CURRICULUM

OF

CROP PHYSIOLOGY

FOR

PhD

(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).

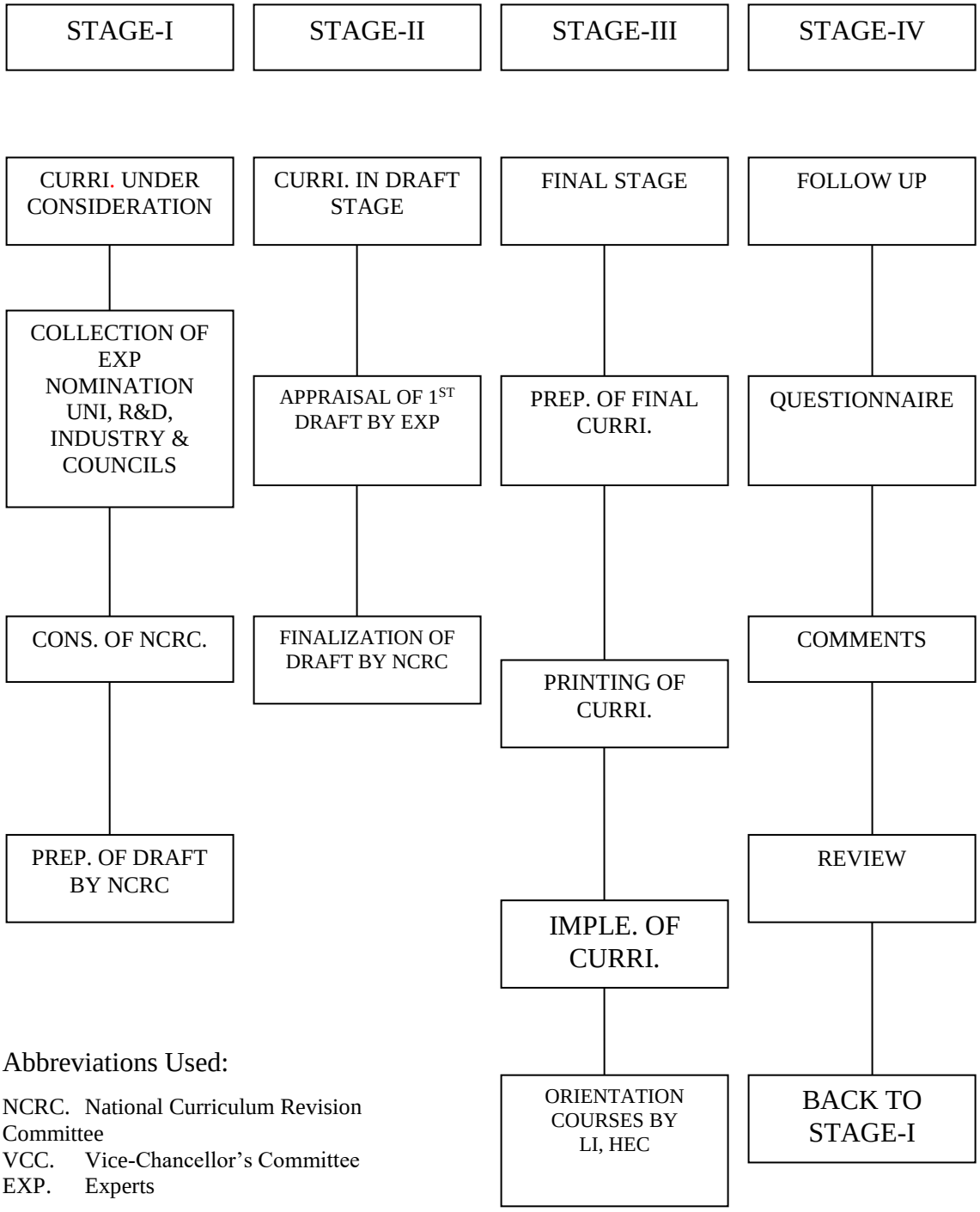
In compliance with the above provisions, the HEC undertakes revamping and refurbishing of curricula after regular intervals in a democratic manner involving universities/DAIs, research and development institutions and local Chamber of Commerce and Industry. The intellectual inputs by expatriate Pakistanis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

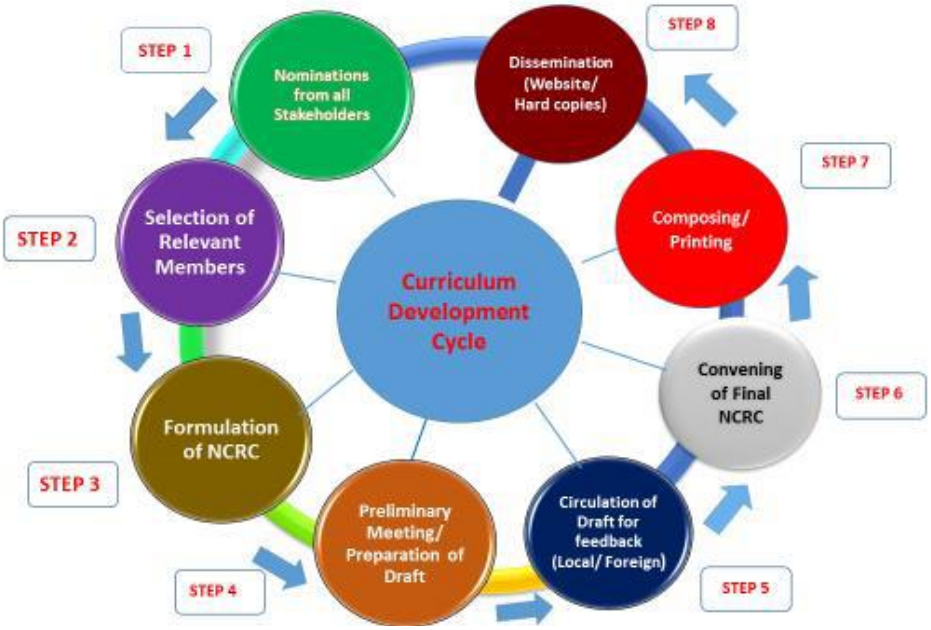
CURRICULUM DEVELOPMENT



Abbreviations Used:

NCRC. National Curriculum Revision Committee
VCC. Vice-Chancellor's Committee
EXP. Experts

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 (*TI*), 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 (*TI*), 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 BUITEMS, 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 Ecophysiologist) 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 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. Sinclain 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. Pergramon 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. Susex, 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. Pessarakli, 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.