

**CURRICULUM OF
CROP PHYSIOLOGY
FOR
BACHELOR, MASTER AND PhD
DEGREE PROGRAMS**

(Revised 2018)



**HIGHER EDUCATION COMMISSION
ISLAMABAD**

CURRICULUM DIVISION, HEC

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PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo to achieve some specific objectives. It includes scheme of studies, objectives & learning outcomes, course contents, teaching methodologies and assessment/ evaluation. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled "Supervision of Curricula and Textbooks and Maintenance of Standard of Education". With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula regularly through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

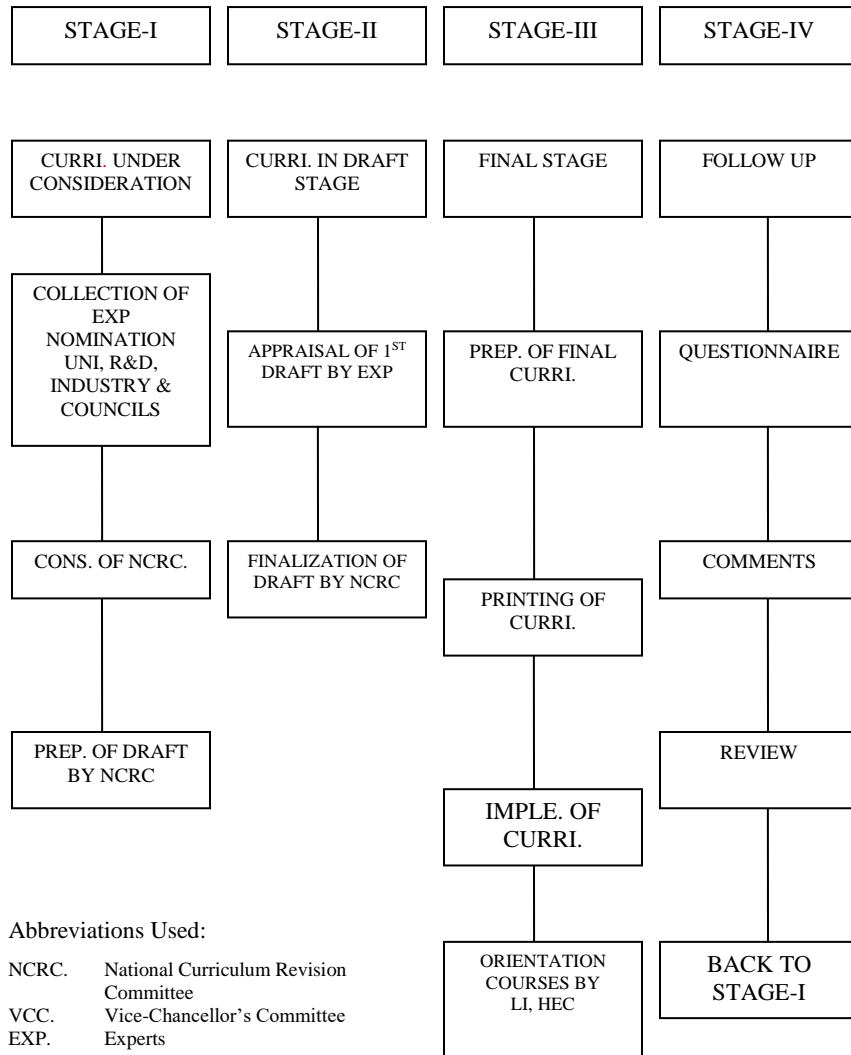
In order to impart quality education which is at par with indigenous needs and international standards, HEC NCRCs have developed unified framework/ templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering.

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC

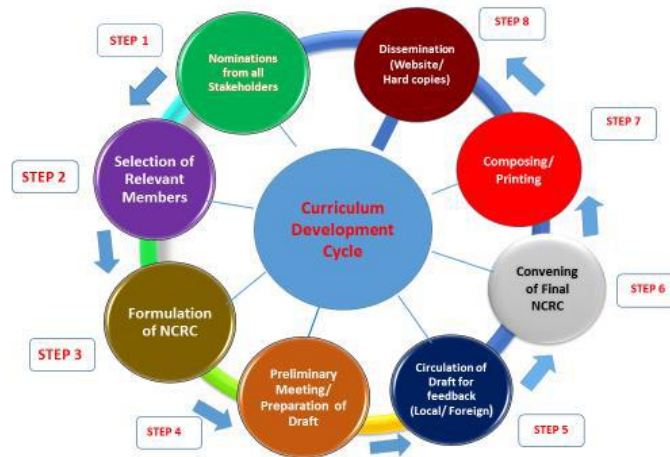
<http://hec.gov.pk/english/services/universities/RevisedCurricula/Pages/default.aspx>

**(Muhammad Raza Chohan)
Director General (Academics)**

CURRICULUM DEVELOPMENT



CURRICULUM DEVELOPMENT CYCLE



**Minutes of National Curriculum Revision Committee
(NCRC) Final Meeting in Crop Physiology, held from
February 19-21, 2018 at HEC Regional Centre, Peshawar**

The final meeting of National Curriculum Revision Committee (NCRC) in the discipline of Crop Physiology for Bachelor, Master and Ph.D degree programmes was held from February 19-21, 2018 (03 days) at HEC, Regional Center, Peshawar. Experts from academia, research and development participated in the meeting. Dr. Muhammad Idrees (Director, Academics Division, HEC, Pakistan) coordinated the NCRC meeting. The list of the participants is as below:

Dr. Qamaruddin Chachar Professor/Dean, Faculty & crop production, Sindh Agriculture University, Tandojam.	Convener
Dr. Fahim Nawaz Assistant Professor, Department of Agronomy, Faculty of Agricultural & Envr. Sciences, Muhammad Nawaz Shareef University of Agriculture, Multan.	Secretary
Dr. Abdul Khaliq Professor Department of Agronomy, University of Agriculture, Faisalabad	Member
Dr. Mukhtar Alam Professor / Dean Faculty of Science, Department of Agriculture, University of Swabi, Anbar Swabi.	Member
Dr. Muhammad Akmal Professor / Chairman, Department of Agronomy The University of Agriculture, Peshawar	Member
Dr. Muhammad Yasin Ashraf (TI), Professor / Head Soil and Environmental Sciences / Manager Academic Cell PAEC / Nuclear Institute for Agriculture & Biology (NIAB), Jhang Road, Faisalabad	Member
Dr. Bashir Ahmad Professor Department of Agronomy The University of Agriculture, Peshawar	Member

Dr. Fauzia Yusuf Hafeez (T), Professor / Advisor, Department of Biosciences, COMSATS Institute of Information Technology, Islamabad	Member
Dr. Shad Khan Khalil Meritorious Professor Department of Agronomy The University of Agriculture, Peshawar	Member
Dr. Jalal-ud-Din Principal Scientific Officer Wheat Wide Crosses Programme, Institute of Crop Sciences, National Agriculture Research Centre (NARC), Islamabad	Member
Dr. Azra Yasmeen* Associate Professor Department of Agronomy Bahauddin Zakariya University, Multan	Member
Dr. Shahjahan Shabbir Ahmed Rana Associate Professor, Department of Biotechnology BUIEMS, Iqbal Hall, Takatu Campus, Airport Road, Quetta	Member
Dr. Sajid Ali Assistant Professor, Institute of Agricultural Sciences, University of the Punjab, Quaid-e-Azam Campus, Lahore	Member
Dr. Rasheda Jabeen* Assistant Professor, Department of Biology & Life Sciences, Lahore Garrison University, Lahore	Member
Dr. Anser Ali Assistant Professor Department of Agronomy, Ghazi University, D. G. Khan	Member
Ms. Irfana Parveen Bhatti* Assistant Professor, Department of Crop Physiology, Sindh Agriculture University, Tandojam.	Member
Dr. Syed Rehmat Ullah Shah Associate Professor, Department of Agronomy, Lasbela University of Agriculture, Water & Marine	Member

Sciences, Balochistan.	
Dr. Muhammad Aamir Iqbal Assistant Professor, Department of Agronomy, The University of Poonch, Rawalakot, Azad Jammu & Kashmir	Member
Dr. Riaz Ahmad Afridi** Research Officer (Plant Ecophysiologicalist) Plant Physiology Research Program, Agriculture Research Institute, Tarnab, Peshawar	Member
Dr. Abdul Aziz Khakwani** Assistant Professor, Department of Agronomy, Faculty of Agriculture, Gomal University, D.I. Khan	Member
Dr. Muhammad Idrees Director (Curriculum), Higher Education Commission, Islamabad	Coordinator

* These members attended preliminary NCRC meeting only

** These members attended the final NCRC meeting only

Recommendations

After thorough discussion, the participants of the National Curriculum Revision Committee in Crop Physiology 2018 formulated the following recommendations for uniform and effective implementation of the HEC policies at national level.

- The committee appreciates the role of HEC in improvement of Higher Education in the country and recommends uniform implementation of its policies including work load and financial matters in all public sector universities.
- The respective departments of agriculture at province and federal level should be approached for recognition of degree in Crop Physiology for recruitment of graduates.
- Funding may be advanced for the purchase of equipment to be used for research and training regarding physiological studies in crops that can be of equally beneficial for sister disciplines.
- Emphasis should be given on the physiological basis of crop adaptation in the context of changing climatic scenario as a futuristic vision for sustaining agricultural productivity.
- The committee strongly recommends that mathematics/biology should be considered as deficiency courses and shall not be

counted towards the total credit hours of the undergraduate degree programs.

- The course of crop physiology may be included in interdisciplinary foundation courses template.
- NCRC recommends to hold regularly meetings of all experts in Crop Physiology (at least once in six months).

Suggestions

- HEC is requested to ensure availability of at least 10 copies of all recommended books to the departmental libraries of all the Agricultural Universities/Faculties/Colleges of the country and to improve the library/documentation of the institutions.
- Professors and Associate Professors should also be considered for different administrative courses run by national policy institutes/public administration staff colleges to enhance administrative and financial management skills.
- To improve the standard of the higher education at national level, the committee recommends that the appointment of local examiners within the city should be discouraged at MSc (Hons.)/MPhil degree programs.
- A final copy of the curriculum (2018) must be provided to at least every faculty member of Crop Physiology all over the country.
- Follow up meetings may be arranged to further revise and finalize the curriculum/learning outcomes and recommendations of present NCRC.
- Viable mechanism for follow up of implementation of recommendations / suggestions should be developed.

The meeting ended with vote of thanks to and from the Chair.

Programme Objectives:

1. Discover, formulate and demonstrate new principles of crop improvement and soil-crop management so that Pakistan's agriculture is socially viable, profitable for the farmer, and competitive on world markets.
2. Discover, formulate, and demonstrate new principles for prevention and management of diseases, insects, and weeds affecting field, specialty food, and amenity crops.
3. Conduct fundamental research to discover new knowledge and advance the frontiers of the crop and pest management sciences.

4. Develop and deliver research results in the environmental sciences to improve agricultural profitability while decreasing adverse impacts on the environment, both local and global.

Vision

Produce innovation-oriented Crop Physiology graduates who can contribute to the betterment of agriculture, environment and society

Mission

To impart the best quality Crop Physiology education through advanced teaching tools providing impetus for sustainable socio-economic development of Pakistan.

PREAMBLE

With the advent of new technologies, the world has turned into a global village. In view of tremendous research taking place world over new ideas and information pours in like a stream, making it imperative to update the curricula after regular intervals, for introducing latest development and innovation in the relevant field of knowledge. In exercise of the powers conferred under Section 3 Sub-Section 2 (ii) of Act of Parliament No. X of 1976 titled "Supervision of Curricula and Textbooks and Maintenance of Standard of Education" the erstwhile University Grants Commission was designated as competent authority to develop review and revise curricula beyond Class-XII. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission under its Ordinance of 2002 Section 10 Sub-Section 1 (v). In compliance with the above provisions, the HEC undertakes revamping and refurbishing of curricula after regular intervals in a democratic manner involving universities/DAIs, research and development institutions and local Chamber of Commerce and Industry. The intellectual inputs by expatriate Pakistanis working in universities and R&D institutions of technically advanced countries are also invited to contribute and their views are incorporated where considered appropriate by the National Curriculum Revision Committee (NCRC).

RATIONALE

Considering the recent advancements in the science and technology and their impacts in the field of Crop Physiology, coupled with contemporary requirements of Outcome Based Education (OBE), there is a dire need to update the curriculum of Crop Physiology program.

SCOPE

The scope of the document is to provide minimum standards in the form of guidelines for the development, delivery and assessment of the Crop Physiology program. The guideline areas include; Program Educational

Objectives (PEOs), Program Learning Outcomes (PLOs) and Course Learning Outcomes (CLOs), scheme of studies, course outlines, credit hours distribution, assessment criterion, and recommendations.

Eligibility Criteria for Bachelor

FSc Pre-Medical/Pre-Engineering or equivalent

Eligibility Criteria for Master

Bachelor in Crop Physiology/Agronomy

Eligibility Criteria for PhD

Master in Crop Physiology/Agronomy

FRAMEWORK FOR 4-Year BSc (Hons.) in Crop Physiology

Non-Agricultural Domain							
Knowledge Area	Subject Area	Name of Course	Cr	Total Courses	Total Credit	% Area	% Overall
Humanities	English	English-I (Functional English)	3	2	6	19.35	4.44
		English-II (Communication Skills)	3				
	Culture	Pakistan Studies	2	2	4	12.9	2.96
		Islamic Studies/Ethics	2				
	Social Sciences	Marketing & Agri Business	3	2	6	19.35	4.44
		Rural Development	3				
Computing	IT	Introduction to Communication Technology	3	1	3	9.70	2.22
Natural Sciences	Mathematics/Biology	Math-I/Botany	3	2	6	19.35	4.44
		Math-II/Zoology	3				
	Statistics	Statistic-I	3	2	6	19.35	4.44
		Statistic-II	3				
Sub-Total:				11	31	100	23

Agricultural Domain							
Interdisciplinary	Agriculture Foundation	Crop Physiology	3	9	27	27.83	21.09
		Agronomy	3				
		Plant Breeding and Genetics	3				
		Entomology	3				
		Plant Pathology	3				
		Food Technology	3				
		Horticulture	3				
		Soil Science	3				
		Agricultural Economics	3				
		Supporting Courses	Breadth Courses				
Forestry & Range Management	3						
Animal Sciences	3						
Basic Bio-Chemistry	3						
Agricultural Engineering	3						
Any other Recommended by Universities	3						
Major Courses	Major Based Core (Depth)	Major	3	18-20	54-60	56.67	42.18
Project/ Internship		Project/ Internship	4		4		
Total:			-	31-35	97-109	100	77
Grand- Total:-			-	42-46	128-140	-	100

SCHEME OF STUDIES FOR 04 YEARS BACHELOR IN CROP PHYSIOLOGY

Semester I	Credits	Semester II	Credits
Islamic Studies/ Ethics (optional for Non-Muslim Students)	2(2+0)	Introduction to Economics and Agricultural Economics	3(3+0)
Functional Mathematics /Biology	3(3+0)	Introductory Genetics	3(2+1)
Introduction to Soil Science	3(2+1)	Introductory Horticulture	3(2+1)
Basic Agriculture	3(2+1)	Introduction to Plant Pathogens	3(2+1)
English Text, Grammar and Composition	3(3+0)	Field Crop Production-I	3(2+1)
Pakistan Studies	2(2+0)	Introductory Biotechnology	3(2+1)
Introduction to Agriculture Extension and Education	2(2+0)		
Total Credit Hours	18	Total Credit Hours	18
Semester III	Credits	Semester IV	Credits
Introductory Plant Breeding	3(2+1)	Introductory Entomology	3(2+1)
Introduction to Biochemistry	3(2+1)	Introductory Crop Physiology	3(2+1)
Introduction to Pest Management	3(2+1)	General Soil Science	3(2+1)
General Biotechnology	3(2+1)	Applied Entomology	3(2+1)
Introductory Food Science & Technology	3(2+1)	Farm Mechanization	2(1+1)
Introductory Animal Husbandry	2(1+1)	Computer Applications	3(2+1)
Total Credit Hours	17	Total Credit Hours	17
Semester V	Credits	Semester VI	Credits
Basic Physiological Processes of Crop Plants	3(2+1)	Physiology of Cereals	3(2+1)
Fundamentals of Nitrogen Fixation	3(2+1)	Seed Physiology	3(2+1)
Nucleic Acid & Protein Synthesis	3(2+1)	Plant Growth Substances	3(2+1)

Plant Cell Structure and Functions	3(2+1)	Physiology of Crop Nutrition	3(2+1)
Elementary Statistics	3(2+1)	General Biochemistry	3(2+1)
Total Credit Hours	15	Total Credit Hours	15
Semester VII	Credits	Semester VIII	Credits
Physiology of Legumes and Cash Crops	3(2+1)	Carbon Metabolism in Plants	3(2+1)
Introductory Molecular Biology	3(2+1)	Physiological Aspects of Tissue Culture	3(2+1)
Stress Physiology	3(2+1)	Crop Ecology	3(2+1)
Plant Water Relations	3(2+1)	Environmental Physiology	3(2+1)
Plant Growth and Development	3(2+1)	Internship and Report Writing	4(0+4)
Total Credit Hours	15	Total Credit Hours	16
Grand Total Credit Hours			130

SCHEME OF STUDIES FOR 04 YEARS BACHELOR IN CROP PHYSIOLOGY

Subject/Title	Credit Hours
1. Introductory Crop Physiology	3 (2-1)
2. Basic Physiological Processes of Crop Plants	3 (2-1)
3. Fundamentals of Nitrogen Fixation	3 (2-1)
4. Plant Cell Structures and Functions	3 (2-1)
5. Physiology of Cereals	3 (2-1)
6. Seed Physiology	3 (2-1)
7. Plant Growth Substances	3 (2-1)
8. Physiology of Crop Nutrition	3 (2-1)
9. Physiology of Legumes and Cash Crops	3 (2-1)
10. Introductory Molecular Biology	3 (2-1)
11. Stress Physiology	3 (2-1)
12. Plant Water Relations	3 (2-1)
13. Plant Growth and Development	3 (2-1)
14. Carbon Metabolism in Plants	3 (2-1)
15. Physiological Aspects of Tissue Culture	3 (2-1)
16. Crop Ecology	3 (2-1)
17. Environmental Physiology	3 (2-1)
18. Internship	4 (0-4)
Total Major Courses Credit Hours	55

Note: Universities and Colleges may adopt their own system for course numbers for different degrees.

DETAIL OF COURSES

Title of the Course: Introductory Crop Physiology

Credit Hours: 3 (2-1)

Prerequisites: N/A

Specific Objectives of Course:

- To familiarize students with basic concepts in crop physiology

Learning Outcomes:

At the end of the course, students will be able to:

1. Know the importance of crop physiology
2. Know the equipment and apparatus used for physiological studies in plants
3. Understand basic concepts and principles underlying physiological processes
4. Prepare solutions of different types and strengths
5. Pursue further studies in the field of crop physiology, agronomy molecular biology, biochemistry and ecology etc.

Theory:

- Concept and significance of crop physiology
- Terminology used in crop physiology
- The plant cell
- Solutions, suspensions colloidal systems and buffers in plant cells-their types and physicochemical properties
- Water uptake and transport in crop plants
- Plant nutrients-their classification and role in plants
- Photosynthesis and respiration
- Seed germination and dormancy
- Growth and development in plants
- Growth substances
- Introduction to biotechnology

Practical:

- Equipment used in crop physiology
- Preparation of solutions/buffers of different concentration and pH
- Measurement of soil and plant water relations
- Seed germination and seedling growth
- Demonstration of nutrient deficiency in crop plants

Teaching Methodology

- Lecturing

- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Gardner F.P. 2013. Physiology of Crop Plants. Springer-Verlag Inc., New York.
2. Hopkins, W. G. 2008. Introduction to Plant Physiology. 4th Ed. John Wiley and Sons. New York.
3. Salisbury, F. B. and C. W. Ross. 2010. Plant Physiology. 5th Ed., Wordsworth Publishing Company. Belmont, California, USA.
4. Salisbury, F. B. and C. W. Ross. 1974. Plant Physiology: Laboratory Manual to 2r.e. Wadsworth Publishing Co Inc.
5. Taiz, L. and E. Zeiger. 2010. Plant physiology. 6th Ed. Sinauer Associates, Inc., Publishers, Sunderland, USA.

Title of the Course: Basic Physiological Processes in Plants

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To create awareness of basic physiological processes in plants

Learning Outcomes:

At the end of the course, students will be able to:

1. Know physiological process of germination
2. Know the assimilation partitioning and translocation of metabolites in plants
3. Understand the process of stomatal movement and its role in maintenance of plant water status
4. Know the types and role of different growth regulators in plants

5. Define photo- and thermo-periodic responses in plants

Theory:

- Seed germination and its requirements
- Modes of germination
- Factors affecting germination
- Absorption of water (ascent of sap)
- Transpiration and guttation
- Translocation of solutes
- Regulation of stomatal movement
- Source-sink relationships
- Partitioning and remobilization of assimilates
- Plant growth regulation
- Photoperiodism and thermoperiodism

Practical:

- Demonstration of modes of germination
- Demonstration of soilless culture (hydroponics, aeroponics etc.)
- Measurement of transpiration rate
- Demonstration of effects of various growth regulators on crop plant

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Copeland, L. O. and M. B. McDonald. 2012. Principles of Seed Science and Technology. 4th Ed. Burgess Publishing Company. Minneapolis, Minnesota, USA.
2. Bhattacharya, A. and Vijay Laxm. 2015. Methods and Techniques in Plant Physiology
3. Meidner, H. 1984. Class Experiments in Plant Physiology. Allen and Unwin. London, UK.
4. Taiz, L. and E. Zeiger. 2010. Plant Physiology. 6th Ed. Sinauer Associates, Inc., Publishers, Sunderland, USA.

Title of the Course: Fundamentals of Nitrogen Fixation

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To know the physiological mechanisms of nitrogen fixation in plants

Learning Outcomes:

At the end of this course, the students will be able to:

1. Know the importance and sources of nitrogen as a plant nutrient
2. Understand the process of nitrogen fixation
3. Know the biological nitrogen fixing systems and assimilation of ammonia
4. Identify the plant growth promoting bacteria and their use in agriculture

Theory:

- Nitrogen and plant growth
- Nitrogen cycle
- Classification of nitrogen fixing microorganisms
- Symbiotic and asymbiotic nitrogen fixation
- Mechanism of BNF
- Nodulation; process and mechanism
- Nitrogenase, ammonia assimilation
- Factors affecting nodulation and BNF
- Introduction to bio-fertilizers and their application in agriculture
- Plant growth promoting rhizobacteria

Practical:

- Demonstration of inoculation methods
- Study of nodule formation under different environmental conditions
- Identification of effective and non-effective nodules
- Methods used to measure biologically fixed nitrogen

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment**Mid Term (40%)**

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Cappuccino, J. G. and N. Sherman. 2010. Microbiology (A Lab manual). 7th ed. Benjamin Cumming, New York, USA.
2. Elmerich, C. and W. E. Newton. 2010. Associative and endophytic nitrogen-fixing bacteria and cyanobacterial associations. Springer-Verlag. Heidelberg, Germany.
3. James, E. K., J. I. Sprent, M. J. Dilworth and W. E. Newton. 2010. Nitrogen-fixing leguminous symbiosis. Springer-Verlag. Heidelberg, Germany.
4. Stacy, G. 1997. Biological Nitrogen Fixation. Chapman and Hall Inc., New York, USA.
5. Werner, D. and W. E. Newton. 2005. Nitrogen fixation in agriculture, forestry, ecology and the environment. Springer-Verlag. Heidelberg, Germany.

Title of the Course: Plant Cell Structure and Function**Credit Hours: 3 (2-1)****Specific Objectives of Course:**

- To develop basic understanding of the cell organelles and their functions

Learning Outcomes:

At the end of the course, students will be able to:

1. Know types of living cells and their structural entities
2. Know different types of water/nutrient/sap movement in plants
3. Understand the metabolic functions in plant cell
4. Know the mechanism of energy flow in respiration and photosynthesis
5. Calculate energetics of different substrates in plant metabolism

Theory:

- Types of living cells: prokaryotic, eukaryotic and mesokaryotic cells
- Structural constituents of cell and their functions
- Apoplast, cell wall and vacuole
- Symplast, cytoplasm, plasmodesmata, plasma membrane, cytosomes, endoplasmic reticulum, golgi complex, micro-bodies, ribosomes, mitochondria, plastids, nucleus, nuclear membrane, microtubules, microfilaments and tonoplast
- Cell metabolism

Practical:

- Slide preparation of various types of cells
- Identification of cell organelles

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment**Mid Term (40%)**

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Campbell, J. and R. Mitchel. 2001. Biology. 6th Ed. Addison Wesley Longman Inc.
2. De-Roberties, E. D. P. and E. M. F. Jr. DeRoberties. 2006. Cell and Molecular Biology. 8th Ed. John Willey and Sons, USA.
3. Taiz, L. and E. Zeiger. 2010. Plant Physiology. 6th Ed. Sinauer Associates, Inc., Publishers, Sunderland, USA.

Title of the Course: Physiology of Cereals

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the physiology of growth and productivity of cereals

Learning outcomes:

After studying this course, students will be able to;

1. Define the physiological growth of plants
2. Understand the physiological basis of ontogenic development in cereals
3. Comprehend the phenomenon of grain development
4. Infer the synthesis and translocation of photosynthates
5. Evaluate the interactive relationship of photosynthetic efficiency and attributes of biomass production

Theory:

- Physiology of leaf growth and tillering
- Site filling dynamics
- Leaf canopy, its architecture and its implications for light interception
- Photosynthetic efficiency and utilization
- Source-sink relationships; partitioning coefficient
- Grain growth and development
- Ripening and maturity
- Indices of economic yield

Practical:

- Identification of growth stages in cereals
- Leaf area measurement and calculation of leaf area index
- Measurements of plant biomass and photosynthetic efficiency

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker

- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Fageria, N. K., V. C. Baligar and R. B. Clark. 2006. Physiology of Crop Production. Academic Press. New York, USA.
2. Evans, L. T. (ed.). 1975. Crop Physiology-some case histories. Cambridge University Press, UK.
3. Hay, K. M. Robert and J. Porter. 2006. The Physiology of Crop Yield (Second Edition). Blackwell Publishing, USA.

Title of the Course: Seed Physiology

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the physiological processes of seed development and its germination

Learning Outcomes:

At the end of the course, students will be able to:

1. Define basic concepts in seed germination and development.
2. Understand the physiology of seed formation
3. Demonstrate the methods used for testing seed health and breaking seed dormancy
4. Critically evaluate the factors influencing seed germination and emergence
5. Suggest appropriate strategies for enhancing seed germination

Theory:

- Definition of seed, seed structure
- Physiology of seed formation and development

- Composition of seed
- Physiology and biochemistry of seed germination
- Factors affecting seed germination and emergence
- Seed viability and seed vigor
- Dormancy and methods of breaking seed dormancy
- Seed longevity and storage

Practical:

- Seed testing for moisture, viability and vigor
- Methods of breaking seed dormancy
- Germination under different moisture, temperature and salt regimes
- Seed vigor enhancement techniques

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Benech-Arnold, R. L. and R. A. Sanchez. 2004. Handbook of Seed Physiology: Application to agriculture. Haworth Press, New York, USA.
2. Bewley, J. D., and M. Black. 1994. Seed: Physiology of Development and Germination. 2nd Ed. Plenum Press. New York, USA.

3. Copeland, L. O. and M. B. McDonalad. 2002. Principles of Seed Science and Technology. 2nd Ed. Burgess Publishing Company. Minneapolis, Minnesota, USA.
4. International Seed Testing Association (ISTA). 2011. International Rules for Seed Testing. Zurichstr-50, CH-8303 Bassersdorf, Switzerland.

Title of the Course: Plant Growth Substances

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the mechanism of biosynthesis, functions, transport and degradation of plant growth substances

Learning Outcomes:

At the end of this course, the students will be able to:

1. Know the nature and role of growth substances in plants
2. Understand the hormonal pathways (biosynthesis, degradation and translocation) in plants
3. Know the ways by which plant growth substances mediate/regulate organogenesis in plants
4. Know the use of plant growth substances in agriculture

Theory:

- Growth substances and their occurrence
- Nature and classification of growth substances
- Biosynthesis and their translocation
- Mode of action and degradation
- Regulation of plant growth
- Application of growth substances in agriculture

Practical:

- Preparation of stock and working solutions of various plant growth substances.
- Effects of different growth substances on seed germination and seedling growth
- Bioassay studies of selected growth substances

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Taiz, L. and E. Zeiger. 2010. Plant Physiology. 6th Ed. Sinauer Associates, Inc., Publishers, Sunderland, USA.
2. Davies P. J. 2010. Plant Hormones: Bio synthesis, signal transduction action, 3rd edition, Springer
3. Lam-som Phan Trans, 2014, Plant Hormones: a window to metabolism, signaling and biotechnological, Springer.
4. Jürgen Kleine-Vehn, Michael Sauer 2017 Plant Hormones. Methods and Protocols Publisher-Humana Press Springer Science+Business Media NewYork

Title of the Course: Physiology of Crop Nutrition

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the physiological basis of plant nutrition and importance, deficiency symptoms and uptake mechanisms of different plant nutrients

Learning Outcomes:

At the end of the course, students will be able to:

1. Define key concepts in plant nutritional physiology
2. Diagnose nutritional disorders in plants
3. Devise appropriate nutrient management strategies for improving crop productivity

Theory:

- Crop nutrition and essentiality criteria of nutrients
- Classification of plant nutrients
- Essential elements; physiological functions and deficiency symptoms of different nutrients

- Mechanisms of uptake and translocation
- Mycorrhizae and their role in nutrient absorption
- Metabolism of nutrients
- Physiological disorders due to nutrient deficiency and toxicities
- Nutrient requirements of different crops and their management for economical crop yield

Practical:

- Techniques of growing plants for nutritional studies (aeroponics, hydroponics, sand and gravel etc.)
Preparation of nutrient media (Hoagland, Yoshida and Johnson etc.) for water culture
- Identification of deficiency and toxicity symptoms of different nutrients

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Epstein, E. and A. J. Bloom. 2005. Mineral Nutrition of Plants: Principles and Perspectives. 2nd Ed. Sinauer Associates Inc. USA.
2. Mangel, K. and E. A. Kirkby. 1999. Principles of Plant Nutrition. International Potash Institute, Switzerland.
3. Marschner, H. 1995. Mineral Nutrition of Higher Plants. Academic Press, London, UK.

Title of the Course: Physiology of Legumes and Cash Crops
Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the physiological processes of yield in non-cereal crops

Learning Outcomes:

At the end of the course, students will be able to:

1. Understand the importance of canopy architecture in plant growth and development.
2. Define the key features of growth and development of legumes and cash crops.
3. Evaluate the basis for yield and quality variation in legumes and cash crops
4. Demonstrate competence in the measurement of plant growth indices and have knowledge of developmental growth stages in non-cereals.

Theory:

- Patterns of canopy development and its architecture in broad leaved crops.
- Dynamics of light interception in relation to canopy development
- Source-sink relationships and dry matter partitioning in sugar, fiber, oil seed, legume, tuber crops and others
- Indices of economic yield

Practical:

- Leaf area measurements and calculations of leaf area indices
- Measurements of plant biomass and photosynthetic efficiency
- Identification of developmental growth stages in non-cereal crops

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%

- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Coombs, J., D. O. Hall, S.P. Long and J. M. O. Scurlock. 1987. Techniques in Bio-productivity and Photosynthesis. 2nd Ed. Pergamon Press. Oxford, UK.
2. Draycott, A. P. 2006. Sugar Beet. Blackwell Publishing Ltd. Oxford, UK.
3. Fageria, N. K., V. C. Baligar and R. B. Clark. 2005. Physiology of Crop Production. Academic Press. New York, USA.
4. Gardner, F. P., R. B. Pearce and R. L. Mitchell. 1988. The Physiology of Crop Plants. Iowa State University Press. Ames, Iowa, USA.
5. Gupta, A. K. and N. Kaur. 2000. Carbohydrate reserves in plants: synthesis and regulation. Vol. 26. Elsevier Science. Amsterdam, The Netherlands.
6. Stewart J. M., D. Oosterhuis, J. J. Heitholt and J. R. Mauney. 2009. Physiology of Cotton. Springer. London, UK.

Title of the Course: Introductory Molecular Biology
Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To impart basic knowledge of molecular biology

Learning Outcomes:

At the end of this course, the students will be able to:

1. Know the molecular basis of heredity in living systems
2. Understand the molecular mechanism of gene expression
3. Understand the interrelationship of biomolecules

Theory:

- Types of biomolecules (Nucleic acids, Proteins and other macromolecules)
- Nature of hereditary materials
- Nucleic acid metabolism
- Relationship between DNA, chromosome and genome
- DNA and RNA structure, replication, transcription, translation and DNA recombination

- Presentations on different mechanisms happening at molecular and crop level
- Introduction to bio-ethics and bio-informatics

Practical:

- Demonstration of DNA extraction
- DNA estimation using Gel Electrophoresis/Spectrophotometer
- Visit to any bio-technological facility

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Berg, J. M., J. L. Tymoczko, and L. Stryer. 2006. Biochemistry. 6th Ed. WH Freeman and Company, New York, USA
2. Lodish, H., C. and A. Kaiser, 2007. Molecular Cell biology. 6th Ed. WH Freeman and Company. New York, USA.
3. Nelson, D., and M. M. Cox. 2009. Lehninger Principles of biochemistry. 5th Ed. WH Freeman and Company. New York, USA

Title of the Course: Stress Physiology

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the types, mechanism of damage and adaptation to environmental stresses in plants

Learning Outcomes:

At the end of this course, the students will be able to:

1. Know the effect of various stresses on plant growth and productivity
2. Identify physiological and biochemical markers for stress tolerance in crops
3. Quantify the relative losses caused by various abiotic stresses

Theory:

- Introduction to biotic and abiotic stresses
- Physiological and biochemical bases of damage caused by moisture, temperature, radiation, pollutants, chemical, mineral and salt stresses
- Responses of plant to various stresses

Practical:

- Demonstration of moisture, salinity and temperature stress on plants

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment**Mid Term (40%)**

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Fitter, H. Alastair and K. M. Robert and Hay. 2002. Environmental Physiology of Plants (Third Edition). Academic Press.
2. Fowden, L., T. Mansfield, J. Stoddart. 1993. Plant Adaptations to Environmental Stresses. Springer-Verlag. Berlin, Germany.

3. Levitt, J. 1980. Responses of Plants to Environmental Stresses. 2nd Ed. Vol-I and II. Academic Press. London.
4. Pessaraki, M. 2010. Handbook of Plant and Crop Stress. 3rd Ed. CRC Press, Taylor and Francis. New York, USA.
5. Taiz, L. and E. Zeiger. 2010. Plant physiology, 6th Ed. Sinauer Associates, Inc., Publishers. Sunderland, USA.

Title of the Course: Plant Water Relations

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the importance of water in plant life.

Learning Outcomes:

After studying this course, students will be able to;

1. Define and describe the physico-chemical characteristics of water
2. Understand water uptake and ascent of sap
3. Comprehend interactive relationship of water potential to water uptake
4. Evaluate various matrix of water potential

Theory:

- Water; importance, physical and chemical properties
- Types of soil moisture
- Water potential and its components; free energy and chemical potential
- Water absorption
- Tensile strength, root pressure and ascent of sap
- Cohesion mechanism and capillary rise in xylem
- Soil, plant, atmosphere continuum
- Transpiration and factors affecting transpiration
- Plasmolysis and permanent wilting point

Practical:

- Techniques and experimental approaches for measurement of plant water status

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Arnon, I. 2012. Agriculture in dry lands-Principles and practices. Elsevier Publishers. USA
2. Kramer, Paul J. and J. S. Boyer. 1995. Water Relations of Plants and Soils. Academic Press, Inc.
3. Kirkham, M. B. 2005. Principles of soil and plant water relations. Elsevier Academic Press. Phoenix, USA.
4. Turner, N. C. 1981. Techniques and experimental approaches for measurement of plant water status. Plant and soil. Vol. 58. Dr. W. Junk Publishers. Hague, Netherland.

Title of the Course: Plant Growth and Development

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the processes of growth and development in plants

Learning Outcomes:

At the end of the course, students will be able to:

1. Differentiate between growth and development in plants
2. Identify growth regions in plants and their physiological relevance to development
3. Define phenological development in plants and the factors influencing it
4. Understand hormonal regulation of growth and development in plants

Theory:

- Concept of growth and development, growth conditions and mechanisms

- Patterns of growth and phases of growth curve
- Life cycle of plant growth
- Factors affecting plant growth and development
- Photoperiodism, thermoperiodism, vernalization and tropisms
- Role of phytohormones in crop growth and development,
- Fruit set, seed development
- Techniques for production of seedless fruits,
- Physiological maturity, abscission and senescence

Practical:

- Identification and measurement of growth regions
- Demonstration of various factors on growth
- Growth analysis of crop plants

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Gardner, F. P., R. B. Pearce and R. L. Mitchell. 1988. The Physiology of Crop Plants. Iowa State University Press. Ames, Iowa, USA.
2. Ilahi, I. 1995. Plant Growth. UGC Press, Islamabad.
3. Tesar, U. K., J. B. 1984. Physiological Aspects of Growth and Development. CSSA and ASA, Madison, WI, USA.
4. Salisbury, F. B. and C. W. Ross. 2010. Plant Physiology. 5th Ed., Wordsworth Publishing Company. Belmont, California, USA.

5. Taiz, L. and E. Zeiger. 2010. Plant Physiology. 6th Ed. Sinauer Associates Inc. MA, USA.

Title of the Course: Carbon Metabolism in Plants

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To create awareness about carbon metabolism in plants

Learning Outcomes:

At the end of the course, students will be able to:

1. Understand the process of photosynthesis and factors affecting it
2. Differentiate between C₃, C₄ and CAM plants
3. Comprehend the synthesis of ATP during photosynthesis
4. Know the process of nitrogen assimilation in plants

Theory:

- Photosynthesis: Photophosphorylation, mechanism and biochemistry of CO₂ fixation in C₃, C₄ and CAM plants
- Photorespiration
- Factors affecting photosynthesis
- Respiration; types and bioenergetics
- Carbohydrate metabolism
- Transformation of inorganic nitrogen into amino acids and proteins

Practical:

- Demonstration of rate of photosynthesis and respiration
- Comparative morphological characteristics of C₃, C₄ and CAM plants

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%

- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Hans, M. and P. Schopfer 2010. Plant Physiology. Springer-Verlag. Heidelberg, Germany.
2. Hopkins, W. G. 2008. Introduction to Plant Physiology. 4th Ed. John Wiley and Sons. New York, USA.
3. Meidner, H. 1984. Class Experiments in Plant Physiology. Allen and Unwin. London, U.K.
4. Taiz, L. and E. Zeiger. 2010. Plant Physiology. 6th Ed. Sinauer Associates, Inc., Publishers, Sunderland, USA.

Title of the Course: Physiological Aspects of Tissue Culture

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To develop an understanding of plant tissue culture and its importance in crop physiology

Learning Outcomes:

After studying this course, students will be able to:

1. Know the importance and recipe of different tissue culture media
2. Know how to maintain aseptic conditions for tissue culture
3. Know different developmental stages for regeneration of a plant through tissue culture
4. Gain a basic knowledge about the factors affecting *in vitro* cultures
5. Know the use of tissue culture techniques in agriculture

Theory:

- Historical background
- Composition of different culture media
- Sterilization techniques (glassware and media)
- Culture conditions and environment
- Physiology of donor and explant
- Physiology of callus formation and its types
- Morphogenesis and factors affecting morphogenesis
- Organogenesis (root and shoot formation)
- Protoplasts, isolation and culture

- Fusion haploid plants and their use in agriculture
- Embryogenesis and factors affecting embryogenesis
- Micro-propagation and its applications
- *In vitro* stress induction with special reference to salt, drought and temperature
- Problems and limitations of tissue culture techniques

Practical:

- Glassware selection, cleaning and sterilization
- Study and preparation of various growth media
- *In vitro* seed germination techniques
- Explant: selection, preparation and propagation techniques
- Methods of callus induction and regeneration

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Anis, M. and N Ahmad. 2016. Plant Tissue Culture: Propagation, Conservation and Crop Improvement. Springer
2. Dodds, J. H. and L. W. Roberts. 1999. Experiments in Plant Tissue Culture. 3rd Ed. Cambridge University Press. Cambridge, UK.
3. Skelsey, F. A. 1984. Biotechnology in Agriculture: New Tool for the Oldest Science.
4. Smith. J. E. 1996. Biotechnology, 3rd Ed. Cambridge University Press. Cambridge, UK.

Title of the Course: Crop Ecology

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the characteristics and services of agro-ecosystems and their dynamics

Learning Outcomes:

At the end of this course, the students will be able to:

1. Know basic terminology prevalent in ecological studies
2. Understand the influence of different biotic and abiotic factors on the ecosystem composition and process
3. Define various processes and services of an ecosystem
4. Understand the influence of ecological optima in agro-ecosystems
5. Know the agro-ecological zones of Pakistan

Theory:

- Ecosystem; concept, species and population dynamics
- Crop ecosystem; aerial and soil environment
- Environmental factors and crop productivity; responses of crop plants to atmospheric, edaphic, biotic, pyric and anthropogenic factors
- Crop yield variability in relation to ecological optima; interaction between organism
- Interference: competition, predation, parasitism, symbiosis and allelopathy
- Ecological strategies for crop productivity
- Natural resource management for ecosystem sustainability
- Agro-ecological zones of Pakistan

Practical:

- Visits to study the soil types, vegetation and water resources of major agro-ecological zones of Pakistan.

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Fitter, A. H. and R. K. M. Hay. 2002. Environmental Physiology of Plants. 4th Ed. Academic Press. London, UK.
2. Hussain. F. 1995. Manual of Plant Ecology. National Book Foundation, Islamabad, Pakistan.
3. Larcher, W. 1995. Physiological Plant Ecology. 3rd Ed. Springer-Verlag. Hiedeberg, Germany.
4. Loomis, R. S. and D. J. Connor. 1993. Crop Ecology, Productivity and Management in Agricultural Systems. Cambridge University Press. New York, USA.
5. Lambers, Hans, F. Stuart Chapin III and L. Thijs. 2008. Plant Physiological Ecology. Springer-Verlag, New York.

Title of the Course: Environmental Physiology

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the physiological responses of crop plants to changing environment

Learning Outcomes:

At the end of the course, students will be able to:

1. Understand the physiological basis of plant responses to various environmental variables
2. Invoke understanding how environmental factors influence crop productivity
3. Understand the adaptive mechanisms in plants for amelioration of environmental extremities
4. Evaluate the impact of changing environment on morphological development and growth of plants

5. Suggest the strategies for better crop productivity under different environmental conditions

Theory:

- Plant environment and its components
- Effect of solar radiation, temperature, precipitation, relative humidity, CO₂ and pollutants on physiology of crop plants
- Environmental control of growth and development: biological, genetic, atmospheric, edaphic and cultural factors
- Physiological strategies for improving crop productivity
- Crop productivity in relation to greenhouse effects, global warming and climate changes

Practical:

- Demonstration of effects of light, temperature, water and injurious salts on crop plants
- To visit sub urban agricultural land for observation of pollutant effects on soil and plants

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Lambers, H., F.S. Chapin, and T.L. Pons. 2009. Plant Physiological Ecology. Springer-Verlag New York Inc.
2. Pessarakli, M. 2014. Handbook of Plant and Crop Physiology, 3rd Ed. Taylor and Francis, Boca Raton, USA.

3. Ross, C.W and F. B. Salisbury. 2011. Plant Physiology 5th Ed., Wadsworth Publ. Co., Belmont, California, USA.
4. Taiz, L. and E., Zeiger. 2010. Plant Physiology 5th Ed. Sinauers Associate, Inc. Sunderland, Massachusetts, USA.

**SCHEME OF STUDIES FOR MASTER IN CROP
PHYSIOLOGY**

Semester I	Credits	Semester II	Credits
Advanced Seed Physiology	3(2+1)	Physiology of Drought	3(2+1)
Biological Nitrogen Fixation	3(2+1)	Plant Molecular Biology	3(2+1)
Advanced Crop Physiology	3(3+0)	Physiological Aspects of Herbicides	3(2+1)
Developmental Physiology of Crops	3(2+1)	Plant Microbes Interaction	3(2+1)
Total	12	Total	12
Semester III		Semester IV	
M. Sc. Thesis Research Work	10 (0+10)	Data Analysis, Thesis Write-up, Seminar & Viva Voce Examination	
		Total Research Work	10(0+10)
		G. Total (Course + Research Work)	34

SCHEME OF STUDIES FOR MASTER IN CROP PHYSIOLOGY

Subject Title	Cr. Hours
1. Advanced Seed Physiology	3 (2-1)
2. Biological Nitrogen Fixation	3 (2-1)
3. Advanced Crop Physiology	3 (3-0)
4. Developmental Physiology of Crops	3 (2-1)
5. Physiology of Drought	3 (2-1)
6. Plant Molecular Biology	3 (2-1)
7. Physiological Aspects of Herbicides	3 (2-1)
8. Plant Microbes Interaction	3 (3-0)
9. Analytical Techniques in Crop Physiology	3 (0-3)
Major Courses Credit Hours	27
Thesis Credit Hours	10(0-10)
Grand total Credit Hours	37

Note: Degree Awarding Institutions may select 24 Credits from above mentioned courses.

DETAIL OF COURSES FOR Masters in Crop Physiology

Title of the Course: **Advanced Seed Physiology**
Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To focus on the latest developments in seed physiology and its practical applications

Learning Outcomes:

At the end of the course, students will be able to:

1. Describe the physiology of reproductive parts of plant.
2. Understand mechanism involved from imbibition to germination and emergence
3. Understand pressure flow hypothesis involved in assimilate translocation from source to sink
4. Understand the apoplastic and symplastic loading and unloading processes
5. Know the postharvest physiological problems and their solutions
6. Practically analyze the seed viability and vigor tests to ensure the quality use of seed

Theory:

- Physiology of seed development
- Source-sink relationship and reserve accumulation
- Factors affecting seed yield and quality
- Desiccation tolerance
- Seed storage, longevity and deterioration
- Process of seed germination; imbibition, activation and reserve mobilization
- Regulation of seed germination: internal and external factors
- Seed enhancements

Practical:

- Seed sampling methods
- Purity tests
- Seed moisture determination
- Seed viability tests
- Germination and Vigor testing:
 - Electrical conductivity test
 - Accelerated aging test
 - Cold test
 - Controlled deterioration test

- Seed enhancement techniques
- Visit to public and private seed sectors

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Benech-Arnold, R. L. and R. A. Sanchez. 2004. Handbook of Seed Physiology. Application to agriculture. Haworth Press. New York, USA.
2. Bewley, J. D., and M. Black. 1994. Seed: Physiology of Development and Germination. 2nd Ed. Plenum Press. New York.
3. Fala, F. 1987. Handbook of Vigor Test Methods. 2nd Ed. ISTA Secretariat, Wageningen, The Netherland.
4. ISTA. 1985. International Rules for Seed Testing. Wageningen, The Netherlands.
5. McDonald, M. B. and L. O. Copland. 2007. Principles of Seed Science and Technology. 2nd Ed. Burgess Publishing Company. Minneapolis, Minnesota, USA.
6. Recent review articles

Title of the Course: Biological Nitrogen Fixation

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the role of symbiotic and asymbiotic plant-microbe relationships in nitrogen fixation

Learning outcomes:

At the end of the course, students will be able to:

1. Know biological nitrogen fixation in symbiotic and non-symbiotic association
2. Understand the sequence analysis expression of nodulation (*nod*) genes in *Rhizobium*
3. Know the sequence analysis and expression of nitrogen-fixing (*nif/fix*) genes in *Rhizobium*
4. Identify the different nitrogen fixing *Rhizobium* and their cross genera association
5. Inoculate and measure the nitrogen fixing ability of different species

Theory:

- Biological nitrogen fixation (BNF)
- Symbiotic and asymbiotic associations in legumes and non-legumes
- Mechanism of BNF
- Nitrogenase; structure and function
- Genetics and regulation of BNF
- Crosstalk between endophyte and host
- Molecular characterization of *nif* and *nod* gene
- Cross inoculation groups
- Estimation of BNF
- Physiological and ecological limitations of BNF
- BNF in agroforestry
- Biofertilizers; production and maintenance of inoculum

Practical:

- Morphology and anatomy of nodules
- Isolation of *Rhizobium* from nodules
- Isolation of plant growth promoting rhizobacteria from roots
- Gram's staining, re-inoculation test
- Nitrogen estimation by Kjeldahl's method/acetylene reduction assay

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Elmerich, C. and W. E. Newton. 2005. Associative and Endophytic Nitrogen Fixing Bacteria and Cyanobacterial Associations. Springer-Verlag. Berlin, Germany.
2. Hardarson, G. 2003. Maximizing the Use of Biological Nitrogen Fixation in Agriculture. Kluwer Academic Publishers. Amsterdam, The Netherlands.
3. James, E. K., J. I. Sprent, M. J. Dilworth and W. E. Newton. 2005. Nitrogen Fixing Leguminous Symbiosis. Springer-Verlag. Berlin, Germany.
4. Klipp, W., B. Masepohl, J. R. Gallon and W. E. Newton. 2005. Genetics and Regulation of Nitrogen Fixation in Free Living Bacteria. Springer-Verlag. Berlin, Germany.
5. Stacy, G. 1997. Biological Nitrogen Fixation. Chapman and Hall Inc. New York, USA.
6. Recent review articles

Title of the Course: Advanced Crop Physiology
Credit Hours: 3 (3-0)

Specific Objectives of Course:

- To bestow upon the students the advancements in the field of crop physiology

Learning Outcomes:

At the end of the course, students will be able to:

1. Describe key-aspects in plant secondary metabolism
2. Understand the influence of environment on growth and development of crops
3. Outline methods of measuring water availability, nitrogen availability and radiation use efficiency

4. Devise strategies to improve crop production by integrating concepts, methods and models based on crop physiology
5. Evaluate how different crops tolerate environmental stresses to produce economic yield

Theory:

- Recent advances in crop physiology
- Secondary plant metabolism and types of physiological damage in plants
- Scavenging systems against physiological damage in crop plants
- Homeostasis in plants
- Stress signaling in plants
- Physiological basis for crop improvement
- Metabolic shift against stresses
- Omics approaches and their application
- Exercise in project development & data interpretation

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Marten, J. and D. E. Sadave. 1994. Plants, Genes and Agriculture. Jones and Bartlett Publishers International. USA.
2. Pessaraki, M. 2010. Handbook of Plant and Crop Stress. 3rd Ed. CRS Press, Taylor and Francis. USA
3. Taiz, L. and E. Zeiger. 2010. Plant Physiology. 6th Ed. Sinauer Associates, Inc., Publishers. Sunderland, USA.

4. Wilkins, M. B. 1992. Advanced Plant Physiology. Longmans Singapore Publishers (pvt) Ltd. Singapore.
5. Recent review articles.

Title of the Course: Developmental Physiology of Crops
Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To elucidate the patterns of growth and development of major crops

Learning Outcomes:

At the end of the course, students will be able to:

1. Decipher the structural organization of plants at various levels
2. Gain in depth understanding of developmental plant physiology
3. Identify growth pattern of leaves and stomata
4. Depict correlations in root and shoot development
5. Understand the phenomena of flowering, fruit set, ripening, after ripening, maturity and senescence

Theory:

- Structural organization of plants at subcellular, cellular, tissue and organ levels
- Basic events of growth; cell growth, division, enlargement and differentiation
- Meristematic tissues and its types
- Physiology of root and shoot initiation and development
- Leaf growth and stomatal development
- Physiology of flowering, fruit set, ripening, maturity, after ripening and senescence

Practical:

- Identification of growth stages of cereals, legumes and oilseed crops
- Root and shoot growth patterns
- Identification of position, number and size of stomata

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Gregory, P. J., J. V. Lake, and D. A. Rose. 2010. Root Development and Function. Cambridge University Press. UK.
2. Hopkins, W. G. 2008. Introduction to Plant Physiology. 4th Ed. John Wiley and Sons. New York, USA.
3. Opik, H. and S. A. Rolfe. 2005. The Physiology of Flowering Plants. 4th Ed. Cambridge University Press. UK.
4. Ottline, L. and S. Day. 2002. Mechanism in plant development. Blackwell. UK.
5. Salisbury, F. B. and C. W. Ross. 2010. Plant Physiology. 5th Ed., Wordsworth Publishing Company. Belmont, California, USA.
6. Taiz, L. and E. Zeiger. 2010. Plant physiology. 6th Ed. Sinauer Associates, Inc., Publishers. Sunderland, USA.
7. Recent review articles

Title of the Course: Physiology of Drought
Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the mechanism of damage and measurement of drought resistance in crop plants

Learning Outcomes:

At the end of the course, students will be able to:

1. Have a global perspective of drought
2. Know the mechanism of adaptation against drought
3. Know the influence of drought on photosynthesis, phytohormones, nitrogen fixation, enzymatic activity and protein synthesis in plants
4. Quantify the extent of drought and its response

Theory:

- Global perspectives of drought
- Water deficit in plants
- Morpho-anatomical consequences of drought
- Mechanisms of drought tolerance in crop plants
- Responses of plants to drought
- Water stress and photosynthetic apparatus
- Photosynthetic adjustments to drought
- Relationships of drought with phytohormones
- Nitrogen fixation, nitrate reductase activity and protein synthesis
- Induction of drought tolerance in crop plants
- Strategies for improving water use efficiency
- Crop research strategies for drought areas

Practical:

- Measurement of soil and plant water content
- Crop growth analysis under drought

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment**Mid Term (40%)**

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Close, T. J. and E. A. Bray. 1993. Plant Responses to Cellular Dehydration during Environmental Stress. Current Topics in Plant Physiology. Vol. 10. American Society of Plant Physiology. Rockville, USA.

2. Paleg, L. G., and D. Aspinall. 1981. The Physiology and Biochemistry of Drought Resistance in Plants. Academic Press. Sydney, Australia.
3. Pessarakli, M. 2010. Handbook of Plant and Crop Stress. 3rd Ed. CRS Press, Taylor and Francis. USA.
4. Smith, J. A. C. and H. Griffiths. 1993. Water deficits: Plant Responses from Cell to Community. Bios Scientific Publishers.
5. Taiz, L. and E. Zeiger. 2010. Plant Physiology. 6th ed. Sinauer Associates, Inc., Publishers. Sunderland, USA.
6. Recent review articles

Title of the Course: Plant Molecular Biology
Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To provide a vision of molecular biology to crop physiologists

Learning Outcomes:

At the end of this course, the students will be able to:

1. Understand the basic principles of molecular mechanisms
2. Evaluate genome structures for combating various stresses
3. Develop understanding regarding role of protein structures in gene regulation
4. Apply molecular knowledge for genetic improvement

Theory:

- Macro molecules in plant; carbohydrates, proteins, lipids
- Nucleotides/Nucleosides and their role; structure of DNA, RNA
- Genes and gene expression
- Protein synthesis, chromosomes, mitotic and meiotic behaviour of chromosomes
- DNA replication & repair mechanism
- Plant genome organization
- Plant transformation and its methods
- Genome editing
- Development of molecular markers for stress tolerance
- Gene regulation, signal transduction
- Chloroplast and mitochondrial genome
- Plant genetic engineering and its application in agriculture

Practical:

- DNA & RNA extraction and PCR amplification
- Bioinformatics tools used in molecular biology
- Isolation and quantification of protein

- Visits to research labs with related facilities

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Lab Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Buchanan, B. B., W. Gruissem and R. L. Jones. 2002. Biochemistry and molecular biology of plants. John Wiley and Sons. USA.
2. Devies, P. 2005. Principles and Methods of Plant Molecular Biology, Biochemistry and Genetics. Student Edition, India.
3. Hafeez, F., Y. Zafar and A. M. Khalid. 2005. Modern Techniques in Biotechnology: a theoretical Manual. NIBGE, Faisalabad.
4. Pena, L. 2005. Transgenic Plants. Methods and Protocol. HUMANA, JN, USA.
5. Recent review articles

Title of the Course: Physiological Aspects of Herbicides

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand physiological basis of herbicide activity and selectivity in crops

Learning Outcomes:

At the end of the course, students will be able to:

1. Know different groups of herbicides and their physico-chemical characteristics
2. Understand the mechanism of herbicide uptake, and their resistance and tolerance by plants
3. Know mode of action of herbicides belonging to various chemical groups
4. Understand the bases of herbicide selectivity
5. Prepare herbicide formulations with correct dosage calculation and their field application

Theory:

- Herbicides and their classification
- Chemical and physical properties of different herbicides
- Surfactants and their significance for enhancing herbicide activity
- Basis of plant selectivity, resistance and tolerance to herbicides
- Mechanism of herbicide uptake
- Physiological mechanisms of herbicide activity in plants: cell division, elongation, germination, early growth, solute transport, cell membrane, structure and function, water and CO₂ exchange, photosynthesis and respiration
- Factors affecting uptake and translocation and activity of herbicides
- Herbicide degradation in plants and their residual activity
- Herbicide toxicity
- Development of herbicide resistance

Practical:

- Calculation of herbicide doses and their calibration
- Demonstration of different methods of herbicide application
- Demonstration of herbicide effects on weeds and crop plants

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Anderson, W. P. 1993. Weed Science Principles. 2nd Ed. West Publishing Company. USA.
2. Ashton, F. M. and A. S. Crafts. 1981. Mode of Action of Herbicides. 2nd Ed. John Wiley and Sons. New York.
3. Cobb, A. H. and J. P. H. Reade. 2010. Herbicides and Plant Physiology. 2nd ed. John Wiley and Sons. West Sussex, UK.
4. Rao, V. S. 2000. Principles of Weed Science. Oxford and IBH Publishing Co. (Pvt). Ltd., New Delhi, India.
5. Recent review articles

Title of the Course: Plant Microbe Interaction

Credit Hours: 3 (3-0)

Objective:

To develop knowledge about utilization of beneficial microorganisms for enhancing plant growth and productivity

Learning Outcomes:

After studying this course, students will be able to:

1. Describe the role of microorganisms in nutrient acquisition by plants
2. Understand the role of microbes in production of secondary metabolites
3. Comprehend the biological control of plant pathogens through micro-organisms
4. Apply and evaluate the seed inoculation techniques

Theory:

- Plant-soil-microbial interactions
- Utilization of microbial interactions for nitrogen fixation
- Microbial interactions facilitating nutrients solubilization
- Production of phytohormones and their role in plant growth
- Microbiological control of bacterial and fungal plant pathogens
- Secondary metabolites with antifungal activities,
- Production of antibiotics, hydrolytic enzymes and siderophores
- Production and maintenance of inoculants and applications
- Development of biofertilizers and biopesticides

Teaching Methodology

- Lecturing
- Assignments
- Guest Speaker(s)

Assessment**Mid Term (40%)**

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 30%
- Assignments 20%

Recommended Books:

1. Hafeez, F. Y., K. A. Malik and Y. Zafar. 2009. Microbial Technologies For Sustainable Agriculture. Crystal Press. Islamabad, Pakistan.
 2. James, E. K., J. I. Sprent, M. J. Dilworth and W. E. Newton. 2005. Nitrogen Fixing Leguminous Symbiosis. Springer-Verlag. Berlin, Germany.
 3. Saghir, M. D. A. Zaidi and J. Musarrat. 2009. Microbes in Sustainable Agriculture. Nova Science Publication. New York, USA.
 4. Siddiqui Z. A. 2006. PGPR: Biocontrol and Biofertilization. Springer, the Netherlands.
 5. Tilak, K. V. B. R., K. K. Pal and R. Dey. 2010. Microbes for Sustainable Agriculture. Int. Printing Publishing House Pvt. Ltd., New Dehli, India.
- Recent review articles

Title of the Course: Analytical Techniques in Crop Physiology

Credit Hours: 3 (0-3)

Specific Objectives of Course:

- To equip the students with analytical techniques used in crop physiology

Learning Outcomes:

At the end of this course, the students will be able to:

1. Understand the analytical approaches and apparatus used in crop physiology

2. Quantify the physiological and biochemical traits
3. Analyze various growth attributes of plants

Practical:

- Centrifugation and use of tracers
- Techniques used for studying water relations in plants
- Chromatography
- Electrophoresis
- Spectrophotometry
- Plant growth analysis

Teaching Methodology

- Demonstration
- Written Assignments
- Guest Speaker
- Lab/Green-house/Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 60%
- Presentation 20%
- Assignments 20%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Coombs, J., D. O. Hall., S. P. Long. J. M. O. Scurlock. 1985. Techniques in Bioproductivity and Photosynthesis. Pergamon Press. Oxford, UK.
2. Dietmar, T. 1998. Nucleic Acid Electrophoresis: Lab Manual. Springer-Verlag. Berlin.
3. Salisbury, F. B. and C. W. Ross. 2010. Plant Physiology. 5th Ed., Wordsworth Publishing Company. Belmont, California, USA.
4. Salisbury, F. B. and C. W. Ross. 1974. Plant Physiology: Laboratory Manual to 2r.e. Wadsworth Publishing Co Inc.
5. Pearcy, R. W., J. R. Ehleringer, H. A. Mooney and P. W. Rundel. 1991. Plant Physiological Ecology: Field Methods and Instrumentation. Chapman and Hall Inc. New York. USA.
6. Recent review articles

SCHEME OF STUDIES FOR PhD IN CROP PHYSIOLOGY

Semester I	Credits	Semester II	Credits
Biophysics of Growth	3(2+1)	Plant Response to Stress	3(2+1)
Physiological Aspects of Crop Yield	3(2+1)	Root Physiology	3(2+1)
Special problem	1(1+0)	Seminar	1(1+0)
Plant Metabolism and Bioenergetics	3(2+1)	Crops for Changing Environments	3(2+1)
Total	10	Total	10
Semester III		Semester IV	
Ph. D. Thesis Research Work (Comprehensive Examination, Synopsis (Seminar & Approval))	20(0+20)	Thesis Research Work	
Semester V		Semester VI	
Thesis Research Work		Thesis Research Work	
Semester VII		Semester VIII	
Thesis Research Work		Data Analysis, Thesis Write-up, Seminar & Viva Voce Examination	
		Total Research Work	20(0+20)
		G. Total (Course + Research Work)	40

SCHEME OF STUDIES FOR PhD IN CROP PHYSIOLOGY

Subject Title	Cr. Hours
1. Biophysics of Growth	3 (2-1)
2. Physiological Aspects of Crop Yield	3 (2-1)
3. Special Problem	1(1-0)
4. Plant Metabolism and Bioenergetics	3 (2-1)
5. Plant Responses to Stress	3 (2-1)
6. Root Physiology	3 (2-1)
7. Seminar	1(1-0)
8. Crops for Changing Environments	3 (2-1)
9. Modeling Crop Growth and Development	3 (2-1)
Major Courses Credit Hours	23
Thesis Credit Hours	20(0-20)
Grand Total Credit Hours	43

Note: Degree Awarding Institutions may select 20 Credits from above mentioned courses.

DETAIL OF COURSES FOR PhD in Crop Physiology

Title of the Course: Biophysics of Growth

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To provide knowledge of biophysical aspects of plant growth

Learning Outcomes:

At the end of the course, students will be able to:

1. Understand the principles and mechanisms of cell wall growth
2. Explain changes and processes of differential growth
3. Establish relationship between water/nutrient uptake and cell wall extension
4. Measure cell membrane permeability and stability
5. Demonstrate and apply methods of physics to study biological structures and processes.

Theory:

- Mode of assimilate partitioning
- Principles of cell wall growth
- Mechanisms of cell wall loosening and extension
- Changes in cellulose microfibril orientation during differential growth
- Relationship of cell wall extension with water and solute uptake
- Regulation of leaf growth, internodal growth and root growth
- Energy transduction and carbon relations during growth
- Effect of UV, IR & laser radiations on seed and growth
- Biomagnetism

Practical:

- Measurement of cell membrane permeability and stability
- Demonstration of effect of magnetism on growth and development of plant

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Lab/Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Holbrook, N. M. and M. A. Zwieniecki. 2011. Vascular transport in plants. Elsevier Academic Press.
2. Misra, A. N. (Editor). 2012. Biophysics (ISBN 978-953-51-0376-9).
3. Nobel, P. S. 2009. Physiochemical and Environmental Plant Physiology. 4th Edition. Elsevier Academic Press.
4. Baskin, T. I. 2005. Anisotropic Expansion of the Plant Cell Wall. Annual Review of Cell Development and Biology. 21: 203–222.
5. Jarvis, M. C. and M. C. McCann. 2000. Macromolecular Biophysics of the Plant Cell Wall: Concepts and Methodology. Plant Physiology and Biochemistry. 38 (1/2): 1–13.
6. Recent review articles

Title of the Course: Physiological Aspects of Crop Yield

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand physiological basis of yield formation in crops

Learning Outcomes:

At the end of the course, students will be able to:

1. Understand the canopy development process and its architecture, and its implications for efficient light harvest.
2. Quantify the relative contribution of variables crop canopies towards dry matter accumulation.
3. Know the process of dry matter partitioning, and its limitations for yield formation.
4. Analyze the relative impact of source and sink capacity on economic yield of crops.

5. Able to identify physiological indicators of yield formation in field crops.

Theory:

- Physiological basis of crop yield
- Development of crop canopy
- Concept of critical and optimum leaf area indices
- Canopy size and architecture for light interception
- Effect of canopy architecture on crop yield
- Radiation use efficiency and the factors influencing it
- Factors affecting pollination and fertilization
- Sink capacity, sink strength and source-sink relationship
- Grain growth and development
- Senescence and degradative processes affecting crops yield

Practical:

- Measurement of leaf area and calculation of LAI
- Calculation of indices of growth
- Calculation of effective seed growth rate and duration
- Total dry matter accumulation and its partitioning
- Calculation of partitioning coefficient

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Boote, K. J., J.M. Bennett, T. R. S. Sinclair and G. M. Paulsen. 1994. Physiology and Determination of Crop Yield, ASA, CSSA, Madison, Wisconsin, USA.

2. Chetti, M. B., S.M. Hiremath and M. Kalpana. 2004. Physiological Approaches for Enhancing Productivity Potential Under Drought Condition. Studium Press.
3. Coombs J., D. O. Hall, S. P. Long, and J. M. O. Scutock. 1987. The Techniques in Bioproductivity and Photosynthesis. 2nd Ed. Pergamon Press Oxford. New York, USA.
4. Fageria, N. K., V. C. Baligar and R. B. Clark. 2005. Physiology of Crop Production. Academic Press. New York, USA.
5. Hay, R. K. M., and J. R. Porter. 2006. An Introduction to the Physiology of Crop Yield. Wiley Blackwell. USA.
6. Fageria, N. K., V. C. Baligar, and R. B. Clark. 2006. Physiology of Crop Production. Food Products Press, New York.
7. Hay, Robert K. M. and John Porter. 2006. The Physiology of Crop Yield (Second Edition). Wiley Blackwell Publishing, USA.
8. Recent review articles

Title of the Course: Plant Metabolism and Bioenergetics

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the processes of plant metabolism and energy relationships

Learning Outcomes:

At the end of the course, students will be able to:

1. Understand thermodynamics in plant systems
2. Explain bio-synthesis of protein, carbohydrates, lipids and other macromolecules
3. Comprehend respiration, its regulation and energetics
4. Perform analytical techniques in crop physiology

Theory:

- Biological architecture; mitochondria and chloroplast
- Oxidation-reduction reactions
- Oxidizing and reducing agents
- Energy transformation in plant systems
- Bio-synthesis: Proteins, carbohydrates, fats and other compounds (e.g. phenolics etc.)
- Respiration, its regulation and energetics

Practical:

- Demonstration of microscopy
- Gas exchange measurement

- Demonstration of biogas plant

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Quiz test 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Taiz, L. and E. Zeiger. 2010. Plant Physiology. 5th Ed. Sinauer Publishers. Sunderland, USA.
2. Bose, B, 2005. Developments in Physiology, Biochemistry and Molecular Biology of Plants.
3. Ashihara, H., A. Crozier and A. Komamine. 2011. Plant Metabolism and Biotechnology. John Wiley and Sons. Sussex, UK.
4. Lehniger, A. L. 1981. The Molecular Basis of Biological Energy Transformation. 2nd Ed. Hopkins University Press, USA.
5. Recent review articles

Title of the Course: Plant Responses to Stress

Credit Hours: 3 (2-1)

Specific Objectives of Course:

- To understand the types and mechanism of plant environmental stresses and their mitigation

Learning Outcomes:

At the end of the course, students will be able to:

1. Understand types of stresses and their impact on morphology, physiological and biochemical processes

2. Know the natural tolerance ability of various crop plants
3. Identify the stress and manage crops accordingly through exogenous applications
4. Learn practically how to induce the stress in different growth media in field, pots and hydroponic experiments

Theory:

- Types of biotic and abiotic stresses
- Mechanism of damage due to different abiotic and biotic stresses
- Types of plant responses to different stresses
- Plant adaptive mechanisms to stresses
- Mitigation of stresses in field crops

Practical:

- Induction of salinity, drought and temperature stress in plants under pots and hydroponics
- Evaluating the effects of drought and salinity stresses on plants
- Mitigation of stresses by seed treatments, foliar and soil application

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Fowden, L., T. Mansfield and J. Stoddart. 1993. Plant Adaptations to Environmental Stresses. Springer-Verlag. Berlin, Germany.

2. Fitter, A. H. and R. K. M. Hay. 2002. Environmental Physiology of Plants. 4th Ed. Academic Press. London.
3. Orcutt, D. M. and E. T. Nelson. 2000. Physiology of Plants under Stress. John Wiley and Sons. USA.
4. Pessaraki, M. 2010. Handbook of Plant and Crop Stress. 3rd Ed. CRC Press, Taylor and Francis. New York, USA.
5. Taiz, L. and E. Zeiger. 2010. Plant physiology, 6th Ed. Sinauer Associates, Inc., Publishers. Sunderland, USA.
6. Recent review articles

Title of the Course: Root Physiology

Credit Hours: 3(2-1)

Specific Objective:

To develop an understanding about the importance of roots in plant growth and development

Learning Outcomes:

At the end of the course, students will be able to:

1. Identify different types of root systems
2. Understand morphological, physiological and anatomical characteristics of roots
3. Explain the mechanism of water and ion absorption and translocation
4. Analyze root functioning in response to changing soil environment

Theory

- Types of root systems and their anatomical features
- Root architecture and composition
- Root developmental physiology; Initiation, maturation and senescence
- Factors affecting root development and physiology
- Root tip growth and differentiation; Meristematic zone, elongation zone, maturation zone
- Root gravitropic response
- Water uptake and movement within roots
- Mineral ions uptake and transport
- Root metabolism and exudation
- Rhizosphere allelopathy as a tool for pest management
- Root symbiosis with bacteria and mycorrhizae

Practical

- Demonstration of patterns of root development in different growth media
- Demonstration of developmental response of roots to nutrients status of rhizosphere
- Measurement of root exudates

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment**Mid Term (40%)**

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books

1. Lambers, H. and T. D. Colmer. 2005. Root Physiology; from Gene to Function. Springer, Netherlands
2. Jones, R., H. Ougham, H. Thomas and S. Waaland. 2012. The Molecular life of Plants. Wiley-BlackWell Publishing, USA.
3. Chaumont, F., Tyerman, D. Stephen. 2017. Plant Aquaporins: From Transport to Signaling. Springer International Publishing.
4. Eshel, A. and T. Beeckman. 2013. Plant Roots; The Hidden Half, 4th Ed. CRC Press, Taylor & Francis Group.
5. de Bruijn, F.J. 2015. Biological Nitrogen Fixation. John Wiley & Sons. Inc, USA
6. Morte, A. and A. Varma. 2014. Root Engineering; Basic and Applied Concepts. Springer-Verlag Berlin, Heidelberg
7. Brewin, N. J. 2010. Root Nodules (Legume–Rhizobium Symbiosis). John Wiley & Sons, Inc. USA.

Title of the Course: Crops for Changing Environments

Credit Hours: 3 (2-1)

Objective:

- To introduce diversified crops to combat changing climatic optima

Learning Outcomes:

At the end of the course, students will be able to:

1. Recognize perspectives of meteorology and crop ecology
2. Understand crop-environment relationships and analyze nature, dynamics and impact of climate change on crops
3. Comprehend physiological basis of crop resilience to climate change
4. Apply practical knowledge to improve crop productivity under changing climate scenario

Theory:

- Regional scenario of changing climatic conditions
- Causes and indicators of climate change
- Impact of climatic extremities on growth and development of crops
- Emerging climatic scenarios and their effect on cropping systems and crop production
- Remote sensing: concept and application
- Introduction and adaptability of climate resilient crops
- Morpho-physiological and phenological attributes of tolerance in climate resilient crops
- Biodiversity as a mean for combating climate change
- Crop diversification for dry land and saline environments-some case histories

Practical:

- Evaluating the comparative performance of climate resilient crops under varying environmental conditions
- Study and assessment of the weedy behavior of introduced crops

Teaching Methodology

- Lecturing
- Assignments
- Guest Speaker(s)
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Pessarakli, M. 2011. Hand book of plant and crop stress. 3rd Ed. CRC press, Taylor & Francis group, N.Y., USA.
2. R. Ortiz. 2011. Agro-biodiversity management for climate Change. In: Lenni, J. M. and D. Wood (Ed.). Agrobiodiversity management for food security: a critical review. CABI. Cambridge, USA.
3. Yadev, S. S., J. L. Hatfield, R. Redden, H. Lotze-Campen and A. Hall. 2011. Crop Adaptation to Climate Change. Iowa state university press. Ames, Iowa, USA.
4. Recent review articles

Title of the Course: Modeling Crop Growth and Development
Credit Hours: 3 (2-1)

Objective:

- Application of crop growth models in agriculture

Learning Outcomes:

At the end of the course, students will be able to:

1. Understand the concept of crop growth models
2. Use crop models in estimating growth rate, productivity and yield fluctuations
3. Simulate crop growth under variable agro-climatic optima
4. Predict yield, productivity and/or quality changes in the crops with respect to adjustment of sowing/cutting timings etc.

Theory:

- Concept and types of crop modelling
- Introduction to growth models for various crops
- Components of a model: recent sub-models
- Purpose, objectives and implications of crop models

- Simulation of crop growth using different models
- Calibration and validation of crop models
- Limitations of crop models
- Meteorological information

Practical:

- Collection and maintenance of data files for model development and simulation of crop growth

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs) 50%
- Presentation 20%
- Assignments 20%
- Report Writing 10%

Recommended Books:

1. Charles-Edwards, D. A., D. Doley and G. M. Rimmington. 1986. Modeling Plant Growth and Development. Sydney, Australia.
2. Charles-Edwards, D. A. 1982. Physiological Determinants of Crop Growth. Academic Press. London.
3. Hay, Robert K. M. and J. Porter. 2006. The Physiology of Crop Yield. 2nd Ed. Wiley Blackwell Publishing, USA.
4. Crostpher, T. 2006. Introduction to Mathematical Modeling of Crop Growth. Brown Walker Press. Florida, USA.
5. Thornley, J. H. M. and J. France. 2007. Mathematical Modeling in Agriculture. 2nd Ed. CABI. Oxford, UK.
6. Recent review articles

ANNEXURE - A

**DETAILS OF COMPULSORY COURSES
COMPULSORY COURSES IN ENGLISH FOR
Undergraduate Level**

English I (Functional English)

Credit Hrs. 3(3-0)

Objectives: Enhance language skills and develop critical thinking.

Course Contents

Basics of Grammar
Parts of speech and use of articles
Sentence structure, active and passive voice
Practice in unified sentence
Analysis of phrase, clause and sentence structure
Transitive and intransitive verbs
Punctuation and spelling

Comprehension

Answers to questions on a given text

Discussion

General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening

To be improved by showing documentaries/films carefully selected by subject teachers

Translation skills

Urdu to English

Paragraph writing

Topics to be chosen at the discretion of the teacher

Presentation skills

Introduction

Note: Extensive reading is required for vocabulary building

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:

1. Functional English

a) Grammar

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492
2. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

1. Reading. Upper Intermediate. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

d) Speaking

English II (Communication Skills)

Credit Hrs. 3(3-0)

Objectives: Enable the students to meet their real life communication needs.

Course Contents

Paragraph writing

Practice in writing a good, unified and coherent paragraph

Essay writing

Introduction

CV and job application

Translation skills

Urdu to English

Study skills

Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills

Letter/memo writing, minutes of meetings, use of library and internet

Presentation skills

Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:

Communication Skills

a) Grammar

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading

1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
2. Reading and Study Skills by John Langan
3. Study Skills by Richard Yorky.

English III (Technical Writing and Presentation Skills)
Credit Hrs.3(3-0)

Objectives: Enhance language skills and develop critical thinking

Course Contents:

Presentation skills

Essay writing

Descriptive, narrative, discursive, argumentative

Academic writing

How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:

Technical Writing and Presentation Skills

- a) Essay Writing and Academic Writing
 1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
 2. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
 3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.
- b) Presentation Skills
- c) Reading
The Mercury Reader. A Custom Publication. Compiled by northern Illinois University. General Editors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharon. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

**ISLAMIC STUDIES
(Compulsory)**

Objectives:

Credit Hrs.3(3-0)

This course is aimed at:

- 1 To provide Basic information about Islamic Studies
- 2 To enhance understanding of the students regarding Islamic Civilization
- 3 To improve Students skill to perform prayers and other worships
- 4 To enhance the skill of the students for understanding of issues related to faith and religious life.

Detail of Courses:

Introduction to Quranic Studies

- 1) Basic Concepts of Quran
- 2) History of Quran
- 3) Uloom-ul-Quran

Study of Selected Text of Holly Quran

- 1) Verses of Surah Al-Baqra Related to Faith (Verse No-284-286)
- 2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
- 3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
- 4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
- 5) Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)

Study of Selected Text of Holly Quran

- 1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
- 2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
- 3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I

- 1) Life of Muhammad Bin Abdullah (before Prophet Hood)
- 2) Life of Holy Prophet (S.A.W) in Makkah

- 3) Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II

- 1) Life of Holy Prophet (S.A.W) in Madina
- 2) Important Events of Life of Holy Prophet in Madina
- 3) Important Lessons Derived from the life of Holy Prophet in Madina

Introduction to Sunnah

- 1) Basic Concepts of Hadith
- 2) History of Hadith
- 3) Kinds of Hadith
- 4) Uloom –ul-Hadith
- 5) Sunnah & Hadith
- 6) Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence

- 1) Basic Concepts of Islamic Law & Jurisprudence
- 2) History & Importance of Islamic Law & Jurisprudence
- 3) Sources of Islamic Law & Jurisprudence
- 4) Nature of Differences in Islamic Law
- 5) Islam and Sectarianism

Islamic Culture & Civilization

- 1) Basic Concepts of Islamic Culture & Civilization
- 2) Historical Development of Islamic Culture & Civilization
- 3) Characteristics of Islamic Culture & Civilization
- 4) Islamic Culture & Civilization and Contemporary Issues

Islam & Science

- 1) Basic Concepts of Islam & Science
- 2) Contributions of Muslims in the Development of Science
- 3) Quran & Science

Islamic Economic System

- 1) Basic Concepts of Islamic Economic System
- 2) Means of Distribution of wealth in Islamic Economics
- 3) Islamic Concept of Riba
- 4) Islamic Ways of Trade & Commerce

Political System of Islam

- 1) Basic Concepts of Islamic Political System
- 2) Islamic Concept of Sovereignty
- 3) Basic Institutions of Govt. in Islam

Islamic History

- 1) Period of Khlaft-E-Rashida
- 2) Period of Ummayyads
- 3) Period of Abbasids

Social System of Islam

- 1) Basic Concepts of Social System of Islam
- 2) Elements of Family
- 3) Ethical Values of Islam

Teaching Methodology

- Lecturing
- Written Assignments

Assessment**Mid Term (40%)**

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Reference Books:

- 1) Hameed ullah Muhammad, "Emergence of Islam" , IRI, Islamabad
- 2) Hameed ullah Muhammad, "Muslim Conduct of State"
- 3) Hameed ullah Muhammad, "Introduction to Islam"
- 4) Mulana Muhammad Yousaf Islahi,"
- 5) Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
- 6) Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993)
- 7) Mir Waliullah, "Muslim Jurisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)
- 8) H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)
- 9) Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001)

Pakistan Studies (Compulsory)

Introduction/Objectives

Credit Hrs.3(3-0)

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline

1. Historical Perspective

- a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
- b. Factors leading to Muslim separatism
- c. People and Land
 - i. Indus Civilization
 - ii. Muslim advent
 - iii. Location and geo-physical features.

2. Government and Politics in Pakistan

Political and constitutional phases:

- a. 1947-58
- b. 1958-71
- c. 1971-77
- d. 1977-88
- e. 1988-99
- f. 1999 onward

3. Contemporary Pakistan

- a. Economic institutions and issues
- b. Society and social structure
- c. Ethnicity
- d. Foreign policy of Pakistan and challenges
- e. Futuristic outlook of Pakistan

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Books Recommended

1. Burki, Shahid Javed. *State & Society in Pakistan*, The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy*. Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. *Pakistan's Foreign policy: An Historical analysis*. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development*. Lahore, 1994.
5. Wilcox, Wayne. *The Emergence of Bangladesh.*, Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota*, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan*, Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development*. Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh*. Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan*, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan*. Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan*, Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, *Pakistan Under Martial Law*, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective*. Islamabad: National Commission on Historical and Cultural Research, 1993.

**COMPULSORY MATHEMATICS
COURSES FOR BSc (Hons) AGRICULTURE**

1. MATHEMATICS I (ALGEBRA)

Prerequisite(s): Mathematics at secondary level

Credit Hours: 3 (3 – 0)

Specific Objectives of the Course:

To prepare the students, not majoring in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions.

Matrices: Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule.

Quadratic Equations: Solution of quadratic equations, qualitative analysis of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations.

Sequences and Series: Arithmetic progression, geometric progression, harmonic progression.

Binomial Theorem: Introduction to mathematical induction, binomial theorem with rational and irrational indices.

Trigonometry: Fundamentals of trigonometry, trigonometric identities.

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)

- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:

1. Dolciani MP, Wooton W, Beckenback EF, Sharron S, *Algebra 2 and Trigonometry*, 1978, Houghton & Mifflin, Boston (suggested text)
2. Kaufmann JE, *College Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
3. Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston

2. MATHEMATICS II (CALCULUS)

Prerequisite(s): Mathematics I (Algebra)

Credit Hours: 3 (3 – 0)

Specific Objectives of the Course:

To prepare the students, not majoring in mathematics, with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities.

Limits and Continuity: Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

Derivatives and their Applications: Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.

Integration and Definite Integrals: Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:

Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8th edition), 2005, John Wiley & Sons, New York.

Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text)

Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston.

Thomas GB, Finney AR, *Calculus* (11th edition), 2005, Addison-Wesley, Reading, Ma, USA.

3. MATHEMATICS III (GEOMETRY)

Prerequisite (s): Mathematics II (Calculus)

Credit Hours: 3 (3 – 0)

Specific Objectives of the Course:

To prepare the students, not majoring in mathematics, with the essential tools of geometry to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Geometry in Two Dimensions: Cartesian-coördinate mesh, slope of a line, equation of a line, parallel and perpendicular lines, various forms of equation of a line, intersection of two lines, angle between two lines, distance between two points, distance between a point and a line.

Circle: Equation of a circle, circles determined by various conditions, intersection of lines and circles, locus of a point in various conditions.

Conic Sections: Parabola, ellipse, hyperbola, the general-second-degree equation.

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:

Abraham S, *Analytic Geometry*, Scott, Freshman and Company, 1969

Kaufmann JE, *College Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston.

Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston.

Note:

1. ***Two courses will be selected from the above three courses of Mathematics.***
2. ***Universities may make necessary changes in the courses according to the requirement as decided by the Board of Studies.***

ANNEXURE - E

Statistics-I

Credit Hrs. 3 (2-1)

Definition and importance of Statistics in Agriculture, Data Different types of data and variables

Classification and Tabulation of data, Frequency distribution, stem-and-Leaf diagram, Graphical representation of data Histogram, frequency polygon, frequency curve.

Measure of Central tendency, Definition and calculation of Arithmetic mean, Geometric mean, Harmonic mean, Median quantiles and Mode in grouped and ungrouped data.

Measure of Dispersion, Definition and Calculation of Range, quartile deviation, Mean deviation, Standard deviation and variance, coefficient of variation.

Practical

- a. Frequency Distribution
- b. Stem-and-Leaf diagram
- c. Various types of Graphs
- d. Mean, Geometric mean Harmonic Mean,
- e. Median, Quartiles Deviation, mean Deviation.
- f. Standard Deviation, Variance, Coefficient of variation,
- g. Skewness and kenosis

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Book Recommended

1. Introduction to Statistical Theory Part- I by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)

2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. A. Concise Course in A. Level Statistic with world examples by J. Crawshaw and J. Chambers (1994)
4. Basic Statistics an Inferential Approach 2nd Ed. (1986) Fran II. Dietrich-II and Thomes J. Keans

Statistics-II

Credit Hrs. 3 (2-1)

Sampling Probability and non-Probability Sampling, Simple random sampling stratified random sampling Systematic sampling error, Sampling distribution of mean and difference between two means. Interference Theory: Estimation and testing of hypothesis, Type—I and type-II error, Testing of hypothesis about mean and difference between two means using Z-test and t-test, Paired t-test, Test of association of attributes using X² (chi-square) Testing hypothesis about variance.

Practicals

- a. Sampling random sampling
- b. Stratified random sampling.
- c. Sampling distribution of mean
- d. Testing of hypotheses regarding population mean
- e. Testing of hypotheses about the difference between population means
- f. Chi-square test
- g. Testing of Correlation Coefficient
- h. Fitting of simple linear regression
- i. One-way ANOVA
- j. Two-way ANOVA

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Book Recommended

1. Muhammad, S. and Kamal S. Introduction to Statistical Theory Part-II (Latest Edition).

2. Muhammad F. Statistical Methods and Data Analysis
3. Steal, G. D, and Tarric, J. H. 1980. Principles and Procedures of Statistics A Bio-material approach, 2nd Edition.
4. Gomez K. A. and Gomez, A. A. 1980. Statistical Procedures for Agricultural Research 2nd Edition.

Note: *Universities may make necessary changes in the courses according to the requirement as decided by the Board of Studies.*

ANNEXURE - F

Course Name: Introduction to Information and Communication Technologies

Course Structure: Lectures: 2 Labs: 1 **Credit Hours:** 3 (3-1)

Pre-requisite: None **Semester:** 1

Course Description:

This is an introductory course on Information and Communication Technologies. Topics include ICT terminologies, hardware and software components, the internet and worldwide web, and ICT based applications.

After completing this course, a student will be able to:

- Understand different terms associated with ICT
- Identify various components of a computer system
- Identify the various categories of software and their usage
- Define the basic terms associated with communications and networking
- Understand different terms associated with the Internet and World Wide Web.
- Use various web tools including Web Browsers, E-mail clients and search utilities.
- Use text processing, spreadsheets and presentation tools
- Understand the enabling/pervasive features of ICT

Course Contents:

- Basic Definitions & Concepts
- Hardware: Computer Systems & Components
- Storage Devices, Number Systems
- Software: Operating Systems, Programming and Application Software
- Introduction to Programming, Databases and Information Systems
- Networks
- Data Communication
- The Internet, Browsers and Search Engines
- The Internet: Email, Collaborative Computing and Social Networking
- The Internet: E-Commerce
- IT Security and other issues
- Project Week
- Review Week

Teaching Methodology

- Lecturing
- Written Assignments

Assessment**Mid Term (40%)**

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Text Books/Reference Books:

1. Norton, P. Introduction to Computers. 6th International Edition (McGraw-Hill)
2. Sawyer, W. Using Information Technology: A Practical Introduction to Computer & Communications, 6th Edition (McGraw-Hill).
3. Hutchinson, S. E. Computers, Communications & information: A user's introduction.
Leon, A. Fundamentals of Information Technology.
Mathewsleon Leon Press.

Functional Biology-I Credit Hours 3(3-0)

Biological Methods

Principles of Cellular Life
Chemical Basis
Structure and Function
Principles of Metabolism
Energy Acquisition
Principles of Inheritance
Mitosis and Meiosis
Chromosomes
Observable Inheritance Patterns
DNA Structure and Function
RNA and Proteins
Genes
Genetic Engineering and Biotechnology
Biodiversity
Fundamental Concept of Biodiversity
One or two examples of each of the following from commonly found organism
Prions
Viruses
Bacteria
Protistans
Algae
Fungi
Plants
Crops
Animals
Invertebrates
Vertebrates

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Reading

1. Roberts, M. M., Reiss and G. Monger. 2000. Advanced Biology, Nelson.
2. Starr, C, and R, Taggart, 2001. Biology: The Unity and Diversity of Life Brooks and Cole.
3. Campbell, N. A., J. B, Reece, L. G. Mitchell, M. R, Taylor. 2001. Biology: Concepts and Connections. Prentice-Hall.

Functional Biology-II Credit Hours 3(3-0)

Myths and Realities of Evolution

Microevolution

Speciation

Macroevolution

Level of Organization

Plants

Tissues

Nutrition and Transport

Reproduction

Growth and Development

Animals

Tissue, Organ System and Homeostasis

Information Flow and Neuron

Nervous System

Circulation and Immunity

Nutrition and Respiration

Reproduction and Development

Ecology and Behavior

Ecosystems

Biosphere

Social Interactions

Community Interactions

Human Impact on Biosphere

Environment Conservation

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Reading

1. Roberts, M. M., Reiss and G. Monger. 2000. Advanced Biology, Nelson.
2. Starr, C, and R, Taggart, 2001. Biology: The Unity and Diversity of Life Brooks and Cole.
3. Campbell, N. A., J. B, Reece, L. G. Mitchell, M. R, Taylor. 2001. Biology: Concepts and Connections. Prentice-Hall.

Note: *Universities may make necessary changes in the courses according to the requirement as decided by the Board of Studies.*

General Recommendations

The committee recommended the following:

1. Department of Crop Physiology be established at PMAS Arid Agriculture University, Rawalpindi, Khyber Pakhtunkhwa Agriculture University, Peshawar, Gomal University, D.I. Khan, Balochistan University of Information Technology Engineering and Management Sciences, (BUIEMS) Quetta, Bahauddin Zakariya University, (BZU) Multan, The Islamia University of Bahawalpur, Lasbela, University of Agriculture, Water and Marine Sciences Uthal and The University of Azad Jamu and Kashmir, Rawlakot Campus like Sindh Agriculture University, Tandojam and University of Agriculture, Faisalabad where this department has already been established.
2. Crop physiology course may be added in agriculture domain and meetings of NCRC in Crop Physiology may be arranged in the series of agriculture domain subjects.
3. Teacher trainings be arranged to acquire new techniques in crop physiology.
4. Adequate number of posts of Crop Physiologists be created in agricultural departments/organizations of the country to strengthen the agricultural system by giving due recognition to this important field.
5. The committee further recommended that Crop Physiology be given an equivalent status as other major disciplines of agricultural specialization (e.g. Agronomy, Soil Science etc.) by the Federal and Provincial Governments to include this field of specialization in subject of preference.
6. National Book Foundation of Pakistan may be requested to print relevant text books in Crop Physiology in consultation with the experts.
7. Due recognition/incentive in the form of impact factor be given to the authors by Higher Education Commission for writing book/book chapter/manual.
8. The Society of Crop Physiologists needs to be established and later on a Journal of Crop Physiology may be published.
9. Internship:
 - a) Last six-months/final semester of the academic program should preferably be reserved for internship. However, where internship opportunities are not available, optional courses should be offered as an alternative.
 - b) HEC should provide remuneration @ Rs.15000/month/internee for the internship.