

**CURRICULUM
OF
CROP PHYSIOLOGY
FOR
MS**

(Revised 2018)



**HIGHER EDUCATION COMMISSION
ISLAMABAD**

CURRICULUM DIVISION, HEC

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PREFACE

The curriculum of subject is described as a throbbing pulse of a nation. By viewing curriculum, one can judge the stage of development and its pace of socio-economic development of a nation. With the advent of new technology, the world has turned into a global village. In view of tremendous research taking place world over new ideas and information pours in like of a stream of fresh water, 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).

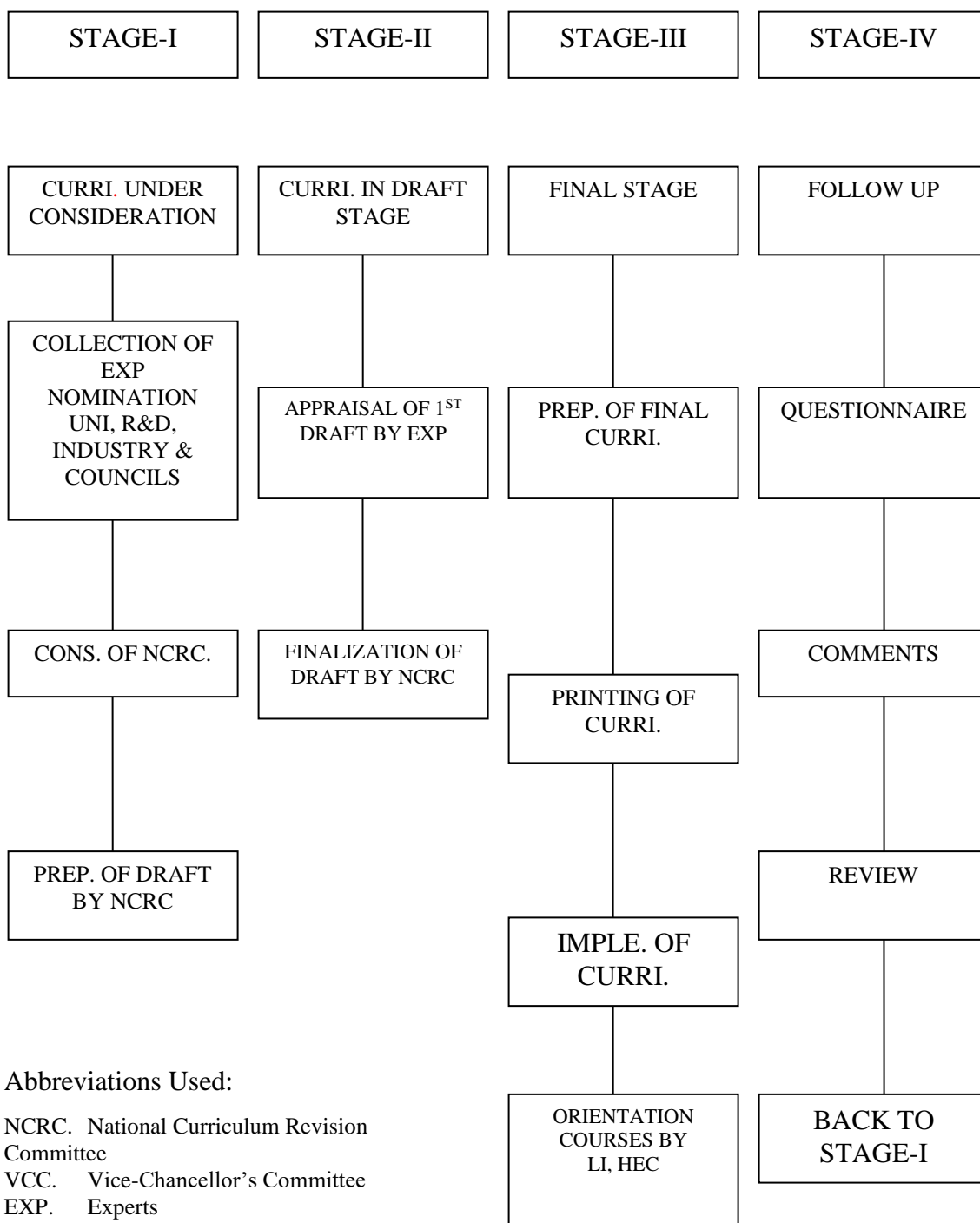
In compliance with the above provisions, the HEC undertakes revamping and refurbishing of curricula after regular intervals in a democratic manner involving universities/DAIs, research and development institutions and local Chamber of Commerce and Industry. The intellectual inputs by expatriate Pakistanis 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).

A committee of experts comprising of conveners from the National Curriculum Revision Committees of HEC in the disciplines of Basic, Applied, Social Sciences, Agriculture and Engineering met in 2007 & 2009 and developed the unified templates to standardize degree programs in the country so as to bring the national curriculum at par with international standards, and to fulfill the national needs. It also aimed to give a basic, broad based knowledge to the students to ensure the quality of education. In line with above, NCRC comprising senior university faculty and experts from various stakeholders and the respective accreditation councils has finalized the curriculum for Crop Physiology. The same is being recommended for adoption by the universities/DAIs channelizing through relevant statutory bodies of the universities.

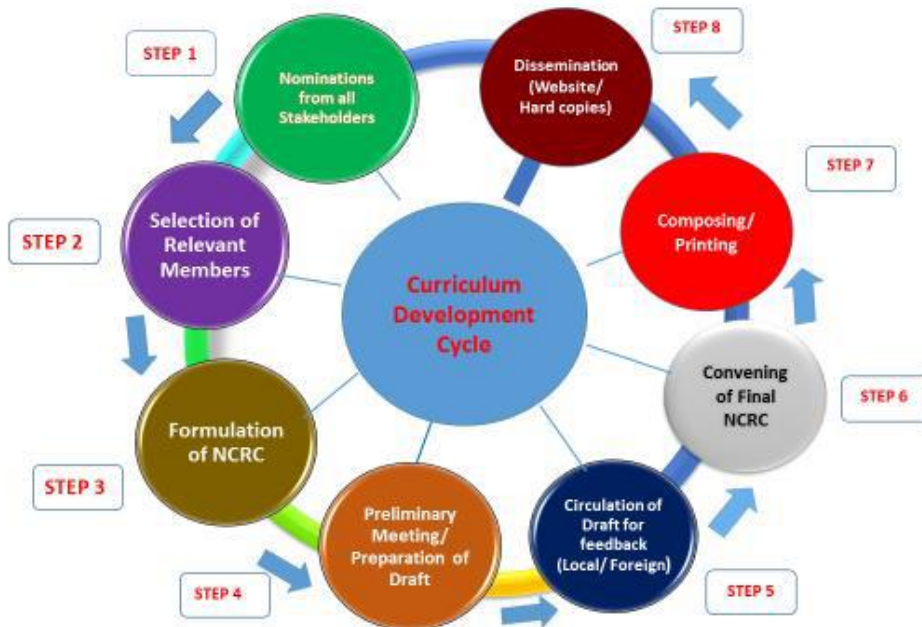
MUHAMMAD JAVED KHAN
Adviser (Academics)

October,2017

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:

1.	Dr. Qamaruddin Chachar Chairman / Professor, Department of Crop Physiology, Sindh Agriculture University, Tandojam.	Convener
2.	Dr. Fahim Nawaz Assistant Professor, Department of Agronomy, Faculty of Agricultural & Envr. Sciences, Muhammad Nawaz Shareef University of Agriculture, Multan.	Secretary
3.	Dr. Abdul Khaliq Professor Department of Agronomy, University of Agriculture, Faisalabad	Member
4.	Dr. Mukhtar Alam Professor / Dean Faculty of Science, Department of Agriculture, University of Swabi, Anbar Swabi.	Member
5.	Dr. Muhammad Akmal Professor / Chairman, Department of Agronomy The University of Agriculture, Peshawar	Member

6.	Dr. Muhammad Yasin Ashraf (<i>TI</i>), Professor / Head Soil and Environmental Sciences / Manager Academic Cell PAEC / Nuclear Institute for Agriculture & Biology (NIAB), Jhang Road, Faisalabad	Member
7.	Dr. Bashir Ahmad Professor Department of Agronomy The University of Agriculture, Peshawar	Member
8.	Dr. Fauzia Yusuf Hafeez (<i>TI</i>), Professor / Advisor, Department of Biosciences, COMSATS Institute of Information Technology, Islamabad	Member
9.	Dr. Shad Khan Khalil Meritorious Professor Department of Agronomy The University of Agriculture, Peshawar	Member
10.	Dr. Jalal-ud-Din Principal Scientific Officer Wheat Wide Crosses Programme, Institute of Crop Sciences, National Agriculture Research Centre (NARC), Islamabad	Member
11.	Dr. Azra Yasmeen* Associate Professor Department of Agronomy Bahauddin Zakariya University, Multan	Member
12.	Dr. Shahjahan Shabbir Ahmed Rana Associate Professor, Department of Biotechnology BUIITEMS, Iqbal Hall, Takatu Campus, Airport Road, Quetta	Member

13.	Dr. Sajid Ali Assistant Professor, Institute of Agricultural Sciences, University of the Punjab, Quaid-e-Azam Campus, Lahore	Member
14.	Dr. Rasheda Jabeen* Assistant Professor, Department of Biology & Life Sciences, Lahore Garrison University, Lahore	Member
15.	Dr. Anser Ali Assistant Professor Department of Agronomy, Ghazi University, D. G. Khan	Member
16.	Ms. Irfana Parveen Bhatti* Assistant Professor, Department of Crop Physiology, Sindh Agriculture University, Tandojam.	Member
17.	Dr. Syed Rehmat Ullah Shah Associate Professor, Department of Agronomy, Lasbela University of Agriculture, Water & Marine Sciences, Balochistan.	Member
18.	Dr. Muhammad Aamir Iqbal Assistant Professor, Department of Agronomy. The University of Poonch, Rawalakot, Azad Jammu & Kashmir	Member
19.	Dr. Riaz Ahmad Afridi** Research Officer (Plant Ecophysiologicalist) Plant Physiology Research Program, Agriculture Research Institute,	Member

	Tarnab, Peshawar	
20.	Dr. Abdul Aziz Khakwani** Assistant Professor, Department of Agronomy, Faculty of Agriculture, Gomal University, D.I. Khan	Member
21.	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

NCRC Agenda

The agenda of NCRC for Crop Physiology was as follows:

1. To finalize the draft curriculum in the discipline of Crop Physiology and to bring it at par with international standards.
2. To finalize the eligibility criteria for Bachelor, Master and PhD level programs.
3. To finalize preface, mission, vision, preamble, and rationale of the subject.
4. To finalize objectives / learning outcomes, list of contents and assessment criteria (formative & summative) aligned with Bachelor programs (vertical approach) and other Master programs (horizontal approach).
5. To incorporate/suggest latest reading materials/references (local & international) against each course.
6. To finalize contents keeping in view the uniformity across other disciplines and avoiding overlapping.
7. To make recommendations for promotion/development of the discipline, keeping in view the futuristic needs of the society.

The meeting started with recitation from the Holy Quran. Mr. Arshad Kamran, Director General, HEC Regional Center Peshawar and Dr. Muhammad Idrees, Director (Curriculum), HEC Islamabad welcomed the members on behalf of Chairman HEC. All the participants introduced themselves highlighting their qualification, experience and area of expertise. Keeping with the tradition, Mr. Arshad Kamran, Director General, HEC Regional Center Peshawar requested the

Convener, Prof. Dr. Qamaruddin Chachar and Secretary, Dr. Fahim Nawaz of the NCRC to continue the proceeding to finalize the curriculum.

In first session, Dr. Muhammad Idrees presented the agenda and objectives of the NCRC. He highlighted the importance of this meeting and emphasized for adaptation of general rules of curriculum development and revision like scope of the subject/programme, horizontal & vertical alignment, rule of flexibility and adaptability keeping in view the futuristic approach, market value/job market and social parity. He also shared a template for finalizing the curricula according to paradigm shift of including learning outcomes (Bloom's Taxonomy), teaching methods and assessment. The template was unanimously accepted to be followed. It was also agreed to add preamble, programme objectives, programme learning outcomes, teaching methodology and assessment segments in the curricula.

Prof. Dr. Qamaruddin Chachar, briefed the participants about outcome of preliminary NCRC meeting. He informed the participants that in preliminary NCRC meeting, a draft regarding the outline of curriculum was prepared after thorough discussion according to the unified framework (guidelines) to institutions offering degrees under the title of Crop Physiology. The house unanimously agreed to pursue the same track to finalize Curriculum in the field of Crop Physiology in current meeting.

In next session the house openly discussed the nomenclature of the discipline, preface, objectives of the programme, learning outcomes, methods of instruction and learning environment, assessment and operational framework. After long deliberations, the committee also finalized such aspects of the degree as framework/scheme of studies, the duration of the programme, number of semesters, number of weeks per semester, total number of credit hours, number of credit hours per semester, weightage of breadth and depth courses and weightage of theory and practical of undergraduate 4-years programme for Crop Physiology. Furthermore, list of courses (core & elective) and semester wise breakup of courses were also discussed and finalized unanimously.

On second day, each course was discussed and the course objectives, learning outcomes, contents, teaching methods, assessment and reference books were reviewed, revised and finalized. After an in-depth discussion draft curriculum of the undergraduate (4-years) programme for Crop Physiology was finalized. In the evening session, the courses of postgraduate programme were reviewed and finalized. The house unanimously agreed to include a new course named Root Physiology for Masters programme. Moreover, it was agreed to merge the course Recent Advances in Crop Physiology into Advanced Crop Physiology with modification in course contents.

On third day, the Secretary briefed the house about the deliberations and progress made during two days exercise of the meeting. The preamble, mission statement, eligibility criteria, and assessment tools in the curricula were finalized. Moreover, semester wise split of the courses was discussed and finalized. In the end, Dr. Muhammad Idrees thanked the Convener, Secretary and all members of the NCRC Crop Physiology for sparing their precious time and taking pain to travel a long way from across the country for the noble cause of finalizing the curriculum. He further stated that their efforts will go a long way in developing workable, useful and market oriented comprehensive degree programme in Crop Physiology. The Convener of the NCRC thanked the members for their keen interest and valuable input in finalizing the curriculum to make it more feasible, competitive, efficient and realistic. The Committee highly appreciated the efforts made by the officials of HEC Regional Centre, Peshawar for making arrangements to facilitate their comfortable stay. The members extended their heartfelt felicitations to the Convener and Secretary of the Committee. The meeting ended with the vote of thanks to Dr. Muhammad Idrees and his team from HEC for providing the academic and professional opportunity for national cause.

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.

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(2+1)	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 (2-1)
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

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Final Term (60%)

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- 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

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- Report Writing 10%

Recommended Books:

1. Marten, J. and D. E. Sadave. 1994. Plants, Genes and Agriculture. Jones and Bartlett Publishers International. USA.
2. Pessarakli, 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

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Final Term (60%)

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- 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

Leaning 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

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Final Term (60%)

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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%)

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- 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 microorganisms

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. Percy, 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