprehensive Exam (Major)	-
4		Written comprehensive Exam (Minor)	-
		Total	**26 (1+25)**

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Semester IV

S.N.	Course No	Course Title	Credits
1	AGRON 692	Doctoral seminar	1+0
2	AGRON 699	Doctoral research	0+25
3		Oral comprehensive	-
		Total	**26 (1+25)**

Semester V

S.N.	Course No	Course Title	Credits
1	AGRON 699	Doctoral research	0+25
		Total	**25 (0+25)**

Semester VI

S.N.	Course No	Course Title	Credits
1	Thesis writing and submission		

1. Four students to be admitted.
2. For calculating time period of PhD (Agronomy) 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 PhD (Agronomy) programme is to be conducted at the end of first semester of PhD degree programme.
4. Written comprehensive viz. Major and Minor exam is to be conducted with completion of major and minor courses respectively by faculty coordinated by department. 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 advisory committee by external examiner after successful completion of written comprehensive.

Department of Natural Resource Management
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Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, M.P.

Ph.D. (Agronomy)

SN	Code		
A.1		**Major Course**	**15 Credit (L+P)**
1.	AGRON 601	Current trends in Agronomy	3(3+0)
2.	AGRON 602	Recent trends in crop growth and productivity	3(2+1)
3.	AGRON 603	Irrigation management	3(2+1)
4.	AGRON 604	Recent trends in weed management	2(2+0)
5.	AGRON 608	Research and publication ethics	2(2+0)
6.	AGRON 691	Doctoral seminar	1(1+0)
7.	AGRON 692	Doctoral seminar	1(1+0)
A.2		**Minor Course**	**07 Credits (L+P)**
1.	SOIL 602	Modern concept in soil fertility	2(2+0)
2.	SOIL 603	Physical Chemistry of Soil	2(2+0)
3.	SOIL 608	Clay Mineralogy	3(2+1)
B.		**Supporting Course**	**06 Credits (L+P)**
1.	STAT 604	Advance statistical method	3(2+1)
2.	STAT 612	Advanced Design of Experiments	3(2+1)
C.	AGRON 699	**Thesis research** (Doctoral research)	**75 credits**
		Grand Total	**103 Credits**

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Course Title with Credit Load
Ph.D. in Agronomy

Course Code	Course Title	Credit Hours
Agron 601*	Current trends in Agronomy	3+0
Agron 602	Recent trends in crop growth and productivity	2+1
Agron 603	Irrigation management	2+1
Agron 604	Recent trends in weed management	2+0
Agron 605	Integrated farming systems for sustainable Agriculture	2+0
Agron 606	Soil Conservation and Watershed Management	2+1
Agron 607	Stress Crop Production	2+1
Agron 608*	Research and Publication ethics	2+0
Agron-691	Doctoral Seminar	1+0
Agron 692	Doctoral Seminar	1+0
Agron 699	Doctoral Research	75

*Indicates Core course for Ph.D.

Course Contents
Ph.D. in Agronomy

I. Course Title : **Current Trends in Agronomy**
II. Course Code : **Agron 601**
III. Credit Hours : **3+0**

IV. Aim of the course

To acquaint the students about recent advances in agricultural production.

V. Theory

Unit I

Agro-physiological basis of variation in yield, recent advances in soilplant-water relationship.

Unit II

Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming.

Unit III

Crop residue management in multiple cropping systems; latest developments in plant managementMechanizationin crop production: modern agricultural precision tools and technilogies, weed management, cropping systems, grassland management, agro-forestry, allelopathy.

Unit IV

GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc.

Unit V

Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy. Conservation agriculture, principles, prospects and importance, potential benefits of CA under climate change scenario, policy issues.

VI. Teaching methods/activities

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

VII. Learning outcome

Recent advances in agricultural production

VIII. Suggested Reading

- Agarwal RL. 1995. *Seed Technology*. Oxford & IBH.
- Dahiya BS and Rai KN. 1997. *Seed Technology*. Kalyani.
- Govardhan V. 2000. *Remote Sensing and Water Management in Command Areas: Agroecological Prospectives*. IBDC.

- ICAR. 2006. *Hand Book of Agriculture*. ICAR.
- Narasaiah ML. 2004. *World Trade Organization and Agriculture*. Sonali Publ.
- Palaniappan SP and Annadurai K. 2006. *Organic Farming - Theory and Practice*. Scientific Publ.
- Sen S and Ghosh N. 1999. *Seed Science and Technology*. Kalyani.
- Tarafdar JC, Tripathi KP and Kumar M. 2007. *Organic Agriculture* Scientific Publ.
- Kumar, R, Swarnkar KS, Singh KS and Narayan S. 2016. *A Text Book of Seed Technology*. Kalyani Publication.
- Reddy SR and Prabhakara G. 2015. *Dryland Agriculture*. Kalyani Publishers.
- Gururajan B, Balasubhramanian R and Swaminath V. 2013. *Recent Strategies on Crop Production*. Kalyani Publishers.
- Venkateswarlu B and Shanker Arun K. 2009. *Climate change and agriculture: Adaptation and mitigation strategies. Indian Journal of Agronomy* 54(2): 226-230.

I. Course Title : **Recent Trends in Crop Growth and Productivity**
II. Course Code : **Agron 602**
III. Credit Hours : **2+1**

IV. Aim of the course

To study the physiology of vegetative and reproductive growth in relation to productivity of different crops in various environments.

V. 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.

VI. Practical

- Field measurement of root-shoot relationship in crops at different growth stages
- Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at

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different stages of crop growth
- Computation of harvest index of various crops
- Assessment of crop yield on the basis of yield attributing characters
- Construction of crop growth curves based on growth analysis data
- Computation of competition functions, viz. LER, IER aggressivity competition index etc in intercropping
- Senescence and abscission indices
- Analysis of productivity trend in un-irrigated areas
- Analysis of productivity trend in irrigated areas

VII. Teaching methods/activities

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

VIII. Learning outcome

Experience on the knowledge of crop growth for agricultural production

IX. Suggested Reading

- Chopra VL and Paroda RS. 1984. *Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants*. Oxford & IBH.
- Delvin RM and Vitham FH. 1986. *Plant Physiology*. CBS Publ.
- Evans LT. 1975. *Crop Physiology*. Cambridge Univ. Press.
- Evans LT. 1996. *Crop Evolution, Adaptation and Yield*. Cambridge Univ. Press.
- Gupta US. (Ed.). 1995. *Production and Improvement of Crops for Drylands*. Oxford & IBH.
- Gupta,US. 1988. *Progress in Crop Physiology*. Oxford & IBH.
- Kramer PJ and Boyer JS. 1995. *Water Relations of Plant and Soils*. Academic Press.
- Mukherjee S and Ghosh AK. 1996. *Plant Physiology*. Tata McGraw Hill.
- Narwal SS, Politycka B and Goswami CL. 2007. *Plant Physiology: Research Methods*. Scientific Pub.
- Tiaz L. and Zeiger E. 2006. Plant Physiology. Sinauer Associates, Inc.

I. Course Title : **Irrigation Management**
II. Course Code : **Agron 603**
III. Credit Hours : **2+1**

IV. Aim of the course

To teach students about optimization of irrigation in different crops under variable agro climatic conditions.

V. Theory

Unit I

Global water resources; Water resources of India, irrigation projects during pre and post independence period and their significance in crop production; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

Unit II

Movement of water in soil-water movement under saturated and unsaturated conditions, Poiseulle's and Darcy's law, general equation of saturated and unsaturated flow of water in soil.

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

Unit III

Water requirement, irrigation needs, factors affecting irrigation need; water use efficiency, Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

Unit IV

Soil and plant water potential, SPAC, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, factors affecting ET, control of ET by mulching and use of anti-transpirents; fertilizer use in relation to irrigation.

Unit V

Crop water stress – water deficits and crop growth, adoptability to the crops. Water availability with relation to nutrient availability.

Unit VI

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 VII

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 VIII

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.

Unit IX

Economic analysis of irrigation and cop planning for optimum use of irrigation water

Unit X

Crop water production function

VI. Practical

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

VII. Teaching methods/activities

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

VIII. Learning outcome

Management of irrigation water for sustainable agriculture

IX. Suggested Reading

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

I. Course Title : Recent Trends in Weed Management

II. Course Code : Agron 604

III. Credit Hours : 2+0

IV. Aim of the course

To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

V. Theory

Unit I

Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; different methods of weed management. Migration, introduction, adaptation of weeds, Invasive weeds – biology and management. Different mechanisms of invasion – present status and factors influencing weed invasion.

Unit II

Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

Unit III

Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, Degradation of herbicides in soil and plants- factors affecting it, primary and secondary metabolites, residue management of herbicides, adjuvants.

Unit IV

Advances in herbicide products and application techniques and methods; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; herbicide rotation and herbicide mixtures.

Unit V

Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

VI. Practical

- Determination of electrical conductivity of plant cell sap
- Determination of osmotic potential and tissue water potential
- Measurement of transpiration rate
- Measurement of stomatal frequency
- Measurement of Relative Water Content of leaf
- Measurement of electrolytic leakage
- Growing of plants in sand culture under salt stress for biochemical and physiological studies
- Studies on effect of osmotic and ionic stress on seed germination and seedling growth
- Measurement of low temperature injury under field conditions
- Studies on plant responses to excess water.

VIII. Teaching methods/activities

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

IX. Learning outcome

Experience on the knowledge of various types of stresses in cropproduction and strategies to overcome these.

X. Suggested Reading

- Baker FWG.1989. *Drought Resistance in Cereals*. Oxon, UK.
- Gupta US. (Ed.). 1988. *Physiological Aspects of Dryland Farming*. Oxford & IBH.
- Kramer PJ.1983. *Water Relations of Plants*. Academic Press.
- Levitt J. 1980. *Response of Plants to Environmental Stresses*. Vols. I, II. Academic Press.
- Mavi HS.1978. *Introduction to Agro-meteorology*. Oxford & IBH.
- Michael AM and Ojha TP.1981. *Principles of Agricultural Engineering*. Vol II. Jain Bros.
- Nilsen ET and Orcut DM. 1996. *Physiology of Plants under Stress – Abiotic Factors*. John Wiley & Sons.
- Singh K. 2000. *Plant Productivity under Environmental Stress*. Agribios.
- Singh KN and Singh RP. 1990. *Agronomic Research Towards Sustainable Agriculture*. Indian Society of Agronomy, New Delhi.
- Somani LL and Totawat KL. 1992. *Management of Salt-affected Soils and Waters*. Agrotech Publ.
- Virmani SM, Katyal JC, Eswaran H and Abrol IP. 1994. *Stressed Ecosystem and Sustainable Agriculture*. Oxford & IBH.

I. Title : **Research and Publication Ethics**

II. Course Code : **Agron 608**

III. Credit Hours : **0+2**

IV. Theory

Unit I

Introduction to philosophy: definition, nature and scope, concept, branches

Unit II

Ethics: definition, moral philosophy, nature of moral judgements and reactions

Unit III

Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and

Unit VI

Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelochemical and alleloherbicides, herbicide bioassays. Recent advances in nonchemical weed management including deleterious rhizobacteria, robotics, biodegradable film, etc.

VI. Teaching methods/activities

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

VII. Learning outcome

Experience on the knowledge of new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

VIII. Suggested Reading

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

I. Course Title : **Integrated Farming Systems and Sustainable Agriculture**

II. Course Code : **Agron 605**

III. Credit Hours : **2+0**

IV. Aim of the course

To apprise about different enterprises suitable for different agroclimatic conditions for sustainable agriculture.

V. Theory

Unit I

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

Unit II

Concept of sustainability in of Integrated farming systems; efficient Integrated farming systems based on economic viability and natural resources - identification and management.

Unit III

Production potential of different components of Integrated farming systems; interaction and mechanism of different production factors; stability of Integrated Farming system based on research/long term information. in different systems

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plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

Unit IV

Publication ethics: Defination, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME, etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatorypublishers and journals

Unit V

Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to checkpublisher copy right and selfarchivingpolicies; software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools viz., JANE, Elsevier Journal Finder, Springer Journal Suggesteretc.

Unit VI

Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open sourcesoftware tools

Unit VII

Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10-index altmetrics.

V. Teaching methods/activities

Classroom teaching with AV aids, group discussion, field practicals and laboratory visit.

VI. Learning outcome

Developed skill for research management, quality publication.

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Course Title with Credit Load
Ph.D. in Soil Science

Course Code	Course Title	Credit Hours
Soil 601	Recent trends in soil physics	2+0
Soil 602	Modern concept in soil fertility	2+0
Soil 603*	Physical chemistry of soil	2+0
Soil 604*	Soil genesis and micromorphology	2+0
Soil 605	Bio-chemistry of soil organic matter	2+0
Soil 606	Soil resource management	3+0
Soil 607	Modelling of soil plant system	2+0
Soil 608	Clay Mineralogy	2+1
Soil 609	Recent trends in soil microbial biodiversity	2+1
Soil 691	Doctoral seminar	1+0
Soil 692	Doctoral seminar	1+0
Soil 699	Doctoral Research	-75

*Indicates Core Courses which are Compulsory for PhD Programme

VI. Teaching methods/activities

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

VII. Learning outcome

Experience on the knowledge of soil physical properties and processes in relation to plant growth.

VIII. Suggested Reading

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

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

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 s 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*. Crossby Lockwood & Sons.
- Epstein E. 1987. *Mineral Nutrition of Plants - Principles and Perspectives*. International Potash Institute, Switzerland.
- Kabata- Pendias Alina 2001. *Trace Elements in Soils and Plants*. CRC / Taylor & Francis.
- Kannajyan 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.

I. Course Title : Physical Chemistry of Soil

II. Course Code : Soil 603

III. Credit Hours : 2+0

IV. Aim of the course

To impart knowledge about modern concepts of physical chemistry of soils and clays, with emphasis on understanding the processes involved with practical significance.

V. Theory

Unit I

Colloidal chemistry of in organic and organic components of soils–their formation, clay organic interaction.

Unit II

Predictive approaches for cation exchange equilibria- thermodynamics, empirical

and diffuse double layer theory (DDL)- relationships among different selectivity coefficients; structure and properties of diffuse double layer.

Unit III

Thermodynamics of nutrient transformations in soils; Climate change effects on minerology and surface properties of variable charge; cationic and anionic exchange and their models, molecular interaction.

Unit IV

Adsorption/desorption isotherms-Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on in organic surfaces and organic surfaces of soil materials (citation of utility in agricultural system).

Unit V

Common solubility equilibria-carbonates, ironoxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

VI. Teaching methods/activities

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

VII. Learning outcome

Experience on the knowledge of soil chemical behaviour on research for solving field problems.

VIII. Suggested Reading

- Bear RE. 1964. *Chemistry of the Soil*. Oxford & IBH.
- Bolt GH and Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.
- Fried M and Broeshart H. 1967. *Soil Plant System in Relation to Inorganic Nutrition*. Academic Press.
- Greenland DJ and Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.
- Greenland DJ and Hayes MHB. 1978. *Chemistry of Soil Constituents*. John Wiley & Sons.
- Jurinak JJ. 1978. *Chemistry of Aquatic Systems*. Department of Soil Science and Biometeorology, Utah State University
- McBride MB. 1994. *Environmental Chemistry of Soils*. Oxford University Press.
- Sparks DL. 1999. *Soil Physical Chemistry*. 2nd Ed. CRC Press.
- Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford University Press.
- Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford University Press.
- Sposito G. 1989. *The Chemistry of Soils*. Oxford University Press.
- Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley.
- van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

I. Course Title : Soil Genesis and Micromorphology

II. Course Code : Soil 604

III. Credit Hours : 2+0

IV. Aim of the course

To impart knowledge about the pedogenic processes in soils and to acquaint with the micro-pedological study of soil profile.

V. Theory

Unit I

Pedogenic evolution of soils; soil composition and characterization.

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I. Course Title : Clay Mineralogy
II. Course Code : Soil 608
III. Credit Hours : 2+1

IV. Theory

Unit I

Definition and concepts of clays and clay minerals, Fundamentals of crystallography – unit cell, external characteristics of crystals, crystallographic notations, crystal systems.

Unit II

Structures and classification of silicate minerals, basics of phyllosilicates, laws governing structural characteristics of phyllosilicates, Goldschmitdt's laws – Laws I and Law II, Classification of Phyllosilicates.

Unit III

Kaolonite group of minerals, Dioctahedral kaolins and Trioctahedral kaolins.

Unit IV

Smectites; properties of smectites, Reference models of structure, principal types based on Hofmann-Marshal-Hendricks (H-M-H) models, occurrence of smectites, transformation and formation in soils.

Unit V

Micas: occurrence and origin in soils, polytypes of micas, structure and formation of muscovites and illite.

Unit VI

Vermicullites: structure, occurrence in soils, formation, relation between vermiculites and montmorillonite.

Unit VII

Chlorite: occurrence and structure of chlorites, "swelling chlorites", formation of chlorite.

Unit VIII

Non-crystalline clays (amorphous materials), subgroups and chemical composition, morphology and structure, physico-chemical properties, influence of non-crystalline clays on soil properties.

Unit IX

Interstratified clay minerals, occurrence and formation in soils, regularly interstratified and partially random interstratified minerals.

Unit X

Genesis and transformation of clay minerals, Generalized conditions for formation and persistence of common clay-size minerals in soils.

Unit XI

Surface chemistry of clay minerals, clay-organic complexes, nanoclay mineralogy.

Unit XII

Clay minerals in different soil orders, role of clay minerals in soil fertility management.

16-11-22

V. Practicals

- Separation of clay for mineralogical study
- X-ray diffraction analysis of clay
- Selective dissolution of clay minerals
- IR, DTA and SEM of clay minerals
- Identification and quantification of clay minerals
- Determination of surface charge of clay minerals
- Potentiometric titration of clay minerals.

VI. Teaching methods/activities

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

VII. Learning outcome

Experience on soil clays and utility in soil research.

VIII. Suggested Reading

- Dixon JB and Weed SB (Co-editors). *Minerals in Soil Environment.*
- Gieseking JE (Ed). *Soil Component*, Vol. 2. Inorganic Components.
- Grim RE. *Clay Mineralogy.*
- Mukherjee SK and Biswas TD (Editors). *Mineralogy of Soil Clays and Clay Minerals.*
- Read HH. *Rutley's Elements of Mineralogy.*
- Wilding LP and Smeck NE. 1983. *Pedogenesis and Soil Taxonomy Part II – Soil Orders.*

I. Course Title : Recent Trends in Soil Microbial Biodiversity

II. Course Code : Soil 609

III. Credit Hours : 2+1

IV. Theory

Unit I

Microbial evaluation and biodiversity, Microbial communities in ecosystems, New insights in below ground diverse of plant performance.

Unit II

Qualitative ecology of microorganisms; Biomass and activities.

Unit III

Nitrogen fixing organisms, Trends in diversity of N fixing organisms. Molecular approaches in characterising N fixing microorganisms.

Unit IV

Serology and molecular characterization, ecological aspects of bio determination, soil waste and water management

Unit V

Biodegradability, testing and monitoring of the bioremediation of xerobiotic pollutants and bacterial fertilizers.

V. Practicals

- Determination of soil microbes using classical techniques.
- Determination of soil microbial diversity using molecular techniques.
- Estimation of soil microbial biomass carbon, nitrogen and phosphorus.
- Estimation of key soil enzyme activities.
- Community level physiological profiling of microbial diversity.

Course Title with Credit load
Ph.D. in Agricultural Statistics

Course Code	Course Title	Credit Hours	Semester
*STAT 601	Advanced Data Analytics	1+2	I
*STAT 602	Simulation Techniques	1+1	I
*STAT 603	Linear Models	2+0	I
*STAT 604	Advanced Statistical Methods	2+1	I
*STAT 611	Baysian Inference	2+0	II
STAT 691	Seminar I	0+1	I
STAT 692	Seminar II	0+1	II
STAT 699	Research	0+75	II-VI
STAT 605	Modeling Techniques for Forecasting	2+1	I
STAT 606	Stochastic Processes	2+0	I
STAT 607	Survival Analysis	2+0	I
STAT 608	Spatial Statistics	1+1	I
STAT 612	Advanced Design of Experiments	2+1	II
STAT 613	Advanced Sampling Techniques	2+1	II
STAT 614	Advanced Statistical Genetics	2+1	II
STAT 615	Advanced Time Series Analysis	2+0	II
STAT 616	Advanced Bioinformatics	2+0	II
STAT 617	Advanced Econometrics	2+0	II
STAT 618	Recent Advances in the Field of Specialization	1+0	II

*Core Courses

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

V. Theory

Unit I

General Gauss Markoff set up, Gauss-Markoff's theorem, Aitken's transformation. 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 disproportionate cell frequencies and interaction, 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. LAR, 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. 1987. *Linear Estimation and Design of Experiments*. Wiley Eastern.
- Rao, C. R. 2001. *Linear Inference and its Application*. Wiley Eastern.
- Searle, S. R. 1998. *Variance Components*. John Wiley.
- Searle, S.R. 1971. *Linear Models*. John Wiley.
- Seber, G.A. F. 1996. *The Linear Hypothesis: A General Theory*. Griffin, Charles and Co. Ltd.
- Sheffe, H. 1999. *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 to agriculturalsciences.

V. Theory

Unit I

Truncated and compound distributions. Fitting of orthogonal polynomials. Pearsonian 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. Distribution 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

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.

VI. 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.

VII. 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 a-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.

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

VI. 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)

I. Course Title : Advanced Design of Experiments

II. Course Code : STAT 612

III. Credit Hours : 2+1

IV. 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.

V. 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

distribution of several order statistics andtheir functions, marginal distributions of order statistics, distribution of range, median, etc.

Unit IV

Fitting of a generalized linear model, mixed model and variance components estimation, MINQUE, MIVQUE, REML.

VI. Practical

- Fitting of truncated distribution,
- Fitting of Pearsonian curves,
- Analysis of association between attributes, categorical data.
- Fitting of non-central t, χ^2 and F distributions.
- Computation of Tests of significance based on t, χ^2 and F distributions.
- Order statistics.

VII. Suggested Reading

- Chatterjee S, Hadi A and Price B. 2013. *Regression Analysis by Examples*. 5th Ed. John Wiley.
- Draper N.R. and Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- Rao C.R. 2009. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.
- Searle S.R, Casella G and McCulloch C.E. 1992. *Variance Components*. John Wiley.
- Searle S.R. 1971. *Linear Models*. John Wiley.

I. Course Title : Modeling Techniques for Forecasting
II. Course Code : STAT 605
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 the area of empirical and mechanistic models and nonlinear estimation and the replications in different disciplines of agricultural sciences.

V. Theory

Unit I

Empirical and mechanistic models. Nonlinear growth models: monomolecular, logistic, Gompertz, Richards. Applications in agriculture and fisheries.

Unit II

Nonlinear estimation: Least squares for nonlinear models, Methods for estimation of parameters like Linearization, Steepest, and Levenberg- Marquardt's Parameterization.

Unit III

Two-species systems. Lotka-Volterra, Leslie-Gower and Holling-Tanner non-linear prey-predator models. Volterra's principle and its applications. Gauss competition model.

Unit IV

Compartmental modelling - First and second order input-output systems, Dynamics of a multivariable system.