



COURSE OUTLINE BRIEFS

DEPARTMENT OF
ENTOMOLOGY



SARGODHA UNIVERSITY
Pathway to Progress

FACULTY OF
AGRICULTURE



OVERVIEW

The Department of Entomology was established in 2007 and got the status of full-fledged department in 2012. The primary aim of the Department is to provide excellence in teaching, research and training as part of undergraduate, post-graduate and doctoral degree programs from a faculty of nationally and internationally recognized scholars for solving the community problems.

The Department has well equipped laboratory with modern and latest equipment to impart quality teaching and research. A well-established biological control laboratory/ insectary have recently been established and will be in operational with many foreign collaborative research projects. The Department offers graduate and postgraduate degree programs. Since its establishment, the Department has produced 170 BSc (Hons), 52 MSc (Hons) and four PhD degree holders. The core areas of research are Insect Biodiversity and Systematics, Acarology, biological control of field crop insect pests by using different parasitoids and predators , bee keeping and effect of different plantations in honey production and correspondingly the honey bees on pollination, host plant resistance to insect pests, Integrated Pest Management with some novel tactics, damage assessment of different stored grain insect pests on stored cereals and their control through novel techniques, Insect Ecology, Physiology and Toxicology.

Under the supervision of highly qualified faculty who, apart from teaching activities, are running many research projects funded by foreign universities, HEC, PARB and PSF. The faculty has always been seeking collaboration with national and international institutes that would enhance academic and research skills of the students of the department.

Academic Programs Offered

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

BSc (Hons) Agriculture

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

Duration: 04 Year Program (08 Semesters)

Degree Requirements: 134 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)
Total Credit Hours		17(14+3)

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)
Total Credit Hours		17(14+3)

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) Non-credit hour course
Total Credit Hours		18(13+5)

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)
Total Credit Hours		18(13+5)

Semester-V

AEXT-6408	Communication Skills in Agricultural Extension	3(2+1)
ENTO-6103	Insect Morphology	3(2+1)
ENTO-6104	Principles of Insect Taxonomy	3(2+1)
ENTO-6105	Insect Ecology	3(2+1)
ENTO-6106	Insect Pests of Household, Man and Animals	3(2+1)
ENTO-6107	Insect Behavior	3(2+1)
Total Credit Hours		18(12+6)

Semester-VI

ENTO-6108	Insect Physiology	3(2+1)
ENTO-6109	Classification of Adult Insects	3(2+1)
ENTO-6110	Agricultural Pests and their Management	3(2+1)
ENTO-6111	Stored Product Pests and their Management	3(2+1)
ENTO-6112	Beneficial Insects	3(2+1)
Total Credit Hours		15(10+5)

Semester-VII

ENTO-6113	Integrated Pest Management	3(2+1)
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ENTO-6114	Plant Resistance to Insect Pests	3(2+1)
ENTO-6115	Insecticides and their Application	3(2+1)
ENTO-6116	Range and Forest Entomology	3(2+1)
ENTO-6117	Agriculture & Environmental Pollution	3(2+1)
Total Credit Hours		15(10+5)

Semester-VIII

AGEC-6523	Agribusiness, Marketing and Trade	3(3+0)
ENTO-6118	Scientific Writing and Presentation	3(2+1)
ENTO-6119	Apiculture	3(2+1)
ENTO-6120	Biological Control of Insect Pests	3(2+1)
ENTO-6121	Internship / Research Project	4(0+4)
Total Credit Hours		16(9+7)

MSc (Hons) Entomology

Eligibility: B.Sc. (Hons.) / B.Sc. 4 Years or equivalent (16 Years of Education) in the relevant field or equivalent degree from HEC recognized institution with at least second Division or CGPA 2.00 out of 4.00.

Duration: 02 Year Program (04 Semesters)

Degree Requirements: 30 Credit Hours

ENTO-7101	Research Methods in Entomology	3(2+1)
ENTO-7102	Origin and Phylogeny of Insects	3(2+1)
ENTO-7103	Environmental Entomology	3(2+1)
ENTO-7104	Numerical Taxonomy	3(2+1)
ENTO-7105	Insecticide Resistance and Management	3(2+1)
ENTO-7106	Molecular Entomology	3(2+1)
ENTO-7107	Medical and Veterinary Entomology	3(2+1)
ENTO-7108	Insects in Relation to Plant Diseases	3(2+1)
ENTO-7109	Special Problem	1(1+0)
ENTO-7110	Seminar	1(1+0)
ENTO-7111	Classification of Immature Insects	3(2+1)
ENTO-7112	Acarology	3(2+1)
ENTO-7113	Pesticides Application Equipment	3(1+2)
ENTO-7114	Insecticide Toxicology	3(2+1)
ENTO-7115	Insect Cytogenetics and Cytotaxonomy	3(2+1)
ENTO-7116	Insecticide and Public Health	3(2+1)
ENTO-7117	Insect Biochemistry	3(2+1)
ENTO-7118	Chemical Ecology of insects	3(2+1)
ENTO-7119	Forensic Entomology	3(2+1)
ENTO-7120	Insect Neurobiology	3(2+1)
ENTO-7121	Insect Rearing Techniques	3(2+1)
STAT-7151	Statistical Methods for Agricultural Research-I	3(3+0)

PhD Entomology

Eligibility: M.Sc. (Hons.) Entomology or Equivalent in the relevant field from HEC recognized institution with at least CGPA 3.00 out of 4.00.

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

Degree Requirements: 18 Credit Hours Course Work + Dissertation

ENTO-8101	Advanced Insect Ecology	3(2+1)
ENTO-8102	Advanced Insect Morphology	3(2+1)
ENTO-8103	Advanced Insect Physiology and Embryology	3(2+1)
ENTO-8104	Advances in Insect Behavior	3(2+1)
ENTO-8105	Insect Nutrition	3(2+1)
ENTO-8106	Advances in Pest Management Research	3(2+1)
ENTO-8107	Advances in Biological Control of Insect Pests	3(2+1)
ENTO-8108	Insect Pathology	3(2+1)
ENTO-8109	Special Problem	1(1+0)
ENTO-8110	Seminar	1(1+0)
STAT-8131	Statistical Methods for Agricultural Research-II	3(3+0)



**BSc
(Hons)
AGRICULTURE
ENTOMOLOGY**

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.

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.

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 χ^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 course is an undergraduate course for BSc (Hons) classes. This course aims to provide concepts of basic morphology of insects, particularly in reference to the Ak-grasshopper. Students will be familiar with the basic internal and external structural (anatomical) features of a model insect. The course includes a detailed description and demonstration of different external and internal morphological and anatomical features of a typical insect taking *Poeciloceris pictus* Ak grasshopper as model insect specimen. Students will be able to comparatively study these insect body features. Moreover, students will get familiarized with permanent and temporary mounts of different body structures and tissues of insects.

Contents

1. Introduction of insect morphology
2. Integument and its layers with its derivatives in insects
3. Regions and segmentation of insect body
4. Comparison of morphology of insect head, thorax and abdomen
5. The appendages of insects in different insect orders
6. Morphology of endoskeleton in insects
7. Morphology of internal organ systems
8. The exocrine and endocrine organs in different insect orders

Practical

1. Structure of insect integument and its derivatives
2. Comparative external and internal morphology of different insect orders
3. Preparation of temporary mounts of chewing and sponging type mouthparts
4. Preparation of temporary mounts of chewing and lapping type mouthparts
5. Preparation of temporary mounts of sucking and siphoning type mouthparts
6. Preparation of temporary mounts of types of antennae and wings in insects
7. Preparation of temporary mounts of male and female insect genitalia
8. External and internal body organs of different insect orders

Recommended Texts

1. Richard, O.W., & Davies, R.G. (1984). *Imm's General Textbook of Entomology, Vol. I (Structure, Physiology & Development)* (10th ed.). New York: Chapman and Hall.
2. Snodgrass, R. (1935). *Principles of Insect Morphology*. U.S.A.: Cornell University Press.

Suggested Readings

1. Chapman, R. F. (2000). *The insects: Structure and Function* (4thed.). U.K.: Hodder and Stoughton Education.
2. Romoser, W.S. (2001). *The Science of Entomology*(3rd ed.). New York: WCB McGraw-Hill .
3. Tonapi, G. T., 1994. *Experimental Entomology. An Aid to Laboratory and Field Studies*. New Delhi, India: CBS Publishers.

The students would be able to understand the basic concepts of taxonomic hierarchy, identification, taxonomic characters, variations, taxonomic keys and preparation of taxonomic papers. Course includes description and practical demonstration of different techniques and skills used in the taxonomic discrimination of the insect species. They will learn about the basic concepts and will also be able to understand about the theory and practice of structuring a taxonomic scientific manuscript and about the theory and understanding of zoological nomenclature of insects. Course will also provide understanding to the students about the graphical and numerical representation of taxonomic data related to different insect taxa.

Contents

1. Introduction
2. History
3. Functions and concepts of insect taxonomy
4. Tasks of taxonomist; taxonomic categories
5. Taxonomic procedures, collection and methods of sampling
6. Identification, taxonomic characters, variations in population and descriptions
7. Taxonomic keys, concepts of species, kinds of species and phylogenies
8. Preparation of taxonomic papers, code of zoological nomenclature
9. Introduction to numerical and molecular taxonomy; phonetics, cladistics

Practical

1. Methods of collection, preservation and labeling of insects
2. Preparation of taxonomic keys
3. Identification of insects, cataloguing and writing descriptions of identified insects
4. Preparation of phenograms, cladogram and phylogenetic trees using morpho-metrics

Recommended Texts

1. Daly, H.V., Doyen, J.T. Purcell, A.H., & Daly, B.B. (1998). *Introduction to Insect Biology and Diversity*. U.K.: Oxford University Press.
2. Kitching, I., Forey P. L., & Humphries, C. J. (1998). *Cladistics: Contents and Practice of Parsimony Analysis*. U.K.: Oxford University, Press.

Suggested Readings

1. Manzoor, F. (2006). *Morphometric Studies on Termite Genus Odontotermes*. Higher Education Commission, Islamabad.
2. Mayer, E., & Ashlock, P.D. (1991). *Principles of Systematic Zoology* (2nd ed.). New York: McGraw Hill.
3. Schuh, R. T., & Andrew, V. Z. B. (2009). *Biological Systematics Principles and Applications*. Ithaca, New York, USA: Cornell University Press.

This course encompasses the basic concepts of insect ecology. It aims to familiarize the students about the key ecological parameters and factors interacting with insects such as natality, mortality, migration, dispersal and other key factors such as density dependent and density independent factors and inter and intra-specific interactions of insect species within a particular habitat, niche or natural and agro-ecosystem. Moreover, there is detailed information about the life table and diversity indices used to determine and understand the basics of an insect's ecology. The students would be well versed with the basic concepts of insect ecology, succession, population, and ecosystem and insect-ecosystem interactions.

Contents

1. Overview of insect ecology, divisions of ecology
2. Habitat and niche
3. Intra and interspecific interactions
4. Natural and agro-ecosystems
5. Flow of energy in ecosystem, trophic relations
6. Food chain, food web and food mesh concepts
7. Ecological succession
8. Population and its characteristics like natality, mortality, migration, dispersal, key factors
9. Density dependent and density independent factors
10. Introduction to life tables and diversity indices

Practical

1. Maintenance and measurement of abiotic factors (temperature, humidity, light, wind etc.) with different instruments
2. Population sampling, estimation and construction of life tables

Recommended Texts

1. Bourtzis, K., & Miller, T. (2003). *Insects Symbiosis*. Boca Raton, FL: CRC Press.
2. Huffaker, C.B., & Robert, L.R.(1984). *Ecological Entomology*. New York: Wiley.

Suggested Readings

1. Odum, E. P., & Gary, W.B. (2005). *Fundamentals of Ecology*. CA, USA: Thomson Brooks.
2. Price, P. W., Denno, R. F., Eubanks, M. D., Finke D. L., & Kaplan I.(2011). *Insect Ecology: Behavior, Populations and Communities*. Cambridge, UK: Cambridge University Press.
3. Rockwood, L.L. (2006). *Introduction to Population Ecology*. New York: Wiley, John & Sons.

Insects interact with man at all levels of their livings. They interfere with the basic interests of human not only in the field but also in their living dwellings. This course is a graduate course for BSc (Hons) classes with major Entomology and it aims to provide information so that the student should be able to identify, collect and manage different insects of household, man and animals. Students will be able to collect, identify and preserve major insect/mite pest species damaging their food products at home or annoying them or their livestock individuals. The students will be demonstrated about the control practices for these household insect pests.

Contents

1. Introduction to insect pests of household, man and animals
2. Identification, biology and control of different social insect pests like ants, termites, cockroaches
3. Identification, biology and control of silver-fish, cricket, powder-post beetle, carpet beetle, cloth-moths, psocids, lice, bed-bugs, fleas, mosquitoes, houseflies and wasps
4. Identification, biology and control of stable flies, flesh flies, blowflies, tsetse flies, blackflies and midges

Practical

1. Collection
2. Identification and demonstration, management of different household, man and animal insect pests

Recommended Texts

1. Agarwal, S. (2009). *Insect Pests of Cereals and their Management*. India: Oxford Book.
2. Atwal, A.S., & Dhaliwal. (2005). *Agricultural Pests of Southeast Asia and their Management*. Ludhiana: Kalyani Publishers.

Suggested Readings

1. Bishopp, F. C. (1916). *Fleas as Pests to Man and Animals, with Suggestions for Their Control*. USA: Harvard Uni Press.
2. Edmen, H. F. (2013). *Handbook of Agricultural Entomology*. New York: John Wiley & Sons.
3. Fernald, H.T. (2008). *Applied Entomology, An Introductory Textbook of Insects in their Relation to Man*. Kessinger Publishing (Amazon).

Study of animals' behavior has been an interesting and vital subject of zoological sciences. In this course of graduate level foraging and feeding behavior, reproductive behavior, escape, and defense behavior, offence and predation behavior and dispersal and migration behavior are discussed. All these behavioral studies help in the proper understanding of the insects' biology and ecology and will help us for the better management and control of insect pests. The course includes very interesting topics related to insect behaviors such as biological functions of behavior including host finding, feeding and reproductive, escape patterns, communication patterns, auditory and social behavioral tactics, defense mechanisms, ways of showing offence and predation, dispersal and migration patterns etc.

Contents

1. Introduction
2. Types of behavior, reflexes, kinesis and taxes, learning, periodicity
3. Patterns of behavior (Communications, Visual, Auditory, Tactile and Chemical), territoriality
4. Control of behavior (Nervous, Endocrine and Genetic)
5. Biological functions of behavior (Host Finding, Feeding and Reproductive, Escape, Defense, Offence and Predation, Dispersal and Migration)

Practical

1. Communication
2. Chemical communication, mating, host finding, auditory and social behavior under lab or field conditions

Recommended Texts

1. Goulson, D. (2003). *Bumble Bees, Behaviour and Ecology*. UK: Oxford University Press.
2. Parihar, R. (2001). *Reproductive Behaviour and Biology of Sex*. New Delhi: Dominant Publishers.

Suggested Readings

1. Daly, H.V., Doyen J.T., Purcell A.H., & Daly, B.B. (1998). *Introduction to Insect Biology and Diversity*. UK: Oxford University Press.
2. Evans, H.E. (1984). *Insect Biology: A Textbook of Entomology*. Boston: Addison-Wesley Publishing.

This course is an undergraduate course for BSc (Hons) classes. This course aims to provide concepts of basic physiology, their functions in insects, particularly in reference to the Ak-grasshopper. The students will be able to understand the basic structural and functional principles of various insect body systems such as insect reproduction, respiratory, circulatory, nervous, muscular, digestive systems and functioning of different insect sense organs. Students will learn about the basics of physiological and chemical functioning of insect communication entities such as synthesis and functioning of insect pheromones and other chemical messenger molecules. Students will understand the thermoregulation process of insects.

Contents

1. Introduction to insect physiology
2. Embryonic and post-embryonic development in insects
3. Physiology of integument
4. The structure and function of insect digestive system
5. The structure and function of insect circulatory, excretory and respiratory systems
6. The structure and function of insect reproductive, muscular and nervous systems
7. The types of sense organs and perception in insects
8. The types of sound and light production organs in insects
9. The mechanism of Thermoregulation in insects
10. Mechanism of hormones and pheromones production and function in insects

Practical

1. Analysis of insect chitin and cuticular proteins
2. Dissection of insect digestive and reproductive systems
3. Analysis of insect digestive enzymes
4. Measurement of respiration rate of insect and insect blood cells
5. Analysis of insect excretory products
6. Measuring response of insect hormones and pheromones

Recommended Texts

1. Berridge, M.J., & Treherne, J.E. (1982). *Advances in Insect Physiology*. London: Academic Press.
2. Chapman, R.F. (1998). *The Insects; Structure and Function* (4th ed.). New York: American Elsevier Publishing.

Suggested Readings

1. Howse, P., Stevens, I., & Jones, O. (1998). *Insect Pheromones and their Use in Pest Management*. London: Chapman and Hall.
2. Kerkut, G.A., & Gilbert, L.I. (1985). *Comprehensive Insect Physiology, Biochemistry and Pharmacology*. Oxford: Pergamon Press.
3. Rockstein, M. (ed.). (1974). *Advances in Insect Physiology* (2nd ed.). London: Academic Press.

Study of insect biodiversity and evolution are integral part of entomological sciences. Adult insect individuals represent the most astonishing biodiversity features as they manifest the distinct features of different species. This course aims to introduce the students about the basics of insect classification and biodiversity of different insect orders up to family level. Students will get familiarized with the concepts of insect classification, biodiversity and their different types. They will learn to study adaptation strategies of adult insects in different geographical areas and about their adaptive and phylogenetic affinities. They will study the available insect fauna diversity in Pakistan and their classification among different hierarchical categories i.e. orders, families, genera etc.

Contents

1. Introduction to insect classification and biodiversity
2. Schemes of classification; types and components of biodiversity
3. History of insects, phylogenetic affinities of different orders
4. Insect adaptation in various geographical regions
speciation and biodiversity
5. Classification of insect orders up to family level with particular reference to insect fauna of Pakistan

Contents (Practical)

1. Collection, preservation, identification and classification of insects up to family level
2. Methods of studying biodiversity

Recommended Texts

1. Afzal, M., & Mufti, S.A. (1998). *Natural History Research*. Islamabad: Pakistan Scientific and Technological Information Center.
2. Collins, W. W., & Qualset, C. O. (1998). *Biodiversity in Agroecosystems*. Boca Raton, New York: Lewis Publishers.

Suggested Readings

1. Triplehorn, C.A., & Jhonson, N.F. (2005). *Borror and DeLong's Introduction to the Study of Insects* (7th ed.). Belmont, CA: Brooks Cole.
2. Wheeler, W.M. (2006). *Insects: their Origin and Evolution*. New Delhi: Discovery Publishing House.
3. Suhail, A. (2008). *A Notebook of Classification of Adult Insects (Insect History, Biodiversity, Collection and Classification* (2nd ed.). Faisalabad: University of Agriculture.

This graduate course, being taught to the students of B.Sc. (Hons.), includes comprehensive description and demonstration of biology and ecology of major agricultural pests of Indo-Pak region including agricultural insect pests, mite pests and vertebrate pests as well. Students will be able to learn about the biological and ecological behavior of major agricultural pests, their damage potential and damage symptoms and about different control strategies against these pests such as about different cultural, legislative, biological, chemical control tactics. At the end of course, students will be able to identify major agricultural pest species, their damage symptoms and will be able to find out the most effective control techniques against these pests.

Contents

1. Introduction
2. Concepts of IPM technology
3. Identification
4. Distribution
5. Host plants, biology, damage and management of mites and insect pests of field crops, vegetables and orchards
6. Brief introduction to important vertebrate pests

Practical

1. Collection
2. Identification
3. Distribution, host plants, biology
4. Nature of damage and management of insect and mite pests of field crops, vegetables and orchards
5. Other important vertebrate pests

Recommended Texts

1. Agarwal, S. (2009). *Insect Pests of Cereals and their Management*. India: Oxford Book.
2. Atwal, A.S., & Dhaliwal, G. S. (2005). *Agricultural Pests of South East Asia and their Management*. Ludhiana: Kalyani Publishers.

Suggested Readings

1. Awasthi, V.B. (2007). *Agricultural Insect Pests and their Control*. Jodhpur, India: Scientific Publishers.
2. Brooks, J.E., Ahmad, E., Hussain, I., Munir S., & Khan A. A. (1990). *A Training Manual on Vertebrate Pest Management*. Islamabad: Pan Graphics Publishers, Islamabad.
3. Fenemore, P.G. (2006). *Applied Entomology*. New Delhi: New Age International.

This course aims to clear the concepts of stored product pest management, food storage principles and storage losses incurred by different insect and mite pests. Students will learn about the basic sampling strategies being used for pest scouting in storage industry and about the biological and ecological aspects of each major stored grain insect or mite pests and will be able to understand different factors affecting grain and other stored food products in storage structures. They can collect, preserve and identify different stored grain insect pests and will also learn about how to rear some of these stored grain insect pests for different studies.

Contents

1. Introduction
2. Identification
3. Biology and management of different stored product pests
4. Principles and types of storages
5. Factors affecting grain and other products in storages
6. Stored product losses and their prevention

Practical

1. Visits to different godowns and demonstration of sampling methods
2. Collection, identification and management of different stored product pests
3. Culture of some stored products insect pests under different climatic conditions

Recommended Texts

1. Ashfaq, M., Saleem, M. A., & Ahmad, F. (2009) *Zari Ajnaski Mahfooz Zakhira Kari* (in Urdu). Lahore: Pak Book Empire, Lahore.
2. Hill, D.S. (2002). *Pests of Stored Food Stuffs and Their Control*. Berlin: Kluwer Academic Publishers.

Suggested Readings

1. Rees, D. (2009). *Insects of Stored Products*. New York: Manson Publishing Company.
2. Zaklandvoi, G. A., & Ratanova. V. F. (1987). *Stored Grain Pests and their control*. London: Oxonian Press.

Insects not only pose different problems to human interest but also some insects are beneficial to humans providing different service/benefits to humans. This course focuses on different types and uses of beneficial insects including medicinal use of insects, aesthetic importance of insects, pollination services by insects, insects as scavengers, decomposers, soil conditioners, entomophagous and weed feeding insects which are employed in biological pest control industry. This course aims to provide the basic information of different entomological cottage industries as well including apiculture, sericulture and lac-culture. The economic importance uses and diseases of all these cottage industries are also discussed under this course.

Contents

1. Introduction
2. Insects of medicinal, food, aesthetic value
3. Insect pollinators and environmental indicators
4. Scavengers, entomophagous and weed-feeding insects
5. Entomological cottage industries (apiculture, sericulture and lac-culture)

Practical

1. Instructions in beneficial insects rearing
2. Collection and identification of beneficial insects (pollinators, predators and parasitoids)

Recommended Texts

1. Ahmad, R. (1979). *A Guide to Bee Keeping in Pakistan* (Extension Book)
2. Aruga, H. (1994). *Principles of Sericulture (Translated from Japanese)* New Delhi: Oxford & IBH Publishing.

Suggested Readings

1. Ashfaq, M., & Suhail A. (2001). *Magasbani Kay Jadeed Treeqay* (in Urdu). Faisalabad: Department of Entomology, University of Agriculture.
2. Ashfaq, M., & Akram W. (2000). *Rasum Ke Keeray Palna* (in Urdu). Faisalabad: Department of Entomology, University of Agriculture.
3. Devillers, J., & Phame M. (2002), *Honey Bees: Estimating the Environmental Impact of Chemicals*. London, UK: Taylor & Francis.

Integrated pest management, or IPM, is a process you can use to solve pest problems while minimizing risks to people and the environment. IPM can be used to manage all kinds of pests anywhere—in urban, agricultural, and wildland or natural areas. This course provides comprehensive information related to the integrated pest management strategies being employed in plant protection sector. It provides students understanding of the basic concepts of insect pest population sampling and fluctuation factors in the field, population assessment, and about the principles, requirements and implementation of IPM. Students will be able to learn about the different strategies such as cultural, physical, mechanical, legislative, chemical, biological, microbial, biotechnological and genetic control measures to be used in an integrated manner to manage or control any insect pest species.

Contents

1. Introduction
2. History, concept and principles of integrated pest management (IPM)
3. Organic farming, economics of pest management
4. Different methods of insect pest scouting and forecasting
5. Losses caused by insect pests to different crops
6. Methods of pest management: cultural, physical, mechanical, legislative, chemical, biological, microbial, biotechnological and genetic control measures
7. Feeding deterrents
8. Insect growth regulators (IGRs) and insect pheromones

Practical

1. Demonstration of different methods of pest scouting and monitoring
2. Nature and extent of damage; assessment of crop losses by different methods
3. Estimation of economic threshold levels of different crop pests
4. Installation of light and pheromone traps
5. Designing of IPM modules of important selected crops

Recommended Texts

1. Atwal, A.S., & Bains, S.S. (2005). *Agricultural Pests of South East Asia and their Management*. Ludhiana: Kalyani Publishers.
2. Awasthi, V.B. (2007). *Agricultural Insect Pests and their Control*. Jodhpur, India: Scientific Publishers.

Suggested Readings

1. Binns, M.R. (2000). *Sampling and Monitoring in Crop Protection*. UK: CABI Publishing.
2. Dent, D. (2000). *Insect Pest Management* (2nd ed.). Ascot, UK: CABI Bioscience, UK Centre.
3. Dhaliwal, G.S., & Arora, R. (2006). *Integrated Pest Management*. Ludhiana, India: Kalyani Publishers.

This course aims to provide concepts of plant resistance against insects. This course discusses the characters of plants and different factors mediating resistance against insect pests. The students will get familiarized by the basic understanding of factors of plant resistance against insects, the mechanisms of resistance such as ecological or induced plant resistance, antixenosis and tolerance mechanisms in the plants. Moreover, genetic basis of the plant resistance and environmental influence of plant resistance mechanisms will be described and demonstrated to students.

Contents

1. Introduction to plant resistance to insect pests
2. The mechanism of resistance in plant against insects
3. Ecological resistance in plants against insects
4. Physiological resistance in plants against insects
5. Induced genetic resistance in plants
6. Antixenosis, antibiosis and tolerance of plants against insects
7. The factors of plant resistance against insects
8. Genetic basis of plant resistance against insects
9. Effect of environment on plant resistance
10. Biotypes of insects
11. Measurement of resistance in plants against insects
12. Development of insect resistant varieties
13. The role of entomologist in breeding for resistance and transgenic crops

Practical

1. Testing of relative cotton and sugarcane characters causing resistance to insects
2. Testing and measurement of relative rice and maize characters causing resistance to insects
3. Testing and measurement of relative pulses and oil seeds characters causing resistance to insects
4. Testing and measurement of relative Citrus characters causing resistance to insects
5. Testing and measurement of relative Fruits characters causing resistance to insects
6. Testing and measurement of relative Vegetables characters causing resistance to insects

Recommended Texts

1. Panda, N., & Khush, G.S. (1995). *Host Plant Resistance to Insects*, Guildford, UK: IRRI, Printed and Bound in UK, Biddles Ltd.
2. Pedigo, L.P. (1996). *Entomology and Pests Management* (2nd ed.). London: Prentice Hall.

Suggested Readings

1. Dhaliwal, G.S., & Singh R. (2005). *Host Plant Resistance to Insects*. New Delhi: Panima Publishing Corporation.
2. Panda, N. (1980). *Principles of Host Plant Resistance to Insect Pests*. Allenheld, London: Packard Publishing.
3. Sadasaban, S., & Thayumanayan, B.(2003). *Molecular Host Plant Resistance to Pests*. USA: CRC Press.

This course aims to provide information to students about concept of toxicity and insecticide formulations, mode of action, residues of insecticides and various types of spray equipment. Course includes the description about the classification of different insecticide formulations on basis of their mode of entry in to target insect body, on basis of their chemical nature, mode of action, toxicity level and formulation types. Moreover, basic structural and functioning principles of major insecticide application apparatus are discussed in this course.

Contents

1. Introduction to insecticides and their application
2. Nomenclature of insecticides
3. Classification on the basis of mode of entry
4. Classification on the basis of chemical nature (natural and synthetic insecticides)
5. Classification on the basis of mode of action
6. Classification on the basis of toxicity
7. Classification on the basis of formulations
8. Compatibility, physico-chemical properties, residues of insecticides
9. Insecticide resistance and its management
10. Hazards and safety measures
11. Functioning of various types of hand and power operated equipment for insecticide application
12. Types of nozzles
13. Information about insecticide legislation

Practical

- 1 Computation, preparation and field application of different formulations of insecticides
- 2 Identification, classification, handling and maintenance of application equipment
- 3 Visit to pesticides industries/field visits

Recommended Texts

1. Pedigo, L.P., & Marlin, E. R. (2009). *Entomology and Pest Management* (6th ed.). New Jersey: Person Education.
2. Saleem, M.A. (2009). *Principles of Insect Toxicology*. Lahore, Pakistan: Izhar sons Printers.

Suggested Readings

1. Dodia, D.A., Petel, I.S., & Petal, G.M. (2008). *Botanical Pesticides for Pest Management*. Jodhpur, India: Scientific Publishers.
2. Ishaaya, I., & Degheele, D. (1998). *Insecticides with Novel Modes of Action: Mechanism and Application*. New Delhi: Norosa Publishing.
3. Mathews G.A. (2002). *Pesticide Application Methods* (4th ed.). UK: Intercept.

The basic objective of this course 'Range and Forest Entomology' is to provide the concepts regarding range land and forest ecosystem entomology. Students will learn about the basic concepts of forest ecosystem, its functioning and important components and factors affecting forest ecosystems. Moreover, this course teaches students about the biology, ecology, damage potential and control practices recommend against some basic major insect pests of forest trees and forest nursery management strategies. Students will be able to understand basic steps and plans for proper integrated pest management of forest nurseries.

Contents

1. Importance of range and forest entomology in range land and forest ecosystems
2. Insect pests of range and forest trees
3. Lawn insects, their identification, distribution
4. Host plants, biology, nature of damage
5. Estimation of losses and management
6. Competition and complementary role of insects with range livestock

Practical

1. Survey and collection
2. Preservation and identification of insect pests of range and forest trees
3. Study of nature of damage and demonstration of control measure
4. Field visits to range/ forests/ forest departments

Recommended Texts

1. Barbose, P., & Wagner, M.B. (1989). *Introduction to Forest and Shade Tree Insects*. London, UK: Academic Press.
2. Dajoz, R. (2000). *Insects and Forests*.UK: Intercept.

Suggested Readings

1. Hashmi, A. A. (1994). *Insect Pest Management, Horticultural and Forest Crops* (Vol. 2). Islamabad: Pakistan Agricultural Research Council.
2. Jha, K. (2003). *Forest Entomology*. India: Ashish Publishing House.
3. Knight, F.B., & Heeiknen, H.J. (1980). *Principles of Forest Entomology*. New York: McGraw Hill Book.

This graduate level course basically aims to provide the concepts of environmental pollution and deterioration with their effects on agriculture, forest and living organisms. It provides the students with basic knowledge of different sources of pollutants, environmental deterioration factors and their effects on agricultural sector, greenhouse effects and different types of pollution with reference of agriculture and forest, pesticide and fertilizers' pollution incurred in soil, air and water resources etc. Students will learn about determining and managing agricultural and environmental pollution.

Contents

1. Introduction
2. General concept of pollutants
3. Sources and nature of pollutants
4. Environmental deterioration, its effect on agriculture
5. Greenhouse effect
6. Types of pollution with reference to agriculture and forest
7. Pesticide and fertilizer pollution
8. Effect of pollution on soil, water, air, plants, living organisms
9. Management of pollution

Practical

1. Identification
2. Determination of sources of pollution in various substrates, viz., air, soil, water

Recommended Texts

1. Misra, S.G., & Mani, D. (1994). *Agricultural Pollution* (Vols. 1 & 2). New Delhi: Ashih Publishing House.
2. Parkash, R., & Choubey, S. M. (1990). *Environmental Pollution and Health Hazards*. India: Society of Biochemistry of India.

Suggested Readings

1. Rizvi, S.M.H. (1994). *Fundamentals of Environmental Pollution*. New Delhi: CBS Publishers.
2. Ashfaq M., & Saleem, M.A. (2010). *Environmental Pollution and Agriculture*. Lahore: Pak Book Empire.
3. Suhail, A., & Ahmad, S. (2003). *A Workbook of Agriculture & Environmental Pollution*. Faisalabad: University of Agriculture, Department of Entomology.

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 Edition. New Jersey: Prentice Hall.
2. Salvatore, D. (2007). *International economics*, 9th Edition. Wiley Publisher.

Suggested Readings

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

Scientific writing and presentation of scientific data is of utmost importance in the field of scientific research. This course is formulated in the way to familiarize the students about research methods, handling of experimental data, writing of a research report and presentation skills. Students at the end of course will be familiarized about planning and conducting a research project, collecting research data, analysis of the data from different aspects and representation and writing the research data in the form of a research paper. Students will be provided information about the Concepts of synopsis, thesis, research paper, research project and monographs and they will learn to improve their scientific presentation skills.

Contents

1. Introduction
2. Literature search for entomological information, citation
3. Collection of data and tabulation
4. Analysis and interpretation of research data
5. Report writing
6. Lab/field experimental designs
7. Concepts of synopsis, thesis, research paper, research project and monographs
8. Presentation skills

Practical

1. Use of internet sources and databases for entomological information
2. Layout of experiments; collection of data, tabulation, analysis and interpretation of research data
3. Writing synopsis, thesis, research paper, research project and monographs
4. Preparation and delivery of multimedia presentations
5. Visit and use of digital libraries

Recommended Texts

1. Davis, M. (2005). *Scientific Papers and Presentations*. London: Academic Press.
2. Dawson, C. (2009). *Introduction to Research Methods: A Guide for Anyone Undertaking a Research Project* (4th ed.). UK: How to Books.

Suggested Readings

1. Ghani, M.A., & Ashfaq, M. (Edit). (1987). *A Resume of Post-Graduate Research, 1929-1985*. Faisalabad: University of Agriculture, Department of Entomology.
2. Gilbert, I., & Himilton, C.J. (1983). *Entomology: A Guide of Information Sources*. London: Mansell Publishing.
3. Gomez, K. A., & Gomez, A. A. (1984). *Statistical Procedures in Agricultural Research* (2nd ed.). New York: Wiley Publishers.

Bee-keeping is one of most ancient and important entomological cottage industry. This course aims to provide the concepts of different species of bees, their behavior and to provide awareness of bee keeping, diseases of bees and their management. Students will learn about the scope of apiculture, types of bee species being used in the world in this industry, their biological and ecological characteristics and about their better management strategies for enhancing their productivity. Moreover, students will be practically demonstrated all the beekeeping activities including season management, queen and colony management and honey extraction protocols etc.

Contents

1. Introduction of apiculture
2. Importance, scope of apiculture industry
3. Bee species and their biology, morphology, behavior and products
4. Bee flora their distribution and flowering time
5. Beekeeping equipment, seasonal management
6. Uniting, dividing and preparation for shifting colonies
7. Bee stings, queen rearing and swarming
8. Pest and diseases of bees and their management
9. Honey extraction
10. Factors affecting honey yield
11. Importance of bees in pollination
12. Honey, its properties and uses
13. Granulation, fermentation and storage of honey
14. Uses of other bee products
15. Beekeeping as an enterprise

Practical

1. Demonstration of bee colonies
2. Observation of colonies and different casts
3. Beekeeping equipment
4. Preparation of frames and comb foundation for their hives
5. Colony inspection; visit to apiaries

Recommended Texts

1. Ahmad, R. (1979). *A Guide to Bee Keeping in Pakistan*. Extension Book.
2. Devillers, J., & Phame M. (2002), *Honey Bees: Estimating the Environmental Impact of Chemicals*. London, UK: Taylor & Francis.

Suggested Readings

1. Goodwin, R.N., & Van Eaton, C. (1999). *Elimination of American Foulbrood without the Use of Drugs. A Manual for Bee Keepers*. Napier, New Zealand: National Bee Keepers Association of New Zealand.
2. Hooper, T. (1991). *Guide to Bees and Honey*. Hampshire, UK: BAS Printers Ltd.

Biological control is one of the emerging control strategies being used against insect pests. This course is of graduate-level related to biological control. The course aims to elaborate the introduction, concept, history and scope, ecological basis of biological control, natural enemies: predators, parasitoids and insect pathogens (mode of action, application, epizootics), advantages and disadvantages, characteristics of bio-control agents, procedure of biological control: introduction; enhancement of bio control agents (introduction, conservation, mass culture, augmentation, release, monitoring and importation); rearing techniques of bio-control agents and their host insects; role of biological control in IPM. The course will enable the students, know about principles and practices of biological control.

Contents

1. Introduction, concept, history and scope
2. Ecological basis of biological control; natural enemies: predators, parasitoids and insect pathogens (mode of action, application, epizootics)
3. Characteristics of bio-control agents and procedure of biological control
4. Enhancement of bio control agents (introduction, conservation, mass culture, augmentation, release, monitoring and importation)
5. Rearing techniques of bio-control agents and their host insects
6. Role of biological control in IPM
7. Commercialization of bio-control agents
8. Quality management in biological control agents rearing

Practical

- 1 Collection, preservation and identification of predators & parasitoids
- 2 Laboratory rearing and culturing of important natural enemies
- 3 Study of extent of parasitism/predation of different bio-control agents
- 4 Storage, shipping and field release methods
- 5 Visit to public/ private bio-control labs

Recommended Texts

1. Barbosa, P. (1998). *Conservation Biological Control*. London: Academic Press.
2. Bellows, T.S., Fisher, T.W., Caltagirone, L.E., Dahlsten, D.L., Huffaker, C., & Gardh, G. (1999). *Handbook of Biological Control: Principles and Applications of Biological Control*. USA: Academic Press.

Suggested Readings

1. Copping, L.G. (2004). *The Manual of Biocontrol Agents*. A World Compendium (3rd ed.). UK: British Crop Protection Council.
2. De Bach, P. & Rosen, D. (1991). *Biological Control by Natural Enemies*. Cambridge, UK: CUP Archive.
3. Hajek, A. (2003). *Natural Enemies: An Introduction to Biological Control*. Cambridge, UK: Cambridge University Press.

The main objective of this course is to give students practical exposure in the field. Students will be assigned individual research assignments and they will learn how to independently execute and finalized a research project and how to collect, analyze and present data of the research experiments. This course is an undergraduate course for B.Sc. (Hons.) classes. This course aims to provide concepts about conduction research project and writing report. Moreover, students are allowed in this course to be attached with research institutions in order to give them practical exposure in their fields. At the end of course, each student is required to write a comprehensive research/internship report.

Contents

1. Designing and Carrying out independent research project
2. Preparing synopsis of research project
3. Conducting field and/or laboratory experiments
4. Reading and presentation of research articles
5. Recording of scientific data using different data collection methods
6. Arranging of data for analysis
7. Learning data analysis tools
8. Analysis of scientific data using statistical packages
9. Describing the analyzed results
10. Writing a scientific report
11. Presentation of scientific project

Recommended Texts

1. Ghani, M.A., & M. Ashfaq (Edit). (1987). *A Resume of Post-Graduate Research, 1929-1985*. Faisalabad: University of Agriculture, Department of Entomology.
2. Gilbert, I., & Himalton, C.J. (1983). *Entomology: A Guide of Information Sources*. London: Mansell Publishing.

Suggested Readings

1. Quinn, G.P., & Michael, J.K. (2002). *Experimental Design and Data Analysis for Biology*. London: Cambridge University Press.



MSc
(Hons)
ENTOMOLOGY

This course enables students to get familiarized with modern equipment used in Entomological Research and provide concept of software in data analysis. The course will aid in students' learning regarding use of state-of-the-art equipment in their subject field and how these equipment work. Techniques and methods in entomological science are critical to understand the physiological and morphological aspects of insect system. The course will enable students to learn micrometry, preparation of permanent slides, and various software and data analysis. Preparations of permanent and temporary slides are important which would aid in learning outcomes of this course.

Contents

1. Introduction to research methods in entomology
2. Techniques and apparatus employed in entomological research
3. Preparation of temporary and permanent mounts
4. Use of Microtomy, camera Lucida, ocular grid and scientific photography
5. Use of Bio-assay techniques, Use of Potter's tower
6. Use of Absorption Spectrophotometer and Use of Ultraviolet visual spectrophotometer
7. Use of Gas chromatography and High-performance liquid chromatography
8. Use of Amino acid analyzer, Electrophoresis, PCR and Recombinant DNA techniques
9. Ultra-centrifugation
10. Scanning and Transmission Electron microscopy and Computer software in entomology

Practical

1. Use of Methods of sampling, Analysis of data and report writing.
2. Insect sampling, collection and preservation techniques, rearing devices
3. Exercises in microtomy, preparation of permanent slides, software for data analysis
4. Scientific photography and electron microscopy
5. Maintenance and measurement of microclimate
6. Bioassay, Demonstration of insect DNA amplification through PCR methods.
7. Use of different equipment in entomological experiments, tabulation, analysis and interpretation of data

Recommended Texts

1. Bancroft, J. D., & Stevens, A. (1990). *Theory and practice of histological techniques*. London: Chaschill Livingstone.
2. Binns, M.R. (2000). *Sampling and monitoring in crop protection*. Wallingford, UK: CABI Publishing.

Suggested Readings

1. Smith, I. 1960. *Chromatographic and electrophoretic techniques* (Vol. 1) (4th ed.). London: William Heinemann Medical Books.
2. Singh, P. and Moore, R. F. (1985). *Handbook of insect rearing* (Vol. 1, 2). USA: Elsevier.

The most recent understanding of the evolution of insects is based on studies of the following branches of science: molecular biology, insect morphology, paleontology, insect taxonomy, evolution, embryology, bioinformatics and scientific computing. Although hexapods, those arthropods having six legs, including insects are the most diverse group of contemporary animals in terms of biological niches and number of species, their origin is highly debated. A key problem is the almost complete absence of fossils that connect hexapods to the other major arthropod subphyla, namely Crustacea, Myriapoda (such as centipedes and millipedes), and Chelicerata (such as scorpions and spiders). Over the years, hexapods (insects, springtails, proturans, and diplurans) have been phylogenetically linked to all of these major arthropod taxa. The recent morphological and molecular-based studies suggest an alternative interpretation that hexapods originated within the crustaceans rather than as a sister group. Aim of this course is to provide the basic concept of insect origin in the time dimension.

Contents

1. Introduction to the Origin and Phylogeny of Insects
2. Evolutionary groups of insects
3. Geological timetable in relation to origin
4. Evolutionary history of insects
5. Theories of origin of insects
6. Mechanisms of evolution
7. Cytological, Cyto-taxonomic and Embryological evidences
8. Phylogenetic theories
9. Origin of species and higher categories
10. Phylogenetic arrangement of orders and families
11. Variation of insects
12. Fossil history of insects

Practical

1. Practical demonstration of origin of species and higher categories
2. Practical demonstration of phylogenetic arrangement of orders and families
3. Practical demonstration of variation of insects

Recommended Texts

1. Borrer, D. J., & DeLong, D. M. (2005). *An introduction to the study of insects* (7th ed.). New York: Macmillan.
2. Dodson, E. C., & Dodson, I. (1986). *Evolution: Process and Product*, (4th ed.). I.W.S. Publishers.

Suggested Readings

1. Hoy, M.A. (2003). *Insect Molecular Genetics: An Introduction to Principles and Application*. San Diego: Elsevier.
2. Marjorie, A.H. (1994). *Insect molecular genetics*. USA: Academic Press.

Aim of this course is to provide the basic concept of impact of environment on insects, and insects as indices of environmental changes. Exploration of diversity and roles of insects in natural and affected environments, impact of insects and pesticides on environmental quality, and discussion of environmental ethics in entomological science. Roles and effect of entomological venture to the environment. Entomological operations threatening to environmental deterioration. Their improvement and solution including entomology and other disciplines relating to conservation of the environment. This Integrated lecture and laboratory course will cover fundamental topics in environmental entomology. The course will also explore how insects influence humanity and their role as biological indicators of overall ecosystem health. Chemical, physical properties and their effect on insects will depict biological constituents of the environment. Upon completing of this course, students will have acquired basic knowledge and skills in identification and study of insects and their role in the environment.

Contents

1. Introduction to Environmental Entomology
2. Diversity of insects in different ecosystems
3. Interactions of various groups of insects with biological constituents of the environment
4. Chemical and Physical constituents of the environment
5. Physical characterization of environmental contaminants
6. Chemical characterization of environmental contaminants
7. Impact of pollutants on insects and Non-target organisms at different levels

Practical

1. Practical demonstration of biological responses to pollutants
2. Practical demonstration of biological responses to Biogeochemical cycles
3. Practical demonstration of insects as indicators of levels of pollution

Recommended Texts

1. *Annual Review of Entomology, 1965 to date*. Palo Alto, California: Ann. Rev.
2. Anonymous (1983). *Agrochemical fate in food and environment*. Vienna: I.A.E.A.

Suggested Readings

1. McEwen, F.L., and Stephenson, G. I. (1979). *The use and significance of pesticides in the environment*. New York: John Wiley and Sons.
2. Perry, A.S. (1998). *Insecticides in agriculture and environment: retrospects and prospects*. New York: Elsevier.

The aim of this course is to provide concepts of numerical taxonomy, aims and principles of numerical taxonomy. Every year brings new and exciting adaptations of existing equipment and the development of new equipment to handle the tasks which previously were considered drudging chores, advancing at snail's pace, not only because of inefficient methodologies but also because scientists generally shun such activities and regulate them to a low priority in their plan of work. This course will help students to their own field for the application of statistical computations to biological problems, technological advances in carrying out statistical computations. The course will help to understand the principles, handling taxonomic data and types along with taxonomic characters. Handling of taxonomic data and collecting evidences is of core importance in numerical taxonomy. This course will bring insight to graduate students to really understand the taxonomic characters of insects involved.

Contents

1. Introduction to numerical taxonomy
2. Aims and principles of numerical taxonomy
3. Taxonomic data and its types and taxonomic characters
4. Taxonomic selection, coding and weightage
5. Handling of taxonomic data
6. Taxonomic evidence and estimation of taxonomic resemblance
7. Construction of a taxonomic system
8. Theory of ranking
9. Population analysis by different methods
10. Population analysis by phenetics analysis
11. Comparison of faunal elements and contemporary approach to classification
12. Phenograms/dendrograms

Practical

1. Characterization, coding and preparation of matrices
2. Generation of phenograms by applying Coefficients of Association
3. Correlation and Taxonomic Distance formulae
4. Construction of phenograms/dendrograms
5. Software programs in Numerical Taxonomy

Recommended Texts

1. Blackith, R. E., & Rayment, R. A. (1984). *Multivariate morphometrics*. London: Academic Press.
2. Clifford, H. T., & Stephenson, W. (1986). *An Introduction to numerical classification*. New York: Academic Press.

Suggested Readings

1. Grimaldi, D., & Engel, M. S. (2005). *Evolution of the insects*. Cambridge Uni. Press.
2. Duncan, T., & Stuessy, T. F. (eds.) (1985). *Cladistics. Theory & methodology*. New York, USA: Van Nostrand Reinhold Press.

This course aims to provide the modern concepts of insecticide resistance in various insect populations. There are a number of ways insects can become resistant to insecticidal crop protection and public health products: Resistant insects may detoxify or destroy the toxin faster than susceptible insects, or quickly rid their bodies of the toxic molecules. Metabolic resistance is the most common mechanism and often presents the greatest challenge. Insects use their internal enzyme systems to break down insecticides. Resistant strains may possess higher levels or more efficient forms of these enzymes. In addition to being more efficient, these enzyme systems also may have a broad spectrum of activity (i.e., they can degrade many different insecticides). The target site where the insecticide acts in the insect may be genetically modified to prevent the insecticide binding or interacting at its site of action thereby reducing or eliminating the pesticide effect.

Contents

1. Introduction to insecticide resistance and management
2. Development and types of resistance
3. Mechanism of resistance: physiological, behavioral, biochemical and genetic
4. Metabolism of insecticides; detoxification mechanism in insects
5. Phase-I reactions such as oxidation, hydrolysis, reduction and dehydrochlorination
6. Phase-II reaction such as conjugation; multiple pathways
7. Induction of detoxification enzymes
8. Management of resistance
9. Case histories of insecticide resistance management (IRM)

Practical

1. Determination of resistance, monitoring
2. Development of resistant and susceptible strains
3. Collection of potentially resistant strains of insects from the insecticide sprayed fields
4. Biochemical basis of resistance
5. Demonstration of resistance breaking techniques

Recommended Texts

1. Onstand, D.W. (Ed.) (2007). *Insect resistance management*. New York: Academic Press.
2. Pedigo, L.P., & Marlin, E. R. (2009). *Entomology and pest management* (6th ed.). New Jersey: Pearson Education.

Suggested Readings

1. Saleem, M. A. (2005). *Insecticides resistance and management*. Multan: B.Z. University Press.
2. Watson, D.L., & Brown, A.W. (1997). *Pesticide management and insecticide resistance*. USA: Academic Press.
3. Onstad D. W. (2008). *Insect resistance management: Biology, Economics, and Prediction*. Jamestown Road, London, UK: Academic Press, Elsevier.

This course aims to provide the modern concepts of molecular entomology and its applications in research and fields. This course provides a broad perspective on the molecular biology of insects and a specific focus on aspects relating to the transmission of insect-borne diseases, provides background information on essential methodologies used in molecular entomological research and discusses the importance of molecular entomology for the development of disease control strategies. The basic developmental, genetic and genomic focused modules utilize the wealth of knowledge gained from studies in the model insect organism. The course will help to understand advanced concepts of medical molecular entomology, evaluate molecular entomology-based strategies for vector-borne disease control and design molecular entomology-based disease control strategies.

Contents

1. Introduction to molecular entomology
2. Insects as a model for molecular study (*Drosophila*, Mosquitoes, Honeybee)
3. Insect genomes; nucleus, chromosomes, DNA and RNA
4. Gene structure and function; gene transcription and translation
5. Concept of introns and exons; central dogma of molecular biology
6. Primer Design and polymerase chain reaction (PCR)
7. Gene cloning and sequencing; restriction analysis, gene libraries
8. Mitochondrial and genomic DNA for insect species identifications
9. Insect population diversity/biotyping; Use of molecular markers in insects
10. RAPD, RFLP, PCR-RFLP, microsatellites and SNPs
11. Linkage and chromosomal mapping, genes regulatory processes, mutagenesis
12. Molecular basis of insect functions (insect behavior, insecticidal resistance)
13. Gene knock-in and knock-out by RNA interference, barcoding
14. DNA and protein sequence alignments and use of bioinformatics tools

Practical

1. Demonstration of insect DNA extractions, PCR amplification
2. Gel electrophoresis, gene cloning and plasmid DNA extractions
3. DNA hybridization (Southern and northern blots); RAPD, RFLP analysis techniques
4. Use of Bio-Informatics software tools

Recommended Texts

1. Hall, B.G. (2007). *Phylogenetic trees made easy: A how to manual* (3rd ed.). Massachusetts, USA: Sinauer Associates.
2. Handler, A. M., James, A.A. (Eds.). (2004). *Insect transgenesis: Methods and applications, Comprehensive review of insect gene transfer, its methodologies, applications and risk assessment and regulatory issues*. Florida, USA: CRC Press.

Suggested Readings

1. Glick, B.R., Pasternak, J. J., & Patten, C. L. (2009). *Molecular biotechnology: Principles and applications of recombinant DNA* (4th ed.). Washington, DC: ASM Press Publishers.
2. Gray, J. Richard, B. (2003). *Insect pheromone biochemistry and molecular biology*. New Jersey: Elsevier, Academic Press.

This course aims to provide the knowledge of identification, biology, epidemiology of insects and other arthropods of medical importance. This course presents current information on the pests that have and continue to plague humans and animals. This course will explore the arthropods of importance in human health and those that impact livestock production, companion animals and wildlife through direct attack and disease transmission. It will include information on their biology, ecology, potential for disease transmission and management. Students will learn to identify the common pests and the principles of epidemiology and pest management. The factors involved in the epidemiology of vector-borne diseases, host, parasite, vector and reservoir, will be stressed, as this is the recurrent theme in medical entomology. Students will be encouraged to share their own experiences throughout the course. The course is useful in understanding primary vectors of medical and veterinary entomology that will help in explaining the reasons underlying the major diseases outbreaks in human history and relate to why these outbreaks occasionally occur in today's modern world.

Contents

1. Introduction to medical and veterinary entomology
2. Epidemiology; identification, biology and management of insects and other arthropods of medical and veterinary importance insect
3. Arthropods transmitting diseases
4. Symptoms and diagnosis; venoms, defense secretions and allergens due to arthropods
5. Economics of livestock and poultry pests with emphasis on different flies, midges, mosquitoes, ticks, mites, beetles and other important insects of medical and veterinary importance

Practical

1. Surveillance and collection of different insects
2. Identification and management of different insect- pests of medical and veterinary importance
3. Collection of insects in relation to diseases of man and domestic animals

Recommended Texts

1. Aldridge, B. (2004). *Medical entomology: Textbook of public health and veterinary*. London: Chapman and Hall.
2. Kettle, D.S. (1995). *Medical and veterinary entomology*. (2nd ed.). UK: CAB International.

Suggested Readings

1. William, R. E. (2009). *Veterinary entomology: livestock & companion animals*. Florida, USA: CRC press.
2. Tyagi, B. K. (2003). *Medical entomology: A handbook of medically Important insects & other arthropods*. Jodhpur, Rajasthan, India: Scientific Publisher.
3. Eldridge F., Edman, E. (2003). *Medical entomology: A textbook on public health and veterinary problems caused by arthropods*. Berlin, Germany: Kluwer Academic Publishers.

This course aims to provide the broad overview of insects in relation to plant diseases with special emphasis on their vector status. Insects in relation to plant diseases will focus on the status, needs, and the principles of insect and diseases in plants. This course will cover the key insects and diseases by these insects in major crops of global importance throughout the world with an emphasis on developing countries in Central and South America, Africa, Asia, and the Middle East. The objective of this course is to familiarize students with common insect and disease problems. Students will gain a basic understanding of the biology and ecology of these pests and the management of biotic and abiotic problems within a plant health care or integrated pest management context. In each class, several diseases or insect pests will be profiled. The course material will be distributed in class and will be used to increase student interaction.

Contents

1. Introduction to insects in relation to plant diseases
2. Identification, biology of insect and mite vectors of plant diseases
3. Mode of transmission of plant pathogens by insects and mites
4. Insect adaptation for pathogen transmission, interrelationship of insect
5. Plant and microorganism, horizontal and vertical transmission
6. Beneficial microorganisms in insect control
7. Study of causing organisms
8. Etiology, symptoms and control of important fungal, bacterial and viral diseases of crop plants transmitted by insects and mites

Practical

1. Identification of insect and mite vectors and pathogens
2. Rearing and handling of insect vectors for plant pathological studies
3. Study of mode of transmission of plant pathogens by insect and mite vectors

Recommended Texts

1. Boucias, D.G. (1998). *Principles of insect pathology*. London: Chapman and Hall.
2. Jeppson, L.R., Keifer, H. H., & Baker, E. W. (1975). *Mites injurious to economic plants*. California, USA: Univ. Calif. Press.

Suggested Readings

1. Leach, J.B. (2007). *Insect transmission of plant diseases*. Delhi, India: Biotech Books.
2. Tanada, Y. (1992). *Insect pathology*. New Jersey: Academic Press.
3. Cater, W. (1973). *Insects in relation to plant disease* (2nd ed.). New York: John Wiley & Sons,

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. The special problem makes you do your work by prioritizing the needs and time frames completing all your tasks peacefully avoiding panic. 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 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 an 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.

This course will be helpful for the identification of immature insect families with the given characteristics. This course will focus on the anatomy/morphology, and taxonomy of immature insects at the ordinal and familial levels. Emphasis is placed on those taxa that exhibit true metamorphosis. Collection and preservation techniques will also be discussed. Laboratory time will emphasize the utilization of taxonomic keys to identify immature insects to order and family (occasionally to genus and species). Field trips will be taken throughout the course of the semester, and an extensive collection of immature insects is required. Two exams will be given that will include keying out unknown specimens and answering questions regarding the lecture material covered. Identification of unknown specimens in the teaching collection will also be required with anatomical and taxonomic descriptions of orders and common families. Students will also be provided with field exposure to various habitats and collecting techniques.

Contents

1. Introduction of classification eggs and immature stages of insects
2. Types of eggs and chaetotaxi of various immature stages for their identification purposes
3. Development of keys for identification of eggs and immature stages of economically important orders up to family level
4. Classification and phylogeny of various insect groups through their eggs and immature stages

Practical

1. Collection and preservation of immature stages of insects
2. Preparation of immature insects for identification
3. Identification and classification of immature stages of following insect orders up to family level

Recommended Texts

1. Borrer, D. J., & DeLong, D. M. (2005). *An Introduction to the Study of Insects*. (7th ed.). New York: Macmillan
2. Grimaldi, D., & Engel, M. S. (2005). *Evolution of the insects*. Cambridge, UK: Cambridge Uni. Press.

Suggested Readings

1. Chu, H.F. (1983). *How to know the immature Insects*. Iowa, US: W.M.C. Brown Publishers.
2. Lawrence, J. F., Hastings, A. M., Dallintz, M. J. Palmy, T. A., & Zurcher, E. J. (1999). *Beetle larvae of the world*. Australia: CSIRO.
3. Peterson, A., (1960). *Larvae of insects, Part-I*, (4th ed.). Arbor, Michigan : Edwards Brothers Inc.
4. Stehr, F., (1991). *Immature insects* (Vol. I &II). USA: Kendall - Hunt Publishing.

This course aims to provide knowledge about the importance of mites and their impact on crops, vegetables, fruits and stored products. The Acarology course will make students proficient in the identification of a broad range of mite diversity. Additionally, the course will broaden graduates understanding of mite ecology, evolution, and biogeography. This course will review the mites associated with crops, ornamental plants and stored products. The major emphasis will be on identification and classification of acari associated with humans and domestic animals. The course will also concentrate on ticks (Ixodida) and will deal with all the other groups of vertebrate parasitic mites. In addition to the standard emphasis of identification, it will include extensive discussions of disease transmission. The discussions of various Mesostigmata (Dowling), Astigmata, including feather mites (Klimov), dust mites (Needham), Trombiculoidea (chiggers) (Welbourn), and miscellaneous Prostigmata (Klompen).

Contents

1. Introduction to acarology
2. Methods of collection, rearing and preservation of different mites
3. Methods of collection, rearing and preservation of different mite related insects
4. External and internal morphology and physiology of mites
5. Reproduction and development of mites and classification of mites
6. Mites as pests of important crops, vegetables, fruit trees
7. Mites in stored products and their management
8. Parasitic and predatory mites
9. Losses caused by and management of mite pests
10. Ecology and dispersal of mites
11. Methods of estimation of mite population
12. Mites and plant diseases and resistance mechanism in mites

Practical

1. Collection, preservation and sampling of mites
2. Rearing techniques and identification of phytophagous mites
3. Predatory, parasitic and stored grain mites
4. Preparation of permanent slides of mites
5. Estimation of mite population, losses in crops, vegetables, fruit plants and stored grains

Recommended Texts

1. Chhillar, B.S., & Gulati, R. (2007). *Agricultural acarology*. Delhi: Daya Publishing House.
2. Evans, G.O. (1992). *Principles of acarology*. C.A.B. Cambridge: International Cambridge University Press.

Suggested Readings

1. Krantz, G.W., & Walter, D.E. (2009). *A Manual of acarology*. Texas: Texas Tech. University Press.
2. Zhang, Z.Q. (2003). *Mites of greenhouses: Identification biology and control*. New York: Elsevier.
3. Sabelis, M. W. (2010). *Trends in acarology: Proceedings of the 12th International Congress*. UK: Springer Dordrecht Heidelberg London.

This course aims to provide concepts of insecticide application equipment in the field. This course is developed primarily for graduates that are intended to work in turf and landscape but can be helpful to anyone who applies pesticides. Learners will be able to describe why calibration is important and be able to list the materials and tools needed in order to calibrate equipment. They will see various examples of pesticide application equipment for liquid, granular, and soil drenching and soil injection applications. The course includes many examples of calculations needed to calibrate equipment. Learners will be able to describe why calibration is important and be able to list the materials and tools needed in order to calibrate equipment. Various examples of pesticide application equipment for liquid, granular, and soil drenching and soil injection applications as well as examples of calculations needed to calibrate equipment, are presented throughout the course.

Contents

1. Introduction to insecticide application equipment
2. History of development of application equipment
3. Different systems of insecticide application
4. Type of dusting equipment
5. The maintenance and operation of hand dusters, bellow type dusters, rotary hand and power dusters
6. Types of spraying equipment
7. Components of a spray machine
8. Maintenance and operation of compression and pump systems, hand, power sprayers
9. Maintenance and operation of hand, power and granular applicators
10. Comparative study of ground and aerial application equipment
11. Calibration methods and measurement of droplet size

Practical

1. Study of different parts and assembling of sprayers, dusters and granule applicators
2. Assembling and working of different application equipment
3. Study of different types of spray guns, lances, hoses and nozzles
4. Aerosols and aerosol bombs
5. Calibration and measurement of droplet size

Recommended Texts

1. Mathews, G.A. (1992). *Pesticides application methods* (4th ed.). New York: Longman.
2. Mathews, G.A. (1984). *Pest management* (1st ed.). New York: Longman.

Suggested Readings

1. Nastec. (2005). *Technology of application of pesticides*. Florida: CRC Press.
2. Pedigo, L.P. (2002). *Entomology and pest management* (4th ed.). New Delhi: Prentice Hall.
3. Pfadt, E. R., (1985). *Fundamentals of applied entomology* (4th ed.). New York: The Macmillan.

The aim of this course is to impart knowledge about toxicity of important groups of insecticides in insects and higher animals with reference to their biochemical and genetic basis of mechanism of action. Insecticide toxicology deals with the nature, properties, effects and the detection of different insecticidal groups in insects, animals, plants, human and environment. This course will impart knowledge about toxicity of important groups of insecticides in insects and higher animals with reference to their biochemical and genetic basis of mechanism of action. The overall course objective is to increase the understanding of processes involved in the toxic response in insects to insecticides, insecticide classification, and consequences of insecticide use. At the end of the course the student is expected to outline the history of insecticides, recognize the major classes of insecticide and understand their mode of action, list and describe processes involved in toxico-dynamics of insecticides, become aware of the limitations of insecticide use such as resistance and environmental contamination and develop a basic understanding on performing insect bioassays.

Contents

1. Introduction and general concepts of insecticide toxicology
2. Theory and principles of bioassay
3. Chemistry and comparative toxicology of some common insecticides
4. Mechanism of action of major groups of insecticides
5. Mammalian and phyto-toxicity of insecticides
6. Enzyme activation and inhibition by insecticides at various levels
7. Detoxification mechanisms
8. Joint action of insecticides, (synergism and antagonism)
9. Handling and standardization of insects in insecticide tests
10. Methods for testing formulations of different insecticides under field and laboratory conditions

Practical

1. Laboratory equipment used in toxicology experiments; gross symptoms produced by representative insecticide groups
2. Relationship between dosages and responses
3. Use of time-mortality determination in comparing the relative toxicity of insecticides
4. Preparation of spectral transmittance and concentration transmittance curves
5. Bioassay of insecticides

Recommended Texts

1. Gupta, H.C.L. (2001). *Insecticides: toxicology and uses*. Udaipur: Agrotech.
2. Hassal, K.A. (1990). *The Biochemistry and uses of pesticides: Structure, metabolism, mode of action and uses in crop protection*. UK: ELBS/Macmillan.

Suggested Readings

1. Srivastava, R.P. (1989). *A textbook of insect toxicology*. Ahmadabad: Himanshu Publication.
2. Wilkinson, C.F. (1976). *Insecticides biochemistry and physiology*. Heyden, London, New York, Rheine: John Wiley and Sons.

This course aims to provide concepts of insect cytogenetics and cytotaxonomy. The purpose of this course is to examine some of the basic concepts and problems relating to insect cytogenetics, which are now available in the cytotaxonomy of insects and to introduce some modern methods to entomologists, especially for those, who wish to use cytological characters to reconstruct phylogeny. The course also deals with characters and cell division in insects, chromosomes and parthenogenesis in insects, i.e., identifying the taxa at different taxonomic levels, determining the rational taxonomic status of a given taxon, and reconstructing the phylogenetic relationship among the taxa studied. These problems are such as correct identification of the taxa studied, rational treatment of the tissue, careful distinction between the true chromosome polymorphism and the sibling species with their dissimilar cytological characters, full understanding of euploidy will have a special attention during this course.

Contents

1. Introduction to insect cytogenetics
2. Study the structure of insect cell
3. Characteristics and cell division in insects
4. The structure, number, diversity and types of chromosomes in insects
5. Chromosomes and Parthenogenesis in insects
6. The impact of ecology on the chromosomes and modern concept of gene
7. The characters determined by genes in insects
8. Gene expression affected by environmental factors
9. Determination of sex in insects
10. Mutations and variations in insects
11. Use of chromosomes in taxonomy

Practical

1. Study of a typical insect reproductive cell, cell division, types and number of chromosomes in important insect groups for identification / classification
2. Study of insect resistance
3. Study of different types of genetic variations in insects
4. Genetical identification of species and biotypes in insects

Recommended Texts

1. Atherly, A. G., Girton, J. R., & McDonald, J. F. (1999). *The science of genetics*. Fort Worth: Saunders College Publishing.
2. Blackman, R.L. Hemitt, G.M. and Ashburner, M. (1980). *Insect Cytogenetics*. Oxford, London: Black-Well Scientific Publications.

Suggested Readings

1. Dnyansayer, V.R. (1992). *Cytology and genetics*. New Delhi: Tata McGraw-Hill Publishing.
2. Hajorie, A. H. (1994). *Insect molecular genetics*. USA: Academic Press.
3. Swanson, C.P., Merz, T., & Young, W. J. (1998). *Cytogenetics - The chromosomes in division, inheritance and evolution* (3rd ed.). New Delhi: Prentice-Hall of India.

The aim of this course is to provide advance concepts of insecticide poisoning, residual effects and their perception on safe use of insecticides. Pesticides are substances or mixtures of substances that are mainly used in agriculture or in public health protection programs in order to protect plants from pests, weeds or diseases, and humans from vector-borne diseases, such as malaria, dengue fever, and schistosomiasis. Exposure to pesticides can be through contact with the skin, ingestion, or inhalation. The type of pesticide, the duration and route of exposure, and the individual health status (e.g., nutritional deficiencies and healthy/damaged skin) are determining factors in the possible health outcome. Within a human or animal body, pesticides may be metabolized, excreted, stored, or bio-accumulated in body fat. Pesticide use as part of a public health program may lead to increased exposure for large segments of the population, including exposure to sensitive subpopulations. This course carefully evaluates human and ecological risks from exposure to pesticides, including bystander and occupational exposure with an emphasis on applicator's health in making decisions about all pesticides, including pesticides with public health uses.

Contents

1. Insecticides poisoning and its importance to public health
2. Toxic effects of insecticides on indoor inhabitants, farmers, field workers and their domesticated animals
3. Distribution of pesticide residues in soil, ground water, drinking wells and air
4. Insecticide residues poisoning in blood, fat bodies. and the acute diseases they cause
5. Public health and environmental consideration
6. Farmers perception of acute poisoning and safe measures
7. First aid procedures; laboratory verification
8. Treatment of insecticide poisoning
9. Insecticides monitoring; safe use of insecticides and knowledge of antidotes
10. Transport, storage and disposal of insecticides
11. Insecticide labeling

Practical

1. Determination of pesticide residues in soil, water, vegetables fruits, milk, cereals, human blood, fat bodies and vital organs
2. Survey for finding farmers/public perception about pesticide poisoning

Recommended Texts

1. Dhaliwal, G. S., & Singh, B. (2000). *Pesticides and environment*. New Delhi, India: Commonwealth Publishers.
2. Gupta, H. C. L. (2001). *Insecticides: toxicology and uses*. Udaipur: Agrotech.

Suggested Readings

1. Oudejans J. H. (1991). *Agropesticides and functions in integrated crop protection*. United Nations. Bangkok, Thailand: ESCAP.
2. Ashfaq, M., & Saleem. M.A. (2010). *Environmental pollution and agriculture*. Lahore, Pakistan: Pak Book Empire.

This course aims to provide concepts of biochemistry of insect energy pathways in different life stages. This will help to understand the insect biochemical cycles necessary for their life. Insect physiology and biochemistry is discussed in the following categories: Nutrient flow through insects including nutrient capture, digestion, absorption, circulation, intermediary metabolism, energy metabolism, detoxification, excretion and electrolyte homeostasis. Embryologic, developmental, reproductive, and neurophysiologic systems are covered, as well as respiration and diapause, including the basic molecular mechanisms. Communication systems including mechanical (tactile, acoustic, visual) and chemical (hormones, pheromones, allomones, kairomones, necromones) in terms of signal characteristics, sending and receiving mechanisms. Selected topics are further explored in laboratory exercises. Students will get basic knowledge of insect communication including mechanical (tactile, acoustic, visual) and chemical (hormones, pheromones, allomones, kairomones, necromones) systems in terms of signal characteristics, sending and receiving mechanisms.

Contents

1. Introduction to insect biochemistry
2. Energy metabolism and production in insects
3. Biochemistry of cuticle, muscles, flight, synaptic transmission, light production, biochromes, hormones and kairomones
4. Biochemical mechanism of Insect growth regulators and diapause in insects
5. Metabolism and role of carbohydrates, proteins and lipids in insects
6. Chemical control of insect behaviour
7. Biochemical defenses in insects

Practical

1. Chemical identification of insect species and biotypes
2. Pheromone extraction, its identification and control in insects
3. Hormonal control of insect growth and development.
4. Quantitative analysis of Amino acids, proteins, uric acids in haemolymph; amylase etc.

Recommended Texts

1. Chapman, R.F., (1998). *Insects: Structure and function*. (4th ed.). New York: Elsevier.
2. Candy, D. J., & Kilby, B. A. (1978). *Insect biochemistry and function* (2nd ed.). London: Chapman and Hall.

Suggested Readings

1. Gilmour, D., (1961). *The Biochemistry of insects*. London: Academic Press.
2. Morgan, E.D. (2004). *Biosynthesis in insects*. London, UK: The Royal Society of Chemistry.
3. Rockstein, M., (1978). *Biochemistry of insects*. New York, USA: Academic Press.
4. Turner, R. B. (1977). *Analytical biochemistry of insects*. New York: Elsevier Scientific Publishing.

The basic objective of this course is to provide knowledge in the area of insect behavioral chemical and physical interaction, host selection and sexual communication. The course deals with the chemical ecology of insects to explain the role of semiochemicals in plant-herbivore, herbivore-carnivore and plant-carnivore interactions. The semiochemicals, mediating tritrophic interactions may be produced by plants, herbivores or their natural enemies. Some semiochemicals attract the herbivores and carnivores and mediate interaction among them, while on the other hand some repel them. The semiochemicals are used by herbivores, parasites and predators as cues to locate food, host or prey. All the organisms in an ecosystem are linked biochemically and their relationship is obvious in food chains and food webs. Another important feature of tritrophic interaction is that the alternate trophic levels in food chain usually have symbiotic relationship. The natural enemies of herbivores favor plant by reducing the herbivore and plants favour the natural enemies by making herbivores more vulnerable to them.

Contents

1. Introduction to chemical ecology of insects
2. Odor dispersion in still air and wind
3. Effect of wind speed and air temperature
4. Chemo- orientation in walking and flying insects
5. Insect-plant interactions
6. Pollinators ecology
7. Chemical and physical interactions
8. Warning coloration and mimicry
9. Warning coloration and predator learning
10. Sexual communication with pheromones and uses of insect pheromones in plant protection

Practical

1. Practical demonstration of parasitoids performance and their host relationship
2. Determination of sources of parasitoid behavioral chemicals
3. Calculation and measurement of modes of mimetic resemblance

Recommended Texts

1. Barbosa, P. and Letournean, D. (1989). *Novel aspects of insect plant interactions*. New York: John Wiley & Sons.
2. Bell. W.J and Carde, R. T. (1994). *Chemical ecology of insects*. London: Chapman and Hall

Suggested Readings

1. Jutsum, A.R. and Gorgen, R.F.S. (1989). *Insect Pheromones in plant protection*. UK: John Wiley & Sons.
2. Harbone, J.A. (1998). *Introduction to ecological biochemistry*. London: Academic Press.

This MSc level course aims to impart knowledge about various insect groups to solve medico-legal cases and different puzzling crimes. This course will examine the roles that insects play in the field of Forensic Science. Specifically, we will be focusing on the entomological contributions that have served to further our understanding of how both human and animal remains decompose. It will aid to identify forensically important insects, in partnership with proper collection and rearing techniques, and how to properly read and analyze scientific papers. The overall goal is to gain an understanding of how forensic entomology is utilized, and to understand how forensic entomology techniques are used to identify forensically important insects, and how insects are used in neglect, abuse, and food contamination cases. The students will be able to properly collect and rear forensically important insects and will learn the proper way to prepare and write a case report.

Contents

1. History and scope of Forensic Entomology
2. Study of various insect groups and other arthropods related to medico-legal investigations
3. Involvement of arthropod in puzzling events of murder, suicide, rape, physical abuse, control
4. Review and survey of insect life histories, life cycle and faunal succession of arthropods related to medico-legal cases and survey of the following insects as indicators
5. Hister beetles (Histeridae), Carrion beetles (Silphidae), Ham beetles (Cleridae), Skin hide beetles (Dermestidae), Blow flies (Calliphoridae)
6. Flesh flies (Sarcophagidae), Lesser corpse flies (Sphaeroceridae), Sun flies (Heleomyzidae), Black soldier flies (Stratiomyidae), Rove beetles (Staphylinidae), House flies (Muscidae), Cheese flies (Piophilidae), Coffin flies (Phoridae), Scarabs beetles (Scarabaeidae)
7. Macrocheles mites as feeder in early stages of decomposition, Tyroglyphids as feeder on dry skin
8. Review of classification of ages in decomposition of human and animal remains
9. Uses of insect and arthropods in investigation of the causes of death and the duration of PMI

Practical

1. Sampling, rearing, and preservation techniques in forensic entomology
2. Survey, identification and biology of insects and arthropods of forensic importance
3. Study and analysis of court room proceedings regarding medico-legal cases
4. Visit to forensic laboratories/hospitals

Recommended Texts

1. Byrd, J. H., & Costner, J. L. (2001). *Forensic entomology*. Florida: CRC Press.
2. Catts, E. P., & Haskell N. H. (1990). *Entomology and death. A procedural guide*. Clemson, SC: Joyce's Print.

Suggested Readings

1. Greenberg, B., & Kunich, J. C. (2002). *Entomology and the law: Flies as forensic indicators*. Cambridge: Cambridge University Press.
2. Smith, K. G. V. (1986). *A manual of forensic entomology*. Ithaca, New York: Comstock's Publishing Associates, Cornell University Press.

Neurobiology is an internationally important research field where biological basic research and medical research come very close. The course will introduce students to read, present and discuss original scientific literature on the subject of neurobiology. The course aim is to present the main topic areas in neurobiology using structure as a guide to function. The main concepts will be demonstrated in the context of the olfactory system using lectures, seminars, discussion and practical laboratory assignments. Analyzing insects enables important insights into the organization of neurons in the central nervous system for the generation and control of natural movements. This course associated analysis always links the actions of neurons directly to the behavior in which they are involved, and uses a combination of intracellular recording and staining methods, behavioral analyses with high-speed video, antibody staining, pharmacology, calcium imaging and confocal microscopy. The course includes understanding cell biology of neurons, coding in neurons by means of electrical potentials, synapse and neurotransmitter function.

Contents

1. Introduction to insect Neurobiology
2. General principles of neuroscience
3. Structure and components of the insect nervous system
4. Ionic basis for resting, receptive and active potentials
5. Synaptic transmission
6. Olfactory system circuitry, coding and plasticity
7. Basis of Cognitive Neuroscience, phases, neural circuits
8. Cellular and molecular mechanism/ pathways underlying learning & Memory
9. Concepts of molecular neurophysiology
10. Introduction to extracellular, intracellular recordings
11. Patch clamp technique, neuron imaging
12. Role of Neurotransmitters, neuromodulators and neuro-hormones

Practical

1. Insects as Model Organisms in Neuroscience to understand particular features of the neuronal networks in learning and memory
2. Plan, perform and analyze experiments in basic neurobiology
3. Dissection of insect brain, Learning and memory experiments with insects
4. Olfactory experiments in the lab especially with honeybee and other model insects
5. Demonstration for different phases of learning and memory with experiments

Recommended Texts

1. Kandel, E. R. Schwartz, J. H., & Jessel, T. M., Siegelbaum, S. A., & Hudspeth, A. J. (Eds.) (2012). *Principles of neural science* (5th ed.). New York: McGraw-Hill, Health Professions Division.
2. Burrows, M. (1996). *The neurobiology of an insect brain*. Oxford: Oxford University Press.

Suggested Readings

1. Bill, S., & Hansson. B.S. (2010). *Insect olfaction* (1st ed.). Berlin: Springer.
2. Papaj D. R., & Lewis, A.C. (Eds.) (1993). *Insect learning. Ecology and evolutionary perspectives*. New York: Chapman and Hall.

The objective of this course is to provide knowledge about insect rearing techniques for natural predators, parasites and other insects of economic importance. This course is dedicated to advancing insect rearing through formal science and technology education with up-to-date rearing practices, data driven research, quality and process control in rearing systems, quantitative diagnostic techniques and insectary problem solving through a multidisciplinary approach. This course is rich in information on all aspects of insect rearing. The course is aimed at helping people who rear insects understand the complexities of the entire range of rearing organization (insects' biology, feeding habits in relationship to rearing quality, basic physiological ecology in a rearing framework, diet chemistry and physics, microbial interactions in the rearing system, quality and process control in rearing systems, and many other subjects that clearly need understanding and attention in order to rear quality insects).

Contents

1. Introduction to Insect Rearing Techniques
2. General principles of rearing
3. Basics of insect feeding and reproductive biology of different insect pests, parasitoids and predators in relation to rearing
4. Insect diets (development of diets, components of diets, diet assessment and quality control and microbiology of insect diet)
5. Insectary environments
6. Packaging technology
7. Quality control in mass-rearing systems

Practical

1. Operation of standard rearing equipment (balances, volumetric equipment, pH meters, microscopes, spectrophotometers, various kinds of diet processing equipment)
2. Diet-making methodology
3. Practical instructions in the rearing of different important insect pests, parasitoids and predators
4. Visit to different insect rearing laboratories

Recommended Texts

1. Cohen, A. C. (2005). *Insect diets, science and technology*. Boca Raton, London, New York, Washington, DC: CRC Press.
2. Brewer, F.D. & Lindig, O. (1984). Ingredients for insect diets. Quality assurance, sources, and storage and handling (pp. 45–50). In King, E. G., & Leppla, N. C. (Eds.) *Advances and challenges in insect rearing*. New Orleans, LA, USA: Agricultural Research Service, United States Department of Agriculture.

Suggested Readings

1. Bernays, E.A., & Chapman, R. F. (1994). *Host-Plant selection by phytophagous insects*. New York: Chapman & Hall, King, E. G., and Leppla, N. C. Eds. USDA, ARS.

This course is designed for MSc (Hons)/MPhil programs of agriculture sciences. This course 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 knowledge will be provided to the students to improve their analytical skills. These activities 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, Inverse Gaussian regression
11. Non-linear regression
12. Dose Response Curves

Recommended Texts

1. Montgomery, D. C. (2017). *Design and analysis of experiments* (9th ed.). New York: John Wiley & Sons.
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. 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.



PhD
ENTOMOLOGY



This course aims to provide the concepts of population growth of insects in different environmental parameters. This course also throws light on the essential and limiting factors required by insects for their survival. Sampling is very important for the assessment of population. Different sampling techniques, modeling and attributes will be studied. The power of reproduction varies with insect. Some insects have high fecundity rate, while, others have very low. Different life stages of insects such eggs, number and shape of eggs, hatching time, habitat, suitable temperature for hatching, larval instar, larval food, duration of larval instars, pupal stage, duration of pupal stages and adult life span will be the focus of this course.

Contents

1. Introduction to advance insect ecology
2. Environmental requirements of insects
3. Essential elements and limiting factors
4. Trophic spectrum
5. Population sampling
6. Population modeling and attributes
7. Fecundity and life tables
8. “K” factor analysis
9. Regression, co-existence & co-habitation
10. Competition and mutual displacement
11. Variations, growth theories and indices

Practical

1. Use of computer simulations in population of insects
2. Computer modeling used by Ecologists
3. Clarification and interpretation of large field data by clustering, transforming, matrices and multi-variate analysis.

Recommended Texts

1. Atwal, A. S., & Bains, S.S. (2005). *Applied Animal Ecology*. Ludhiana: Kalyani Publishers.
2. Siemann, E., & Weisser, W.W. (Eds.) (2004). *Insects and Ecosystem Function*. Berlin: Springer Science & Business Media.

Suggested Readings

1. Borrer, D. J., & DeLong, D.M. (2005). *An Introduction to the Study of Insects*. (7th ed). New York: Macmillan.
2. Raman, A. (1997). *Ecology and Evolution of Plant Feeding Insects in Natural and Man-made Environments*. India: International Scientific Publications.

This course aims to provide the concepts of structure and function of various organs along with organ systems of insects. Insects are identified on the basis of DNA barcoding. But in spite of advancement in insect sciences and insect molecular biology, the importance of the insect morphology cannot be denied. Insects are identified on basis of different integument processes such as setae, spines, spurs and scales. The structure and color of insect integument have different variation. Insects have different type of mouthparts such as sucking, chewing, lapping and licking type based on their feeding mode. The objective of this course also includes the modification of labrum, mandibles, maxillae, and labium in different insect orders. Similarly, the modifications of head, thorax and abdomen structures are also important for insect identification. Insect appendages such as antennae, wings and genitalia are important for insect classification.

Contents

1. Introduction to Advanced Insect Morphology
2. Study of structure of integument
3. Insect Integument processes (setae, spines, spurs, scales, etc.)
4. Modifications of various mouthpart structures
5. Segmentation and structure of head, thorax and abdomen
6. Wing structure in insect orders and families of economic importance
7. Other body appendages in adult and immature insects
8. Comparative study of genitalia in various groups of insects
9. Thermoregulatory, visual, auditory, glandular and luminous organs in insects

Practical

1. Comparative structure of insect head, thorax, abdomen and their appendages in different insect orders
2. Preparation of temporary and permanent mounts of different body parts and integument
3. Comparative structure of genitalia in various insect orders, examination of different types of setae, spines, spurs and scales in insects; dissection of soft-parts and organ systems
4. Study of visual, auditory, thermoregulatory, scent, sound producing and luminous organs

Recommended Texts

1. Champan, R.F. (2000). *The Insects: Structure and Function* (4th ed.). UK: Hodder and Stoughton.
2. Duporte, E. M. (1977). *Manual of Insect Morphology*. New York: Reinhold Publishing Corp.

Suggested Readings

1. Gillott, C. (1995). *Entomology* (2nd ed.). New York and London: Plenum Press.
2. Mcgavin, G.C.(2001). *Essential Entomology*. New York: Oxford University Press.

Insect Physiology is the study of the body functions of insect systems. As a component of this course, we will examine some major biochemical molecules and actions to study structures and functions within the physiological systems. The students in this course will become familiar with the physiological systems in insects, such as digestion, respiration, circulation, excretion, reproduction, reception and perception. Students will identify the importance of hormonal system in insects, and how hormonal system controls the insect system. Students will develop an understanding how insect physiology is important as a major research area in entomology. This course will enable students to study the embryonic development and comparative embryology in different group of insects. Insects become resistant to insecticides with the excessive use of insecticides. To control the insects, the understanding of insecticide resistance mechanism in insects is important to study. Students will be able to study the bases of insecticide resistance in insects with focus on hormones, pheromones and glandular secretions.

Contents

1. Introduction to advanced insect physiology and embryology
2. Advances in physiology of integument, growth, development and diapauses
3. Digestion, respiration, circulation, excretion, reproduction, reception and perception
4. Neuro-muscular physiology, Enzymatic functions
5. Biological clocks; embryonic development and organogenesis in different groups of insects
6. Study of comparative embryology in different groups of insects
7. Physiology of locomotion and resistance and physiology of hormones and pheromones
8. Physiology of glandular secretion, thermoregulation, sound and light production

Practical

1. Genetic and hormonal control of insect growth
2. Development and breaking of diapauses
3. Digestion in different parts of alimentary canal and salivary glands
4. Oxygen consumption and carbon dioxide production and determination of respiratory quotient
5. Qualitative and quantitative analysis of haemocytes
6. Estimation of blood proteins and uric acid in excreta and water loss
7. Pheromones as sex attractants and determination of visual, gustatory, olfactory and acoustic
8. Thermoregulatory responses and experiment on wing beat frequency

Recommended Texts

1. Berridge, M.J., & Treherne, J.E. (1982). *Advances in Insect Physiology*. New York: Academic Press.
2. Chapman, R.F. (1998). *The Insects; Structure and Function*.(4thed.). New York: American Elsevier Publishing.

Suggested Readings

1. Howse, P., Stevens, I., & Jones, O. (1998). *Insect Pheromones and their Use in Pest Management*. London: Chapman and Hall.
2. Kerkut, G.A., & Gilbert, L.I. (1985). *Comprehensive Insect Physiology, Biochemistry and Pharmacology*. Oxford, New York, Toronto, Sydney, Paris, Frankfurt: Pergamon Press.
3. Rockstein, M. (Ed.) (1973-1974). *Advances in Insect Physiology*. (Vols. 1-6) (2nd ed.). New York: Academic Press.

Insect behavior is defined as the response of insect body to internal and external stimuli. The study of behavior involves the study of insect relationship with their environment. Students will be able to understand the basic concepts to define insect behavior, define the major internal and external processes that are responsible for insect behavior, figure out the relationship of an insect habitat with insect behavior. Students will use scientific approaches in laboratory and field to observe the insect behavior. As insects are among the most diverse organisms on earth and their behavior is equally diverse. Thus, insects can be used as model systems, easily studied and manipulated, to understand the general principles of behavior. The course will help the students to learn the type of insect behavior, different type of sensory receptor such as mechano-reception, hygro-reception, thermo-reception, photoreception. Behavior in insect is controlled by nervous system and insect hormonal system. Overall, this course aims to observe, record, and analyze each species' behavioral repertoire in order to understand the roles of development, ecology, physiology and evolution in shaping that behavior.

Contents

1. Introduction and types of behavior
2. Sensory receptors (mechanoreception, hygromoreception, thermo-reception, photoreception)
3. Nervous system and behavior
4. Hormones and behavior
5. Displacement (causes of migration, classes of migration, adaptive nature of migration)
6. Communication (chemical, acoustic, communication, visual, tactile communications)
7. Sexual behavior and reproduction
8. Host selection and feeding behavior
9. Defense (behavioral, structural, coloration defenses)
10. Population behavior
11. Social behavior

Practical

1. Practical demonstration of orientation, navigation and homing
2. Survey and communication behaviour, migration and its types
3. Use of pheromones in field crops and their role in tactile behavior

Recommended Texts

1. Borrer, D. J., & DeLong, D.M. (2005). *An Introduction to the Study of Insects* (7th ed.). New York: Macmillan.
2. Grimaldi, D., & Engel, M.S. (2005). *Evolution of the Insects*. Cambridge: Cambridge Uni. Press.

Suggested Readings

1. Dentinger, D.L., Giebultowicz, J., & Sanders, D.S. (2001). *Insect timing: Cicadid Rhythmicity to season availability*. New York: Elsevier.
2. Gillott, C. (1995). *Entomology*. (2nd ed.). New York and London: Plenum Press.
3. Pedigo, L.P. (2002). *Entomology and Pest Management*. (4th ed.). New Delhi: Prentice Hall.
4. Ryan, M.F.(2002). *Insect Chemoreception Fundamental and Applied*, Kluner

Insect Nutrition is defined as the nutrients and other substances present in food that help to maintain growth, reproduction and health of an insect. Nutrition includes food intake, absorption, assimilation, biosynthesis, catabolism to excretion. This course will enable the students to learn the dietary requirements (micro and macro nutrients) of insects, approximate digestibility, ECI (efficiency of conversion of ingested food in bio mass), ECD (efficiency of conversion of digested food in to bio mass), RCR (relative consumption rate) and RGR (relative growth rate). At the end of this course, students will be able to prepare artificial diet for insect rearing and they will determine the co-efficient of digestion, phago-stimulation, tritrophic interactions between insect and predator/parasitoids. Overall, this course will impart the knowledge on insect synthetic diets for promotion of their natural growth and development.

Contents

1. Introduction
2. Dietary requirements of insects; micro and macro nutrients
3. Insects diet; determination of AD (approximate digestibility)
4. ECI (efficiency of conversion of ingested food in biomass)
5. ECD (efficiency of conversion of digested food in to biomass)
6. RCR (relative consumption rate)
7. RGR (relative growth rate)
8. Artificial diets for insects rearing
9. Micro-organisms and insect nutrition
10. Co-efficient of digestion
11. Growth and development
12. Metabolism; nutrition and host specificity
13. Phago-stimulation, tritrophic interactions between insect and predator/parasitoids

Practical

1. Preparation of synthetic diets for different groups of insects
2. Rearing of insects on synthetic, semi-synthetic and natural diets
3. Determination of co-efficient of utilization

Recommended Texts

1. Cohen, A.C. (2004). *Insect Diets: Science and Technology*. Florida: CRC Press.
2. Gilmour, D. (1965). *The Metabolism of Insects*. Edinburgh and London: Oliver and Boyd.

Suggested Readings

1. Singh, P. (1977). *Artificial Diets for Insects, Mites and Spiders*. New York: Plenum Pub.
2. Fraenkel, G. S. (1947). *Bibliography on Insect Nutrition*. USA: Cornell University Press.
3. Rodriguez, J. G. (1973). *Insect and mite nutrition: significance and implications in ecology and pest management*. Amsterdam: North-Holland Pub.

Pest management is the control of insect pests by using all insect control methods such as cultural, mechanical, physical, biological, genetic, legislative and chemical control methods. This course will provide useful information to students about the latest insect sampling techniques, determination of decision threshold, use of transgenic and genetically modified crops, use of genetic control of insect pests in IPM, role of insect growth regulators in IPM, use of stem injection method and use of pheromones in pest management research. Remote sensing is the emerging technology in insect pest management. The damage and attack by insects is assessed by remote sensing technique. This course also focuses on the use of remote sensing in insect pest control and use of radiation and radioisotopes in entomology. The most important part of this course is to visit the institute particularly nuclear institute working in insect control. Overall, this course aims to provide the concepts of advances in pest management research in Pakistan and over the globe.

Contents

1. Introduction to advances in pest management research
2. Latest insect sampling techniques
3. Determination of decision thresholds
4. Use of transgenic and genetically modified crops
5. Use of genetic control of insect pests in IPM
6. Role of insect growth regulators in IPM
7. Use of stem injection method
8. Use of pheromones in pest management research
9. Remote sensing of insect pests control
10. Use of radiation and radioisotopes in entomology

Practical

1. Visit to different relevant institutions

Recommended Texts

1. Dent, D.(1996). *Integrated Pest Management*. London: Chapman and Hall.
2. Pedigo, L.P. (2002). *Entomology and Pest Management* (4th ed.). New Delhi: Prentice Hall.

Suggested Readings

1. Alfred, D.V. (2007). *Pests of fruit crops, A color Handbook*. Manson Publishing
2. Mayer, C.D. (2004). *Biotechnological Approach for the Integrated Management*. London: Wiley Inter Sciences.
3. Upadhyay, R. K., Mukerji, K. G. , Chawola, B. P., & Dubey, O. P. (1998). *Integrated Pest and Disease Management*. New Delhi: A.P.H. Publishing.

Biological control of insects is the use of living insects or pathogens to control the insect pests. This course will enable students of entomology to know the history, development, scope of biological control, ecological basis of biological control, biological characteristics of natural enemies like predators, parasitoids and microorganism. Students will understand the problems in rearing and release of biological control agents, augmentation, conservation and establishment of natural enemies. The course focuses on estimating parasitism levels, host-parasitoid and host-predator interaction, numerical and functional response, strategies for rearing high quality of insect bio-control agents, integration of chemical and biological control, problems of super, multi and hyper-parasitism and predators, effect of pesticides on natural enemies and effect of natural enemies on non-target organism. Commercialization of natural enemies is very important step of biological control. Overall, the course provides latest concepts of the principles of biological control, rearing, screening, introduction, augmentation and conservation of natural enemies, super, multi and hyper parasitism and their problems in biological control.

Contents

1. Introduction; history, development and scope of BC with special reference to Pakistan
2. Ecological basis of biological control
3. Biological characteristics of natural enemies (predators, parasitoids, microorganism)
4. Scope and problems in introduction, rearing and release
5. Augmentation, conservation and establishment of natural enemies
6. Estimating parasitism levels, host-parasitoid and host-predator interaction
7. Integration of chemical and biological control
8. Problems of super, multi and hyper-parasitism and predators
9. Effect of pesticides on natural enemies and on non-target organisms
10. Case studies of biological control insect pests
11. Future opportunities and challenges of biological control

Practical

1. Survey and collection of natural enemies
2. Rearing of parasitoids, predator and micro-organisms of economic importance
3. Study of extent of parasitism / predation of different biocontrol agents
4. Methods for supplying insects and methods of release in the field
5. Visit to bio-control labs

Recommended Texts

1. Gunasekaran, M., & Weber, D. 1996. *Molecular Biology of the Biological Control of Pests and Diseases of Plants*. U.S.A: ESA Publications.
2. Hajek, A. 2004. *Natural Enemies: An Introduction to Biological Control*. Cambridge: Cambridge University Press.

Suggested Readings

1. Irshad, M. (2008). *Biological Control of Insects and Weeds in Pakistan*. Islamabad: HEC.
2. Lentern, J.C.V. (2003). *Quality Control and Production of Biological control Agents: Theory and testing procedures* (1st ed.). Wallingford, England: CABI.
3. Maramorosch, K. (1991). *Biotechnology for Biological Control of Pests and Vectors* (1st ed.). Florida, USA: CRC Press.

Insect Pathology is the study of pathogens infecting insects. In nature, different pathogens such as virus, bacteria, fungi and nematodes cause diseases to the insects. These pathogens can be used against insect for their control. There are different successful examples of insect pathogens which are commercially used for the management of insect pests. In this course, the prime objective is that the students should learn the mechanism of resistance and immunity in insects against pathogens, types of pathogens causing diseases to insect, transmission, host range, persistence and virulence of insect pathogens, types of injuries and methods of infection by pathogens in insects, pathogenic diseases and their diagnosis in insects, extra-cellular and intracellular microbiota of healthy insects, control of microbial diseases of useful insects and role of pathogens in IPM. Students will practically isolate, purify, culture and identify insect pathogen from diseased insects and soil. Then these isolated pathogens will be used for toxicity assays against different insects. Overall, this course aims to provide concepts of pathogens causing disease in insects and how these pathogens could be used against insect pests in the field.

Contents

1. Introduction of insect pathology
2. History and scope of insect pathology
3. The mechanism of resistance and immunity in insects against pathogens
4. Types of pathogens causing diseases to insect
5. Transmission, host range, persistence and virulence of insect pathogens
6. Types of injuries and methods of infection by pathogens in insects
7. Pathogenic diseases and their diagnosis in insects
8. Extra-cellular and intracellular microbiota of healthy insects
9. Control of microbial diseases of useful insects and role of pathogens in IPM

Practical

1. Isolation, purification, culture and identification of insect pathogens from the diseased insects
2. Isolation, purification, culture and identification of insect pathogens from the soil
3. Performing bioassays of isolated pathogens against different insects
4. Diagnosis of different pathogenic diseases
5. Control of microbial diseases of useful insects
6. Determination of extent of pathogenicity by pathogens in insects

Recommended Texts

1. Lacey, L. A. (1997). *Manual of Techniques in Insect Pathology*. UK: The Bath Press.
2. Boucias, D.G. (1998). *Principles of Insect Pathology*. London: Chapman Hall.

Suggested Readings

1. Burges, H.D., & Hurrey, N.W. (1972). *Microbial control of Insects and Mites*. London: Academic Press.
2. Poinar, G.O. Jr., & Thomas, G.M. (1978). *Diagnosis for the Identification of Insect Pathogens*. New York: Plenum Press.
3. Tanada, Y., & Kaya, H. (1992). *Insect Pathology*. New York: Academic Press.

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, develop writing skills, enhance time management and organizing skills. The special problem makes you do your work by prioritizing the needs and time frames completing all your tasks peacefully avoiding panic. Special problem writing work provides 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 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 an 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.

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*. Pakistan: 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, W. G. & Hunter, J. S. (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*. USA: Chapman and Hall.