



# COURSE OUTLINE BRIEFS

DEPARTMENT OF  
**AGRONOMY**



FACULTY OF  
**AGRICULTURE**



## **OVERVIEW**

The Department of Agronomy is working under the umbrella of College of Agriculture since its establishment in 2005. We are serving the nation through conducting high impact applied research in all aspects of crop production, crop growth modeling, crop mechanization, weed science and natural resource management to address immediate problems and anticipate future challenges. The Department aims at producing the graduates capable to perform in a competitive environment of field-oriented work and contribute to country's national economy.

The Department is offering PhD, MSc (Hons) and BSc (Hons) programs to produce highly skilled and technically sound manpower to solve the problems related to crop production and soil management. Our vision is to provide leadership in agronomic education with focus on problem oriented research and mission to generate, integrate and apply knowledge about crop plants that are grown for food, feed, fiber and the general benefit of people. The mission of the Department is to find and disseminate answers to problems through the integration of teaching, research and extension/outreach efforts.

The Department is one of the leading departments in the country having nine PhDs in its faculty with a number of scholarships and awards. Some of the prestigious awards include Australian Government Post-Doc Fellowship Award, HEC Fellowships, Faculty Development Fellowship, International Technology Award, International Innovation Gold Medal and National Innovation Award.

## Academic Programs Offered

1. BSc (Hons) Agriculture
2. MSc (Hons) Agronomy
3. PhD Agronomy

### BSc (Hons) Agriculture

Eligibility: At least 45% marks in intermediate or equivalent.

Duration: 04 Year Program (08 Semesters)

Degree Requirements: 136 Credit Hours

#### Semester-I

Course Code	Course Title	Credit Hours
SAES-5801	Introduction to Soil Science-I	3(2+1)
AGRO-5901	Basic Agriculture	3(2+1)
ZOOL-6141/ MATH-5128	Introduction to Biology-I (for Pre-Engineering students)/ Mathematics (for Pre-Medical students)	3(3+0)/ 3(3+0)
URCI-5109	Introduction to Information & Communication Technologies	3(2+1)
URCE-5102	English-II (Language Comprehension & Presentation Skills)	3(3+0)
URCI-5105/ISLS-5108	Islamic Studies/ Ethics (for Foreigner or Non-Muslims)	2(2+0)/ 2(2+0)

#### Semester-II

AGRO-5902	General Crop Production	3(2+1)
SAES-5802	Introduction to Soil Science-II	3(2+1)
FWRW-5701	Introduction to Forest and Watershed Management	3(2+1)
AEXT-5401	Introduction to Agricultural Extension and Rural Development	3(3+0)
URCE-5103	English-III (Academic Writing)	3(3+0)
URCP-5106	Pakistan Studies	2(2+0)

#### Semester-III

PLBG-5201	Introductory Genetics	3(2+1)
ENTO-5101	Introductory Entomology	3(2+1)
PLPT-5301	Introduction to Plant Pathogens	3(2+1)
HORT-5601	Introductory Horticulture	3(2+1)
FWRW-5702	Introduction to Rangelands and Wildlife Management	3(2+1)
AGEC-5501	Introduction to Agricultural Economics	3(3+0)
URCC-5110	Citizenship Education and Community Engagement	3(3+0)

**Semester-IV**

PLBG-5202	Introductory Plant Breeding	3(2+1)
ENTO-5102	Applied Entomology	3(2+1)
PLPT-5302	Introductory Plant Pathology	3(2+1)
HORT-5602	Horticultural Crop Production	3(2+1)
FSAT-5101	Introduction to Food Science and Technology	3(2+1)
STAT-5126	Statistics for Agricultural Sciences	3(3+0)

**Semester-V**

AEXT-6408	Communication Skills in Agricultural Extension	3(2+1)
AGRO-6903	Agro-Technology of Major Crops	3(2+1)
AGRO-6904	Arid and Rainfed Agriculture	3(2+1)
AGRO-6905	Concepts of Crop Physiology	3(2+1)
AGRO-6906	Irrigation Agronomy	3(2+1)
AGRO-6907	Agro-Ecology	3(3+0)

**Semester-VI**

AGRO-6908	Biological Nitrogen Fixation	3(2+1)
AGRO-6909	Plant Nutrients and Growth Regulators	3(2+1)
AGRO-6910	Farm Record and Management	3(2+1)
AGRO-6911	Seed Production Technology	3(2+1)
AGRO-6912	Forage and Fodder Production	3(2+1)
AGRO-6913	Layout of Field Experiments	2(2+0)

**Semester-VII**

AGRO-6914	Principles of Weed Science	3(2+1)
AGRO-6915	Crop Management under Stressful Environments	3(2+1)
AGRO-6916	Conservation Agronomy	3(2+1)
AGRO-6917	Introduction to Crop Modeling	3(2+1)
AGRO-6918	Environment and Crop Production	3(2+1)

**Semester-VIII**

AGEC-6523	Agribusiness, Marketing and Trade	3(3+0)
AGRO-6919	Organic Farming	3(3+0)
AGRO-6920	Plant and soil Analysis	3(2+1)
AGRO-6921	Research and Scientific Writing	3(2+1)
AGRO-6922	Research Project / Internship	4(0+4)

## MSc (Hons) Agronomy

Eligibility: BSc (Hons)/BSc 4 Years or equivalent (16 Years of Education) in the relevant field with minimum CGPA 2.50/4.00 + Departmental Test

Duration: 02 Year Program (04 Semesters)

Degree Requirements: Minimum 30 Credit Hours (24 Credit Hours of Course Work+ 06 of Dissertation)

AGRO-7101	Applied Crop Ecology	3(3+0)
AGRO-7102	Agro-Environment Conservation	3(2+1)
AGRO-7103	Agro-meteorology	3(3+0)
AGRO-7104	Allelopathy and Crop Productivity	3(2+1)
AGRO-7105	Applied Conservation Agronomy	3(3+0)
AGRO-7106	Sustainable Agriculture	3(3+0)
AGRO-7107	Crop Management on Problem Soils	3(3+0)
AGRO-7108	Crop Nutrition Management	3(2+1)
AGRO-7109	Special Problem	1(1+0)
AGRO-7110	Seminar	1(1+0)
AGRO-7111	Farming and Cropping Systems	3(3+0)
AGRO-7112	Field Crop Experimentation	3(2+1)
AGRO-7113	Seed Science and Technology	3(2+1)
AGRO-7114	Stress Physiology	3(2+1)
AGRO-7115	Water Relations in Plants	3(2+1)
AGRO-7116	Weed Management	3(2+1)
AGRO-7117	Climate Change and Agriculture	3(3+0)
STAT-7151	Statistical Methods for Agricultural Research-I	3(3+0)

## PhD Agronomy

Eligibility: MSc (Hons) Plant Pathology or equivalent with minimum CGPA 3.00/4.00 +  
Departmental Test

Duration: 03-05 Year Program (06-10 Semesters)

Degree Requirements: Minimum 18 Credit Hours Course Work, Comprehensive Exam. +  
Dissertation

AGRO-8101	Advanced Agronomy	3(2+1)
AGRO-8102	Advanced Irrigation Agronomy	3(2+1)
AGRO-8103	Dry land Agronomy	3(3+0)
AGRO-8104	Biological Crop Potential	3(2+1)
AGRO-8105	Crop Modeling	3(2+1)
AGRO-8106	Herbicides and Crop Production	3(2+1)
AGRO-8107	Seed Physiology	3(2+1)
AGRO-8108	Modern Concepts in Crop Productivity	3(2+1)
AGRO-8109	Special Problem	1(1+0)
AGRO-8110	Seminar	1(1+0)
AGRO-8111	Crop and Environment	3(3+0)
AGRO-8112	Postharvest Technology of Crops	3(2+1)
STAT-8131	Statistical Methods for Agricultural Research-II	3(3+0)



**BSc**  
**(Hons)**  
**AGRICULTURE**  
**AGRONOMY**

This is an introductory course designed to introduce the concept and significance of soil science to the students of agriculture at undergraduate level. It provides information to the students about soil science, its branches, their environmental significance, weathering of rocks and minerals, their classification, physical properties of soil and their significance in agriculture. The course would provide awareness to the students about impact of agricultural and industrial wastes on our environment. In addition, this course also teaches the students, skills to collect soil and water samples for physico-chemical analysis. Laboratory exercises are designed to develop skills for analysis of irrigation water and soil samples which would highlight and support the importance of both water and soil quality analysis for judicious use of resources.

#### *Contents*

1. Introduction to Soil and environment
2. Definition of earth, geology and soil science
3. Disciplines of soil science
4. Lithosphere, hydrosphere and biosphere
5. Soil forming rocks and minerals: types and their formation
6. Weathering of rocks and minerals: definition. Agents and classification
7. Parent materials: definition and types
8. Soil formation: definitions, processes and factors
9. Soil profile: definition and description
10. Physical properties of soil and their significance
11. Introduction to soil classification and land use capability classes
12. Soil, water and air pollution: sources and types

#### *Practical*

1. Methods of soil sampling and handling
2. Preparation of saturated soil paste
3. Determination of soil water contents
4. Analysis of irrigation water, report writing and interpretation
5. Textural analysis of soil

#### *Recommended Texts*

1. Bashir, E., & Bantel, R. (2001). *Soil Science*. Islamabad: National Book Foundation.
2. Brady, N.C., & Weil, R.R. (2007). *The Nature and Properties of Soils* (14th ed.). New Jersey: Pearson Education.

#### *Suggested Readings*

1. Brady, N.C., & Weil, R.R. (2009). *Elements of the Nature and Properties of Soils* (3rd ed.). New Jersey, USA: Pearson Education.
2. Hillel, D. (2008). *Soil in the Environment: Crucible of Terrestrial Life*. Burlington: Elsevier.
3. Das, D.K. (2011). *Introductory Soil Science* (3rd ed.). New Delhi: Kalyani Publications.

Basic Agriculture is a course designed to provide the students with the basic knowledge of agriculture. It will enable the students to understand the basic terminologies of agriculture, its different branches, allied disciplines, salient features of agriculture in Pakistan including climate and land resources. There will be detailed discussions about the various agro-ecological zones of Pakistan. Basic knowledge about agricultural inputs such as seed, fertilizer, irrigation and post-harvest technology would be communicated to the students. The students will be able to understand the conventional and international system of land measurements. Crop growth related problems like weeds, insect pests will be elaborated. The students will be able to understand the conventional and international system of land measurement. The knowledge of post-harvest technology is also shared with the students.

#### *Contents*

1. Agriculture, history, importance, branches and allied sciences
2. Salient features of Pakistan's agriculture
3. Climate, land and water resources
4. Agro ecological zones of Pakistan
5. Farming systems
6. Tillage: objectives and types
7. Seed: types and quality
8. Crop nutrients, manures and fertilizers, sources and methods of application
9. Irrigation: systems, types and management
10. Crop protection measures
11. Crop rotation
12. Harvesting, processing, storage and marketing of farm produce
13. Agro-based industries
14. Environmental pollution and health hazards

#### *Practical*

1. Land measuring units
2. Demonstration of hand tools and tillage implements
3. Identification of meteorological instruments
4. Identification of crop plants, weeds and seeds
5. Identification of organic and inorganic fertilizers
6. Calculation of nutrient-cum-fertilizer unit value
7. Demonstration of various irrigation methods
8. Field visits

#### *Recommended Texts*

1. Bashir, E. & Bantel, R. (2001), *Soil Science*, Islamabad: National Book Foundation.
2. Brady, N.C., & Weil, R.R. (2013). *Elements of the Nature and Properties of Soils* (3rd ed.). New Jersey: Pearson Education.

#### *Suggested Readings*

1. Hillel, D. (2008). *Soil in the Environment: Crucible of Terrestrial Life*. Burlington: Elsevier.
2. Singer, M. J., & Munns, D. N. (2002). *Soils- An Introduction* (5th ed.). New Jersey: Prentice-Hall.

3. Das, D.K. (2011). *Introductory Soil Science* (3rd ed.). New Delhi: Kalyani Publications.

**ZOOL-6141**

**Introduction to Biology I**

**3(3+0)**

The purpose of this course is to produce a sense of practical relevance of biology to everyday life. This will make students comprehend life by understanding some of the molecular processes that occur in and around cells to make students cognizant of biologic phenomena (nature, body, etc.) on an evolutionary, ecological, behavioral, physiologic, tissue, cellular, and molecular level. In this subject, students will examine how life is organized into hierarchical levels; how living organisms use and produce energy; how life grows, develops, and reproduces; how life responds to the environment to maintain internal stability; and how life evolves and adapts to the environment. Moreover, it will also enable the students to investigate the biological molecules, homeostasis in vertebrates, and the influence of hormones on coordination and control systems of animal body. Upon completion of this subject, students will be having an enhanced knowledge and appreciation of the basics of growth and development plans of animals and can develop cogent and critical arguments based on the course material.

#### *Contents*

1. Introduction
2. Nature and scope of biology
3. Branches of biology
4. Relationship between biology and psychology
5. Biological molecules: Carbohydrates, Proteins, Fats, Nucleic acids, Water
6. The cell: Structure and function of cell, Cell organelles, Different types of cells
7. Homeostasis: Osmoregulation, Structure and functions of Nephron, Thermoregulation
8. Coordination and control: Structure and physiology of Neuron
9. Introduction to central and peripheral nervous system
10. Hormones
11. Basics of growth and development
12. Embryonic and post embryonic development

#### *Recommended Texts*

1. Campbell, M., & Christopher, J.P. (2016). *Organismal homeostasis*. New York: Momentum press.
2. Snow, A. L., & Leonardo, M. J. (Eds.) (2013). *Immune homeostasis: Methods and protocols*. New York: Humana Press.

#### *Suggested Readings*

1. Anna, A. S., & Richard, B. P. (2019). *An Introduction to Conservation Biology* (2nd ed.). Oxford: Oxford University Press.
2. Campbell, N. A., Mitchell, L. G., & Reece, J. B. (2009). *Biology: Concepts and connections* (6th ed.). San Francisco: Addison Wesley Longman.
3. Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Reece, J. B. (2017). *Campbell biology*. New York: Pearson.

This course is built upon the mathematical concepts, principles and techniques that are useful in almost all undergraduate programs. The main objectives of the course are to enhance student's competency in application of mathematical concepts in solving problems and to improve their level of quantitative approach. Upon the successful completion of this course students would be able to develop understanding about mathematical functions, building and solving linear and quadratic equations, matrices and determinants with application, sequences and series, and basic financial mathematics. This course has been designed to prepare the students, not majoring in mathematics, but with the essential tools of financial mathematics, algebra and geometry to apply the concepts and the techniques in their respective disciplines. The aim of teaching and learning mathematics is to encourage and enable students to recognize that mathematics permeates the world around us, appreciate the usefulness, power and beauty of mathematics, enjoy mathematics and develop patience and persistence when solving problems.

### *Contents*

1. Real Numbers
2. Relations and Functions
3. Inequalities
4. Quadratic Functions and Complex Numbers
5. Linear Equations and Quadratic Equations: Formation of Linear equation
6. Solving Linear equation involving one variable
7. Solution of Quadratic equation: factorization, square completion method & quadratic formula
8. Application of quadratic equation
9. Sequence and Series
10. Types of Sequences; A. P, A. M., G. P., H. P
11. Trigonometric Functions, Trigonometric Applications
12. Graph of Functions and Modelling
13. Limits and Continuity
14. Derivatives, Integration
15. Probability and Binomial Theorem

### *Recommended Texts*

1. Gantert, A. X. (2009). *Algebra 2 and trigonometry*. New York: Amsco School Publication.
2. Kaufmann, J. E. (1994). *College algebra and trigonometry* (3rd ed.). Boston: PWS-Kent Pub.

### *Suggested Readings*

1. Anton, H. (1999). *Calculus: A new horizon* (6th ed.). New York: John Wiley.
2. Nauman, K. (2019). *Basic mathematics I: algebra and trigonometry* (2nd ed.). Lahore: Al-Hassan Pub.
3. Stewart, J. (2012). *Calculus* (7th ed.). Belmont: Brooks/Cole.
4. Swokowski, E. W. (1993). *Fundamentals of algebra and trigonometry* (8th ed.). Boston: PWS-Kent Pub.

The course introduces students to information and communication technologies and their current applications in their respective areas. The students will learn the basic understanding of computer software, hardware, and associated technologies to get maximum benefit related to their study domain. Students will learn how the information and communications systems can improve their work ability and productivity, how Internet technologies like e-commerce applications and mobile computing can influence the businesses and workplace. At the end of semester, students will get basic understanding of computer systems, storage devices, operating systems, e-commerce, data networks, databases, and associated technologies. They will also learn Microsoft Office tools that includes Word, Power Point, Excel. They will also learn Open office being used on other operating systems and platforms. Specific software's related to specialization areas are also part of the course. The course will also cover computer ethics, social media norms and cyber laws.

### *Contents*

1. Introduction, Overview and its types
2. Hardware: Computer Systems & Components, Storage Devices and Cloud Computing
3. Software: Operating Systems, Programming and Application Software
4. Introduction to Programming Language
5. Databases and Information Systems Networks
6. The Hierarchy of Data and Maintaining Data
7. File Processing Versus Database Management Systems
8. Data Communication and Networks
9. Physical Transmission Media & Wireless Transmission Media
10. Applications of smart phone and usage
11. The Internet, Browsers and Search Engines
12. Websites Concepts, Mobile Computing and their applications
13. Collaborative Computing and Social Networking
14. E-Commerce & Applications
15. IT Security and other issues
16. Cyber Laws and Ethics of using Social media
17. Use of Microsoft Office tools (Word, Power Point, Excel)
18. Mobile apps or other similar tools
19. Other IT tools/software specific to field of study

### *Recommended Texts*

1. Vermaat, M. E. (2018). *Discovering computers: digital technology, data and devices*. Boston: Course Technology Press.

### *Suggested Readings*

1. Schneider, G. M., & Gersting, J. (2018). *Invitation to computer science*. Boston: Cengage Learning.
2. Timothy J. O., & Linda I. (2017). *Computing essentials* (26th ed.). San Francisco: McGraw Hill Higher Education.

The course seeks to develop a linguistic competence by focusing on basic language skills in integration to make the use of language in context. It also aims at developing students' skills in reading and reading comprehension of written texts in various contexts. The course also helps in developing students' vocabulary building skills as well as their critical thinking skills. The contents of the course are designed based on these language skills: listening skills, pronunciation skills, comprehension skills and presentation skills. The course provides practice in accurate pronunciation, stress and intonation patterns and critical listening skills for different contexts. The students require a grasp of English language to comprehend texts as organic whole, to interact with reasonable ease in structured situations, and to comprehend and construct academic discourse. The course objectives are to enhance students' language skill management capacity, to comprehend text(s) in context, to respond to language in context, and to write structured response(s).

### *Contents*

1. Listening skills
2. Listening to isolated sentences and speech extracts
3. Managing listening and overcoming barriers to listening
4. Expressing opinions (debating current events) and oral synthesis of thoughts and ideas
5. Pronunciation skills
6. Recognizing phonemes, phonemic symbols and syllables, pronouncing words correctly
7. Understanding and practicing stress patterns and intonation patterns in simple sentences
8. Comprehension skills
9. Reading strategies, summarizing, sequencing, inferencing, comparing and contrasting
10. Drawing conclusions, self-questioning, problem-solving, relating background knowledge
11. Distinguishing between fact and opinion, finding the main idea, and supporting details
12. Text organizational patterns, investigating implied ideas, purpose and tone of the text
13. Critical reading, SQ3R method
14. Presentation skills, features of good presentations, different types of presentations
15. Different patterns of introducing a presentation, organizing arguments in a presentation
16. Tactics of maintaining interest of the audience, dealing with the questions of audience
17. Concluding a presentation, giving suggestions and recommendations

### *Recommended Texts*

1. Helgesen, M., & Brown, S. (2004). *Active listening: Building skills for understanding*. Cambridge: Cambridge University Press.
2. Mikulecky, B. S., & Jeffries, L. (2007). *Advanced reading power: Extensive reading, vocabulary building, comprehension skills, reading faster*. New York: Pearson.

### *Suggested Readings*

1. Horowitz, R., & Samuels, S. J. (1987). *Comprehending oral and written language*. San Diego: Academic Press.
2. Roach, C. A., & Wyatt, N. (1988). *Successful listening*. New York: Harper & Row.

Islamic Studies is the academic study of Islam and Islamic culture. The basic sources of the Islamic Studies are the Holy Qur'an and Sunnah or Hadith of the Holy Prophet Muhammad ﷺ. The learning of the Qur'an and Sunnah guides the Muslims to live peacefully. It engages the students in the study of Islam as a textual tradition inscribed in the fundamental sources of Islam; Qur'an and Hadith, history and cultural contexts. The subject seeks to introduce Islam through a large variety of expressions (literary, poetic, social, and political) and through a variety of methods (literary criticism, hermeneutics, history, sociology, and anthropology). It provides introduction to foundations of Islam that include Qur'anic studies, Hadith and Seerah of Prophet Muhammad (PBUH), Islamic philosophy, and Islamic law, culture and theology through the textual study of Qur'an and Sunnah. It is one of the best systems of education which grooms a person with the qualities which he/she should have as a human being.

### *Contents*

1. Study of the Qur'an
2. *Surah Al-Baqarah, Al-Furqan, Al-Ahzab, Al-Mu'minoon, Al-An'am, Al-Hujurat, Al-Saff*
3. Study of the Hadith (Introduction to Hadith literature, Selected Ahadith (Text and Translation))
4. Introduction to Qur'anic Studies
5. Basic Concepts of Qur'an
6. History of Quran
7. Basic Concepts of Hadith
8. History of Hadith
9. Kinds of Hadith
10. Uloom –ul-Hadith
11. Sunnah & Hadith
12. Seerat ul-Nabi (PBUH), necessity and importance of Seerat
13. Pact of Madinah, Khutbah Hajjat al-Wada' and ethical teachings of Prophet (PBUH)
14. Legal Position of Sunnah
15. Islamic Culture & Civilization
16. Characteristics of Islamic Culture & Civilization
17. Historical Development of Islamic Culture & Civilization
18. Comparative Religions and Contemporary Issues
19. Impact of Islamic civilization

### *Recommended Texts*

1. Hassan, A. (1990). *Principles of Islamic jurisprudence*. New Delhi: Adam Publishers.
2. Zia-ul-Haq, M. (2001). *Introduction to al-Sharia al-Islamia*. Lahore: Aziz Publication.

### *Suggested Readings*

1. Hameedullah, M. (1942). *Muslim conduct of state*. Lahore: Sh M Ashraf Publisher.
2. Hameedullah, M. (1957). *Introduction to Islam*. Lahore: Sh M Ashraf Publisher.
3. Hameedullah, M. (1980). *Emergence of Islam*. New Delhi: Adam Publishers.

This course is an introduction to the philosophical study of morality including the theory of right and wrong behavior, the theory of value (goodness and badness), and the theory of virtue and vice. Besides providing familiarity with the primary questions addressed within moral philosophy and the most influential answers given by well-known philosophers, this course is designed to help students develop their abilities to read, explicate, analyze, and evaluate philosophical literature, write and express themselves well about their own ethical positions, and think critically and analytically about ethical issues. This course is intended for the students who have had little or no prior exposure to philosophy. It will provide a broad but reasonably detailed examination of the central issues of moral philosophy and will also consider how these can be applied to several contemporary moral problems. This course has been designed to familiarize about some of the most important theories and figures of moral philosophy in the hope that you can develop a clear understanding of the questions that recur in ethical debate.

### *Contents*

1. Overview of moral philosophy
2. Theoretical ethics
3. Moral concepts and justify moral principles and theories
4. Applied ethics: an Islamic point of view
5. Metaphysics and morality
6. Moral objectivism and relativism
7. Features of moral objectivism
8. Qur'an and sunnah on ethics
9. Individual relativism
10. God and morality
11. Criticism and its manners
12. Reason and emotion
13. Principles of moral reasoning
14. Ethics in *Seerah* and *Taswwuf*
15. Gender and morality
16. Significant Muslim masters of ethics
17. Rule-utilitarianism, moral foundations of authorities
18. The social contract, libertarianism, welfare liberalism

### *Recommended Texts*

1. Mackenzie, J. S. LL. D. G. (1983). *A manual of ethics*. London: University Tutorial Press.
2. Nadwi, S. S. (1999). *Ethics in Islam*. Karachi: Darul-Ishaat.

### *Suggested Readings*

1. Cahn, S. M., & Markie, P. (2019). *History, theory, and contemporary issues*. Oxford: Oxford University Press.
2. Williams, B. (1972). *Morality: An introduction to Ethics*. Cambridge: Cambridge University Press.

This course will acquaint the students with the basic concepts of Agronomy and crop production. It has been designed to develop understanding among the students about production technology of major and minor field crop grown under the agro-ecological conditions of Pakistan. In addition, the commonly followed cropping systems schemes and patterns by the farmers in the country are also discussed in detail indicating the potential opportunities and issues. It also deals with the scientific management of crop environment and pests of field crop cultivated in the country. This course contains the practical aspects of crop production such as demonstration of improved sowing methods, intercultural operations, harvesting and threshing. The student will have a comprehensive knowledge of the production of crop from sowing to the harvesting.

#### *Contents*

1. Concept of crop production
2. Classification of field crops
3. Cropping scheme, cropping patterns, cropping systems, cropping intensity
4. Production technology of major field crops: cereals (wheat, rice, maize, barley)
5. Sugar crops (sugarcane, sugar beet) and fiber crops (cotton, jute)
6. Traditional oil seed crops (rapeseeds, mustards, peanut, linseed, sesame etc.)
7. Non-traditional oil seed crops (sunflower, soybean, safflower)
8. Grain legumes (chickpea, lentil, green gram, black gram)
9. Fodders (berseem, lucerne, oats, sorghums, millets, mott grass, cowpea)
10. Special crops (tobacco)
11. Green manure crops (Guara, Dhancha, Pigeon pea, Senji etc.)

#### *Practical*

1. Identification of crops and their seeds
2. Demonstration of improved sowing methods of crops
3. Delinting of cotton seed
4. Raising of crop nurseries and transplanting
5. Intercultural practices
6. Seed Inoculation
7. Seed treatment with fungicides
8. Demonstration of harvesting and threshing operations
9. Field visits

#### *Recommended Texts*

1. Balasubramaniyan, P., & Palaniappan, S. P. (2004). *Principles and practices of agronomy*. Jodhpur: Agrobios.
2. Khalil, I.A., & Jan, A. (2002) *Cropping technology*. Islamabad: National Book Foundation.

#### *Suggested Readings*

1. Martin, J.H., Waldren, R.P., & Stamp, D.L. (2006). *Principles of field crop production* (4th ed.). New York: The McMillan.
2. Nazir, M.S., Bashir, E., & Bantel, R. (Eds.) (1994). *Crop production*. Islamabad: National Book Foundation.

This course provides information to the students about chemistry of soils especially soil colloids and their environmental significance. How organic matter play a role for enhancing availability of macro and micronutrients from soil environment? This subject also clears the concept of the students about soil pH and its significance regarding nutrients availability from soil to plant. This course also delivers knowledge to the students how to use sagaciously essential elements for better crop growth and production. Acquisition of specific and technical understanding of the students to select best management strategies for soil reclamation and land evaluation. In addition, this introductory course also improves the skills of the students how to calculate percent nutrients in available fertilizer and their chemical analysis about their percent grade.

#### *Contents*

1. Soil colloids and clays: description and environmental significance
2. Sources of charges on soil colloids
3. Cation and anion exchange properties of soil and their significance
4. Basic cation saturation percentage
5. Soil pH and its importance
6. Buffering of soil
7. Soil organic matter: sources, composition and significance
8. Elements essential for plant growth: macro and micronutrients, organic and inorganic fertilizers
9. Salt-affected and waterlogged soils: types, reclamation and management
10. Soil erosion: causes and remedies: soil and water conservation
11. Environmental impact of agricultural and industrial wastes

#### *Practical*

1. Fertilizers: Identification, composition and calculation of nutrient percentage
2. Fertilizer analysis for N, P and K
3. Soil analysis for EC and pH
4. Determination of soil organic matter

#### *Recommended Texts*

1. Bashir, E., & Bantel, R. (2001). *Soil Science*. Islamabad: National Book Foundation.
2. Brady, N.C., & R.R. Weil. (2007). *The Nature and Properties of Soils* (14th ed.). New Jersey: Pearson Education.

#### *Suggested Readings*

1. Brady, N.C. & R.R. Weil. (2009). *Elements of the Nature and Properties of Soils* (3rd ed.). New Jersey: Pearson Education.
2. Hillel, D. (2008). *Soil in the Environment: Crucible of Terrestrial Life*. Burlington: Elsevier.
3. Singer, M.J., & Munns, D.N. (2002). *Soils - An Introduction*. (5th ed.). New Jersey: Prentice-Hall.

Forest and Watershed management emphasize the understanding of forest resources in relation to watershed with practical knowledge of forest survey and its analysis and interpretation in a valid manner. The objectives of studying this course are to acquaint the students with basic knowledge of forestry, develop understanding about principles used in watershed management, to impart knowledge about forest resources in Pakistan, and to teach skills to the students about practical forest and watershed management in Pakistan. Watershed management is closely related to forest management as the selection and implementation of different forestry practices play a crucial role in it. Students will learn different biological and engineering approaches to control and regulate water flow and reduce the sedimentation of the streams and lakes fed by this water.

#### *Contents*

1. Introduction to Forest and watershed management
2. Forest resources of Pakistan (description, composition, distribution and status)
3. Importance of these natural resources of Pakistan
4. Constraints and problems in natural resource management
5. Principles of sustainable forest management
6. Forestry practices (Agroforestry, social forestry etc.)
7. Watershed Management: Principles, Watersheds of various streams/rivers of Pakistan, their area, distribution, land use patterns, climatic, physiographic, ecological and socio-economic features
8. Hydrological cycle
9. Management problems and potentials of various watersheds, afforestation programmes
10. Watershed as a source of power generation and irrigation
11. Watershed research and education

#### *Practical*

1. Identification of important forest tree species
2. Visits to various forest types and watershed areas
3. Watershed measurements (instruments, area, drainage, flow etc.)

#### *Recommended Texts*

1. Franzel, S., Scherr, S.J. (2001). *Trees on the Farm*. Wallingford: CAB International.
2. Quraishi, M. A. A. (1999). *Basics of Forestry and Allied Sciences*. Lahore: A-One Publishers.

#### *Suggested Readings*

1. Quraishi, M.A.A. (2002). *Watershed Management in Pakistan*. Faisalabad: Department of Forestry, University of Agriculture.
2. Quraishi, M.A.A. and Siddiqui, M.T. (2002). *Practical manual of watershed management*. Faisalabad: Department of Forestry, University of Agriculture.
3. Sheikh, M.I. (1999). *Forests and Forestry in Pakistan*. Lahore: A-One Publishers.
4. Siddiqui, M.T., Sands R., & Shah, A.H. (2009). *Glossary of forestry terms*. Faisalabad: Pulschay Publisher.

## **AEXT-5401 Introduction to Agricultural Extension and Rural Development 3(3+0)**

The purpose of this course is to give a brief introduction of Agricultural Extension education at undergraduate level. The students must know the history and philosophy of agricultural education in the development of present era agricultural system across the world. The concepts of extension education and rural development, principles of effective extension work, concepts of program planning, research, program evaluation and their importance in agricultural extension and rural development work, role of communication and ICTs in extension work and development activities in rural areas for the growth of the masses are important to disseminate among undergraduate students, so that students will prepare themselves to learn more advance ideas in agricultural education and research. The students will be able to perform better in dissemination of different agricultural technologies.

### *Contents*

1. Agricultural extension: definition, objectives and importance
2. Types of education, Brief history/recent trends in agricultural extension
3. Organizational setup of agricultural extension in Pakistan
4. Rural development, its definition/concept, objectives, importance and indicators
5. Elements of rural development process
6. Rural development through agricultural extension work in Pakistan
7. Characteristics and problems of Pakistani farmers
8. Current issues and problems of rural development and extension work in Pakistan
9. Roles and duties of extension workers at various organizational levels
10. Extension programs and activities since 1947 to date in Pakistan
11. Role of communication and ICT in extension and rural development work
12. Principles of effective extension work
13. Adoption and diffusion of agricultural innovations
14. Agricultural technology and its application for Pakistani farmers
15. Extension, research and farmer's linkages
16. Basic concept of planning, monitoring and evaluation in agricultural extension

### *Recommended Texts*

1. Ison, R., & Russell, D. (2004). *Agricultural Extension and Rural Development: Breaking out of Knowledge Transfer Traditions*. Cambridge: Cambridge University Press.
2. Ray, G.L. (2006). *Extension Communication and Management*. New Delhi: Kalyani Publishers.

### *Suggested Readings*

1. Bashir, E. (2005). *Extension Methods* (2nd ed.). Islamabad: National Book Foundation.
2. Narasaiah, M.L. (2003). *Approaches to Rural Development*. New Delhi: Discovery Publishing House.
3. Leeuwis, C., & Van den Ban, A. (2004). *Communication for rural Innovation: Rethinking Agricultural Extension* (3rd ed.). New Jersey: Wiley-Blackwell.

Academic writing is a formal, structured and sophisticated writing to fulfill the requirements for a field of study. The course aims at providing understanding of writer's goal of writing (i.e. clear, organized and effective content) and to use that understanding and awareness for academic reading and writing. The objectives of the course are to make the students acquire and master the academic writing skills. The course would enable the students to develop argumentative writing techniques. The students would be able to the content logically to add specific details on the topics such as facts, examples and statistical or numerical values. The course will also provide insight to convey the knowledge and ideas in objective and persuasive manner. Furthermore, the course will also enhance the students' understanding of ethical considerations in writing academic assignments and topics including citation, plagiarism, formatting and referencing the sources as well as the technical aspects involved in referencing.

### *Contents*

1. Academic vocabulary
2. Quoting, summarizing and paraphrasing texts
3. Process of academic writing
4. Developing argument
5. Rhetoric: persuasion and identification
6. Elements of rhetoric: Text, author, audience, purposes, setting
7. Sentence structure: Accuracy, variation, appropriateness, and conciseness
8. Appropriate use of active and passive voice
9. Paragraph and essay writing
10. Organization and structure of paragraph and essay
11. Logical reasoning
12. Transitional devices (word, phrase and expressions)
13. Development of ideas in writing
14. Styles of documentation (MLA and APA)
15. In-text citations
16. Plagiarism and strategies for avoiding it

### *Recommended Texts*

1. Bailey, S. (2011). *Academic writing: A handbook for international students* (3rd ed.). New York: Routledge.
2. Swales, J. M., & Feak, C. B. (2012). *Academic writing for graduate students: Essential tasks and skills* (3rd ed.). Ann Arbor: The University of Michigan Press.

### *Suggested Readings*

1. Craswell, G. (2004). *Writing for academic success*. London: SAGE.
2. Johnson-Sheehan, R. (2019). *Writing today*. Don Mills: Pearson.
3. Silvia, P. J. (2019). *How to write a lot: A practical guide to productive academic writing*. Washington: American Psychological Association.

The course is designed to acquaint the students of BS Programs with the rationale of creation of Pakistan. The students would be apprised of the emergence, growth and development of Muslim nationalism in South Asia and the struggle for freedom, which eventually led to the establishment of Pakistan. While highlighting the main objectives of national life, the course explains further the socio-economic, political and cultural aspects of Pakistan's endeavors to develop and progress in the contemporary world. For this purpose, the foreign policy objectives and Pakistan's foreign relations with neighboring and other countries are also included. This course has been developed to help students analyze the socio-political problems of Pakistan while highlighting various phases of its history before and after the partition and to develop a vision in them to become knowledgeable citizens of their homeland.

#### *Contents*

1. Contextualizing Pakistan Studies
2. Geography of Pakistan: Geo-Strategic Importance of Pakistan
3. Freedom Movement (1857-1947)
4. Pakistan Movement (1940-47)
5. Muslim Nationalism in South Asia
6. Two Nations Theory
7. Ideology of Pakistan
8. Initial Problems of Pakistan
9. Political and Constitutional Developments in Pakistan
10. Economy of Pakistan: Problems and Prospects
11. Society and Culture of Pakistan
12. Foreign Policy Objectives of Pakistan and Diplomatic Relations
13. Current and Contemporary Issues of Pakistan
14. Human Rights: Issues of Human Rights in Pakistan

#### *Recommended Texts*

1. Kazimi, M. R. (2007). *Pakistan Studies*. Karachi: Oxford University Press.
2. Sheikh, J. A. (2004). *Pakistan's Political Economic and Diplomatic Dynamics*. Lahore: Kitabistan Paper Products.

#### *Suggested Readings*

1. Hayat, S. (2016). *Aspects of Pakistan Movement*. Islamabad: National Institute of Historical and Cultural Research.
2. Kazimi, M. R. (2009). *A Concise History of Pakistan*. Karachi: Oxford University Press.
3. Talbot, I. (1998). *Pakistan: A Modern History*. London: Hurst and Company.

The course provides an overview of Genetics. Genetics is a field of biology that studies how traits are passed from parents to their offspring. The passing of traits from parents to offspring is known as heredity, therefore, genetics is the study of heredity. This introduction to genetics takes you through the basic components of genetics such as DNA, genes, chromosomes and genetic inheritance. Genetics is built around molecules called DNA. DNA molecules hold all the genetic information for an organism. It provides cells with the information they need to perform tasks that allow an organism to grow, survive and reproduce. A gene is one particular section of a DNA molecule that tells a cell to perform one specific task. Heredity is what makes children look like their parents. During reproduction, DNA is replicated and passed from a parent to their offspring. This inheritance of genetic material by offspring influences the appearance and behaviour of the offspring. The environment that an organism lives in can also influence how genes are expressed.

### *Contents*

1. Definition of genetics, concepts of heredity and variation
2. Cell and cell divisions. Mendelian genetics: chromosome
3. Theory of heredity, various genotypic and phenotypic ratios and their modifications
4. Differences between allelic and non-allelic interactions (epistasis), illustration of epistasis
5. Pleiotropy and multiple allelism
6. Multiple factor hypothesis
7. Linkage and crossing over
8. Sex determination: sex-linked and sex influenced traits
9. Chromosomal aberrations
10. Nucleic acids: nature, structure and function
11. Classical vs modern concepts of gene

### *Practical*

1. Study of cell divisions and gametogenesis
2. Calculation of monohybrid and dihybrid ratios
3. Numerical examples: gene interaction, multiple alleles and multiple factor inheritance
4. Calculation of linkage from test cross and  $F_2$  data

### *Recommended Texts*

1. Klug, W.S., & Cummings, M. R. (2003). *Concepts of Genetics* (7th ed.). Singapore: Pearson Education.
2. Singh, B.D. (2004). *Genetics*. New Delhi: Kalyani Publishers.

### *Suggested Readings*

1. Khan, I.A., Azhar, F.M., Ali, Z., & Khan, A.A. (2008). *Solving Numerical Genetic Problems*. Faisalabad: University of Agriculture.
2. Singh, P. (2003). *Elements of Genetics* (2nd ed.). Delhi: Kalyani Publishers.
3. Stansfield, W.D. (1988). *Theory and Problems of Genetics* (4th ed.). New York: McGraw-Hill Book.

This course is aimed to make the students familiar with the basic information about the study of insects. Students would be able to know about arthropods and especially insects with their morphological features, identify insects of economic importance and acquire working skills for collecting, mounting, and preserving insects. The course briefs about the basic external and internal morphological and anatomical features along with their basic functioning principles. Students will learn about the insect classification and nomenclature so that they can easily identify the insect order, family and type and can properly collect, mount and preserve these invertebrates for further studies. Insect body features and their habits help for their identification. This is the basic course that enables students to further understand the ways and techniques adopted for the control and management of economically important insect pests.

#### *Contents*

1. Introduction
2. Phylum Arthropoda and its classification
3. Metamorphosis and its types
4. External and internal morphology and physiology with a reference to typical insect, 'ak' grasshopper, *Poekiloceruspictus*
5. Insect classification and nomenclature
6. Salient characters of insect orders with important families and examples of important members

#### *Practical*

1. Characters of classes of Arthropoda
2. Collection and preservation of insects
3. Morphology and dissection of a typical insect (digestive, reproductive, excretory, nervous, circulatory and tracheal systems)
4. Temporary mounts of different types of appendages of insects
5. Observations for types of metamorphosis

#### *Recommended Texts*

1. Lohar, M.K. (1998). *Introductory Entomology*. Hyderabad: Kashif Publications.
2. McGavin, G. C. (2001). *Essential entomology: an order-by-order introduction*. USA: Oxford University Press.

#### *Suggested Readings*

1. Mani, M.S. (1990). *General Entomology* (4th ed.) Delhi: Oxford/IBH Publishing.
2. Tonapi, G.T. (1994). *Experimental Entomology, an Aid to Lab. and Field Studies*. Delhi: C.B.S. Publishers.

Plant pathology is a science that studies plant diseases and attempts to improve the chances for survival of plants when they are faced with unfavorable environmental conditions and parasitic microorganisms that cause disease. As such, plant pathology is challenging, interesting, important, and worth studying. It is also, however, a science that has a practical and noble goal of protecting the food available for humans and animals. Plant diseases, by their presence, prevent the cultivation and growth of food plants in some areas; or food plants may be cultivated and grown but plant diseases may attack them, destroy parts or all of the plants, and reduce much of their produce, i.e., food, before they can be harvested or consumed. The objective of this course is to acquaint the students with basic concepts and identification of plant pathogens. The course covers all aspects of plant pathogens which include their economic importance, morphology, reproduction and ecology. The course also covers classification of different plant pathogens. In addition to plant pathogens, phanerogamic parasites, viroids and fastidious bacteria will also be covered briefly during this course.

#### *Contents*

1. Introduction and economic importance
2. General characteristics (morphology, reproduction and ecology)
3. Identification of plant pathogens including fungi, prokaryotes, viruses, viroids, nematodes, fungus like organisms and phanerogamic parasites
4. Taxonomic position of economically important plant pathogens

#### *Practical*

1. Orientation of laboratory equipment
2. Sterilization of glassware
3. Preparation of media and isolation of different plant pathogens
4. Study of characteristics of various plant pathogens through slides
5. Live specimens and their comparative account/study

#### *Recommended Texts*

1. Agrios, G. N. (2005). *Plant Pathology* (5th ed.). Burlington: Elsevier Academic Press.
2. Ahmad, I., & Bhutta, A.R. (2005) *Textbook of introductory Plant Pathology*. Islamabad: NBF Publisher.

#### *Suggested Readings*

1. Bos, L. (1999). *Plant viruses, unique and intriguing pathogens: a textbook of plant virology*. Netherlands: Backhuys Publishers.
2. Mehrotra, R. S., & Aggarwal, A. (2003). *Plant Pathology* (2nd ed.). India: Tata McGraw Hill Education.
3. Ravichandra, N. G. (2013). *Fundamentals of plant pathology*. India: PHI Learning.
4. Windham, M. T., Trigiano, R. N., & Windham, A. S. (2003). *Plant pathology: concepts and laboratory exercises*. UK: Taylor and Francis.

Students will learn the fundamentals of plant structure and how cells, tissues, organs and whole plants develop and function. Students will then explore how environmental factors affect growth and development, and how humans manipulate them to produce horticultural crops: fruits, vegetables, flowers and landscape plants. Students will learn the division of horticulture and classification of horticultural plants as well as plant parts and their modifications. This course would help understand propagation methods, punning, training and laying out of an orchard, vegetable farm. This course will help students to identify the key issues being faced by the growers such as purchasing of plants from nursery, establishing an orchard, pruning, training and wind breaks. Taking this course would broaden their vision regarding the horticulture industry at domestic and international level. Labs are designed to emphasize and reinforce the principles covered in lecture and will give students a hands-on introduction to horticulture.

#### *Contents*

1. Introduction, history, importance and future scope
2. Definition and divisions of horticulture
3. Classification of horticultural crops, Plant parts, their modifications and functions
4. Plant environment
5. Climate (temperature, light, humidity etc)
6. Soil (structure, texture, fertility etc)
7. Phases of plant growth, Propagation of horticultural plants

#### *Practical*

1. Visit of nurseries, commercial gardens and public parks
2. Identification and nomenclature of important fruits, vegetables and ornamental plants
3. Garden tools and their uses, Media and its preparation
4. Techniques of propagation

#### *Recommended Texts*

1. Carrol, L., Shry, J.R., & Reily, H.E. (2011). *Introductory Horticulture* (8th ed.) Albany: Delmar-Thomson Learning.
2. Christopher, E. P. (2012). *Introductory Horticulture*. New Delhi: Biotech books.

#### *Suggested Reading*

1. Hartmann, H.T., Kester, D.E., Davies, E.T., & Geneve, R.L. (2009). *Plant Propagation–Principles and Practices* (7th ed.). New Delhi: Prentice-Hall India Learning.
2. Peter, K.V. (2009). *Basics of Horticulture*. New Delhi: New India publishing Agency.

The course will introduce the students with knowledge of rangelands and their importance as major land use in Pakistan. Students will be able know the characteristics of rangelands of the country and complexities associated with management of rangelands. The course describes the range ecosystem, its components and types of range vegetation in different ecological zones of the country with brief discussion of the botany of range grasses, shrubs and trees, range plant ecology, range animal behavior, rangeland stocking rate and selection of grazing system. There is a comprehensive discussion on principles of scientific management of all the components of range ecosystem and its relationship with wildlife. The key objectives of this course are to introduce the rangeland resources and associated wildlife of Pakistan to make the students identify major range vegetation types and wildlife species of the country and to provide information about the problems of rangelands and their scientific management.

#### *Contents*

1. Introduction to Rangelands, scope and importance, basic terminology
2. Components of Rangelands, Constraints and problems of rangelands
3. Rangeland Resources of Pakistan; ecological zones and vegetation types
4. Range ecosystem, Principles of Rangeland Management
5. Grazing systems of the world, Grazing systems and grazing pattern in Pakistan
6. Range improvement techniques
7. Wildlife: Definition and values
8. Ecosystem concept, characteristics and management requirements for regional eco-systems in Pakistan including arid, wetland, forest, mountain and coastal ecosystems
9. Introduction to protected areas (National Park, Game Reserve and Wildlife Sanctuary)

#### *Practical*

1. Identification and preservation of important Grasses and Plant species of a rangeland
2. Visits to various Rangeland types and Plantations
3. Quantitative analysis of range vegetation
4. Identification of important wildlife species

#### *Recommended Texts*

1. Holechek, J. (1989). *Range Management, Principles and Practices*. Newberry: Prentice Hall.
2. Quraishi, M. A. A., Khan, G.S., & Yaqoob, M. S. (1993). *Range Management in Pakistan*. Faisalabad: University of Agriculture.

#### *Suggested Readings*

1. Mohammad, N. (1989). *Rangeland Management in Pakistan*. NARC: Published by ICIMOD.
2. Quraishi, M.A.A., & Ishaque, M. (1995). *Practical Manual of Range Management*. Faisalabad: University of Agriculture.
3. Stoddard, L.A., Smith, A.D., & Box, T.W. (1975). *Range Management*. New York: McGraw Hill.

The objective of this course is to introduce the students to economic principles and the economic way of thinking. This course is helpful for students to teach them the basic economics foundation about the allocation of scarce resources, that scarcity forces choice, tradeoffs exist and that every choice has an opportunity cost. After completing the course, students will develop understanding of the basic concepts of economics and their application in agriculture. Students should read content and complete course assignments prior to deadlines. Students are expected to actively participate in discussions and submit exercises in-time. Students are also expected to complete exams on the date and time allotted. It is their responsibility to be familiar with and understand all previously covered material prior to each new chapter.

#### *Contents*

1. Definitions and overview of economics and related terms, Subject Matter & Scope
2. Contents of consumer behavior; Scale of preferences; Utility, Indifference Curve & related concepts
3. Demand & Supply analysis, Elasticity of Demand and Supply, Market Equilibrium
4. Production, factors of production, laws of return and their significance in agriculture
5. Concept of macroeconomics approaches to national income estimation
6. Growth, Unemployment & Inflation
7. Important macroeconomic issues in agriculture sector of Pakistan

#### *Recommended Texts*

1. Parkin, M. (2010). *Economics*, (10th ed.). Boston: Addison Wesley Publishing.
2. Penson, J. B., Capps O., Rossen, C. P., & Woodward, R. (2013). *Introduction to Agricultural Economics* (5th ed.). New Jersey: Prentice Hall.

#### *Suggested Readings*

1. Cramer, G. L., Jensen, C. W., Southgate Jr., D. D. (2001). *Agricultural Economics and Agribusiness* (8th ed.). New Jersey: Wiley Publisher.
2. Mankiw, N. G. (2011). *Principles of Economics* (5th ed.). Mason: South-Western Cengage learning Publisher.
3. Penson, J. B., Capps, O., Rossen C. P., & Woodward, R. (2013). *Introduction to Agricultural Economics* (5th ed.). New Jersey: Prentice Hall.

In order to secure the future of a society, citizens must train younger generations in civic engagement and participation. Citizenship education is education that provides the background knowledge necessary to create an ongoing stream of new citizens participating and engaging with the creation of a civilized society. Community engagement seeks to better engage the community to achieve long-term and sustainable outcomes, processes, relationships, discourse, decision-making, or implementation. This course will provide a critical interrogation of the central conceptual issues as well as an examination of how to design a program of effective community engagement. This course begins by asking: Why involve citizens in planning and policymaking? This leads to an examination of the politics of planning, conceptualizations of "community" and, to the tension between local and professional knowledge in policy making. This course will also analyze different types of citizen engagement and examine how to design a program of public participation for policy making. Approaches to evaluating community engagement programs will also be a component of the course.

### *Contents*

1. Introduction to Citizenship Education and Community Engagement: Orientation
2. Introduction to Active Citizenship: Overview of the ideas, Concepts, Philosophy and Skills
3. Identity, Culture and Social Harmony: Concepts and Development of Identity
4. Components of Culture and Social Harmony, Cultural & Religious Diversity
5. Multi-cultural society and inter-cultural dialogue: bridging the differences, promoting harmony
6. Significance of diversity and its impact, Importance and domains of inter-cultural harmony
7. Active Citizen: Locally active, globally connected
8. Importance of active citizenship at national and global level
9. Understanding community, Identification of resources (human, natural and others)
10. Human rights, Constitutionalism and citizens' responsibilities: Introduction to human rights
11. Universalism vs relativism, Human rights in constitution of Pakistan
12. Public duties and responsibilities
13. Social Issues in Pakistan: Introduction to the concept of social problem, Causes and solutions
14. Social Issues in Pakistan (Poverty, Equal and Equitable access of resources, unemployment)
15. Social Issues in Pakistan (Agricultural problems, terrorism & militancy, governance issues)
16. Social action and project: Introduction and planning of social action project
17. Identification of problem, Ethical considerations related to project
18. Assessment of existing resources

### *Recommended Books*

1. Kennedy, J. K., & Brunold, A. (2016). *Regional Context and Citizenship Education in Asia and Europe*. New York: Routledge Falmer.
2. Macionis, J. J., & Gerber, M. L. (2010). *Sociology*. New York: Pearson Education.

### *Suggested Books*

1. British, Council. (2017). *Active Citizen's Social Action Projects Guide*. Scotland: British Council.
2. Larsen, K. A., Sewpaul, V., & Hole, G. O. (Eds.). (2013). *Participation in Community Work: International Perspectives*. New York: Routledge.

This course is designed to help understand the basis of plant breeding and the application of genetic principles for the improved heredity of plants. The objectives of the course include: how to improve yield, quality, disease-resistance, drought and frost-tolerance and important characteristics of the crops? How to create desired genotypes and phenotypes for specific breeding objectives as per crop? The process of creating variation and then utilizing the variation for the plant improvement, understanding how to exploit the available natural variation and if natural variation is not having selection potential then the method of artificial creation of variation, understanding the reproductive mechanisms in major crops, application of genetic principles in crop improvement, understanding breeding methods in self-pollinated crops and the principle of breeding self-pollinated crops as homozygosity. Students will also learn about comparative advantage of different breeding methods in terms of time required for breeding a crop variety and understand breeding methods in cross pollinated crops.

#### *Contents*

1. Introduction to plant breeding and its role in crop improvement
2. Reproductive systems in major crop plants
3. Genetic variation and its exploitation, creation of variation through genetic recombination, mutation and heteroploidy
4. Breeding self-pollinated crops: introduction, mass selection, pure line selection; hybridization, pedigree method, bulk method and backcross techniques
5. Breeding cross-pollinated crops: introduction, mass selection, recurrent selection
6. Development and evaluation of inbred lines
7. Development of hybrids, synthetic and composite populations
8. Breeding clonally propagated crops
9. New trends in plant breeding

#### *Practical*

1. Descriptive study of floral biology
2. Scientific names, chromosome number and ploidy level of important field crops
3. Selfing and crossing techniques in major crops
4. List of approved varieties in major field crops
5. Field visits of different research organizations

#### *Recommended Texts*

1. Sleper, D. A., & Poehlman, J.M. (2006). *Breeding Field Crops* (5th ed.) Ames, USA: Iowa State University Press.
2. Chahal, G.S., & Gosal, S.S. (2003). *Principles and Procedures of Plant Breeding*. New Delhi: Narosa Publishing House.
3. Singh, B. D. (2003). *Plant Breeding: Principles and Methods*. New Delhi: Kalyani Publishers.

#### *Suggested Readings*

1. Singh, P. (2003). *Essentials of Plant Breeding*. New Delhi: Kalyani Publishers.
2. Khan, M.A. (Ed.). (1994). *Plant Breeding*. Islamabad: National Book Foundation.
3. Acquaah, G. (2009). *Principles of Plant Genetics and Breeding*. UK: John Wiley & Sons.

The students would be able to acquire the knowledge of different practical aspects of entomology. For instance, they will learn to identify the major insect pest species of agricultural, horticultural and forest crops, vegetables, fruits, stored grains and household pests. Course aims to demonstrate the students about the identification of insect pests, their control methods and pesticide application equipment with basic objective to enhance farmer's productivity through better management and control of insect pests. Moreover, course includes the basic information and introduction related to entomological cottage industries (i.e. honeybee farming, silkworm rearing and lac culture) in order to enhance the productivity of farming community. This course is the continuation of the introductory course which involves the techniques and practices used for the application of the basic entomological knowledge for the control and management of economically important agricultural insect pests and best possible utilization of useful aspects of insects.

#### *Contents*

1. Introduction
2. Causes of success and economic importance of insects
3. Principles and methods of insect control i.e. cultural, biological, physical, mechanical, reproductive, legislative, chemical and bio-technological control
4. Introduction to IPM; insecticides, their classification, formulations and application equipment
5. identification, life histories, mode of damage and control of important insect pests of various crops, fruits, vegetables, stored grains, household, termites and locust
6. Entomological industries: apiculture, sericulture and lac-culture

#### *Practical*

1. Collection, identification and mode of damage of insect pests of various crops, fruits, vegetables, stored grains and household
2. Insecticide formulations, their dilutions and safe handling
3. Use of application equipment, instructions in apiculture, sericulture and lac-culture

#### *Recommended Texts*

1. Atwal, A.S. (2005). *Agricultural Pests of Southeast Asia and their Management*. Ludhiana: Kalyani Publishers.
2. Pedigo, L. P., & Rice, M. E. (2014). *Entomology and Pest Management* (6th ed.). USA: Waveland Press.

#### *Suggested Readings*

1. Duncton, P.A. (2007). *The Insect: Beneficial and Harmful Aspects*. Ludhiana: Kalyani Publishers.
2. Mathews, G.A. (2004). *Pesticide Application Methods* (3rd ed.). New York: John Wiley & Sons.

Plant Pathology or Phytopathology is the branch of agriculture, which deals with the study of plant diseases. The detailed study includes the importance and occurrence, symptoms, cause, etiology, disease cycle, epidemiology and management of diseases. Disease may be defined as “abnormal changes in physiological processes which disturbs the normal activity of plant organs”. Disease is a condition in which the functions of the organism are improperly discharged, or in other words, it is a state, which is physiologically abnormal and threatens the life of the being or organs. Disease is a variation from normal physiological activity, which is sufficiently permanent or extensive to check the performance of normal functions by the plant or completion of its development. The objective of this course is to acquaint the students with basic concepts of Plant Pathology. The course comprises history of different plant diseases, their symptoms, etiology, epidemiology and management. The course also has brief introduction of different plant pathogens which include fungi, viruses, bacteria and nematodes. The course also covers historical background of different plant pathogens and the discoveries related to management of different diseases.

#### *Contents*

1. Introduction and history of plant pathology
2. Basic characteristics of fungi, bacteria, viruses and nematodes
3. Concept of disease in plants; economic importance of plant diseases
4. Nature and cause of (biotic and abiotic) diseases
5. Components of plant disease development
6. Diagnosis of plant diseases
7. Principles of plant disease management
8. Introduction to IDM and IPM; symptoms, etiology
9. Mode of infection, disease cycle and management of representative diseases of agricultural and horticultural crops

#### *Practical*

1. Demonstration of lab equipment and reagents
2. Collection, preservation and identification of plant diseases based on symptoms
3. Isolation and inoculation techniques
4. Demonstration of Koch's postulates

#### *Recommended Texts*

1. Agrios, G. N. (2005). *Plant Pathology* (5th ed.). Burlington: Elsevier Academic Press.
2. Chaube, H.S., & Singh, R. (2002). *Introductory Plant Pathology*. India: International Book.

#### *Suggested Readings*

1. Mehrotra, R.S., & Aggarwal, A. (2003). *Plant Pathology* (2nd ed.). India: Tata McGraw Hill Education.
2. Strange, R.N. (2006). *Introduction to Plant Pathology*. USA: John Wiley & Sons.

The objective of this course is to familiarise students with production of horticultural crops such as fruit, vegetables and ornamental crops. Students are expected to understand various stages of fruit, vegetables and ornamental plants phenology and physiology in order to solve related problems for horticultural crops. After completing this course student will be able to grow and manage horticultural crops successfully on a commercial scale. This course would help understand students regarding the key phenomenon's related with fruits such as incompatibility, fruits set, and biennial bearing. Similarly, students will also learn about disease and insect problem in vegetables and ornamental plants. This course will help students to identify the key issues being faced by the growers such as alternate bearing, fruit drop and possible options to control these issues using different approaches.

#### *Contents*

1. Establishment of orchards, vegetable farms and ornamental gardens
2. Site selection, layout methods, wind breaks and their role
3. Management practices: irrigation, manures and fertilizers, training and pruning, cultivation and weed control
4. Climate, soil, propagation, rootstocks, cultivars, important pests, harvesting, post-harvest handling and marketing of important horticultural crops (fruits, vegetables and ornamentals) of the region

#### *Practical*

1. Practice in layout methods
2. Selection of plants from nursery, propagation methods
3. Planting and after care
4. Production techniques and identification of important cultivars of horticultural crops of the region

#### *Recommended Texts*

1. Acquaah, G. (2009). *Horticulture: Principles and Practices* (4th ed.). New Delhi: Prentice-Hall India Learning.
2. Adams, C. R., Bamford, K.M., & Early, M. P. (2012). *Principles of Horticulture* (6th ed.). New York: Routledge.

#### *Suggested Readings*

1. Singh, B. (2007). *Horticulture at a Glance*. Ludhiana: Kalyani Publishers.
2. Pradeepkumar, T. (2008). *Management of horticultural crops* (Vol. 11). New Delhi: New India Publishing.
3. Yadav, P.K. (2007). *Fruit Production Technology*. Lucknow: International Book.

This is an introductory course which enables the students to understand the basics of food science and technology. Students will study the physical, biological, and chemical makeup of food; the causes of food deterioration; and the concepts underlying food processing. Food scientists and technologists apply scientific disciplines including chemistry, engineering, microbiology, and nutrition to the study of food to improve the safety, nutrition, wholesomeness and availability of food. Depending on their area of specialization, food scientists may develop ways to process, preserve, package, and/or store food according to industry and government specifications and regulations. It could involve enhancing the taste, making it last longer, making sure it's safe to eat, or even boosting its nutritional content. Students will explore and gain an understanding into the history of food science and the factors that have shaped food science in Pakistan, organizations involved in food manufacturing, food regulatory processes, food composition, its classification depending on sources, consumption pattern and basic analysis of food components.

#### *Contents*

1. Introduction to food science, food technology, relationship with other disciplines
2. Career opportunities. Significance of food science and technology
3. Food industry: history, developments, important food industries in Pakistan
4. Food sources: plants, animals and marine
5. Food constituents and their functions: water, carbohydrates, lipids, proteins, vitamins, minerals
6. Classification of foods on the basis of perishability and pH
7. Food spoilage agents: enzymes, microorganisms, pests, physical factors
8. Principles of food preservation: prevention or delay of autolysis, microorganisms, and pests

#### *Practical*

1. Use of basic food laboratory equipment
2. Estimation of Moisture, Fat, Protein, Carbohydrates, Fiber and Ash content in food samples
3. Determination of soluble solids, total solids, pH, Acidity, total sugars, Specific gravity, and Refractive index

#### *Recommended Texts*

1. Awan, J. A. (2018). *Food science and technology*. Faisalabad: Unitech Communications.
2. Robert, L. S., Ramirez, A. O., & Clarke, A. D. (2015). *Introducing Food Science*. (2nd ed.). Florida: CRC Press.

#### *Suggested Readings*

1. Stewart, G. F., & Amerine, M. A. (2012). *Introduction to food science and technology*. New Jersey: Elsevier.
2. Potter, N. N., & Hotchkiss, J. H. (2012). *Food science*. Berlin: Springer Science & Business Media.

This course is designed for undergraduate programs of agriculture sciences. The objective of this course is to impart basic and applied knowledge about statistics for collection, presentation, analysis and interpretations of data related to agriculture issues. After completing this course agriculture student will be able to understand the general concepts of basic statistics, to conduct agriculture surveys, to understand design of experiments, and other statistical tools. These statistical concepts are further will be helpful to complete a research related to agriculture sciences. Moreover, over students will also learn some statistical software such as Minitab, SPSS and Design Expert to improve their computational and analytical skills. Through this course, students will be able to understand and analyze the agricultural problems in field as well as in lab conditions.

### *Contents*

1. Definition and importance of Statistics in Agriculture
2. Data, Different types of data and variables
3. Classification and Tabulation of data
4. Frequency distribution, Graphical representation of data
5. Measure of Central tendency and Measure of Dispersion.
6. Calculation of averages, Range, variance, Standard deviation, and coefficient of variation
7. Regression and Correlation Analysis: Simple and Multiple regression, correlation cases
8. Sampling and its types: Probability and non-Probability Sampling, Simple random sampling, stratified random sampling, Systematic sampling, Sampling and non-sampling error
9. Sampling distribution of mean and difference between two means
10. Inference 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
11. Test of association of attributes using  $\chi^2$  (chi-square) Testing hypothesis about variance
12. ANOVA and its assumptions, One-way ANOVA, Two-way ANOVA

### *Recommended Texts*

1. Muhammad, F. (2000). *Statistical methods and data analysis*. Pakistan: Ilmi Kitab Khana.
2. Rao, G. N. (2007). *Statistics for agricultural sciences* (2nd ed.). Hyderabad: BS Publication.

### *Suggested Readings*

1. Lawal, B. (2014). *Applied statistical methods in agriculture, health and life sciences*. USA: Springer.
2. Sahu, P. K. (2016). *Applied statistics for agriculture, veterinary, fishery, dairy and allied fields*. USA: Springer.
3. Crawshaw, J. & Chambers, J. A. (1994). *Concise course in A. level statistic with world examples*. USA: Springer.

The world has embraced the largest revolution so far in the history of mankind called communication revolution. Everything has been tagged to communication. Communication provides the way to resolve mutual conflicts not only between two individuals, groups but also between the countries. Communication has lot more importance in the development of leadership qualities among the masses of civil society. The aim of this course is to develop the communication and leadership skills among future extensionists. At the completion of this course, the students will be able to conceptualize the concepts communication process and demonstrate improved communication/leadership skills being used for agricultural technology dissemination among different stakeholders.

#### *Contents*

1. Concept, Purpose and scope of communication in Agricultural extension
2. Forms of communication in the past, present and future
3. Communication and the concept of global community
4. Communication as the problem-solving approach
5. Communication process, elements and their role in effective communication
6. Principles of communication
7. Basic communication models
8. Forms of communication: interpersonal, intrapersonal and impersonal; Written, verbal and non-verbal communication
9. Barriers to communication and measures to overcome these barriers

#### *Practical*

1. The students will be involved in developing and critically analyzing different extension messages. Each student will have to design a project for class presentation
2. Students will have to practice different forms of communication in the class

#### *Recommended Texts*

1. Calvert, P. (2000). *The communicator's Handbook. Tools, Techniques and technology* (4th ed.). USA: Maupin House Publishing.
2. Muhammad, S. (2005). *Communication Skills & Leadership Development*. Faisalabad: Unitech Communications.

#### *Suggested Readings*

1. Murphy, H. A., Hildebrandt, H. P., & Thomas, J. P. (2000). *Effective business communication*. Islamabad: NBF.

This is a course about theories and practice of Agronomy. The course aims to elaborate the comprehensive study of food security issues which are being faced by the developing world and the consequences regarding its distribution throughout the world. It familiarizes the students about the history of major crops being cultivated in Pakistan. The advanced husbandry of the major crop cultivated in the country with special emphasis on critical production factors is also discussed in detail. The course also explains plant characteristics and phenological development of major crops. The improved sowing methods along with different management practices for major crops are also demonstrated in the field. The students will be able to estimate the crop yields for major crops.

#### *Contents*

1. Food security (food availability, access, nutritional security)
2. Origin, morphology, adaptation and economic importance and agro-technology of major cereals
3. Major oilseeds
4. Major pulses
5. Fiber crops
6. Major fodders
7. Special focus on regional crops
8. Management of irrigation, the timing of planting and harvesting
9. Pest management, fertilization, postharvest handling and marketing etc.
10. Management constraints and technological measures to optimize crop productivity
11. Modern techniques for crop improvement

#### *Practical*

1. Demonstration of improved sowing methods
2. Raising and transplanting of rice nursery
3. Delinting of cotton seed by conventional and modern techniques
4. Techniques of maintaining optimum plant population under field conditions
5. Plant characteristics and phenological development of major crops
6. Introduction to sugar industry.
7. Demonstration of methods used for estimating crop yields for major crops

#### *Recommended Texts*

1. Jenkins, A. (2018). *Agronomy and Crop Production*. New York, USA: Syrawood Publishing House.
2. Nazir, M.S., Bashir, E., & Bantel, R. (Eds.) (1994). *Crop Production*. Islamabad: National Book Foundation.

#### *Suggested Readings*

1. Benkeblia N. (2018). *Climate Change and Crop Production: Foundations for Agroecosystem Resilience*, Florida USA: CRC Press, Taylor and Francis.
2. Balasubramaniyan (2004). *Principles and Practices of Agronomy*, Jodhpur, India: Agro bios.
3. Oerke, E.C., Dehne, H.W., Schönbeck, F., & Weber, A. (2012). *Crop Production and Crop Protection: Estimated Losses in Major Food and Cash Crops*. Amsterdam : Elsevier Science.

A large part of the surface of the world is arid, characterized as too dry for conventional rain fed agriculture and the aim of the course is to enhance the understanding for sustainable productivity of agriculture in arid and semi-arid areas while protecting the natural resource-based i.e. land & water resources, range land and precious vast natural biodiversity present in the area. Causes of aridity, its impact on crops and management strategies to improve local agriculture in arid zones under limited moisture regimes will be addressed. It will cover all aspects of arid zone agriculture including the dryland tracts of Pakistan, factors which limits crop yields and water harvesting techniques. This course will enable students to learn and practically perform water harvesting and moisture conservation techniques that can be used for successful crop production in arid zones.

### *Contents*

1. Introduction, concept and causes of aridity
2. Climatic zones of Pakistan and their features
3. Climatic factors such as light, temperature, rainfall, relative humidity, wind, etc.
4. Their effects on crop yield
5. Crop growth and yield responses to moisture supply in different soils
6. Evapotranspiration (ET), relation between crop yield and ET
7. Dry farming
8. Water conservation practices, tillage, fertilizer use, sowing date and plant density
9. Crop rotations and cropping patterns in rain fed regions
10. Water harvesting practices

### *Practical*

1. Demonstration of rainwater harvesting and conservation techniques
2. Determination of soil moisture
3. Mulching and tillage practices for moisture conservation
4. Field visits

### *Recommended Texts*

1. Farooq, M., & Saiddique, K.H.M. (2017). *Innovation in Dryland Agriculture*. Switzerland: Springer Publishers.
2. Khan, S.R.A. (2004). *Crop Management in Pakistan with Focus on Soil and Water*. Lahore: Directorate of Agricultural information.

### *Suggested Readings*

1. Farooq, M., & Saiddique, K.H.M. (2016). *Conservation Agronomy*. Switzerland : Springer Publishers.
2. Arnon, I. (2012). *Agriculture in Dry Lands: Principles and Practices*. London: Elsevier.
3. Hudson, N.W. (2004). *Soil and Water Conservation in Semi-arid Areas*. India: Scientific Publishers.

The aim of the course is to introduce the students with physiology of the crop plants. The mechanism of growth and development crop plant are complex mechanisms which consist of several physiological processes starting from germination of seed to maturity of fruit. This course introduces all such physiological processes like physiology of seed germination, emergence, photosynthesis, respiration etc. All these processes are working in integration and balance way which ultimately leads to growth and development. The course familiarizes the students about the phenology of the crop plants, synthesis of food and its distribution in the different plant parts and yield estimation using physiological parameters. The growth deteriorative processes in plants like aging, senescence and abscission are also discussed in this course.

#### *Contents*

1. Concept and importance of crop physiology
2. Carbon metabolism
3. Factors affecting photosynthesis, respiration and transpiration
4. Photosynthetic efficiency of different crop plants
5. Growth and development, Photo morphogenesis
6. Physiology of seed germination, dormancy, seedling establishment tillering and stem
7. Physiology of root, leaf, flower and seed development, senescence and abscission
8. Source-sink relationships in crop plants
9. Photoperiodism, vernalization and tropism
10. Physiological determinants of crop yield

#### *Practical*

1. Equipment used in crop physiology
2. Preparation of solutions of various strengths
3. Demonstration of various types of seed germination
4. Respiratory losses of food reserves during seed germination
5. Determination of water content of plant and seed and water transpired by plants
6. Identification of crop growth stages

#### *Recommended Texts*

1. Pessarakli, M. (2014). *Handbook of Plant and Crop Physiology* (3rd ed.). Florida: CRC Press, Taylor and Francis.
2. Taiz, L., & Zeiger, E. (2006). *Plant Physiology* (4th ed.). Florida: Sinauers Associate.

#### *Suggested Readings*

1. Franklin, P. G., Pearce, R. B. & Mitchell, R.L. (2003). *Physiology of Crop Plants*, India: Scientific Publishers.
2. Sadras, V., Calderini, D. & Press, A. (2014). *Crop Physiology: Applications for Genetic Improvement and Agronomy*. USA: Academic press.
3. Lal, M.A., & Bhattia, S.C. (2018). *Plant Physiology, Development and Metabolism*. Switzerland: Springer Publishers.

Irrigation is the process of applying controlled amounts of water to crops at needed intervals. In dry areas and during periods of less than average rainfall, irrigation helps to grow agricultural crops, maintain landscapes, and manage disturbed soils. This is an undergraduate level course in Department of Agronomy. The aim of the course is to provide knowledge to students about irrigation principles and management. The course of Irrigation Agronomy provides the students with a comprehensive introduction in irrigation agronomy and management and skills to calculate the crop water and irrigation water requirement at field and scheme level using various irrigation methods. Various irrigation methods viz. basin irrigation, border irrigation, bed / ridge – furrow irrigation, corrugation irrigation, sun-surface irrigation, drip irrigation, sprinkler irrigation etc. will be discussed in this course.

#### *Contents*

1. Concept of irrigation agronomy and water management
2. Sources of irrigation water and their efficient use in crop production.
3. Introduction to different irrigation methods, their feasibility in various regions.
4. Irrigation scheduling and water use efficiency in field crops.
5. Irrigation water losses and their control through on-farm water management practices.
6. Current agro-technology for efficient use of irrigation water in crops.
7. Irrigation water pollution and measures to minimize it

#### *Practical*

1. Estimation of potential evapotranspiration by different methods
2. Calculation of water use efficiency in field crops
3. Potential soil moisture deficit and its calculation

#### *Recommended Texts*

1. Reddy, S. R. (2012). *Irrigation Agronomy*, Ludhiana, New Delhi: Kalyani Publishers.
2. Abraham, T. (2017). *Principles and Practices of Irrigation Agronomy*. Germany: Lambert Academic Publishing.

#### *Suggested Reading*

1. Reddy, G.K., & Reddy, S. R (2016). *Irrigation Agronomy*. Ludhiana, New Delhi: Kalyani Publishers.
2. Choudhary M. R. (2016). *A Textbook of Irrigation & Drainage (Practices for Agriculture)*. Faisalabad: University of Agriculture Faisalabad.

Agroecology is the study of environmental processes applied to agroecosystems. Agroecologists deal with the study of different types of agroecosystems. The field of agroecology is associated with a variety of farming methods, whether those are organic, conventional, integrated, intensive or extensive. This course gives the students the knowledge in the field of agro-ecology and agro-ecosystems. It includes a brief comparison of ecological structures and functioning between agricultural and natural ecosystems and use of these comparisons to understand the major similarities and differences between agricultural and natural ecosystems. There is a description of the basic processes that are taking place in agro-ecosystem like primary productivity, biogeochemical cycling and energy flow. This course develops an understanding among students about the emerging problems related to agro-ecosystems like loss of biodiversity, increased infestation of pests and diseases, health issues and deterioration of natural resources as well the solutions to these problems.

#### *Contents*

1. Ecosystem; definition and components
2. Ecological pyramids; process within the ecosystem
3. Primary production processes; measuring primary production
4. Estimation of primary production in ecosystems
5. Biogeochemical cycling process; cycling of CO<sub>2</sub>, nitrogen, water, phosphorus and Sulphur
6. Factors within the ecosystem
7. Agro ecosystem; Structure, primary producers, consumers, decomposers; Primary productivity
8. Energy flow; Competition, crop yields and variability in relation to the ecological optima
9. Responses of crop plants to biotic and abiotic factors

#### *Recommended Texts*

1. Martin, K., & Sauerborn, J. (2013). *Agroecology*. Amsterdam, The Netherlands: Springer.
2. Perfecto, I., & Vandermeer J. H. (2017). *Ecological Complexity and Agroecology*. UK: Routledge Publishers.

#### *Suggested Readings*

1. Agren, G.I., & Andersson, F.O. (2011). *Terrestrial Ecosystem Ecology: Principles and Applications*. Cambridge: Cambridge University Press.
2. Begon, M., Townsend, C.R., & Harper, J.L. (2006). *Ecology: From Individuals to Ecosystems* (4th ed.). Oxford: Blackwell Publishing.
3. Méndez, V. E., Bacon C.M., Cohen R., & Gliessman S.R. (2015). *Agroecology: A Transdisciplinary, Participatory and Action-oriented Approach*. New York: CRC Press Taylor & Francis Group.

Nitrogen is the most important nutrient required by plants, being an essential component of all amino acids and nucleic acids. Atmosphere consists of 78% nitrogen gas (N<sub>2</sub>) but plants are unable to use this form of nitrogen. Biological nitrogen fixation is one alternative to nitrogen fertilizer. It is carried out by prokaryotes using an enzyme complex called nitrogenase and results in atmospheric N<sub>2</sub> being reduced into a form of nitrogen diazotrophic organisms and plants are able to use (ammonia). This course is to teach students the scope and mechanism of biological nitrogen fixation. It will cover all aspects of BNF including the factors which enhance and limits this universal process. This course focuses the importance of legumes crop in nitrogen fixing.

#### *Contents*

1. Importance of nitrogen
2. Nitrogen cycle; Assimilation of nitrate and ammonium ions;
3. Nitrogen fixation; Biological nitrogen fixation, its potentialities, perspectives and limitations
4. BNF in a symbiotic and non-symbiotic association in legumes and non-legumes, stages in nodulation, Nitrogenase: structure and function, Mechanism and biochemistry of BNF
5. Gaseous exchange in nodules
6. Role of leghemoglobin
7. Effect of environment on nitrogen fixation
8. Stem nodules
9. Prospects for making new symbiosis
10. Physiological limitations and genetic improvements of biological nitrogen fixation
11. Possibilities of engineering non- legume plants for nitrogen fixation

#### *Practical*

1. Demonstration of inoculation methods
2. Study of nodule formation under different environmental conditions, Career material for effective inoculants
3. Identification of effective and non-effective nodules, Methods used to measure biologically fixed nitrogen/report

#### *Recommended Texts*

1. Taize, L., & Zeiger, E. (2002). *Plant and Physiology*, (3rd ed.). Massachusetts: Sunderland: Sinauers Associate.
2. Yoshiaki, N. (2017). *Nitrogen Fixation*, Dordrecht. Netherland: Springer.

#### *Suggested Readings*

1. Bruijn, F.J. (2015). *Biological Nitrogen Fixation*, New York: Wiley-Blackwell.
2. Ross, C.W., & Salisbury, F.B. (2011). *Plant Physiology* (5th ed.). Belmont, California: Wadsworth Publications.

There are 17 elements essential for plant growth and development. These include nitrogen, phosphorus, potash, calcium, magnesium, sulfur, iron, manganese, zinc, copper, boron, molybdenum, chlorine and nickel. Plant nutrition is an important field of agriculture that deals with the study of plant nutrients, the criteria of their essentiality, beneficial elements, and mechanism of their uptake, translocation, assimilation, metabolism, mobility and deficiency symptoms within plants. This course is a graduate-level course which gives the students a theoretical and practical understanding about the plant nutrients and mechanisms of their uptake by plants. There will be detailed discussions about the available forms of different plant nutrients, their fertilizers / sources, mode of absorption, assimilation and redistribution in plants. In addition, there will be a brief description of plant growth hormones, their classification, site of synthesis and action as well as their commercial uses.

#### *Contents*

1. Mineral nutrients, classification, functions and deficiency symptoms
2. Criteria for essentiality of mineral nutrients
3. Factors affecting nutrient availability
4. Mechanisms of nutrient uptake and translocation in the plants
5. Composition and types of fertilizers;
6. Biosynthesis, translocation and functions of growth regulators-auxins, gibberellins, cytokinins, abscisic acid and ethylene

#### *Practical*

1. Raising plants in different growth media with various nutrients
2. Identification of deficiency symptoms
3. Demonstration of nutrient uptake
4. Demonstration of plant responses to growth regulators
5. Influence of growth regulators on plant growth

#### *Recommended Texts*

1. Naeem, M., Ansari, A.A., & Gill, S.S. (2017). *Essential Plant Nutrients: Uptake, Use Efficiency, and Management*. Switzerland: Springer Publishers.
2. Taize, L., & Zeiger, E. (2006). *Plant Physiology*. North Carolina: Sinauer Associates.

#### *Suggested Readings*

1. Chandrasekaran, B., Annadurai, K., & Somasundaram, E. (2010). *A Textbook of Agronomy*. New Dehli: New Age International Limited.
2. Hasanuzzaman, M., Fujita, M., Oku, H., Nahar, K., & Hawrylak-Nowak, B. (2018). *Plant Nutrients and Abiotic Stress Tolerance*. The Netherland: Springer.

This course provides the knowledge of farm and farm related management techniques in form of theoretical and practical. This course delivers the basic knowledge in the field of farm management, maintenance farm records and farm layout. The students will have the knowledge of different farming systems and types of the farming. They will be able to prepare a layout of the farm which is a basic requirement for managing a farm on sustainable basis. The students will be practically trained through different techniques related to farm record managements like book keeping, double entry system, journal and ledger, cash book, trial balance, profit and loss account, bank accounts, discount, interest, appreciation and depreciation, preparation of profit and loss account and balance sheet.

#### *Contents*

1. Concept of farm management and maintenance of farm records
2. Definition and fundamental principles of farming system and types of farming
3. Layout of farms; Objective and advantages of keeping farm records
4. Different systems of bookkeeping
5. Principles of double entry system and their application
6. Objective of journal and ledger; classification of accounts
7. Drawing ledger, cash book, drawing up a trial balance
8. Profit and loss account/income statement
9. Bank accounts, bank cheques, discount, interest, bad debts
10. Appreciation and depreciation of live and dead stock, land and buildings, plant and machinery
11. Preparation of trading, profit and loss account and balance sheet

#### *Practical*

1. Demonstration of farm layout
2. Training in maintenance of crop
3. Livestock and dead stock registers
4. Preparation of a balance sheet and different types of accounts
5. Calculation of appreciation and depreciation of different farm articles
6. Working out cost of production of major crops grown in irrigated and non-irrigated areas
7. Layout of farms and demonstration plots

#### *Recommended Texts*

1. Ghani, M.A., & Ahmad, E. (2000). *Principles of Accounting*. Lahore: Pak. Imperial Book Depot; Chock Urdu Bazar.
2. Shresther, A. (2003). *Cropping System*. New York: Food products Press, An imprint of the Haworth Press.

#### *Suggested Readings*

1. Maredia, K.M., Dakouo, D. & Mota-Sanchez, D. (Eds.) (2003). *Integrated Pest Management in the Global Arena*. Switzerland: CABI.
2. Moses, B., & Carson (2009). *Bookkeeping and Accounts for Beginners*. India: Custom Books.
3. Wood, F., & Robinson, S. (2009). *Bookkeeping and Accounts* (7th ed.). Pennsylvania: Trans-Atlantic Publication.

The aim of the course is to familiarize students about fundamentals of seed production technology. It focuses on both theoretical and practical foundation of students towards the importance of seeds, their production and morphology. The course explicitly develops an understanding of seed development, germination, vigor, viability, seed maturation, harvesting, drying, packing, tagging and seed marketing. It acquaints the students with the principles of seed production for agronomic crops and the techniques used in seed conditioning. It enhances student's vision to seed enhancement, seed testing laws and regulations related to marketing high quality seed. The knowledge of seed act and laws and seed industry is also discussed in detail. The students will be familiarized with economic liberalization and seed trade in the world.

### *Contents*

1. Introduction, orientation, concept and perspective of seed technology
2. Seed production terms, their definition and types of seeds
3. Seed production practices in self and cross-pollinated crops
4. Origin of seed industry; National and international seed centers
5. Origin of new varieties, variety development and plant variety production
6. Seed problems: Germination, stand failures, mixtures, weeds, genetics
7. Seed certification classes: Nucleus breeder seed, pre-basic, basic, certified and approved class
8. Seed analysis, sampling, processing; Seed vigor and viability
9. Seed longevity and storage
10. Seed certification: Regulations schemes and field inspection; Seed distribution and marketing
11. Seed act and laws; Seed industry; Economic liberalization and seed trade

### *Practical*

1. Seed identification
2. Seed testing equipment
3. Study of seed structures
4. Sampling techniques for seed testing
5. Purity analysis of seed
6. Seed viability, vigor and germination tests
7. Study visits to seed production farms/ processing industry

### *Recommended Texts*

1. Dar, S.H (2018). *Methods of Hybrid Seed Production in Major Crops*. New Delhi, India: Educreation Publishing.
2. McDonald, M.B., & Copeland, L.O. (2012). *Seed Production Principles and Practices*. New Delhi: CBS Publisher and Distributers.

### *Suggested Readings*

1. Basra, A. S. (2006). *Handbook of Seed Science and Technology*. New York: Food Products Press.
2. Jayanthi, M., Sumathi, S., & Venudevan, B. (2018). *Scientific Seed Production of Horticultural Crops*. New Delhi: New India Publishing Agency.

Forages and fodders are important agronomic crops that constitute important and basic component of animal feed. To develop skills regarding fodder production technology in graduate level students, a separate course was included in scheme of studies. This is very important course due to increasing demand of fodder for livestock throughout the year. The students will be taught about the different fodders their complete production technology and management. The knowledge about pasture management and factors affecting productivity of pasture are also discussed in detailed. It makes the students able to know different choices of fodder availability during different season throughout the year. Techniques of fodder preservation silage, hay, haylage will be practically demonstrated and students will be equipped with all such techniques after completion of this course.

#### *Contents*

1. Importance and characteristics of forages and fodders
2. Critical period of fodder scarcity.
3. Factors influencing productivity and quality
4. Methods of increasing biomass production
5. Factors affecting chemical composition and nutritive value of forages
6. Preservation of fodders and forages (silage and hay making)
7. Toxicity due to chemicals and poisonous plants
8. Establishment of grasses and legumes in range lands
9. Constraints in fodder production and remedies.

#### *Practical*

1. Identification of forage, fodder crops and poisonous plants
2. Estimation of sprout density
3. Carrying capacity
4. Preparation of fodder calendar
5. Measurement of cover frequency
6. Preparation of silage and hay

#### *Recommended Texts*

1. Balasubramaniyan, P.O., & Polanippan, S.P. (2001). *Principles and Practices of Agronomy*. New Delhi: Agrobios.
2. Hedayetullah, M., & Zaman, P. (2019). *Fodder Crops of the World (Vol-I). Major fodder crops*. Florida: Apple Academic Press.

#### *Suggested Readings*

1. Advan, R.L., & Bezerra, L.R. (2018). *New Perspective in Forage Crops*. Croatia: Intech Open.
2. Singh, A.K. (2011). *Forage and Fodder*. New Delhi: Daya Publishing House.

This course gives a concept of field experiments to the students. It is a very important course for the conducting of field research and acquaints students about principles and techniques of designing field experiments. The agricultural graduate must be well versed in laying out field experiments. This course will enable the students to layout the field experiment in a scientific way. This course also provides information about the experimental error and number of replications to be used. The students will learn about the experimental designs, their application and advantages and disadvantages along with calculations of inputs for experimental units. The students will be able to design and layout the field experiments on scientific basis which is the fundamental requirement for a scientific research in agriculture.

#### *Contents*

1. Concept and importance of Field experiments
2. Layout plans and types
3. Nature of field trials
4. Layout designs and their suitability under varying conditions
5. Classification of designs
6. Paired plot design
7. Completely randomized design
8. Randomized complete block design
9. Latin Square Design
10. Randomization and its methods

#### *Recommended Texts*

1. Garson, G.D., & Sarsfield, R. (2018). *Research Designs*. USA: Statistical Association Publishers.
2. Selvamuthu, D., & Das, D. (2018). *Introduction to Statistical Methods, Design of Experiments and Statistical Quality Control*. Singapore: Springer.

#### *Suggested Readings*

1. Islam, M. A., & Al-Shiha, A. (2018). *Foundations of Biostatistics*. Singapore: Springer.
2. Hoshmand, A.R. (2006). *Design of experiments for Agriculture and Natural Science* (2nd ed.). FL, USA: CRC Press, Taylor and Francis.

The Principles of Weed Science is a course that consists of very basic principles and techniques of weed management in crops. The weeds are among most problematic enemies of crops that cause huge yield losses in crops and deteriorate the aesthetic and economic value of lands. This course aims to nurture students regarding principles of weed science. It focuses on a detailed introduction to weed science with special emphasis on weeds of Pakistan and their management strategies. At the end of this course, the students will be able to identify the weeds problem and suggest an appropriate solution for managing the weeds. The course explicitly elaborates the issues related to chemical weed control like herbicide resistance and suggests measures to overcome these problems without decreasing yield of field crops.

#### *Contents*

1. Definition and importance of weeds
2. Yield losses and harmful effects of weeds
3. Classification and biology of weeds
4. Weed-crop interference, Competition and allelopathic interactions.
5. Methods of weed management; preventive, cultural, mechanical, biological and chemical.
6. Weed control in major field crops
7. Integrated weed management
8. Herbicide resistance and tolerance against weeds and crops
9. Technical information regarding current herbicides
10. Mulching and soil solarization

#### *Practical*

1. Weed collection and identification
2. Demonstration of various hand tools & implements for weed control
3. Trials for testing the germination of different weeds and treatment for breaking their dormancy
4. Calibration and demonstration of sprayers for herbicide application
5. Survey into weed flora of different agro-ecological zones

#### *Recommended Texts*

1. Zimdhal, R. L. (2018). *Fundamental of Weed Science* 5th Ed. New York: Elsevier, Academic Press.
2. Jabran, K. & Chauhan, B. (2018). *Non-Chemical Weed Control*, Oxford: Academic Press.

#### *Suggested Readings*

1. Korres, N.E., Burgos, N.R. and Stephen & Duke O. (2019). *Weed Control: Sustainability, Hazards, and Risks in Cropping Systems Worldwide*, New York: CRC.
2. Tanveer, A. (2008). *Biology and Ecology of Weeds*, Islamabad: Higher Education Commission.
3. Tanveer, A. (2006). *Weeds and their control*, Islamabad: Higher Education Commission.

Any environmental factor that causes reduction in yield of crops is called stress. There are two categories of stress i.e. the stresses due to or nonliving abiotic factors are called abiotic stresses and stresses due to living organisms are called biotic stress. This course is a graduate-level course which gives the students a theoretical and practical understanding about the various environmental stresses under field conditions. It also contains a practical knowledge for the use of agro-management practices for successful crop production and ultimately getting higher yields. The student will be able to suggest different management approaches to ameliorating the stress effects for crop production. Moreover, the methods of imposing abiotic stresses under lab conditions and noting the patterns of vegetative growth of crop plants will also be demonstrated.

#### *Contents*

1. Components of crop productivity
2. Crop environment and its components
3. Environmental optima for crop growth and development
4. Concept of stress and stressful environments under field conditions
5. Modifications in growth and developmental of crop plants under biotic and abiotic stresses
6. Approaches for ameliorating the stress effects for crop production

#### *Practical*

1. Acquaintance with the symptoms of stresses on crop.
2. Visits to affected areas and noting the vegetative and reproductive growth patterns of crop plants.

#### *Recommended Texts*

1. Hasanuzzaman, M., Fujita, M., Oku, H., & Islam, M. T. (2019). *Plant Tolerance to Environmental Stress: Role of Phytoprotectants*. New York: CRC press.
2. Pessarakli, M. (2019). *Handbook of Plant and Crop Stress* (4th ed.). New York: CRC press.

#### *Suggested Readings*

1. Shabala, S. (Ed.) (2017). *Plant Stress Physiology*. Switzerland: Cabi Publishers.
2. Taize, L., & Zeiger E. (2006). *Plant Physiology*. North Carolina: Sinauer Associates Inc.
3. Venkateswarlu, B., Shanker, A. K., Shanker, C., & Maheswari, M. (Eds.) (2011). *Crop Stress and its Management: Perspectives and Strategies*. New York: Springer Science & Business Media.

The rainfed areas in the country are exposed to problem of soil erosion and water runoff. The soil and water conservation should be the main focus of all agronomic practices in rain fed agricultural conditions. This is graduate level course of theories and practical of Conservation Agronomy. This course aims to elaborate the comprehensive study of soil and water conservation issues which are being faced by the developing world. It also familiarizes the students about practices being used at farm level that help in agricultural resource conservation. The course explicitly relates practically soil and water conservation structures, effect of organic mulches, tillage practices for water conservation and measurement of soil erosion and run off.

#### *Contents*

1. Concept, importance and objectives of conservation
2. Agronomic practices for resource conservation
3. Tillage practices such as contouring, terracing, benching
4. Leveling, grading, watbandi
5. Zero tillage and minimum tillage
6. Chiseling, deep ploughing and planking
7. Species and cultivars selection
8. Crop rotation and weed management
9. Cover cropping; Strip cropping
10. Fertilizers and green manuring
11. Mulching and crop residue management
12. Micro water-shed management under rainfed conditions

#### *Practical*

1. Demonstration of soil water conservation structures
2. Effect of different mulches
3. Demonstration of tillage practices for soil and water conservation
4. Measurement of run off and soil erosion
5. Visit to different soil and water conservation centers/institutes

#### *Recommended Texts*

1. Hudson, N.W. (2004). *Soil and water conservation in semi-arid areas*. New Delhi: Scientific Publishers.
2. Keesstra, S., Prima, S.D., Castellini, M., & Pirastru, M. (2019). *Soil Water Conservation Dynamics and Impact*. Basel, Switzerland: MDPI Books.

#### *Suggested Readings*

1. Kassam, A., Reicosky, D., Calegari, A., Friedrich, T., Hobbs, P., Chakraborty, D., Fayad, J. A., Landers, J., Araújo, A.G., Albertengo, J., & Goddard, T. (2019). *Advances in Conservation Agriculture-System and Science*. Cambridge: Burleigh Dodds Science Publishing Limited.
2. Maloo, S.R. (2002). *Sustainable Crop Production under Stress Environments*. Udaipur: Agro-tech Publishing Academy.
3. Khalil I.A., & Jan, A. (2002). *Cropping Technology*. Islamabad: National Book Foundation.

Models are mathematical tools and software that give some output in response to entering input data. The crop models are especially designed to give an introduction of crop modeling and to use them for determining the growth and yield response of crop to certain input or environmental variable. Introduction to crop modeling is a graduate-level course which gives the students a theoretical and practical understanding about crop growth models. The crop modeling encompasses many diverse interests and emerging problems, especially climate change. To fulfill the need to address crop management regarding fertilizer application, water requirement to promote sustainable agricultural production by crop modeling, there will be detailed discussion of different types of models which are being used in agricultural sciences.

#### *Contents*

1. History and introduction of crop growth modeling
2. Importance and uses
3. Introduction to decision support system for agro-technology transfer
4. Components of a model
5. Input data set for different models
6. Modeling and crop improvement
7. Modeling: a tool for future predictions

#### *Practical*

1. Demonstration and practice of crop growth models:
2. CERES-wheat, DSSAT V.4.6.
3. APSIM
4. Measurement of different environmental variables from observatories

#### *Recommended Texts*

1. Boote, K. (2019). *Advances in crop Modelling for a Sustainable Agriculture*. Cambridge: Burleigh Dodds Science Publishing Ltd.
2. Mavi, H.S., & Tupper, G.J. (2005). *Agro meteorology Principles and Application of Climate Studies in Agriculture*. Lucknow: International Book Distribution Co.

#### *Suggested Readings*

1. Sivakumar, M.V.K., & Hansen, J. (2007). *Climate Predictions and Agriculture*. Berlin, Heidelberg, New York: Springer.
2. Sivakumar, M.V.K. & Motha, R.P. (2005). *Increasing Climate Variability and Change: Reducing the Vulnerability of Agriculture and Forestry*. Dordrecht: Springer.
3. Wallach, D., Makowski, D., Jones, J., & Brun, F. (2019). *Working with Dynamic Crop Models; Methods, Tools and Examples for Agriculture and Environment*. Amsterdam: Academic Press.

This course provides theoretical and practical skills to the students regarding crop production under changing environmental conditions and how environmental factors influence on the food security in the current scenario. Dynamics in environmental conditions at aerial and soil levels have variable effect on crop growth and development. Different environmental factors like temperature, relative humidity, wind and CO<sub>2</sub> have significant effect on crop production. This course explains the sources of greenhouse gasses emission and their effect on agricultural/crop production. The knowledge of plant response in the form of photosynthesis and transpiration is also discussed in this course. In this course, crop adaptation strategies are studied under changing environmental and climatic conditions. The students will get hands-on training about the measurement of environmental variables and calculation of drought indices.

#### *Contents*

1. Environment, climate change and food security
2. Types and classification of environment
3. Dynamics of aerial and soil environment in a crop canopy at macro and micro level
4. Influence of environmental factors; Radiation, Temp, Water, Wind, CO<sub>2</sub> and Vapour pressure
5. Photosynthesis
6. Respiration
7. Transpiration
8. Greenhouse effect on crop production
9. *El Nino* and *La Nino* phenomenon
10. Crop adaptation to changing climate

#### *Practical*

1. Measurements and estimation of different environmental variables
2. Calculations of potential evapotranspiration and different drought indices
3. Measurement of solar radiation in crops

#### *Recommended Texts*

1. Bal, S.K., Mukherjee, J., Choudhury, B.U., & Dhawan, A.K. (2018). *Advances in Crop Environment Interaction*. Singapore: Springer Nature Singapore Pvt. Ltd.
2. Dris, R., Mohan, J., & Khan, I.A. (2002). *Environment and Crop Production*. New York: Science Pub. Inc.

#### *Suggested Readings*

1. Hasanuzzaman, M., Fujita, M., Oku, H., & Islam, M. T. (2019). *Plant Tolerance to Environmental Stress: Role of Phytoprotectants*. New York: CRC.
2. Hammer, G.L., Nicholls, N., & Mitchell, C. (2000). *Application of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems*. London: Kluwer Academic Publisher.
3. Wallach, D., Makowski, D., Jones, J., & Brun, F. (2019). *Working with Dynamic Crop Models; Methods, Tools and Examples for Agriculture and Environment*. Amsterdam: Academic Press.

Students will be involved in learning activities that generally prepare them to apply the economic and business principles involved in the organization, operation, and management of the farm, ranch or agribusiness. Typical instructional activities include hands-on experiences with applying modern economic and business principles involved in the organization, operation, and management of agricultural businesses including the production and marketing of agricultural products and services and knowhow of new trends in international trade of agricultural commodities. After completing the course, students will be well equipped with the basic concepts of Agribusiness and Trade. Students should read content and complete course assignments prior to deadlines. Students are expected to actively participate in discussions and submit exercises in-time. Students are also expected to complete exams on the date and time allotted. It is their responsibility to be familiar with and understand all previously covered material prior to each new chapter.

### *Contents*

1. Definition, concepts, Important features and scope of Agribusiness Management
2. Elements and Functions of management
3. Forms of business organizations
4. Agribusiness financial management
5. Agricultural Marketing; Marketing channels, functionaries and margins
6. Role of agri. marketing in economic development
7. Agricultural marketing problems
8. The changing world and interdependence
9. Basis of trade; gains from trade
10. Concept of absolute and comparative advantage; pattern of trade
11. Brief introduction of major trade agreements

### *Recommended Texts*

1. Kohls, R.L., Uhl, J.N., & Hurt, C. (2007). *Marketing of Agricultural Products* (10th ed.). New Jersey: Prentice Hall.
2. Salvatore, D. (2007). *International economics* (9th ed.). New Jersey: Wiley Publisher.

### *Suggested Readings*

1. Hoekman, B. M., Mattoo, A., & English, P. (2002). *Development, Trade and the WTO-A Handbook*. Washington D.C: The World Bank.
2. Downey, W.D., & Erickson, S. P. (2002). *Agribusiness Management*, Singapore: McGraw Hill Education.

Organic farming is a technique, which involves cultivation of plants and rearing of animals in natural ways. This process involves the use of biological materials, avoiding synthetic substances to maintain soil fertility and ecological balance thereby minimizing pollution and wastage. This is graduate level course of theories of Agronomy. This course aims to familiarize students with the concept of organic farming and its field application. It also familiarizes about the history of organic farming in the world and Pakistan and its advanced husbandry in field with special emphasis on critical production factors. The comparison of the quality of food under different eco-systems is also discussed in the course. The course explicitly relates practically principles of organic farming, soil and crop management with their impacts on crop yield.

#### *Contents*

1. Concept and brief history of organic farming
2. Principles of organic agriculture
3. Soil and crop management
4. Preparation of organic matter, humus, sewage sludge, organic compost
5. Conversion of conventional to organic farming
6. Maintenance of buffer zone
7. Components of organic farming
8. Hazards of inorganic farming
9. Farm waste recycling
10. Organic mulches
11. Nature save products for control of weeds and diseases management
12. Quality of food and crop productivity under natural ecological systems

#### *Recommended Texts*

1. Chandran, S., Unni, M. R., & Thomas, S. (Eds.) (2019). *Organic Farming: Global Perspectives and Methods*. Cambridge: Woodhead Publishing.
2. Fossil, P.V. (2007). *Organic Farming: Everything you need to know*. St.Paul: MBI Publishing Co.

#### *Suggested Readings*

1. Palaniappan, S. P., & Annadurani K. (2006). *Organic Farming Theory and Practice*. Jodhpur: Scientific Publishers.
2. Scott, Si, S. Z., Schumilas, T., Scott, S., & Chen,A.(2018). *Organic Food and Farming in China: Top-down and Bottom-up Ecological Initiative*. London: Routledge publishers.
3. Sharma, A.K. (2012). *A Handbook of Organic Farming*. Jodhpur, India: Agrobios.

The analytical work related to plants is the basic requirement for researchers in the field of agriculture. This course is designed to not only provide knowledge of analytical analysis of plants and soil but also give hands-on training about them. This course improves theoretical and practical knowledge of the students regarding different types and use of balances. In this course, students are trained in preparation of solutions of known concentrations-normal, molar, molal, ppm, etc. Moreover, preparation of stock solutions for drawing standard curves; In this course, soil and plant sampling techniques are studied and preparation of plant and soil samples for analytical work. The students learn about different protocols used for estimation soil and plant micro and macro nutrients.

### *Contents*

1. Types and use of different balances
2. Preparation of solutions of known concentrations – normal, molar, molal, p.p.m, etc.
3. Quality Control and Standardization Procedures
4. Preparation of stock solutions for drawing standard curves
5. Soil physical analysis- moisture content, water holding capacity, particle size distribution
6. Dry and wet Aggregate Analysis
7. Soil Bulk Density- disturbed and undisturbed samples
8. Total Pore Space and Porosity
9. Plant Analysis- Moisture Factor, Nitrogen and Phosphorus
10. Plant Analysis- Macronutrients (Dry Ashing)
11. Plant Analysis- Micronutrient (Wet Digestion)
12. Preparation of plant and soil samples for analytical work
13. Soil Chemical Analysis -Estimation of EC, pH, N, P, K, Na.
14. Soil Chemical Analysis -Estimation of organic matter

### *Practical*

1. Demonstration of analytical methods in the laboratory
2. Recording data
3. Computation work and recommendations

### *Recommended Texts*

1. Basak, R.K (2004). *Soil Testing and Recommendation*. New Delhi: Kalyani Publisher.
2. Ricke, S., Atungulu, G., Rainwater, C., & Park, S. (2017). *Food and Feed Safety Systems and Analysis*. New York: Academic Press.

### *Suggested Readings*

1. Wallach, D., Makowski, D., Jones, J., & Brun, F. (2019). *Working with Dynamic Crop Models; Methods, Tools and Examples for Agriculture and Environment*. Amsterdam: Academic Press.
2. Hasanuzzaman, M., Fujita, M., Oku, H., & Islam, M. T., *Plant Tolerance to Environmental Stress: Role of Phytoprotectants*. New York: CRC.
3. Hammer, G.L., Nicholls, N. & Mitchell, C. (2000). *Application of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems*, London: Kluwer Academic Publisher.

This is a graduate level course in Department of Agronomy. The aim of the course is to introduce the students about the research methodology and planning a research experiment in the field of agronomy. This course will introduce the method of collecting data and analyze the data and develop a skill to presentation in tabulated or graphical form. This course enhances the capability of students to write good scientific papers. The course emphasizes quality of writing and dissemination with a view to improve readability, maximize the contribution of the research done and improve the opportunities for publishing. It also concerns the quantity of scientific production by initially addressing the issue of increasing productivity through peer-guidance, best practice in scientific writing.

#### *Contents*

1. Concept of research,
2. Scientific method and experiment
3. Planning and execution of trials
4. Experimental designs and layout
5. Research trial observations
6. Collection, processing and analysis of data
7. Measures of experimental variability
8. Interpretation and summarization of results
9. Types of scientific writing and developing a research proposal

#### *Practical*

1. Writing of research proposal
2. Layout of field experiments
3. Collection, tabulation and analysis of data
4. Presentation of data in tables, curves, histograms, etc.
5. Writing of scientific paper/report

#### *Recommended Texts*

1. Garson, G.D., & Sarsfield, R. (2018). *Research Designs*. New York: Statistical Association Publishers.
2. Heard S.B. (2016). *The Scientist's Guide to Writing: How to Write More Easily and Effectively Throughout Your Scientific Career*. New Jersey: Princeton University Press.

#### *Suggested Readings*

1. Mack, C.A (2018). *How to Write a God Scientific Paper*. Bellingham: SPIE Publishers.
2. Khalil, S K., & Shah, P. (2007). *Scientific Writing and Presentation*. Islamabad: HEC.
3. Martha, D. (2005). *Scientific Papers and Presentations*. San Diego, California: Academic Press.

Internship opportunities can provide students with unique exposure to research in other environments, including private industries, federal agencies, other countries, or other universities. Because of their value to the graduate student experience, the Department of Agronomy offers this course. It is intended to apprise students of the basics of how to design and conduct research, data analysis as well as technical report writing and presentation. Further, it covers a wide spectrum of experiments designed for students at undergraduate level. The experiments are selected to provide insight into the basic principles and techniques of Agronomy. At the end of the semester, a study tour is arranged of provincial and federal research institutes to acquaint the students with recent research activities going on there. Pesticide companies' visits are also arranged time to time for this course during the semester. The core objective of this course is to train the students in such a way that at the completion of this course students may design their future research proposals.

#### *Contents*

1. Proposal development, on spot field training
2. Report writing and project presentation. (Format as per thesis manual of the university concerned).

#### *Recommended Texts*

1. Ghafoor, A. (2016). *Manual for synopsis and thesis preparation*. Faisalabad: University of Agriculture Press.
2. Relevant latest literature on target issues.

#### *Suggested Readings*

1. Reviews, research articles
2. Illustrated Manuals, Compendiums
3. Pocket books



**MSc**  
**(Hons)**  
**AGRONOMY**



Environment is of utmost importance in crop production. Agricultural practice should be of such nature that it should not harm our environment in any way. The environmental deterioration and climate change are the biggest issues of the current era. This course has been designed with special focus to address the ecological impacts of present-day agriculture. This is a post-graduate level course that will enable the students to impart better understanding of ecological optima and its relevance to crop production. It includes comparison of ecological structures and functions between agricultural and natural ecosystems. The emerging problems related to biodiversity, infestation of pests and diseases, and deterioration of natural resources. The knowledge of the ecology of major crop has also been included in this course.

### *Contents*

1. Ecosystem concepts
2. Dynamics of Agro-ecosystems
3. Ecology of crop plant domestication
4. Ecological risk assessment
5. Ecological evaluation of different farming systems
6. Ecological characteristics of intensive agriculture
7. Environmental pollution
8. Crop productivity and ecological optima
9. Biodiversity and its ecological role in agro-ecosystems
10. Ecology of economic crops, oil seed crops, pulses & misc. crops, sugar crops, etc.

### *Recommended Texts*

1. Perfecto, I., & Vandermeer, J. H. (2017). *Ecological Complexity and Agroecology*. Abingdon: Routledge Publishers.
2. Martin, K., & Sauerborn, J. (2013). *Agroecology*. Amsterdam, The Netherlands: Springer.

### *Suggested Reading*

1. Méndez, V. E., Bacon, C.M., Cohen, R. & Gliessman, S.R. (2015). *Agroecology: A Trans-disciplinary, Participatory and Action-oriented Approach*. New York: CRC Press Taylor & Francis Group.
2. Ågren, G.I. & Andersson, F.O. (2011). *Terrestrial Ecosystem Ecology: Principles and Applications*. New York: Cambridge University Press.
3. Corner D.J. (2011). *Crop Ecology: Productivity and Management in Agricultural Systems* (2nd ed. ).New York: Cambridge University Press.

Due to current agricultural practices, the crop environment is continuously facing deterioration. The intensive agriculture has led to widespread reduction of species and habitats. Loss of biodiversity is one of the biggest issues faced by the current intensification in agriculture. So to conserve the environment on long term sustained basis, the present agricultural practices need to be revisited. To address issues of environmental sustainability, this course is being taught to MSc students. This is a post graduate level course Department of Agronomy developed to make the students to enhance the understanding of agro-environment for sustainable productivity. The course covers the management and recycling of the wastes to keep the environment healthy. It also give knowledge about the uses and threats of agro-chemical.

#### *Contents*

1. Agro-chemicals: use and abuse
2. Uptake, persistence, degradation and residual effects of Agro-chemicals on ecosystem
3. Management and recycling of agro-industrial wastes: solid waste, farm waste, sewage sludge etc
4. Role of agriculture in environmental conservation
5. Integrated approaches to reduce the use of agro-chemicals in agriculture

#### *Practical*

1. Demonstration of management and recycling of agro-industrial wastes and solid wastes
2. Farm wastes and sewage sludge management

#### *Recommended Texts*

1. Bal, S.K., Mukherjee, J., Choudhury, B.U., & A.K. Dhawan. (2018). *Advances in Crop Environment Interaction*. Singapore: Springer Nature Singapore Pvt. Ltd.
2. Singh, J. S., & Seneviratne G. (2017). *Agro-Environmental Sustainability (Vol 2). Managing Environmental Pollution*. Heidelberg: Springer international publishing.

#### *Suggested Readings*

1. Hasanuzzaman, M., Fujita, M., Oku, H., & Islam, M. T. (2019). *Plant Tolerance to Environmental Stress: Role of Phytoprotectants*. New York: CRC.
2. Sulphey, M.M., & Safeer, M. (2014). *Introduction to Environment Management*. New Delhi: PHI Learning Pvt. Ltd.

Agro-meteorology is the branch of agriculture that deals with study of weather and climate and its relationship with crop production. With a better understanding about relationship between weather and crop growth and development, one can make use of weather and climate information in a better way. Moreover, this information could be utilized to enhance or expand agricultural crops and/or to increase crop production. The present scenario of climate change has further increased the importance of this subject. That is why; this course is being taught to post graduate level to acquaint students with comprehensive knowledge about the aspects of meteorology related to the agriculture. It provides important knowledge about meteorological optima and its relevance to crop production. The relationship between crop plants and crop pests is also covered in relation to the weather and climate. The modern technologies used in Agro-Metrology are also covered in this course.

#### *Contents*

1. Scope of agricultural meteorology
2. Agricultural zones of Pakistan
3. Crop adaptation and distribution in relation to climate
4. Crop weather-relationships regarding crop growth and yield formation
5. Diurnal and seasonal variation in photoperiod and light integral
6. Agro-climatic normal of major crops, Atmospheric pollution and plant productivity
7. Climate change and its potential effects on crop production
8. Weather and pests of crops
9. Crop monitoring and forecasting
10. Drought monitoring and planning for mitigation
11. Remote sensing; Geographical Information System (GIS)
12. Global Positioning System (GPS) and their application in agricultural meteorology
13. Use of climate information to improve agricultural productivity.

#### *Recommended Texts*

1. Follett, C., McHaffie, P., & Hwang, S. (2018). *GIS: An Introduction to Mapping Technologies*. New York: CRC Press.
2. Palmer S. (2017). *Agrometeorology*. New York: Scitus Academics.

#### *Suggested Readings*

1. Tusi, J.B.Y. (2018). *Fundamentals of Global Positioning System Receivers: A Software Approach*. New Dehli: Wiley.
2. Liang S. (2017). *Comprehensive Remote Sensing*. Oxford: Elsevier.
3. Ahmad, L., Kanth, R.H., Parvaze S., & Mahdi, S.S. (2017). *Experimental Agrometeorology: A Practical Manual*. Heidelberg: Springer.

Allelopathy is the study of allelochemicals and their impact on agro-ecosystems. The allelochemicals are secondary metabolites that are synthesized and released into environment by almost all types of plants. The chemicals modify the growth and development of neighboring plants. Due to potential effects of these chemicals on crop production, allelopathy has been emerged out as an important branch of Agronomy. Allelopathy could be used for effective management of weeds, insect-pests and diseases in crop ecosystems. Keeping in view, this course is an important part of post-graduate scheme of studies of Agronomy. It aims to accustom the students with the concept and role of allelopathy in agriculture. It covers the aspects of mechanism of action, production, abortion and translocation of allelochemicals. It will enable the students to plant pest management strategies using allelopathy and enhance crop productivity.

#### *Contents*

1. Concept and history of allelopathy
2. Types of allelochemicals
3. Mechanism of allelochemicals' action
4. Factors influencing production and effectiveness of allelochemicals
5. Production, release, absorption and translocation of allelochemicals
6. Role of allelopathy in agro-eco systems
7. Interactions among cropping systems
8. Utilization of allelopathy for pest management
9. Enhancing crop productivity by utilizing allelopathy
10. Recent research trends in allelopathy

#### *Practical*

1. Preparation of allelopathic plant water extracts
2. Comparison of crop cultivars for their allelopathic effects under controlled / field conditions
3. Demonstration of allelopathic effects of crop extracts/residues on seed germination and seedling growth of crops/weeds
4. Identification of allelopathic chemicals

#### *Recommended Texts*

1. Jabran K. (2017). *Manipulation of Allelopathic Crops for Weed Control*. Heidelberg: Springer.
2. Farooq, M., & Wahid, A. (2012). *Allelopathy: Current Trends and Future Applications*. Heidelberg: Springer.

#### *Suggested Readings*

1. Price, J.E. (2015). *New Developments in Allelopathy Research*, New York: NOVA Science Publishers.
2. Zeng, R.S., Malik, A.U., & Luo, S.M. (2008). *Allelopathy in Sustainable Agriculture and Forestry*. New York: Springer.
3. Fujii, Y. & Hiradate, S. (Eds.) (2007). *Allelopathy: new concepts & methodology*. New York: CRC Press.

The soil and water conservation is the major issue in the rainfed areas of the country. Conservation Agronomy deals with principles and practices aimed at conserving soil and mainly include farming systems that cause minimum soil disturbance, maintain permanent soil cover and allow maximum diversification of crop species. To develop an understanding among students about the applied aspects of conservation agronomy, this course is being taught at post graduate level. This course aims to equip students with concept of conservation and to develop understanding about resource conservation with special emphasis on soil and water. The aspects of resource conservation using farm machinery, biological and engineering approach. In addition, the recent developments in field of conservation agronomy will also be discussed in detail.

#### *Contents*

1. Principles, objective and types
2. Water resources, their conservation and economic use in irrigated and non-irrigated regions
3. Modern conservation practices in irrigated and non-irrigated areas
4. Integrated resource conservation in different farming systems
5. Conservation agronomy and climate change
6. Use of farm machinery in conservation techniques
7. Conservation structures; Biological conservation
8. Recent developments in the field of conservation agronomy

#### *Recommended Texts*

1. Singh R.P., Kolok, A.S. & Hunt, S.L.B. (2019). *Water Conservation, Recycling and Reuse: Issues and Challenges*, Singapore: Springer.
2. Farooq, M. & Saiddique, K.H.M. (2017). *Innovation in Dryland Agriculture*, Switzerland: Springer Publishers.

#### *Suggested Readings*

1. Hansman, H. (2019). *Downriver: Into the Future of Water in the West*. HighBridge Audio; Unabridged edition, The University of Chicago: Chicago Press.
2. Farooq, M. & Saiddique, K.H.M. (2016). *Conservation Agronomy*. Switzerland: Springer Publishers.

Sustainable agriculture is a type of agriculture that focuses on producing long-term crops and livestock while having minimal effects on the environment. This type of agriculture tries to find a good balance between the need for food production and the preservation of the ecological system within the environment. To develop a clear understanding among post-graduate students about principles and practices of sustainable agriculture, this course is being taught. This course aims to acquaint students with comprehensive knowledge about management of agricultural resources on sustainable basis. It includes sustainable utilization of land and water resources and biodiversity. The course also focuses on the issues and strategies for crop improvement and livestock management. The effect of climate change is also discussed keeping in view the sustainable utilization of the resources.

#### *Contents*

1. Definition, concept and significance
2. Evolution of sustainable agriculture
3. Management practices for sustainable agriculture
4. Sustainable utilization of land water, resources and agro-biodiversity
5. Integrated nutrient management
6. Sustainable Weed management
7. Concept of integrated agriculture
8. Challenges in Pakistan's Agriculture
9. Present scenario and future prospects
10. Analytical overview: issues and strategies for improvement of crop management
11. Analytical overview: issues and strategies for improvement of livestock management, fisheries
12. Cottage industry, national resource management and rural development
13. Institutions and policies: issues and options
14. Integrated farming systems to sustain farm productivity
15. Alternate and uses Agriculture
16. Climate change and carbon sequestration
17. Latest research methodologies related to the above topics

#### *Recommended Texts*

1. Khan, I.A., & Khan, M.S. (2018). *Developing Sustainable Agriculture in Pakistan*. New York: CRC.
2. Verma, D.K. (2019). *Microbiology for Sustainable Agriculture, Soil Health, and Environmental Protection*. New York: Apple Academic Press.

#### *Suggested Readings*

1. Parray J.A., & Shameem, N. (2019). *Sustainable Agriculture: Advances in Plant Metabolome and Microbiome*. New York: Elsevier Science, Academic Press.
2. Campanhola C., & Pandey,S. (2018). *Sustainable Food and Agriculture: An Integrated Approach*. New York: Elsevier Science, Academic Press.

This course aims to acquaint students with comprehensive knowledge about different soil problems. The students will be introduced about different soil problem being faced by the farmers in the country. The course covers different causes, management and reclamation processes for problematic soils and techniques for raising crops successfully on problem soils. The site-specific practices related to the problem of the soil and different cropping patterns are also covered in this course. Site specific cultural practices, land preparation, sowing methods, fertilizer and irrigation adjustments, specific cropping patterns for economic crop production in problem soils, crop management practices for economic crop production in problem soils and demonstration of degraded soils will also be the part of this course.

#### *Contents*

1. Concept and perspective of crop productivity in Problem Soils
2. Soil problems, salt affected, water deficit and water-logged soils
3. Improvement and reclamation of problem soils
4. Site specific cultural practices
5. Land preparation, sowing methods
6. Fertilizer and irrigation adjustments
7. Specific cropping patterns for economic crop production in problem soils
8. Crop management practices for economic crop production in problem soils
9. Demonstration of degraded soils

#### *Recommended Texts*

1. Hasanuzzaman, M., Fujita, M., Oku, H., Nahar, K. B., Hawrylak-Nowa. (2018). *Plant Nutrients and Abiotic Stress Tolerance*. The Netherland: Springer.
2. Pessarakli, M. (2019). *Handbook of Plant and Crop Stress* (4th ed.). New York: CRC.

#### *Suggested Readings*

1. Hasanuzzaman, M., Fujita, M. Oku, H., & Islam, M.T. (2019). *Plant Tolerance to Environmental Stress: Role of Phytoprotectants*. New York: CRC.
2. Shabala, S. (Ed.) (2017). *Plant Stress Physiology*. Egham, London: CABI Publishers.
3. Usman, S. (2011). *The Basic Soil Problems and Possible Solutions in Agriculture*. Kent: Natural Resource Institute, Plant Health and Environmental Group, University of Greenwich.

There are seventeen elements essential for plant growth and development. These include nitrogen, phosphorus, potash, calcium, magnesium, sulfur, iron, manganese, zinc, copper, boron, molybdenum, chlorine and nickel. Plant nutrition is an important field of agriculture that deals with the study of plant nutrients, the criteria of their essentiality, beneficial elements, and mechanism of their uptake, translocation, assimilation, metabolism, mobility and deficiency symptoms within plants. This is a post graduate level course and aims to acquaint students with comprehensive knowledge of the crop nutrition. The knowledge of mineralization and dynamics of crop nutrients under stressful environment is also covered in this course. It also includes information about mechanism of nutrient uptake by plants and their assimilation. Use of remote sensing and other modern tools for precise nutrient management is also covered under this course.

#### *Contents*

1. Crop nutrition in modern agriculture
2. Rationale for use of fertilizers
3. Biofortification
4. Physiological classification of minerals
5. Dynamics of plant nutrients in normal, flooded and salt affected soils
6. Nutrient uptake and assimilation
7. Nutrient losses and causes of low nutrient use efficiency
8. Improving nutrient use efficiency
9. Balanced nutrition and integrated plant nutrient management systems
10. Concept of remote sensing in crop nutrition
11. Nutrient indexing

#### *Practical*

1. Demonstration of nutrient deficiency symptoms
2. Preparation of different nutrient solutions for field, pots and hydroponic cultures
3. Nutrient analysis (macro and micro) of soil and plants

#### *Recommended Texts*

1. Chand S. (2019). *Integrated Nutrient Management for Sustainable Agriculture*. New Delhi: Daya publishing House.
2. Meena, R.S. (2019). *Nutrient Dynamics for Sustainable Crop Production*. New York: Springer international publishers.

#### *Suggested Readings*

1. Hasanuzzaman, M., Fujita, M.M., Oku, H., Nahar, K. & Hawrylak-Nowak, B. (Eds.) (2018). *Plant Nutrients and Abiotic Stress Tolerance*. The Netherland: Springer.
2. Rengel, Z. (2019). *Achieving Sustainable Crop Nutrition*. London: Burleigh Dodds Science Publishing Limited.

The special problem is intended to instruct students on proper techniques for scientific research and methodologies. The students are expected to prepare directed assignment and collect information and material related to current research interest. Special problem means an assignment that is expected to be temporary and is designated as a special assignment by the academic supervisor in its sole discretion. The main purpose of special problem is to increase the learning capabilities of students. The more we use our brains, the more they develop. Students learn a lot more when they read or practice something by themselves. Similarly, the purpose of assignments is to increase the practical skills of students. The main objectives of special problem assigned to students are to enhance the knowledge of a subject, helps to develop writing skills and to enhance time management and organizing skills. It enhances your planning and organizing skills: The special problem make you do your work by prioritizing the needs and time frames. It helps you in completing all your tasks very peacefully instead of creating any panic. Scopes for improvement: Special problem writing work gives students a lot of scope to improve themselves.

The seminar is intended to instruct students on proper techniques for presentation of scientific material. Each student is expected to prepare and present a scientific seminar and to submit written documentation supporting that seminar. A seminar is a form of academic instruction, either at an academic institution or offered by a commercial or professional organization. It has the function of bringing together small groups for recurring meetings, focusing each time on some particular subject, in which everyone present is requested to participate. Seminars provide a chance to interact with experts from the specific field. Discussing about the relevant topics of the particular subject, students tend to learn about the latest information and new skills related to the concerned subject. Seminars are important and beneficial for those who have difficulty learning in a typical classroom setting where reading and writing are required. There is often a sense of friendship associated with seminar attendance, because everyone is attending with a like interest in learning about a subject important to them. Attending a seminar has numerous benefits, including improving communication skills, gaining expert knowledge, networking with others and renewing motivation and confidence.

A farming system is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate. This is a post graduate level course and aims to acquaint students with comprehensive knowledge of concept and components of the farming and cropping systems and to identify the issues of farming/cropping systems and demonstrate research methods for sustainable production. The concept of precision agriculture is also discussed for different farming systems. The course also focuses on different cropping and farming systems being practiced under different Agro-ecological zones in the country. The students will be updated about the emerging trends and research methodologies being used in the field of farming and cropping systems.

#### *Contents*

1. Concept, scope, classification and components
2. Agricultural resources, their utilization and management
3. Major farming and cropping systems of Pakistan
4. Role of tillage, root dynamics, cover crops, crop residues in cropping system
5. Assessing input use efficiencies in various farming/cropping systems
6. Role of precision agriculture in farming system
7. Study of allied enterprises (livestock, poultry, aquaculture, mushroom culture, tunnel farming)
8. Emerging trends in farming/cropping system research
9. Researchable issues and research methods in farming and cropping systems

#### *Recommended Texts*

1. Dixon, J., Garrity, D.P., Boffa, J.M., Williams, T.O., Amede, T., Auricht, C., Lott, R. & Mburathi, G. (2019). *Farming Systems and Food Security in Africa: Priorities for Science and Policy under Global Change*. London: Routledge.
2. Brun, F., Wallach, D., Makowski, D. & Jones, J.W. (2006). *Working with dynamic crop models: evaluation, analysis, parameterization, and applications*. The Netherlands: Elsevier.

#### *Suggested Readings*

1. Jenkins, A. (2018). *Agronomy and Crop Production*. New York: Syrawood Publishing House.
2. Shannon, D.K., Clay, D.E., & Kitchen, N.R. (2018). *Precision Agriculture Basics*. New York: American Society of Agronomy.
3. Balasubramaniyan, P., & Palaniappan, S.P. (2009). *Principles and Practices of Agronomy*. Jodhpur: Agrobios.

This is a post graduate level course and aims to acquaint students with comprehensive knowledge regarding the statistical aspects for experimentation. The main objective of the course is to plan the experiments according to different design and layout therein the field and to collect the data, analysis it and interpretation. This course will elaborate the methods of scientific inquiry, types of experiments and experimental designs, F and T tests, regression and correlation and research results reporting. A comprehensive discussion and practical execution about planning and layout of field experiments, data collection, tabulation, statistical analysis of data and its interpretation are essential part of this course. The students also get practical training about data collection and statistical analysis using different statistical packages.

#### *Contents*

1. Methods of scientific inquiry
2. General types of experiments
3. Principles of experimental design
4. Planning, layout and conducting field experiments
5. Recording research observations
6. Transformation of data
7. Planned F test
8. Data processing, analyses and its statistical interpretation
9. Means separation
10. Probability
11. F and t distributions
12. Regression and correlation
13. Research results reporting

#### *Practical*

1. Statistical calculations based on sample data
2. Exercise in the layout of experiments
3. Transformation of Experimental data
4. Preparation of analysis of variance table
5. Use of different tests of significance
6. Factorial experiments and their uses in scientific research
7. Reporting results of experiment; calculation of linear regression and correlations
8. Use of statistical packages for data

#### *Recommended Texts*

1. Selvamuthu, D., & Das, D. (2018). *Introduction to Statistical Methods, Design of Experiments and Statistical Quality Control*. Singapore: Springer.
2. Islam, M.A., & Al-Shiha, A.(2018). *Foundations of Biostatistics*, Singapore: Springer.

#### *Suggested Readings*

1. Selvamuthu, D., & Das, D. (2018). *Introduction to Statistical Methods, Design of Experiments and Statistical Quality Control*. Singapore: Springer.
2. Garson, G.D., & Sarsfield, R. (2018). *Research Designs*. New York: Statistical Association Publishers.

Seed is the basic input in crop production. Without a good quality seed, one could not expect a higher crop yield. To understand the physiological aspects of good quality seed production. This is a post graduate level course and aims of augmenting students' capacity regarding principles of seed production and innovations in seed technology. The students are familiarized with the recent trends and technologies being used in the field of seed science. The legislation and quarantine laws regarding the seed are also taught to the students. The course focuses on the ecological aspects of seed production, seed certification and production of transgenic crop seed. The concepts of genetically modified organisms and trans-genetics are also discussed in the course. The practical training about testing seed quality is also given to the students.

#### *Contents*

1. Functional concept of seed production
2. Recent trends in seed technology and management
3. Hybrid and synthetic seed production
4. Ecological aspects of seed production
5. Seed certification standards; Seed storage, structures and related problems
6. Seed industry. Import/export of seed
7. Seed legislation and quarantine laws; genetically modified seeds (GMOs)
8. Trans-genetics for crop improvement
9. Seed quality, control and management; Seed fortification and invigoration
10. Seed health. Organic seed production.

#### *Practical*

1. Analysis for quality tests: physical purity, seed viability, germination and vigor tests
2. Seed cleaning, grading, treatment
3. Sampling techniques involved in seed testing
4. Visit to seed farms, storage houses and processing plants

#### *Recommended Texts*

1. Dar, S.H. (2018). *Methods of Hybrid Seed Production in Major Crops*. New Delhi: Educreation Publishing.
2. Copeland, L.O., & McDonald, M.B. (2005). *Principles of Seed Science and Technology* (4th ed.). New Delhi: Academic Publishers.

#### *Suggested Readings*

1. Jayanthi, M., Sumathi, S., & Venudevan, B. (2018). *Scientific Seed Production of Horticultural Crops*. New Delhi: New India Publishing Agency.
2. Bewley, J.D., & Black, M. (2012). Physiology and Biochemistry of Seeds in Relation to Germination (Vol. 2). *Viability, Dormancy, and Environmental Control*. New York: Springer-Verlag.
3. McDonald, M.B., & Copeland, L.O. (2012). *Seed Production Principles and Practices*. New Delhi, India: CBS Publisher & Distributers.

Any environmental factor deviating from its optimum level becomes a stress. These are the stresses that cause failure in achieving potential yields of crops. The stress may be due to some abiotic factor of environment that is termed as abiotic stress or may be due to any biotic factor or living organisms of environment that is called biotic stress. To develop skills among students to understand the phenomena and cope with different types of stresses for successful crop production, this course is being taught at post-graduate level. This course aims to acquaint students with comprehensive knowledge regarding various stresses influencing crop production. The course also focuses on the effect of stresses on plant growth and their management for successful crop husbandry.

#### *Contents*

1. Concept of stress physiology
2. Plant stress factors and their impact on productivity of cropping systems
3. Types of stresses (water, nutrient, salt, temperature, CO<sub>2</sub>, light, competition, etc.)
4. Crop responses and adaptation to different stresses
5. The individual and interactive impact of different stresses on plant growth and development
6. Agro-management practices for successful crop husbandry under stress environments

#### *Practical*

1. Experiments to study plant behavior to various types of stresses
2. Field visits to demonstrate types of stresses and their impact on crop productivity

#### *Recommended Texts*

1. Pessarakli, M. (2019). *Handbook of Plant and Crop Stress* (4th ed.). New York: CRC.
2. Hasanuzzaman, M., Fujita, M., Oku, H., & Islam, M.T. (2019). *Plant Tolerance to Environmental Stress: Role of Phytoprotectants*. New York: CRC.

#### *Suggested Readings*

1. Dail, W. (2019). *Stress Physiology of Woody Plants*. New York: CRC.
2. Fitter, A.H., & Hay, R.K. (2012). *Environmental physiology of plants*. London: Academic press.

Water is of pivotal importance for all living things including plants. It is a medium of all metabolic processes within plants. The plant cannot grow and develop without water. To develop know how of basic physical and chemical properties of water, and its metabolic and physiological roles / functions in plants, this course is being taught at to students at post-graduate level. This is aims to acquaint students with comprehensive knowledge regarding relationship between plants and water. This course focuses on the physical and chemical properties and movement of water in the soil and plants. The practical knowledge of measuring the water contents and water potential is being given to the students. The students will be able to measure indices of the water stress in the plants.

#### *Contents*

1. Importance of water in plants
2. Physical and chemical properties of water
3. The ascent of sap; The cohesion mechanism, anatomy of pathway
4. Water potential gradient, Capillary rise in xylem
5. Free energy and chemical potential
6. Water potential and its components
7. Analysis of chemical potential
8. Standard state, hydrostatic pressure, water activity and osmotic potential
9. Van't Hoff equation, matric potential
10. Ohm's law to study the movement of water in the soil-plant atmosphere system

#### *Practical*

1. Techniques and experimental approaches for measurement of plant water status
2. Measurement of water content, water potential, pressure chamber technique and psychrometric techniques
3. Methods of inducing water stress in plants

#### *Recommended Texts*

1. Livingston, B.E. (2019). Howkin, L.A., & Pulling, H.E. *The Water-Relation Between Plant and Soil*. London: Creative Media Partners, LLC.
2. Kirkham, M.B. (2014). *Principles of Soil and Plant Water Relations*. USA: Academic Press.

#### *Suggested Readings*

1. Magill, G., & Benedict, J. (2019). *Cascading Changeling in Global Water Crisis*. Cambridge: Cambridge School publishing.
2. Lange, O.L. (2012). *Physiological Plant Ecology II: Water relations and carbon assimilation* (Vol. 12). USA: Springer Science & Business Media.
3. Blum, A. (2011). *Plant Water Relations, Plant Stress and Plant Production*, (pp. 11-52). New York: Springer.

The weeds are among most problematic enemies of crops that cause huge yield losses in crops and deteriorate the aesthetic and economic value of lands. To keep weed population below their economic threshold level in crops is of utmost importance. To develop skills and enhance the knowledge of students about modern weed management techniques, this course is being taught to post graduate level students. This course aims to acquaint students with comprehensive knowledge of weed competition and management in field crops and horticultural. It covers the knowledge of weed management thresholds and the critical period for weed control. The issues like weed invasion and herbicide resistance in weeds will be discussed in detail. The students will get hands-on training about identification of weeds and determination of weed competition and herbicide resistance.

#### *Contents*

1. Concept of weed management and its significance in modern agriculture
2. Weed management using principles of competition
3. Integrated weed management
4. Weed management for field crops
5. Weed Management for Horticultural crops
6. Weed management in lawn, turf grass, pastures, forestry and range lands
7. Management of problematic, parasitic and non-cropped area
8. Invasive weeds and their management
9. Herbicide tolerant crops
10. Herbicide resistant weeds and their management
11. Natural products as lead for new herbicides

#### *Practical*

1. Identification and collection of weeds
2. Demonstration of competitive effect of weeds on crop growth
3. Determination of critical period of weed interference in crops
4. Use of tillage implements for effective and economical weed control
5. Testing of herbicide resistance in weeds

#### *Recommended Texts*

1. Zimdahl, R.L. (2018). *Fundamentals of Weed Science*. (5th ed.). USA: Academic Press.
2. Korres, N.E., Burgos, N.R., & Stephen O. Duke (2019). *Weed Control: Sustainability, Hazards, and Risks in Cropping Systems Worldwide*. USA: CRC.

#### *Suggested Readings*

1. Walia, U.S. (2014). *Weed Management* (2nd ed.). New Delhi, India: Kalyani Publishers.
2. Chauhan, B.S., & Bahajan, G. (2017). *Recent Advances in Weed Management*. New York: Springer.

The climate change is the biggest issue now-a-days all over the world. The crop production is most affected by climate change. The yields of our crops are facing drastic reductions due climate change. Under the present scenario of climate change, successful crop production has become a challenge. To built-up knowledge and skills among students of post-graduate level about adaptation strategies for successful crop production under climate change, this course is being taught. This course aims to acquaint students with comprehensive knowledge about the changes in climate and its effect on the production of crops. The objective of the course is to enable students know about crop production under changing climate and develop strategies for the mitigation of effects of climate change.

#### *Contents*

1. Climate and agriculture
2. Climate variability and change-past, present and future scenario
3. Impact of climate change in different regions
4. Influence of climate change on productivity of major and minor crops
5. Implications of changing climatic scenario for pests, livestock and natural resources
6. Strategies for managing climate change and vulnerability
7. Capacity building and action plan for policy makers and planners
8. Climate monitoring, Mitigation and Adaptation strategies for climate change
9. Carbon sequestration

#### *Recommended Texts*

1. Anboumozhi, V., Breiling, M., Pathmarajah, S., & Reddy, V.R. (2012). *Climate Change in Asia and the Pacific: How can Countries Adapt?*. New Delhi: SAGE Publication India Pvt. Ltd.
2. Hillel, D., & Rosenzweig, C. (2013). *Handbook of Climate Change and Agroecosystems: Global and Regional Aspects and Implications*. London, UK: Imperial College Press.

#### *Suggested Readings*

1. Choudhary, K.K., Kumar, A., & Singh, A.K. (2019). *Climate Change and Agricultural Ecosystems: Current Challenges and Adaptation*. New Delhi: Woodhead Publishing.
2. Lipper, L., McCarthy, N., Zilberman, D., Asfaw, S., & Branca, G. (2017). *Climate Smart Agriculture: Building Resilience to Climate Change*. Berlin, Heidelberg, New York: Springer.

This course designed for MSc (Hons)/MPhil programs of agriculture sciences provides the applied statistics background for survey and experimental work in Agriculture. Case studies and critical examples are used to work through commonly experienced research problems (from sampling designs to the ethical consideration) and to explain how they may be approached, solved or prevented with statistical means. The importance of statistical science in agriculture is obvious, where the collection, analysis and interpretation of numerical data are concerned. Statistical principles apply in all areas of experimental work and they have a very important role in agricultural experiments. Statistics plays an important role in experimentation. While many scientific problems could be solved by different statistical procedures. Furthermore, some statistical software's knowledge will be provided to the students to improve their analytical skills. These activities will further support the student's research.

### *Contents*

1. Importance of Statistics in agriculture research
2. Selection of statistical tools based on scale of measurements
3. Analysis of Count and Frequency data
4. Measures of central tendency and dispersion
5. Some concepts of hypothesis testing. T, Z, Chi-square and F tests. Contingency Tables
6. Diversity Indices
7. Concept of ANOVA and its types
8. Correlation Analysis: Simple correlation, multiple correlation and Partial correlation
9. Regression Analysis: Simple and multiple regression
10. Generalized linear models: logistic regression, Poisson regression, Gamma regression
11. Inverse Gaussian regression
12. Non-linear regression
13. Dose Response Curves

### *Recommended Texts*

1. Montgomery, D. C. (2017). *Design and Analysis of Experiments* (9th ed.). New York, USA: John Wiley & Sons.
2. Rao, G. N. (2007). *Statistics for Agricultural Sciences* (2nd ed.). BS Publication.

### *Suggested Readings*

1. Gbur, E. E., Stroup, W. W., McCarter, K. S., Durham, S., Young, L. J., Christman, M., West, M., & Kramer, M. (2012). *Analysis of generalized linear mixed models in the agricultural and natural resources sciences*. USA: Soil Science Society of America.
2. Lawal, B. (2014). *Applied Statistical Methods in Agriculture, Health and Life Sciences*. New York: Springer.
3. Sahu, P. K. (2016). *Applied Statistics for Agriculture, Veterinary, Fishery, Dairy and Allied Fields*. New York: Springer.



**PhD**  
**AGRONOMY**

This course is designed to deepen understanding about the new advancements taking place in Agronomy, and advanced concepts of crop growth and development. This is an era of technological advancement. This is especially true in case of agriculture as to feed the ever-increasing human population has become a matter of great challenge for agriculture. All the disciplines of agriculture are inter-connected with one another. The innovation in one discipline is helpful to others. For instance, the advancements in the field of molecular biology in the form of new genotypes of crops are ultimately judged and evaluated by the agronomists. Similarly, the issues faced by the farming community could not be solved until and unless the possible solutions of these issues are not addressed by the agronomists.

#### *Contents*

1. Phenological development of crop plants
2. Determinants of crop growth
3. Factors affecting development of crop canopy
4. Photosynthesis and respiration
5. Crop management for improving photosynthetic efficiency and harvest index
6. Crop growth analysis
7. Biological relevance of different growth functions and curve fitting in crop growth studies
8. Selected topics on recent advances in agronomy
9. Evaluation of the recent research of the entire field
10. Lectures and discussions by the specialists in the areas of their research

#### *Practical*

1. Phenological development stages of crop plants
2. Use of classical growth formulae for determining various crop growth indices
3. Estimation of crop growth rates derived from different fitted growth functions
4. Demonstration and calculation of radiation interception and use efficiency

#### *Recommended Texts*

1. Ahmad, L., & Mahdi S.S. (2019). *Satellite Farming: An Information and Technology Based Agriculture*. Heidelberg, Germany: Springer.
2. Krishna K.R. (2018). *Agricultural Drones: A Peaceful Pursuit*. USA: Apple Academic Press.

#### *Suggested Readings*

1. Sparks, D.L. (2017). *Advances in Agronomy* (Vol. 146). *Elsevier Science, Agronomy for Sustainable Development*. All volumes of last three years. INRA-CMSE-PME, Dijon, France and The Netherlands: Springer.
2. Coombs, J., Hall, D.O. & Long, S.P. (Eds.) (2014). *Techniques in Bio productivity and Photosynthesis*. New York: Elsevier, Pergamon International Library of Science, Technology, Engineering and Social Studies.

Irrigation is the process of applying controlled amounts of water to crops at needed intervals. In dry areas and during periods of less than average rainfall, irrigation helps to grow agricultural crops, maintain landscapes, and manage disturbed soils. This is a post graduate level course and aims to acquaint students with comprehensive knowledge of irrigation Agronomy. The students will have knowledge of water stress and its impact on the performance of crops. The concept of water use efficiency is also discussed in detail. The main objective of the course is to educate about estimation/measurement of environment variables used in irrigation scheduling and its impact on the crop productivity. This course also covers the knowledge of water stress on crops and its management.

#### *Contents*

1. Relationship between irrigation and crop yields
2. Methods of irrigation scheduling
3. Moisture sensitive periods; Indices of drought
4. Crop water stress index
5. Response of yield to irrigation
6. Penman's irrigation-yield response analysis
7. Concept of potential soil moisture deficit and limiting deficit
8. Crop response to total water received and drought
9. Criteria for drought resistance
10. Concept of lost time for growth and crop yield
11. Water use efficiency and factors affecting it

#### *Practical*

1. Measurement of plant and soil moisture contents
2. Demonstration of irrigation scheduling for different crops
3. Water flow measurements with different techniques
4. Visits to controlled irrigation systems

#### *Recommended Texts*

1. Abraham, T. (2017). *Principles and Practices of Irrigation Agronomy*. Germany: Lambert Academic Publishing.
2. Choudhary, M.R. (2016). *A textbook of Irrigation & Drainage (Practices for Agriculture)*. Faisalabad: Study Aid Foundation for Excellence; University of Agriculture.

#### *Suggested Readings*

1. Reddy, G.K., Reddy, S.R. (2016). *Irrigation Agronomy*. Ludhiana, New Delhi: Kalyani Publishers.
2. Biswas R.K. (2015). *Drip and Sprinkler Irrigation*, New Delhi: New Indian Publishing Agency.
3. Reddy, S.R. (2012). *Irrigation Agronomy*, Ludhiana. New Delhi: Kalyani Publishers.

A large part of the surface of the world is arid, characterized as too dry for conventional rain fed agriculture and the aim of the course is to enhance the understanding for sustainable productivity of agriculture in arid and semi-arid areas while protecting the natural resource-based i.e. land & water resources, range land and precious vast natural biodiversity present in the area. This is a post graduate level course and aims to broaden the understanding of problems, limitations and potentials of arid areas. It also contains knowledge related to the dry farming, agronomic management of drought and dry spells. This course also provides knowledge relevant to use techniques like water harvesting and soil and water conservation to be used for sustainable crop production in dry land.

#### *Contents*

1. Constrains and techniques of arid agriculture
2. Characteristics of dry land agriculture
3. Problems, prospects and strategies of dry land agriculture
4. Moisture availability index; Aridity index
5. Moisture deficit index
6. Agronomic approaches for dry land agriculture
7. Managing dry spells during crop periods
8. Lay farming for non-arable lands
9. Recommendations for dry farming areas
10. Plant adaptation to water stress
11. Soil and rainfall characteristics in dry land farming
12. Soil and moisture conservation techniques
13. Water shed management; Water harvesting; Sustainable dry land crop production

#### *Recommended Texts*

1. Arnon, I. (2012). *Agriculture in Dry Lands: Principles and Practice*. Amsterdam: Elsevier.
2. Wani, S.H. (2018). *Biochemical, Physiological and Molecular Avenues for Combating Abiotic Stress Tolerance in Plants*. India: Academic publishers.

#### *Suggested Readings*

1. Farooq, M. & Saiddique, K.H.M. (2017). *Innovation in dryland Agriculture*, Switzerland: Springer Publishers.
2. Farooq, M., & Saiddique, K.H.M. (2016). *Conservation Agronomy*. Switzerland: Springer Publishers.
3. Iglesias A, Assimacopoulos, D., Lanen, V., & Henny, A.J., (2018). *Drought: Science and Policy*. New Jersey: John Wiley and Sons Ltd.

This is a post graduate level course and aims to acquaint students with comprehensive knowledge about the concept of biological potential and exploitation in crops. This course not only covers the Agro-physiological factors but also their effect on the potential of the crops. The students will learn about the growth and physiological parameters of crop plants and their measurements. The course also covers principles governing plant growth and development, factors limiting the crop growth and yield. The processes and phenomena estimating the economical yields of crops using different methods is also discussed in the course. Moreover, the skills and techniques of collecting data related to various agronomic and physiological parameters of crops will also be discussed and demonstrated practically to the students.

#### *Contents*

1. Concept of biological crop potential
2. Agro-physiological factors limiting yield potential of crops
3. Ecological optima in relation to crop productivity
4. Blackman's principle of limiting factor
5. Determinants of crop growth
6. Components of plant leaf area expansion, crop canopy development
7. Canopy architecture and interception of solar radiation
8. Potential for increasing photosynthetic efficiency
9. Dry-matter partitioning
10. Modern agro-physiological techniques for harvesting maximum potential of field crops
11. Crop plants in relation to environment

#### *Practical*

1. Collection of data pertaining to actual and potential yields of various crops/varieties
2. Determination of leaf area and dry weight of field crops
3. Calculation of relative growth rate, net assimilation rate, etc.
4. Determination of leaf area index, leaf area duration and harvest index of various field crops
5. Comparative study of crop canopy development in cereals, oilseeds and grain legumes

#### *Recommended Texts*

1. Gosal, S.S., & Wani, S.H. (2018). *Biotechnologies of Crop Improvement, Transgenic Approaches*. New York: Springer International Publishers.
2. Rigobelo, E.C. (2016). *Plant Growth*. Croatia: Open tech.

#### *Suggested Readings*

1. Ahmad, P., & Rasool, S. (2014). Emerging Technologies and Management of Crop Stress Tolerance (Vol. 1). *Biological Techniques*. New York: Academic Press
2. Lal, M.A., & Bhatla, S.C. (2018). *Plant Physiology, Development and Metabolism*. New York: Springer International Publishers.

Models are mathematical tools and software that give some output in response to entering input data. The crop models are especially designed for determining the growth and yield response of crop to certain input or environmental variable. This is a post graduate level course and aims to acquaint students with comprehensive knowledge about crop modeling. This course will help to enhance the knowledge of system science, system analysis, crop modeling and its application in agriculture. The students will learn about the types of modeling and statistical parameters used in crop modeling. The practical knowledge to calibrate and validate different statistical models is also covered in this course. At the end of the course, students will be able to make the model application in research and education for crop improvement and risk analysis in agriculture.

#### *Contents*

1. Philosophy and terminology of system science, scope of system analysis
2. Crop modeling, concept and types of models, specification and uses
3. Statistical parameters in modeling
4. Parameterization and evaluation of crop models
5. Model application in crops, soil, water and agro meteorology
6. Modeling for crop improvement and risk assessment
7. Crop models application in research, education and extension
8. Integration of crop models with GIS and remote sensing
9. Inter-comparison and improvement of crop models

#### *Practical*

1. Working with different models like DSSAT, APSIM, AQUACROP
2. Setting of appropriate coefficients for cultivars, calibration, evaluation and validation
3. Preparation of different input files
4. Crop management and experimental data files
5. Preparation of weather and soil files
6. Working with sequence, seasonal, economic analysis, easy grapher etc.

#### *Recommended Texts*

1. Boote, K. (2019). *Advances in crop Modelling for a sustainable Agriculture*. Cambridge: Burleigh Dodds Science Publishing Ltd.
2. Mavi, H.S., & Tupper, G.J. (2005). *Agro meteorology Principles and Application of Climate Studies in Agriculture*. Lucknow: International Book Distribution Co.

#### *Suggested Readings*

1. Floor, M.B., & Van Ittersum, M. (2010). *Environmental and Agricultural Modeling: Integrated Approaches for Policy Impact Assessment*. Heidelberg: Springer.
2. Wallach, D., Makowski, D., Jones, J., & Brun, F. (2019). *Working with Dynamic Crop Models; Methods, Tools and Examples for Agriculture and Environment*. Amsterdam: Academic Press.

Chemical weed control is most popular weed control method due to quick and efficient weed management. However, more technicalities and issues are related to chemical weed control. To impart an understanding among students related to technical aspects and issues concerned with herbicides, this course is being taught at post-graduate level. This course aims to acquaint students with comprehensive knowledge about herbicides and their use for crop maximization. The course focuses on classification and mode of actions of herbicide. Herbicide residues, selectivity and formulation is also covered in this course. The practical knowledge of herbicide application, residue studies and herbicide resistance is also part of this course. The current issues regarding herbicides like herbicide resistance weeds are also part of this course.

#### *Contents*

1. Herbicides: importance, nomenclature, registration; classification systems
2. Chemical classification; Herbicides mode of action
3. Herbicide formulations; surfactants and adjuvants
4. Application and incorporation techniques and equipment
5. Spray drifts management
6. Herbicide selectivity
7. Herbicide mixtures and compatibility
8. Effect of herbicide residues on succeeding crops
9. Herbicide residues in soil
10. Herbicide hazards, toxicity, environmental pollution
11. Storage, transportation and disposal of herbicides
12. Herbicides resistance, methods to combat herbicide resistance

#### *Practical*

1. Calculation of herbicide dosage
2. Determination of active ingredients in various herbicide formulations
3. Types of sprayers, their parts and spray calibration
4. Boom height adjustment and study of overlapping
5. Study of residual effects on soil and succeeding crops
6. Tank mixing of herbicides

#### *Recommended Texts*

1. Shobha, S., Choudhury, P.P., & Sharma, A.R. (2019). *Herbicide Residue Research in India*. Singapore: Springer.
2. Foy, C.L. (2018). *Adjuvants for Agrichemicals*. New York: CRC.

#### *Suggested Readings*

1. Volova, T.G., Shishatskaya, E.I., Zhila, N.O., Prudnikova, S.V., & Boyandin, A.N. (2019). *New Generation Formulations of Agrochemicals: Current Trends and Future Priorities*. New York: Apple Academic Press, Incorporated.
2. Mesnage, R., & Seralini, G.R. (2018). *Toxicity of Pesticides on Health and Environment*. Switzerland: Frontier in Environmental Sciences.
3. Arora, S. (2018). *Pesticide Risk Assessment*. Oxford Shire: CABI publishers.

Seed is the basic input in crop production. Without a good quality seed, one could not expect a higher crop yield. To understand the physiological aspects of good quality seed production, this course is being taught to students at post-graduate level. This course aims to enhance students' understanding of physiological processes in seeds. The Processes starting from seed formation to the storage of seed are being covered in this course. The physiological problems related to seed along with their solution are included in this course. The students will have a concept of source sink relationship and will be able to strengthen the seed sink in crop plants. The course focuses on the ecological aspects of seed production, seed certification and production of transgenic crop seed.

#### *Contents*

1. Seeds and human beings
2. Review of embryogenesis
3. Physiological development of "seed"
4. Implications of seed maturation
5. Chemical composition of seed, its phylogenetic implications
6. Importance in storage, energy relationships
7. Occurrence and persistence of dormancy in cultivated, weedy and wild species
8. Methods of overcoming dormancy
9. Role of growth regulators in seed development and dormancy
10. Seed sink strength and intensity
11. Seed food reserves, location and composition
12. Physiological and biochemical manifestation of seed aging
13. Seed deterioration-factors influencing rate of deterioration, theories of seed dying
14. Seed enhancement-production and yield
15. Requirements for germination-re-hydration and water relations, temperature and oxygen relations

#### *Practical*

1. Seeds germination, monocot, dicot flower & seed structure
2. Seed priming techniques and their performance under different moisture regimes
3. Changes in protein and carbohydrate contents of seeds during germination
4. Determination of enzyme activities (amylase, glutamine synthetase) in germinating seeds

#### *Recommended Texts*

1. Dar, S.H. (2018). *Methods of Hybrid Seed Production in Major Crops*. New Delhi: Educreation Publishing.
2. McDonald, M.B., & Copeland, L.O. (2012). *Seed Production Principles and Practices*. New Delhi: CBS Publisher & Distributers.

#### *Suggested Readings*

1. Jayanthi, M., Sumathi,S., & Venudevan, B. (2018). *Scientific Seed Production of Horticultural Crops*, New Delhi: New India Publishing Agency.
2. Bewley, J.D., & Black, M. (2012). *Physiology and Biochemistry of Seeds in Relation to Germination (Vol. 2). Viability, Dormancy, and Environmental Control*. New York: Springer-Verlag.
3. Copeland, L.O., & McDonald, M.B. (2005). *Principles of Seed Science and Technology (4th ed.)*. Kluwer, New Delhi: Academic Publishers.

This is a post graduate level course and aims to give the students an insight understanding of Agro-physiological factors affecting crop potential. To harvest the maximum out of possessed genetic potential of a variety by integrating all the yield determinants is the main focus of agronomist. The course also focuses on modern concept being used in the field of crop production including organic farming, precision agriculture, use of robotics in agriculture and remote sensing. The issue of the global warming is affecting the agricultural productivity directly and impact of global warming and changing climate on crop productivity is discussed in detail. The students are also familiarized with the use of biotechnology for crop improvement through genetic modification for improvement of crop productivity in the country.

#### *Contents*

1. Concept and indices of agricultural productivity
2. Key issues limiting agricultural productivity in Pakistan
3. Significance of crop management in determining crop productivity
4. Dynamics of stand establishment; Multiple cropping; Manipulation of different tillage systems
5. Manipulation of crop development by the use of growth regulators
6. Concept and components of good agricultural practices (GAP)
7. Organic farming
8. Precision agriculture and its tools
9. Remote sensing and its application in Agriculture
10. Biotechnology in improving crop production
11. Global warming in relation to crop productivity

#### *Practical*

1. Study of different factors influencing stand establishment under field conditions
2. Evaluation of some case histories for economic feasibility of different cropping systems
3. Field observation of different tillage systems
4. Field visits and observation on GAP
5. Demonstrations on the simulation of effects of global warming on agricultural productivity
6. Visits to various agricultural research facilities

#### *Recommended Texts*

1. Ahmad, L., & Mahdi, S. S. (2019). *Satellite Farming: An Information and Technology Based Agriculture*. Heidelberg: Springer.
2. Krishna, K.R. (2018). *Agricultural Drones: A Peaceful Pursuit*. New York: Apple Academic Press Incorporated.

#### *Suggested Readings*

1. Krishna, K.R. (2018). *Agricultural Drones: A Peaceful Pursuit*. New York: Apple Academic Press Incorporated.
2. Sparks, D.L. (2017). *Advances in Agronomy (Vol. 146)*. Elsevier Science. *Agronomy for Sustainable Development*. All volumes of last three years. New York: INRA-CMSE-PME, Dijon, France and Springer.

The special problem is intended to instruct students on proper techniques for scientific research and methodologies. The students are expected to prepare directed assignment and collect information and material related to current research interest. Special problem means an assignment that is expected to be temporary and is designated as a special assignment by the academic supervisor in its sole discretion. The main purpose of special problem is to increase the learning capabilities of students. The more we use our brains, the more they develop. Students learn a lot more when they read or practice something by themselves. Similarly, the purpose of assignments is to increase the practical skills of students. The main objectives of special problem assigned to students are to enhance the knowledge of a subject, helps to develop writing skills and to enhance time management and organizing skills. It enhances your planning and organizing skills: The special problem make you do your work by prioritizing the needs and time frames. It helps you in completing all your tasks very peacefully instead of creating any panic. Scopes for improvement: Special problem writing work gives students a lot of scopes to improve themselves.

The seminar is intended to instruct students on proper techniques for presentation of scientific material. Each student is expected to prepare and present a scientific seminar and to submit written documentation supporting that seminar. A seminar is a form of academic instruction, either at an academic institution or offered by a commercial or professional organization. It has the function of bringing together small groups for recurring meetings, focusing each time on some particular subject, in which everyone present is requested to participate. Seminars provide a chance to interact with experts from the specific field. Discussing about the relevant topics of the particular subject, students tend to learn about the latest information and new skills related to the concerned subject. Seminars are important and beneficial for those who have difficulty learning in a typical classroom setting where reading and writing are required. There is often a sense of friendship associated with seminar attendance, because everyone is attending with a like interest in learning about a subject important to them. Attending a seminar has numerous benefits, including improving communication skills, gaining expert knowledge, networking with others and renewing motivation and confidence.

Environment is of utmost importance in crop production. Agricultural practice should be of such nature that it should not harm our environment in any of the way. The environmental deterioration and climate change are the biggest issues of the current era. This is a post graduate level course and aims to acquaint students with comprehensive knowledge to identify the issues related to environment and their effect on crop production. The global warming and green house effects are directly influencing the climate all over the globe. This course will also demonstrate methods for sustainable production under climate change. The course also focuses on different techniques and approaches to combat with climate change and successful crop production under deteriorating environmental conditions.

#### *Contents*

1. Crop environment, components, determinants and their role in crop productivity
2. Microclimate in relation to crop management
3. Global warming and green house effects
4. Environmental pollution and plant growth
5. Energy exchange by plants in ecosystem
6. Evapotranspiration and its reduction approaches
7. Anti-transpirants and reflectants
8. Plant physiological aspects and plant architecture

#### *Recommended Texts*

1. Bal, S.K., Mukherjee, J., Choudhury, B.U., & Dhawan, A.K. (2018). *Advances in Crop Environment Interaction*. Singapore: Springer Nature Singapore Ltd.
2. Hasanuzzaman, M., Fujita, M, Oku, H., & Islam, M.T. (2019). *Plant Tolerance to Environmental Stress: Role of Phytoprotectants*. New York: CRC.

#### *Suggested Readings*

1. Hasanuzzaman, M., Nahar, K., & Hossain, M.A. (2019). *Wheat Production in Changing Environments: Responses, Adaptation and Tolerance*. Singapore: Springer International Singapore.
2. Singh, J.S., & Seneviratne, G. (2017). *Agro-Environmental Sustainability (Vol. 2). Managing Environmental Pollution*. Singapore: Springer international publishing.

The handling of the crop after harvesting is of supreme importance as poor postharvest handling may not only result the quantitative losses but also qualitative losses. This is a post graduate level course and aims to acquaint students with comprehensive knowledge about the treatment of agricultural produce after the harvesting. The main objective of this course is to equip the students for preserving the produce quality and quantity of different crops and their value addition for effective marketing and enhancing farm income. The students not only learn about the harvesting cleaning and grading of the crop produce their storage and various biotic and abiotic factors affecting the farm produce after harvesting of crops but also practically demonstrate these postharvest techniques.

### *Contents*

1. Concepts, objectives and importance of postharvest technology in field crops
2. Pre and post-harvest grain losses
3. Abiotic (temperature, rain, relative humidity) factors causing grain losses
4. Biotic (insects, diseases, rodents) factors causing grain losses
5. Over maturity and delayed harvest losses in crops
6. Grain longevity and storage, grain treatment for safe storage
7. After-care in harvesting, threshing, processing, cleaning and grading
8. Modern technology for harvesting, threshing, shelling, drying, grading of cereals and legumes
9. Reaping, beating/threshing, cleaning and drying of different cereals
10. Picking, ginning and separating lint and seed of cotton
11. Cutting, stripping and topping of sugarcane
12. Harvesting, beating/threshing and cleaning of grain legumes and oilseeds
13. Digging, cleaning, topping and washing of root and tuber crops
14. Marketing of field crop products

### *Practical*

1. Demonstration of harvesters, reapers threshers (wheat and paddy) and ginner (cotton)
2. Field demonstration for sugarcane cutting and sugar beet digging by manual methods
3. Seed processing, cleaning, grading and packing practices in cereals, legumes, oilseeds, condiments, spices and vegetables etc.
4. Visits to local farms

### *Recommended Texts*

1. Paliyath G., & Subraminian, J. (2019). *Post-harvest biology and Nanotechnology*. UK: Wiley.
2. Yahia, E.M. (2019). *Postharvest Technology of Perishable Horticultural Commodities*. Amsterdam: Elsevier Science.

### *Suggested Readings*

1. Freitas, S.T., & Preek, S. (2019). *Postharvest Physiological Disorders in Fruits and Vegetables*, New York: CRC.
2. Arnon, I.(2012). *Agriculture in Dry Lands–Principles and Practices*. Amsterdam: Elsevier.
3. Goyal, A., & Asif, M. (2013). *Crop production*. Rijeka, Croatia: In Tech, under CC license.

Modern agricultural production is characterized by various activities that require use of statistical methods. Statistics is a discipline which mainly deals with data quantifications. Even in the case of nonnumerical data, statistical methods use transformations to change nonnumerical data to numerical data, with the aim of achieving some level of quantification to make conclusions about the matter of interest. Data in agriculture is of numerical character accompanied with variability of data. Statistics can be used as a tool for agricultural research. It can help research workers to design his experiments and to evaluate objectively the resulting numerical data. This course focus on advanced design of experiment tools which will be helpful to find out the factors of output related to agriculture experiments. Moreover, students will learn some statistical software's like Minitab, R, and Design Expert to analyze their experimental data. The knowledge of statistical software will improve the computational and analytical skills of the students.

### *Contents*

1. Basic principles of experimental design
2. Layout analysis of CRD, RCBD, Latin Square Designs
3. Estimation of Missing Observations in RCBD and Latin Square Design
4. BIBD, PBIBD, Split plot Designs and its variations
5. Multiple comparison tests
6. Effect of violation of assumptions of underlying ANOVA
7. Factorial Experiments,  $2^n$ ,  $3^n$ ...  $P^n$
8. Mixed levels factorial experiments
9. Confounding and its types. Fractional replication. Application and construction of contrasts
10. Response surface methodology
11. Introduction of multivariate analysis
12. Principle component analysis
13. Factor analysis
14. Cluster Analysis
15. Correspondence analysis

### *Recommended Texts*

1. Muhammad, F. (2000). *Statistical methods and data analysis*. Lahore: Ilmi Kitab Khana.
2. Montgomery, D. C. (2017). *Design and analysis of experiments* (9th ed.). New York: John Wiley & Sons.

### *Suggested Readings*

1. Box, G. E. P., Hunter, J. S., & Hunter, W. G. (1978). *Statistics for experimenters*. New York: John Wiley & Sons.
2. Dillon, W. R., & Goldstein, M. (1984). *Multivariate analysis: Methods and applications*. New York: John Wiley & Sons.
3. Cox, D. R. (2000). *The theory of the design of experiments*. New York: Chapman and Hall.