

CURRICULUM

OF

PLANT BREEDING AND GENETICS

BSc (Hons)
MSc (Hons)

(Revised 2014)



HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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PREFACE

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

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

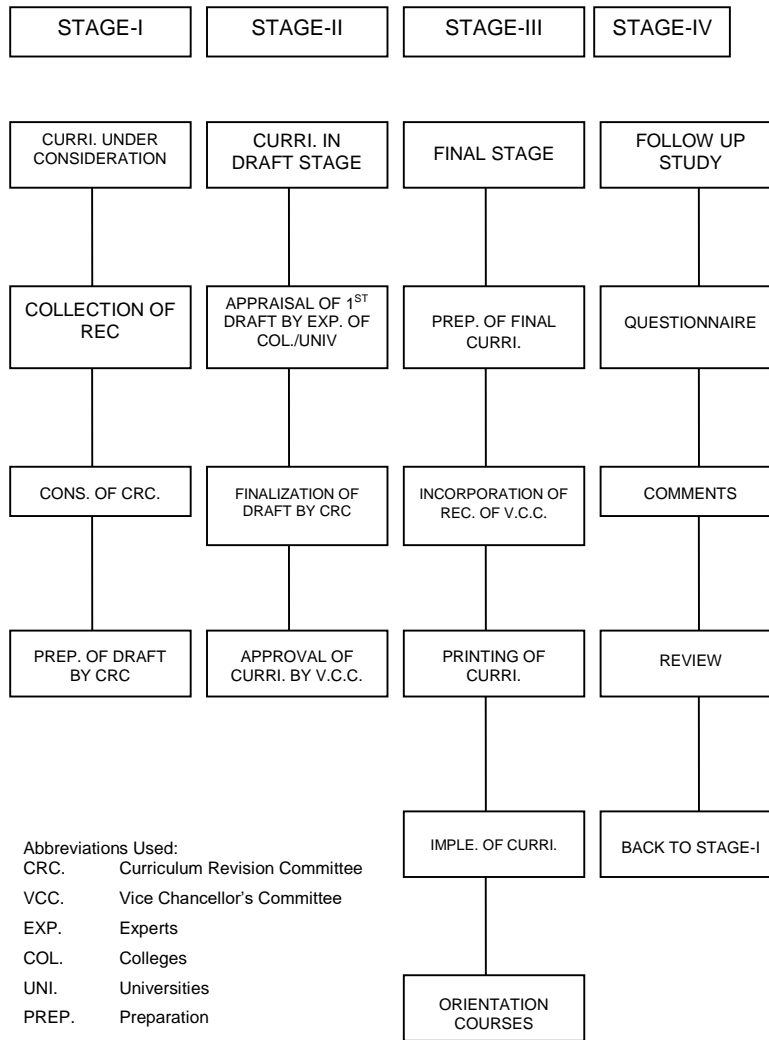
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector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

In order to impart quality education which is at par with international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

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

(Fida Hussain)
Director General (Academics)

CURRICULUM DEVELOPMENT PROCESS



**MINUTES OF THE FINAL MEETING OF HEC NATIONAL
CURRICULUM REVISION COMMITTEE FOR PLANT
BREEDING & GENETICS HELD AT HEC REGIONAL
CENTRE, KARACHI FROM MAY 07-09, 2014.**

The Final meeting of National Curriculum Revision Committee (NCRC) in the discipline of Plant Breeding & Genetics was held from May 07-09, 2014 at HEC Regional Centre, Karachi to finalize the draft of BSc/MSc (Hons) prepared in its preliminary meeting held on September 9-11, 2013 at the University of Agriculture, Peshawar, with recommendations for the promotion and development of the discipline. The following members attended the meeting:-

| Sr. No. | Name & Address | |
|----------------|---|-------------------------|
| 1. | Dr. Hidayat-ur-Rahman, Professor, Department of Plant Breeding and Genetics, University of Agriculture, Peshawar. h_rahman_pbg@yahoo.com | Convener |
| 2. | Dr. Fida Muhammad Professor & Chairman Department of Plant Breeding & Genetics, University of Agriculture, Peshawar fidauoa@yahoo.com | Member |
| 3. | Dr. Iftikhar Hussain Khalil Professor Department of Plant Breeding & Genetics, University of Agriculture, Peshawar. drihkhalil@yahoo.com | Member/Secretary |
| 4. | Dr. Zulfiqar Ali Associate Professor, Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. zulfiqar_ali@uaf.edu.pk | Member |
| 5. | Dr. Abdul Qayyum, Associate Professor/Chairman, Department of Plant Breeding & Genetics, | Member |

| Sr. No. | Name & Address | |
|--------------------|--|---------------|
| | University College of Agriculture, Bahauddin Zakaryia University, Multan. raoqayyim@bzu.edu.pk | |
| 6. | Dr. Ghulam Sarwar Markhand, Professor, Department of Botany, Shah Abdul Latif University, Khairpur. gmarkhand@gmail.com | Member |
| 7. | Dr. Saif Ullah Ajmal Professor, Department of Plant Breeding & Genetics, PMAS Arid Agriculture University, Rawalpindi. gondaldr@yahoo.com | Member |
| 8. | Dr. Saeed Rauf, Assistant Professor, Department of Plant Breeding & Genetics, University College of Agriculture, University of Sargodha, Sargodha. saeed_rauf2001@yahoo.com | Member |
| 9. | Mr. Shah Nawaz Mari, Assistant Professor, Department of Plant Breeding & Genetics, Sindh Agriculture University, Tandojam. shahmari21@yahoo.com | Member |
| 10. | Dr. Shahid Ali, Assistant Professor/HOD, Centre for Biotechnology and Microbiology, University of Swat. shahid2_khan@hotmail.com | Member |
| 11. | Mr. Habib Rehman Lakho Lecturer, Department of Plant Breeding & Genetics, Lasbela University of Agriculture, | Member |

Sr. No. Name & Address

Water & Marine Sciences, Uthal,
Balochistan.

habib.agri@luawms.edu.pk

12. Dr. Muhammad Jamil, **Member**
Assistant Professor,
Department of Biotechnology & Genetic
Engineering,
Kohat University of Science &
Technology,
Kohat 26000, KPK.

2. The following members, who attended the preliminary meeting, could not attend the final meeting due to other engagements:

1. Dr. Khizar Hayat Bhatti, **Member**
Assistant Professor/HOD,
Department of Botany,
University of Gujrat, Gujrat.
khizar.hayat@uog.edu.pk
2. Prof. Dr. Raziuddin, **Member**
Professor,
Department of Plant Breeding and
Genetics,
The University of Agriculture, Peshawar.
drraziuddin@gmail.com
3. Dr. Muhammad Kausar Nawaz Shah, **Secretary/Member**
Professor / Chairman,
Department of Plant Breeding &
Genetics,
PMAS Arid Agriculture University,
Rawalpindi.
knshah@uuar.edu.pk

3. The meeting started with recitation of Verses from the Holy Quran by Mr. Riaz-ul-Haque. After brief introduction of participants, Mr. Ghulam Hyder Khan, Director RC Karachi, HEC inaugurated the session and welcomed the participants on behalf of the Executive Director, HEC and thanked them for their participation in this important exercise.

4. Prof. Dr. Hidayat-ur-Rehman, Department of Plant Breeding and Genetics, University of Agriculture, Peshawar, as **Convener** of the committee, nominated Dr. Iftikhar Hussain Khalil, Professor, Department of Plants Breeding & Genetics, University of Agriculture, Peshawar as **Secretary** of the meeting. Mr. Haque then requested the Convener of the Committee to start Technical Session in accordance with the agenda.
5. The Committee after thorough deliberations and having three days discussions finalized the draft curriculum of the Plant Breeding & Genetics for BSc/MSc (Hons) degrees, including revisiting of recommended books. The Committee agreed that the Recommendations framed during the meeting will be published as **Annexure** in the final booklet of curriculum circulated by HEC for Adoption/Implementation to universities/degree awarding institutes of Pakistan.
6. Mr. Riaz-ul-Haque, Assistant Director Curriculum, HEC thanked the Convener and all members of the committee for sparing precious time and for their quality contributions. The committee appreciated Mr. Riaz-ul-Haque, for his coordination and lauded the efforts by Mr. Ghulam Hyder Khan, Director RC Karachi and other officials for providing local hospitality.
7. The meeting ended with vote of thanks to and from the chair.

Template for 4-Year BSc (Hons) in Agricultural Disciplines

| 1. Compulsory Courses | Credits Hours |
|--|------------------------|
| Mathematics / Biology (2 courses) | 6 (3-0) (2-1) |
| Statistics 1 & 2 | 6 (3-0) (3-0) |
| Computers / IT | 3 (2-1) |
| Pakistan Studies | 2 (2-0) |
| Islamic Studies | 2 (2-0) |
| Communications Skills | 3 (3-0) |
| English | 3 (3-0) |
| Basic Agriculture | 3 (2-1) |
| | Sub-Total 28 |
| | |
| 2. Interdisciplinary Foundation Courses | |
| Agronomy | 3 (2-1) |
| Plant Breeding & Genetics | 3 (2-1) |
| Entomology | 3 (2-1) |
| Plant Pathology | 3 (2-1) |
| Food Technology | 3 (2-1) |
| Horticulture | 3 (2-1) |
| Soil Sciences | 3 (2-1) |
| Agriculture Economics | 3 (2-1) |
| | Sub-Total 24 |
| | |
| 3. Supporting Courses {6-8 courses (3 Cr. hr.) amongst below} | |
| Agriculture Extension | |
| Forestry & Range Management | |
| Animal Science | |
| Marketing & Agri Business | |
| Rural Development | |
| Human Nutrition | |
| Agriculture Chemistry | |
| Agriculture Engineering | |
| Water Management | |
| Any other discipline recommended by the university | |
| | Sub-Total 18-24 |
| | |
| Sub-Total during the first four semesters | 70-76 |
| Semester 5, 6, 7 & 8 | 56-60 |
| Project / Internship | 04 |
| Grand Total | 130-140 |

- 1 credit of theory = one contact hour per week for 16-18 weeks and 1 practical/Lab hour = 3 contact hours per week for 16-18 weeks.
- In case of non availability of department of supporting courses, courses from foundation courses can be opted.

**Scheme of Studies for
BSc (Hons) Degree Programs in
Plant Breeding and Genetics**

| Course No. | Title | Credit Hours |
|---|--|---------------------|
| PBG 401 | Introductory Genetics | 3(2-1) |
| PBG 402 | Introductory Plant Breeding | 3(2-1) |
| 5th Semester Courses | | |
| PBG 501 | Principles of Genetics | 3(2-1) |
| PBG 503 | Breeding Field Crops | 3(2-1) |
| PBG 505 | Cytogenetics | 3(2-1) |
| PBG 507 | Fundamentals of Plant Biometry | 3(3-0) |
| PBG 509 | Modern Techniques in Plant Breeding | 3(2-1) |
| | | Total= 15 |
| 6th Semester Courses | | |
| PBG 502 | Breeding Fibre Crops | 3(2-1) |
| PBG 504 | Breeding Sugar Crops | 3(2-1) |
| PBG 506 | Breeding Maize and Millets | 3(2-1) |
| PBG 508 | Biodiversity and Plant Genetic Resources | 3(3-0) |
| PBG 510 | Molecular Genetics | 3(2-1) |
| | | Total= 15 |
| 7th Semester Courses | | |
| PBG 601 | Breeding Oilseed Crops | 3(2-1) |
| PBG 603 | Breeding Pulse Crops | 3(2-1) |
| PBG 605 | Breeding Vegetable Crops | 3(2-1) |
| PBG 607 | Breeding Cereal Crops | 3(2-1) |
| PBG 609 | Experimentation in Plant Breeding | 3(2-1) |
| | | Total= 15 |
| 8th Semester Courses* | | |
| PBG 602 | Breeding Fodder and Forage Crops | 3(2-1) |
| PBG 604 | Breeding Minor Crops | 3(2-1) |
| PBG 606 | Crop Variety Registration and Intellectual Property Rights | 3(3-0) |
| PBG 608 | Breeding for Crop Quality Traits | 3(2-1) |
| PBG 610 | Fundamentals of Research & Scientific Writing | 3(3-0) |
| PBG 612 | Genomics in Agriculture | 3(2-1) |
| PBG 614 | Bio-safety Measures in Crop Improvement | 3(2-1) |
| PBG 616 | Breeding Medicinal Plants | 3(2-1) |
| PBG 618 | Internship or Research Project | 4(0-4) |

*Only 13 credit hours will be mandatory including PBG 618 being compulsory. Courses listed in 5-8th semester can be swapped as and when needed except core courses.

Objectives

To enable students to understand:

- Basic concepts of genetics
- Mechanism of heredity
- Chemical and molecular nature of nucleic acids

Theory

Definition of genetics, concepts of heredity and variation. Cell and cell divisions. Mendelian genetics: chromosome theory of heredity, various genotypic and phenotypic ratios and their modifications. Differences between allelic and non-allelic interactions (epistasis), illustration of epistasis with suitable examples. Pleiotropy and multiple allelism. Multiple factor hypothesis. Linkage and crossing over. Sex determination: sex linked and sex influenced traits. Chromosomal aberrations. Nucleic acids: nature, structure and function. Classical vs modern concepts of gene.

Practical

Study of cell divisions and gametogenesis. Calculation of monohybrid and dihybrid ratios. Numerical examples relating to gene interaction, multiple alleles and multiple factor inheritance. Calculation of linkage from test cross and F_2 data.

Recommended Books

1. Singh, B.D. 2004. Genetics. Kalyani Publishers, New Delhi, India.
2. Klug, W.S. and M. R. Cummings. 2003. Concepts of Genetics. (7th ed.), Pearson Education, Singapore.
3. Singh, P. 2003. Elements of Genetics. (2nd ed.) Kalyani Publishers, Delhi, India.
4. Stansfield, W.D. 1988 Theory and Problems of Genetics. 4th ed. McGraw-Hill Book Co, NY.
5. Khan I.A. F.M. Azhar, Z. Ali and A.A. Khan. 2008. Solving Numerical Genetic Problems. Dept. Plant Breed. Genet. Uni. Agri. Faisalabad.

World Wide Web

http://anthro.palomar.edu/mendel/mendel_1.htm

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|---------|------------------------------------|--------|
| PBG 402 | Introductory Plant Breeding | 3(2-1) |
|---------|------------------------------------|--------|

Objectives

To make students to understand:

- Basis of plant breeding
- Reproductive mechanisms in major crops
- Application of genetic principles in crop improvement
- Breeding methods in self and cross pollinated crops

Theory

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

Practical

Descriptive study of floral biology, scientific names, chromosome number and ploidy level of important field crops. Selfing and crossing techniques in major crops. List of approved varieties in major field crops.

Recommended Books

1. Sleper, D. A. and J.M. Poehlman. 2006. Breeding Field Crops. (5th ed.) Iowa State University Press, Ames, USA.
2. Chahal, G.S. and S.S. Gosal. 2003. Principles and Procedures of Plant Breeding. Narosa Publishing House, New Delhi, India.
3. Singh, B. D. 2003. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi, India.
4. Singh, P. 2003. Essentials of Plant Breeding. Kalyani Publishers, New Delhi, India.
5. Khan, M.A (Editor). 1994. Plant Breeding. National Book Foundation, Islamabad.
6. Acquaah, G. 2009. Principles of Plant Genetics and Breeding. John Wiley & Sons, UK.

Objectives

To enable students to understand:

- Expansion of Mendelian inheritance
- Chemical nature of genetic material
- Genetic control of protein synthesis
- Molecular basis of gene
- Mutation and its types

Theory

Pleiotropy and various types of gene interactions. Multiple alleles. Polygenic inheritance. Sex determination, XO, XX/XY systems and sex-linked inheritance. Genic balance theory. Holandric genes. Extra chromosomal inheritance. Linkage and crossing over. Three-point and multipoint linkage tests and chromosome mapping. Properties of genetic material. DNA as genetic material. Watson and Crick Model of DNA structure and its implications. Genetic code, RNA and protein synthesis. Gene mutation.

Practical

Solving problems on dihybrid and multihybrid segregating generations and backcrosses. Numerical examples relating to multiple allelism and polygenic inheritance, sex linked inheritance, linkage and crossing over. Chromosome mapping.

Recommended Books

1. Klug, W.S. and M.R. Cummings. 2010. Concepts of Genetics. Dorling Kindersley, Pvt. (Ltd.) New Delhi, India.
2. Brooker, R.J. 2005. Genetics: Analysis and Principles. (2nd ed.,) McGraw-Hill Company, New York, USA.
3. Griffiths, A.J.F., J.H. Miller, D.T. Suzuki, R.C. Lewontin and W.M. Gelbart. 2005. An Introduction to Genetic Analysis. W.H. Freeman and Company, New York, USA.
4. Singh, B.D. 2004. Genetics. Kalyani Publishers, New Delhi, India.
6. Stansfield, W.D. 1988 Theory and Problems of Genetics. (4th ed.) McGraw Hill Book Co, NY.
7. Khan, I.A. F.M. Azhar, Z. Ali and A.A. Khan. 2008. Solving Numerical Genetic Problems. Dept. Plant Breed. Genet. Uni. Agri. Faisalabad.

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| PBG 502 | Breeding Fibre Crops | 3(2-1) |
|---------|-----------------------------|--------|

Objectives

To enable students to understand:

- Developmental history of various fibre crops
- Breeding fibre crops for yield and quality characteristics
- Breeding methods for incorporating resistance against biotic and abiotic stresses

Theory

Introduction to fibre crops. Role of fibre crops in national and international economy. Current breeding work on cotton and other fibre crops in Pakistan. Cotton genetic resources: species grown in Pakistan. Objectives of breeding fibre crops. Breeding methods. Concepts of ideotype breeding in cotton. Coloured and organic cotton. Genetics of host-plant resistance. Fibre quality attributes and their relationship with morphological traits. Development of hybrid and transgenic cotton. Scope and perspective of *Bt* cotton in Pakistan.

Practical

Selfing and crossing techniques in fiber crops. Identification of different species of cotton. Collection of data on different quantitative traits of cotton, data analysis and its interpretation. Testing of fibre traits in cotton. Visit to research stations and fiber testing laboratories.

Recommended Books

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. (5th ed.) Iowa State University Press Ames, USA.
2. Shiron, J. (Editor). 2004. Transgenic Cotton. Science Press, 16 Donghuangchenggen North Street Beijing, China.
3. Singh, P. 2004. Cotton Breeding. Kalyani Publishers. New Delhi. India.
4. Johnie, N.J. and S. Saha. 2001. Genetic improvement of Cotton-emerging techniques. Oxford and IBH Publishing Co., New Delhi, India.
5. Mauney, J.R. 1984. Cotton. ASA, CSSA and SSSA. Agronomy Monograph. Amer. Soc. Agron., Madison, Wisconsin, USA.

Objectives

To enable students to understand:

- Achievements made in plant breeding
- Strategies of plant breeding
- Various breeding methods in self and cross pollinated crops

Theory

History, achievements, objectives, and strategies of plant breeding. Genetic variability: basis of plant breeding, components of variability. Threshold characters: penetrance and expressivity. Breeding methods in sexually (self and cross-pollinated) and asexually propagated crops. Development of doubled haploids. Mutation breeding. Wide hybridization. Estimation of heritability. Heterosis: genetic basis and exploitation. Male sterility and self-incompatibility. Breeding crops for biotic and abiotic stresses. Ideotype breeding and its limitations. Role of biotechnology in plant breeding.

Practical

Selfing and crossing techniques in field crops. Data recording using descriptors, its analysis and interpretation. Assessment of variability in crops for biotic and abiotic stresses. Visits to field and research institutes.

Recommended Books

1. Singh, B.D. 2007. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi, India.
2. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. (5th ed.) Iowa State University Press Ames, USA.
3. Singh, P. 2004. Essentials of Plant Breeding. Kalyani Publishers, New Delhi, India.
4. Chahal, G.S. and S.S. Gosal. 2002. Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches. Alpha Science International Ltd., Oxford, UK.
5. Khan, M.A. (Editor). 1994. Plant Breeding. National Book Foundation, Islamabad, Pakistan.
6. Acquaah, G. 2009. Principles of Plant Genetics and Breeding. John Wiley & Sons, UK.

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| PBG 504 | Breeding Sugar Crops | 3(2-1) |
|---------|-----------------------------|--------|

Objectives

To enable students to understand:

- Breeding methods in sugar crops
- Constraints in sugarcane breeding
- Different genetic systems in sugar crops

Theory

Importance, origin, classification and botanical features of sugar crops. Genetics and cytogenetics of sugar crops. Evolution of noble cane and present status. Flowering: a breeding constraint, artificial induction of flowering and hybridization techniques. Selection strategies and development of new varieties. Sugarcane improvement through modern approaches. Exploitation of somaclonal variation and micropropagation for improvement of sugarcane. Sugarbeet: genetic resources, induction of flowering and seed production strategies.

Practical

Identification of sugarcane species and varieties using morphological descriptors. Study of sugarcane flowering mechanisms. Morphological features of sugar beet varieties. Evaluation of sugarcane and sugar beet for quality parameters. Visit to sugar industries/research institutes.

Recommended Books

1. Henry, R.J. and C. Kole. 2010. Genetics, Genomics and Breeding of Sugarcane. Taylor and Francis, London, UK.
2. Malik, K.B. 2009. Cane and Sugar Production. Punjab Agriculture Research Board, Lahore, Pakistan.
3. Draycott, A.P. 2006. Sugar beet. Blackwell Publishing Ltd., Oxford, UK.
4. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. (5th ed.) Iowa State University Press, Ames, Iowa, USA.
5. James, G. 2004. Sugarcane. Blackwell Publishing Co., Ames, Iowa, USA.

World Wide Web

1. <http://sugarcane-breeding.tn.nic.in>
2. <http://khbreeding97.webs.com/sugarcropsresinst.htm>

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| PBG 505 | Cytogenetics | 3(2-1) |
|---------|---------------------|--------|

Objectives

To enable students to understand:

- Structure and functions of cell organelles
- Chromosomal structure, functions and their abnormalities

Theory

Description of cell organelles and their role in inheritance. Genetic regulation of cell cycle. Cytological differences in mitosis and meiosis. Morphology and classification of chromosomes. Fine structure of chromosomes. Specialized chromosomes (polytene and lamp brush). Heterochromatin and euchromatin. Karyotype analysis of crop species, construction of ideograms, arm ratio and centromere index. Flow cytometry for chromosome analysis. Chromosome banding techniques. Structural and numerical changes in chromosomes. Cytological basis and proofs of crossing over.

Practical

Preparation of different solutions, preservatives, fixatives and stains for cytological studies. Collection of suitable plant material for cytological studies. Observation of chromosomes at various mitotic and meiotic stages. Use of colchicine for chromosome duplication. Micrometry.

Recommended Books

1. Singh, R.J. 2003. Plant Cytogenetics. CRC Press, Baton Rouge, USA.
2. Ravindranath, N.H. 2002. Elements of Modern Cytology, Genetics and Evolution. Kalyani Publishers, New Delhi, India.
3. Clark, M.S. and W.J. Wall. 1996. Chromosomes: The Complex Code. Chapman and Hall Ltd., London, UK.
4. Jahier, J., A.M. Chevre, R. Delourme, F. Eber, and A.M. Tanguy. 1996. Techniques of Plant Cytogenetics. Science Publishers Inc, New York, USA.

World Wide Web

1. www.molecularcytogenetics.org

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|---------|-----------------------------------|--------|
| PBG 506 | Breeding Maize and Millets | 3(2-1) |
|---------|-----------------------------------|--------|

Objectives

To enable students to understand:

- Evolutionary pathways of maize and millet
- Breeding methods in maize and millet
- Hybrid maize production and its scope

Theory

Economic importance and origin of maize and millets. Types of maize and their significance. Breeding methods: various selection procedures, recurrent selection and development of inbred lines. Heterosis, its significance, genetic basis and exploitation. Combining ability analysis. Hybrid seed production of maize and millets, and use of male sterility. Population improvement and handling of segregating generations. Quality protein maize (QPM). Breeding for biotic and abiotic stresses. Maize and millet improvement through modern biotechnological techniques. Current scenario and future prospects in maize breeding.

Practical

Handling of inbred lines and hybrid material in maize. Development of various crosses and populations in maize and millets. Layout of experiments and recording of data on various growth stages at vegetative and reproductive phases. Visit to maize and millets research institutes and industry.

Recommended Books

1. Dana. S. 2001. Plant Breeding. Partha Sankar Basu Publishing Co. Kolkata, India.
2. Sprague, G. F. and J. V. Dudley (ed.). 1988. Corn and Corn Improvement. 3rd ed. ASA, CSSA and SSSA. Agronomy Monograph 18, Amer-Soc. Agron., Madison, Wisconsin, USA.
3. Chaudhry, A.R. 1983. Maize in Pakistan. Punjab Agric. Res. Coordination Board, Univ. of Agric., Faisalabad, Pakistan.
4. Hallauer, A.R. and J.B. Miranda. 1988. Quantitative Genetics in Maize Breeding. (1st ed.) Iowa State University Press, Ames, Iowa.
5. FAO. 1980. Improvement and production of Maize, Sorghum and Millet. Vol. 2, Food and Agric. Org. of the United Nations, Rome, Italy.

| | | |
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| PBG507 | Experimentation in Plant Breeding | 3(2-1) |
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Objectives

To enable students to understand:

- Concepts of Biostatistics
- Various experimental layout and designs
- Statistical softwares

Theory

Concept of experimental units. Treatments and local control. Major designs (CRD, RCBD & LS) and their lay-out for experiments under field and lab conditions. Basic statistics of variability and comparison tests. Concepts of variances in non-segregating and segregating populations for broad and narrow-sense heritability. Concepts of variance components (genetic and environmental) from expected mean squares for heritability estimation. Concepts of selection intensity, differential and response, realized heritability and expected genetic advance.

Practical

Use of softwares for estimation of basic statistics. Construction of ANOVA. Numerical problems related to estimation of genetic, environmental and phenotypic variances/co-variances from ANOVA/ANCOVA.

Recommended Books

1. Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedures for Agricultural Research. 1984. (2nd ed.) John Wiley & Sons.
2. Singh, R.K. and B.D. Chaudhary. 2004. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, N. Delhi, India

Objectives

To enable students to understand:

- Importance of biodiversity in plant breeding
- Strategies of germplasm collection and conservation
- Role of novel techniques in germplasm identification and preservation

Theory

Importance of plant biodiversity, characteristics of wild and domesticated plant species. Origin and distribution patterns of crop species. Centres of origin and genetic diversity. Wild relatives of crops, Exploration of genetic resources. Principles and strategies of germplasm collection. Seed bank and its role in biodiversity conservation. Mechanism of gene banking: maintenance, evaluation and conservation (*In situ* and *ex situ*). Utilization of genetic resources in crop research and plant breeding. Introduction to national and international germplasm centers. Visit to gene banks.

Recommended Books:

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. (5th ed.,) Iowa State University Press, Ames, USA.
2. Dhillon, B.S., R.K. Tyagi and A. Lal. 2004. Plant Genetic Resource Management. Narosa, New Delhi, India.
3. Brown, A.H.D., O.H. Frankel, D.R. Marshall and J.T. Williams. 1989. The Use of Plant Genetic Resources. Cambridge University Press, Cambridge, UK.

Objectives

To enable students to understand:

- Application of genetic principles in cereal breeding
- Various reproductive systems in cereals
- Variety development and release procedures

Theory

Importance of cereals; wheat, rice, barley, oats and triticale. Status of cereals; global and local perspective. Evolution, origin, and phenology of cereal crops. Breeding techniques and objectives in cereals. Yield and quality parameters in cereals. Breeding for biotic and abiotic stresses. Procedure for variety development. Preliminary and multi-location yield trials (NUYT, DUS test). Genetic improvement using novel techniques. Development of commercial hybrids, exploitation of male sterility systems for hybrid development in cereals.

Practical

Development of genetic material using appropriate mating techniques. Assessment of various phenological stages in cereal crops. Handling of segregating populations. Data recording of various plant attributes using descriptors.

Recommended Books

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. (5th ed.,) Iowa State University Press, Ames, USA.
2. Morris, P.C. and J.H. Bryce. (ed.). 2000. Cereal Biotechnology. Woodhead, New York, USA.
3. Nanda, J.S. 2000. Rice Breeding and Genetics: Research Priorities and Challenges. Pak Book Corporation, Lahore, Pakistan.
4. Heyne, E.G. (ed.). 1987. Wheat and Wheat Improvement. (2nd ed.,) ASA, CSSA and SSSA. Agronomy Monograph 13, Amer. Soc. Agron., Madison, Wisconsin, USA.
5. Fehr, W.R. 1987. Principles of Cultivar Development, Vol. 2: Crop Species. Macmillan Pub Co., NY, USA

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| PBG 510 | Molecular Genetics | 3(2-1) |
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Objectives

To enable students to understand:

- Concept of genetic codes and gene function
- Basics of genetic engineering and biotechnology

Theory

Chemistry of nucleic acids; DNA replication; types of RNA, DNA transcription and translation. Features of the genetic code, split gene and redundant DNA. Gene mutation, molecular basis of gene mutation and factors affecting mutation rate. Transposable elements. Gene cloning techniques in crop plants. Gene mapping. Marker assisted analysis and QTL mapping.

Practical

DNA extraction, isolation and quantification. DNA amplification/PCR. Gel electrophoresis, Primer designing.

Recommended Books

1. Klug, W.S. and M.R. Cummings. 2010. Concepts of Genetics. Dorling Kindersley, Pvt.(Ltd.) New Delhi, India.
2. Rothwell, V.N. 1993. Understanding Genetics: A Molecular Approach. 2nd ed., John Wiley and Sons New York, USA.
3. Bilgrami, K.S. and A.K. Pandey. 1992. Introduction of Biotechnology. CBS Publishers & Distributors, New Delhi, India.
4. Maniatis, T., E.F. Fritsch and J. Sambrook, 1989. Molecular Cloning. A Laboratory Manual. Cold Spring Harbor, USA.

Objectives

To enable students to understand:

- Status of oilseeds in Pakistan
- Significance of conventional and non-conventional oilseed crops
- Breeding methods in oilseed crops

Theory

Introduction to conventional and non-conventional oilseed crops. Status of edible oil in national economy. Significance of brassica, sunflower, groundnut, cotton, oil palm, olive, soybean as oilseed crop, and production constraints. Industrial oilseed crops (castor beans, Jatropha, Coconut). Origin and classification of oilseeds. Breeding objectives, strategies and methodologies of oilseed crops. Genetics of male sterility and its use in sunflower hybrid seed production and other oilseed crops. Development of double-zero varieties in rapeseed mustard crops.

Practical

Identification oilseed crops, their reproductive biology. Estimation of oil quality. Development of breeding populations of oilseed crops and selection practices in segregating populations. Visit to oilseed research institutes and industry.

Recommended Books

1. Nagata, T. and S. Tabata (ed).2003. Brassica and Legumes: From Genome Structure to Breeding. Springer Verlag, New York, USA.
2. Verma, D.P.S. 1996. Soybean: Genetics, Molecular Biology and Biotechnology. Biotechnology in Agriculture Series, No 14. CABI Publishing Co. USA.
3. Kimber, D. and D.I. McGregor. 1995. Brassica Oilseeds: Production and Utilization. Cambridge, UK.
4. Robbelen, G. and R.K. Downey. 1990. Oil Crops of the World: their Breeding and Utilization, McGraw-Hill Publishing Company, New York, USA.

World Wide Web

1. <http://www.parc.gov.pk/1SubDivisions/NARCCSI/CSI/rapeseed.html>
2. http://archive.idrc.ca/library/document/091017/chap3_e.html

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| PBG 602 | Breeding Fodder and Forage Crops | 3(2-1) |
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Objectives

To enable students to understand:

- Significance of fodder and forages in livestock sector
- Genetic and cytoplasmic basis of reproductive systems in forages
- Breeding methods in fodder and forages

Theory

Introduction to major fodder and forage crops. Genetic resources and classification of fodder and forage crops. Reproductive systems in fodder and forage crops. Apomixis and its role in fodder and forage crops. Male sterility and self-incompatibility: genetic and cytoplasmic basis. Breeding objectives and methods for improvement. Quality components in fodder and forage crops, anti-quality agents and remedies. Application of biotechnology in fodder and forage crops.

Practical

Floral morphology, pollination, fertilization and seed setting in fodder and forage crops. Handling of apomictic, self and cross-pollinated fodder and forage species. Hay and silage production techniques. Mixed fodder cropping. Determination of nutritive quality and nutritive value. Visit to research organizations, livestock farms and feed industry.

Recommended Books

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. Iowa State University Press, Ames, Iowa, USA.
2. Rognli, O.A., E.T. Solberg, I. Schjelderup.(eds.). 1994. Breeding Fodder Crops for Marginal Conditions. Series: Developments in Plant Breeding, SpringerLink, USA.
3. Chatterjee, B.N, 1989. Forage Crop Production: Principles and Practices. Oxford and IBH Publishing Co. Ltd., New Delhi, India.
4. Sleper, D.A., K.H. Asay and J.F. Pedersen, (eds.) 1989. Contributions from Breeding Forage and Turf Grasses. CSSA Special Publication 15, Amer. Soc. Agron., Madison, Wisconsin, USA.
5. Boller, B., U.K. Posselt, and F. Veronesi. (eds) 2010 Fodder Crops and Amenity Grasses. Springer.

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|---------|-----------------------------|--------|
| PBG 603 | Breeding Pulse Crops | 3(2-1) |
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Objectives

To enable students to understand:

- Significance and status of pulses
- Constraints in pulse breeding
- Breeding methods for biotic and abiotic stresses

Theory

Introduction to pulse crops. Significance of pulses in human diet. Status of pulses in Pakistan: an overview, reasons of low yield in pulse crops. Botanical description, objectives and breeding methods in pulse crops. Intra and Inter-specific hybridization in pulse crops. Limitations in hybridization. Special consideration on fertilizer, and irrigation responsive cultivars, reduced photoperiod sensitivity and biotic and abiotic stresses. Genetic mechanism of nitrogen fixation in pulses. Role of mutation breeding in pulses. Use of innovative tools for improvement of pulses.

Practical

Reproductive biology of important pulses. Hybridization techniques in major pulse crops. Phenological data notes and analysis. Study of rhizobium nodulation and nitrogen fixation in various pulse crops. Visit to research stations.

Recommended Books

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. Iowa State University Press, Ames, Iowa, USA.
2. Ali, M. 2006. Drought Management Strategies for Pulse crops. Agrotech. Publishing Academy, Udaipur, India.
3. Nagata, T. and S. Tabata (ed). 2003. Brassica and Legumes - From Genome Structure to Breeding. Springer Verlag, New York, USA.
4. Singh, D.P. (ed). 2001. Genetics and Breeding of Pulse Crops. Kalyani Publishers New Delhi, India.
5. Persley, G.J. (ed.). 1984. Tropical Legume Improvement. Biotech Anutech Pvt. Ltd., Canberra, Australia.

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| PBG 604 | Breeding Minor Crops | 3(2-1) |
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Objectives

To enable students to understand:

- Significance and status of minor crops
- Breeding objectives of minor crops
- Breeding methods in minor crops

Theory

Introduction and importance of minor crops: tea, guar, sesame, linseed, groundnut, tobacco and other local crops. Breeding objectives, methodologies and selection procedures; recurrent selection, general and specific combining ability. Breeding for biotic and abiotic stresses. Genotype x environment interactions and stability analysis. Processing and value addition in minor crops.

Practical

Selfing and crossing techniques. Layout of experiments, recording and analysis of data on various plant parameters. Screening of germplasm for biotic and abiotic stresses. Visit to research Institutes and industry.

Recommended Books

1. Singh, B.D. 2007. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi, India.
2. Douglas, C.A. 2005. Evaluation of Guar Cultivars in Central and Southern Queensland. RIRDC Publications, Australia.
3. Goodman, J. (ed). 2004. Tobacco in History and Culture: An Encyclopedia. Charles Scribner's Sons.
4. Ram, H.H. and H.G. Singh. 2003. Crop Breeding and Genetics. Kalyani Publishers, New Delhi, India.

Objectives

To enable students to understand:

- Significance and classification of vegetables
- Reproductive mechanisms in various vegetables
- Role of innovative tools in vegetable improvement

Theory

Introduction, importance and classification of vegetable crops. Reproductive systems of important vegetable crops. Breeding objectives of vegetable crops. Constraints in breeding and hybridization of vegetables and possible improvement strategies. Pure and hybrid seed production in vegetables. Breeding vegetables for off-season cultivation. Breeding for quality, biotic and abiotic stresses and shelf-life. Role of innovative tools for improvement of vegetable crops.

Practical

Study of reproductive biology of important vegetables. Selfing and crossing techniques in major vegetables. Layout of field experiments and data recording for various genetic parameters. Visit to research stations.

Recommended Books

1. Arya, P.S. 2003. Vegetable Breeding, Production and Seed Production. Kalyani Publisher, New Delhi, India.
2. Kalloo, G. and B.O. Bergh. (Eds) 1999. Genetic Improvement of Vegetable Crops. Pergoman Press, New York. USA.
3. Swiader, J.M., G.W. Ware and J.M. McCollum. 1992. Producing Vegetable Crops. 4th ed. Interstate Publisher Inc., Danville, Illinois, U.S.A.
4. Bassett, M.J. (ed.) 1986. Breeding Vegetable Crops. Avi Publishing Co., Inc. Westport, Connecticut, U.S.A.

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| PBG 606 | Crop Variety Registration and Intellectual Property Rights | 3(3-0) |
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Objectives

To enable students to understand:

- Registration of crop varieties and seed certification
- Intellectual property rights
- Concerns of Plant Breeders and farmers rights

Theory

Intellectual Property Rights (IPR): introduction, need and implementation of IPR; issues and challenges. Strategies to maximize benefits from IPR. Plant Breeder's Rights Act: background, requirements; advantages and disadvantages. Plant Variety Protection (PVP) and farmer's rights. Patenting biological material. International harmonization of patent laws. Plant variety registration and approval. Production of various classes of seeds and certification procedures. An overview of "WTO, Biological Diversity Act, TRIPS and seed industry in Pakistan".

Recommended Books

1. Helfer, L.R. 2004. Intellectual Property Rights in Plant Varieties: International legal regimes and policy options for national governments. FAO Legislative Study 85, Food and Agriculture Organization, Rome, Italy.
2. Erbisch, F.U. and K.M. Mareid (eds). 2003. Intellectual Property Rights in Agricultural Biotechnology. CABI Publishing Company, USA.
3. Helfer, L.R. 2002. Intellectual Property Rights in Plant Varieties: an overview with options for national governments. FAO Legal Papers, Online #31, Food and Agriculture Organization, Rome, Italy.
4. Evenson, R.E. 1999. Intellectual Property Rights; access to plant germplasm and crop production scenarios in 2020. Crop Sci., 39:1630-1635.
5. www.wipo.org

Objectives

To enable students to understand:

- Modern breeding tools in crop improvement.
- Application of new techniques in plant breeding.

Theory

Basics of molecular biology. Introduction to modern techniques. DNA amplification and Polymerase Chain Reaction. DNA fingerprinting. Methods of genetic transformation. Molecular markers and marker assisted selection in plant breeding. *In-vitro* culture techniques. Biotechnological approaches to drought tolerance, salt tolerance, pest resistance and protein quality in various field crops. Importance of transgenic plants. Introduction to genomics.

Practical

Safety measures in the biotech laboratory. Orientation to various lab equipment. Introduction to aseptic techniques, autoclaving, sterilization, use of laminar flow and fume hoods. Storage and weighing of chemicals. Preparation of stock-solutions, adjusting pH, making dilutions. Media preparation. Callus formation and micro-propagation.

Recommended Books

1. Loodish, H. 2004. Molecular Cell Biology. (5th ed.,) John Wiley and Sons, New York, USA.
2. Paul, C and K. Harry. 2004. Handbook of Plant Biotechnology. John Willy and Sons, New York, USA.
3. Muglani, G.S. 2003. Advanced Genetics. Narosa Publishing House, New Delhi, India.
4. Razdan, M.K. (Ed) 2003. Introduction to Plant Tissue Culture. (2nd ed.,) Intercept, New York, USA.
5. Brown, T.A. 2000. Essential Molecular Biology: A Practical Approach. Oxford University Press, New York, USA.
6. Brown, T.A. 2010. Gene cloning and DNA analysis: An introduction. Willy-Blackwell, UK.

World Wide Web.

1. www.accessexcellence.org/LC/ST/st2bgplant.html

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| PBG 608 | Breeding for Crop Quality Traits | 3(2-1) |
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Objectives

To enable students to understand:

- Regional and International quality standards in cereal crops.
- WTO role in marketing via quality control of crops

Theory

Defining the quality aspects of crop products, role of WTO in classification and standardization of quality parameters, relationship of crop quality with yield and yield components. Introduction to techniques and procedures to evaluate quality traits in different crops. Genetic improvement of quality traits in different crops.

Practical

Instruments used to evaluate quality parameters in crop plants. Introduction to various techniques for measuring quality traits in various crops.

RECOMMENDED BOOKS

1. A.O.C.S. 1999. Official and Tentative Methods of the American Oil Chemists Society. A.O.C.S. Chicago, Illinois, USA.
2. A.S.T.M. 1999. Standards on Textile Materials. Amer. Soc. for Testing and Materials, Philadelphia, USA.
3. Gupta, U.S. 2000. Crop Improvement: Quality Characters. Vol 3. Science Publishers Incorporated.
4. Jullano, B.O. 1993. Grain Quality Evaluation of World Rices, IRRI, Manila, Philippines.
5. Mathur, R.B.L. 1992. Hand Book of Cane Sugar Technology. (2nd ed.) Oxford and IBH, Publ. Co. (Pvt), Ltd, New Delhi, India.

Objectives

To enable students to understand

- Application of biometrical techniques in genetics and breeding
- Recording and analyzing qualitative and quantitative data
- Various statistical techniques used in plant breeding

Theory

Concept of quantitative, qualitative traits and their analysis. Chi-square test. Variance and covariance: components of variance and covariance. Regression and correlation. Heritability types, selection pressure, selection differential, response to selection and genetic advance. Heterosis, heterobeltiosis, potence ratio and combining ability. Introduction to different genetic models.

Practical

Estimation of correlations, regression, heritability, selection differential, response to selection, genetic advance, heterotic effect and inbreeding depression.

Recommended Books

1. Singh, R.K. and B.D. Chaudhary. 2004. Biometrical Methods in Quantitative Genetics Analysis. Kalyani Publishers, New Delhi, India.
2. Kang, M.S. and M. Kang (ed). 2003. Handbook of Formulae and Software for Plant Geneticists and Breeders. Harworth Press Inc, Los Angelus, USA.
3. Singh, P. 2000. Biometrical Techniques in Plant Breeding. (2nd ed.,) Kalyani Publishers, New Delhi, India.
4. Baker, W.A. 1992. Manual of Quantitative Genetics. (5th ed.) Academic enterprises, Pullman, USA.
5. Ali, Z. 2010. Analyzing and Understanding Genetic Problems: Classical and Conventional Approach. VDM, Germany.

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| PBG 610 | Preparation of Research Project and Scientific Writing | 3(2-1) |
|---------|---|--------|

Objectives

To enable students to understand:

- Different types of research and scientific reports.

Theory

Introduction of concept of science and scientific method. The concept, purpose and kinds of research project and Scientific Reports. Collection and organizing source materials: reviewing the literature and preparing bibliography. The techniques of composition: rules of scientific writing, word usage in scientific writing, style for composing scientific writing. Writing thesis, scientific papers, and project reports; table of contents, list of tables, the use of scientific quotations, illustrations, appendices, statistics and tables, standard abbreviations. Preparing preliminary draft, editing, and evaluating the final draft. Preparation of PC forms. Plagiarism, its types and testing methods. Policy of HEC on Plagiarism.

Practical

Exercise of scientific writing and research proposal. Exercise of collecting material from different sources on assigned topics and oral presentations. Use of reference manager, endnote and Turnitin software.

Recommended Books

1. Anderson, J., B.H. Durston and M. Poole. 1992. Thesis and Assignment Writing. Wiley Eastern Ltd. New Delhi, India
2. Andrew, C.O. 1993. Applied Agricultural Research: Foundations and Methodology. West view Press
3. Everything You Wanted to Know About Making Tables and Figures. <http://abacus.bates.edu/~ganderso/biology/resources/writing/HTWtablefigs.html>
4. Gatner, E.S. M. and F. Cordasco. 1959. Research and Report Writing. Barnes and Noble, Inc., New York, USA
5. Gopen, G.D. and J. A. Swan. 1990. The Science of Scientific Writing. American Scientist, 78: 550-558.
6. Ghafoor, A. 2007. Manual for Synopsis and Thesis Preparation. University of Agriculture, Faisalabad.
7. Ghafoor, A., G. Murtaza, and S.I. Hussain. 2006. Fundamentals of Scientific Communications and Presentations. Allied Book Centre, Lahore.
8. Guidelines for Writing Scientific Papers. <http://www.bms.bc.ca/library/Guidelines>

9. Handbook of postgraduate Research students. UHI Millennium Institute, Perth College, Scotland, UK. WWW.PERTH.AC.UK.
10. McGranaghan, M. Guidelines on writing a research. <http://www2.hawaii.edu/~matt/proposal.html>, <http://www.imechanica.org/node/588>
11. Plagiarism Policy. 2007. HEC booklet.
12. Tischler, M.E. Scientific Writing Booklet. Dept. of Biochemistry and
13. Biophysics, University of Arizona, USA. www.biochem.arizona.edu/marc/Sci-Writing.pdf
14. William R.L. 2001. Fine-Tuning Your Writing. Wise Owl Publishing Co., Madison, USA

Objectives

To enable students to understand:

- Emerging trends of genomics in relation to Agriculture and Crops Breeding

Theory

Genomics: Introduction, scope and application in agriculture. Genome organization and structure. Methods of DNA sequencing. Construction of DNA libraries, gene identification in a genome sequence. Transcriptome analysis: Microarray and DNA chip, genomic variation analysis. Application of genomics in forward and reverse genetics, metabolomics, phylogenomics, and proteomics.

Practical

Exploring the database for gene/protein sequences and retrieval. Primer designing. Translation tools. Construction of a phylogentic tree. Sequence annotation tools. Submitting a gene/protein sequence in Gene banks.

Recommended Books

1. Brown, T.A. 2006. Gene Cloning and DNA Analysis, and Introduction. (5th ed.). Blackwell Science Ltd. UK.
2. Brown, T.A. 1989. Genetics: A Molecular Approach, Van Nostrand Reinhold (International) Co. Ltd. London.
3. Evans, D.E., J.O.D. Coleman and A. Kearns. 2003. Plant Cell Culture, BIOS Scientific Publishers, USA.
4. Gardner, E. J., M. J. Simmons and D. P. Snustad. 1991. Principles of Genetics. 8th ed. John Wiley and Sons, Inc., New York, USA.
5. Lesk, A.M. 2000. Introduction to Bioinformatics. Oxford University Press, Inc. New York, USA.
6. Orengo, C., Jones, D. and Thornton, J. 2003. Bioinformatics: Genes, Proteins and Computers. BIOS Scientific Publishers Limited. Cornwmwell Press, Trowbridge, UK.
7. Singh, B.D. 2004. Plant Breeding: Principals and Methods, Kalyani Publishers, India.
8. Slater, A., N. Scott, and M. Fowler. 2004. Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press Inc., USA.

Articles

1. Hodges, E., Z. Xuan¹, V. Balija, M. Kramer, M. N. Molla, S. W. Smith, C. M. Middle, M. J. Rodesch, T. J. Albert, G. J. Hannon and W. R.

- McCombie. 2007. Genome-wide In Situ Exon Capture for Selective Resequencing. *Nature Genetics*, 39:1522 – 1527
2. Ronaghi, M. 2001. Pyrosequencing Sheds Light on DNA Sequencing. *Genome Res.*,11:3-11
 3. Shendure J., R. D.Mitra, C. Varma and G.M. Church. 2004. Advanced Sequencing Technologies: Methods and Goals. *Nature Genetics*, 5: 335-344

Websites

1. www.expasy.ch
2. www.justbio.com
3. www.ncbi.nlm.nih.gov/entrez/index.html

Objectives

To enable students to understand:

- Importance of biosafety laws and standards related to GM crops.

Theory

Concept of biosafety measures. Cartagena protocol on biosafety; field and laboratory biosecurity and biosafety; risk assessment; development of biosafety measures in crop improvement, agencies regulating biosafety rules. Potential threats of agricultural biotechnology, transgenic plants and animals. Regulations to access safety of GM crops.

Practical

Classes of chemicals, handling, storage and transportation of hazardous chemicals. Safe work practices. Making plans of risk assessment; Handling radioactive material. Assays to quarantine biological materials.

Recommended Books

1. Borém, A, F.R. Santos, and D.E. Bowen, 2003. Understanding Biotechnology, Prentice Hall, USA.
2. George T. Tzotzos, Genetically Modified Organisms: A Guide to Biosafety, 1995. CAB International, USA
3. Salerno, R.M. and J. Gaudio. Laboratory Biosecurity Handbook. CRC Press, Taylor and Francis Group, USA.

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| PBG 613 | Breeding Medicinal Plants | 3(2-1) |
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Objectives

To enable students to understand:

- Significance of medicinal plants in national and international perspectives
- Role of conventional and molecular tools for improvement of medicinal plants

Theory

History of uses of medicinal plants. Present status of commercially grown medicinal plants. Germplasm collection, evaluation, and diversity among medicinal plants; *ex situ* and *in situ* conservation. Objectives and problems in breeding medicinal plants. Breeding methods, use of mutation, and modern techniques for improvement of medicinal plants. Marker assisted selection for medicinal value related traits.

Practical

Identification of medicinal plants. Reproductive biology, selfing and artificial hybridization techniques in medicinal plants. Handling of segregation generations. Measurement of economic yield and medicinal value related traits.

Recommended Books

1. Heywood, V. 1991. Conservation of Medicinal Plants: International Consultation Papers. World Conservation Union, World Health Organization, World Wide Fund for Nature. Cambridge University Press, UK.
2. Johnson, C.B. and C. Franz. 2002. Breeding Research on Aromatic and Medicinal Plants. The Haworth Press Inc. USA
3. Yaniv, Z. and U. Bachrach. 2005. Handbook of Medicinal Plants. The Haworth Press Inc. USA.

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| PBG 614 | Internship or Research Project | 4(0-4) |
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Objectives

To enable students to understand:

- Importance of planning and conducting research project
- Data collection, analysing and interpretation
- Logical presentation of results

Practical

Students will be required to undertake internship at various agricultural research organizations, private companies, extension/adaptive/private farms.

OR

To undertake a research project at university fields/laboratories aimed at their practical training. Planning, layout and execution of experiment. Collection, analysis, and interpretation of data.

Upon completion of internship/research project, students are required to submit a report and give presentation of internship/research experiment.

Recommended Books

1. Khalil, S.K. and P. Shah. 2007. Scientific Writing and Presentation. Higher Education Commission, Islamabad, Pakistan.

**Post Graduate Courses
Core Courses for MSc (Hons) Students**

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|---------|------------------------------|--------|
| PBG 701 | Principles of Plant Breeding | 3(2-1) |
| PBG 702 | Advanced Genetics | 3(3-0) |
| PBG 703 | Molecular Plant Breeding | 3(2-1) |
| PBG 704 | Cytogenetics of Crop Plants | 3(2-1) |

General Courses for Post Graduate Students

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| PBG-705 | Breeding and Genetics of Fodder Crops | 3(2-1) |
| PBG-706 | Breeding for Stress Environments | 3(2-1) |
| PBG-707 | Mutation Breeding | 3(2-1) |
| PBG-708 | Population Genetics | 3(3-0) |
| PBG-709 | Cereal Genetics and Breeding | 3(2-1) |
| PBG-710 | Cotton Genetics and Breeding | 3(2-1) |
| PBG-711 | Genetics and Breeding of Oilseed Crops | 3(2-1) |
| PBG-712 | Genetics and Breeding of Sugar Crops | 3(2-1) |
| PBG-713 | Genetic Engineering in Plants | 3(2-1) |
| PBG-714 | Evolution of Field Crops | 3(3-0) |
| PBG-715 | Advanced Cytogenetic | 3(3-0) |
| PBG-716 | Plant Genomics | 3(2-1) |
| PBG-717 | Advanced Methods in Plant Breeding | 3(2-1) |
| PBG-718 | Genetics of Plant Disease and Insect Resistance | 3(2-1) |
| PBG-719 | Development of Hybrid and Seed Production | 3(2-1) |
| PBG-720 | Biometrical Techniques in Plant Breeding | 3(2-1) |
| PBG-721 | Special Problem | 1(1-0) |
| PBG 722 | Seminar (MSc Hons) | 1(1-0) |
| PBG 723 | Thesis (MSc Hons) | 10(0-10) |
| PBG-724 | Special Problem | 1(1-0) |
| PBG-724 | Seminar-I (PhD) | 1(1-0) |
| PBG-725 | Seminar-II (PhD) | 1(1-0) |
| PBG-726 | PhD Dissertation | 20(0-20) |

Theory

Role of Plant Breeding in crop improvement. Variability in natural populations and its exploitation. Creation of genetic variation using conventional and non-conventional techniques. Specific objectives in various self and cross pollinated crops. Breeding methods in self- pollinated crops. Breeding methods in cross pollinated crops. Heterosis and its exploitation in crop improvement. Development, evaluation and improvement of inbred lines. A, B and R lines in hybrid seed production. Variety evaluation committee. Novelty and DUS characteristics in varietal registration. Seed certification. Seed production system of approved, pure line and hybrid varieties. Reverse breeding. Marker assisted selection in plant breeding.

Practical

Hybridization techniques in self-pollinated and cross pollinated crops. Handling of segregating and inbred generations. Layout of experiments and collection of experimental data, its tabulation and interpretation. Estimating effective population and sample size. Visits to various research institutes.

Recommended Books

1. Sleper D.A. and J.M. Poehlman. 2006. Breeding Field Crops. Blackwell Publishers, Iowa Sate University Press, Ames, USA.
2. Singh, B.D. 2004. Plant Breeding, Principles and Methods. Kalyani Publishers, New Delhi, India
3. Khan, M.A., E. Bashir, and R. Bantel (Editors). 1994. Plant Breeding. National Book Foundation, Islamabad.
4. Fehr, W.R. 1987. Principles of Cultivar Development. Volume I. Theory and Technique. MacMillan Publishing Co., New York.
5. Allard, R. W. 1999. Principles of Plant Breeding. John Wiley and Sons, New York, USA.
6. Chahal, G.S. and S.S. Gosal. 2002. Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches. Alpha Science International Ltd., Oxford, UK.
7. Acquaah, G. 2009. Principles of Plant Genetics and Breeding. John Wiley & Sons, UK.

Theory

Classical and modern concepts of gene. Genetic material: a brief review: structure, function, organization, replication and properties of genetic material. Gene, genetic code, Wobble hypothesis and one gene-one polypeptide concept. Gene expression and regulation in prokaryotes and eukaryotes. Genetic recombination. Gene interaction: control, basis and importance. Mutation: classification, biochemical basis, factors affecting the rate of mutation and repair mechanism. Transposable genetic elements. Cytoplasmic inheritance: Origin and biological implications, genetics of killer traits. Introduction to non-conventional gene manipulation techniques: epigenetics and gene cloning. DNA sequencing techniques.

Recommended Books

1. Klug, W.S. and M.R. Cummings. 2010. Concepts of Genetics. Dorling Kindersley, Pvt. (Ltd.), New Delhi, India.
2. Snustad, D.P. and M.J. Simmons. 2009. Principles of Genetics. John Wiley and Sons, Inc., New York, USA.
3. Hartl, D.L. 2005. Genetic Analysis of Genes and Genomes. (6th ed.) John and Bartlett Publishers, NY, USA.
4. Lewin, B. 2004. Genes VIII. John Wiley and Sons, NY, USA.
5. Reece, R.J. 2004. Analysis of Genes and Genomes. John Wiley & Sons, NY, USA.
6. Brown, T.A. 2010. Gene Cloning and DNA analysis: An Introduction. Willy-Blackwell, UK

Theory

Introduction to molecular breeding. Quantitative genetics and plant improvement. Genotype x environment interaction (GEI).Molecular dissection of GEI. Applications of molecular markers. Development of mapping populations. Molecular dissection of complex traits. Molecular maps and types of mapping. Introduction to quantitative trait loci. QTL mapping. Understanding the genetic architecture of quantitative traits. Multiple QTLs. Bayesian and linkage disequilibrium mapping. Linkage analysis, map construction, experimental design and testing marker segregating patterns. Assumptions of different map functions. Problems and possible solutions in QTL analysis. Construction of molecular linkage map – a case study from cereals. Fine mapping of QTL and map based cloning. Markers assisted selection. Validation of marker-trait associations. Marker assisted gene introgression, selection for QTLs. Future prospects in molecular plant breeding. Genotyping by sequencing.

Practical

DNA extraction. Primer designing. PCR, gel scoring, phenotypic and genotypic data collection. Software based data analysis to develop QTLs. *In silico* mapping – physical position of a marker- a case study in completely sequenced plant genome. Analysis of upstream and downstream genes of a marker. Genome browsing of sequenced plant genomes. Promoter analysis.

Recommended Books

1. Camp N.J., and A. Cox 2002. Quantitative Trait Loci: Methods and Protocols: Humana Printing Inc.
2. Kang, M.S. 2002. Quantitative Genetics, Genomics, and Plant Breeding: CABIPublishing.
3. Kole, C. 2007. Genome Mapping and Molecular Breeding in Plants: Springer.
4. Wu, R, C. Ma and G. Casella. 2010. Statistical Genetics of Quantitative Traits: Linkage, Maps and QTL: Springer Publishing Company, Incorporated.
5. Xu, Y. 2010. Molecular Plant Breeding: CABI Publishing.

Theory

Cytogenetics and its importance in crop improvement. Ultra fine structure of cell and its organelles. Overview of cell cycle. Cytological evidences of crossing over. Chromosomal aberrations; deficiencies and duplications, their phenotypic effects, genetic and cytological tests. Use of translocations and inversions in genetic studies and evolution. Methods of locating break points. Genetic studies in translocations and inversions in different crops. Heteroploidy, genetic and cytological behavior.

Practical

Use of various microscopes in cytological studies. Slide preparation of mitotic and meiotic cell divisions from different plant material. Karyotype study of different crop plants. Banding techniques (ISH, FISH & GISH).

Recommended Books

1. Bass, H.W. and J.A. Brichler. 2010. Plant Cytogenetics: Genome Structure and Chromosome Function. Springer Publishers, New York, USA.
2. Gupta, R.K. 1999. Cytogenetics. Rastogi Publishers, Meerut, India.
3. Singh, R.J. 2003. Plant Cytogenetics. CRC Press, London, UK.
4. Prasad, G. 1998. Introduction to Cytogenetics. Kalyani Publishers, New Delhi, India.
5. Sinha, U, and S. Sinha. 1998. Cytogenetics, Plant Breeding and Evolution. Vikas Publishing House Pvt Ltd, New Delhi, India.

Theory

Reproductive mechanisms in various fodder crops. Male sterility and self-incompatibility factors and their consequences. Genetic systems in fodder crops. Breeding objectives in fodders. Genetics of high productivity and quality parameters. Breeding procedures and techniques, introduction, selection and evolution of new varieties/species. Testing of inbred lines; production of hybrid fodder. Interspecific and intergeneric crosses in fodder species such as sorghum-sudangrass hybrid, bajra-napier hybrid. Use of polycross methods in fodders. Developing synthetic varieties. Evaluation for quality; proteins, carbohydrates and digestibility. Breeding for greater seedling vigour, persistence of stand and disease and insect resistance.

Practical

Classification of various *rabi* and *kharif* fodders. Study of floral structure in different fodder crops. Selfing and crossing techniques for various fodders; handling breeding material and its evaluation.

Recommended Books

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. Iowa State University Press, Ames, Iowa, USA.
2. Bhatti, M.B. and S. Khan (eds.) 1996. Fodder production in Pakistan. Proceedings of the National Conference on the Improvement, Production and Utilization of Fodder Crops in Pakistan, held on March 25-27, 1996 at NARC, Pakistan Agricultural Research Council, Islamabad.
3. Poehlman, J.M. 1995. Breeding Field Crops. Iowa State University Press, Ames, Iowa, USA.
4. Rognli, O.A., E.T. Solberg, and I. Schjelderup. (eds.). 1994. Breeding Fodder Crops for Marginal Conditions. Series: Developments in Plant Breeding, Springer Link, USA.

Theory

Definition and types of stresses: environmental, soil and physiological. Importance of stress breeding in local and global scenarios. Response of crop plants to environmental stresses. Concepts of resistance and tolerance. Genetic variability for stress tolerance and its evaluation for improvement. Selection indices under various stresses: salinity, water and temperature shocks. Induction of stress tolerance, adaptive mechanisms. Identification of genetic resources for tolerant genes and their transfer to indigenous varieties. Screening and micro-screening techniques; breeding and selection strategies for stress tolerance in perspectives of climatic changes. Molecular basis of stress tolerance.

Practical

Field and laboratory study of stress parameters. Screening under simulated stress conditions. Genetic analysis of tolerance related traits. Visits to research institutes.

Recommended Books

1. Goyal, S.S., S.K. Sharma and D.W. Rains (eds.) 2003. Crop Production in Saline Environments: Global and Integrative Perspectives. Haworth Press, London UK.
2. Hall, A.E. 2001. Crop Responses to Environment. CRC Press LLC, Boca Raton, Florida, UK.
3. Gupta, U.S. 1997. Crop Improvement Vol. 2 Stress Tolerance. Oxford and IBH Publishing Co. (Pvt) Ltd., New Delhi, India.
4. Pessarakli, M. (ed.) 1994. Handbook of Plant and Crop Stress. Marcel Dekker Inc., New York. USA.
5. Mooney, H.A., W.E. Winner, and E.J. Pell. 1991. Response of Plants to Multiple Stresses. Academic Press, San Diego, California, USA.
6. Singh, B.D. 2004. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi, India

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| PBG 707 | Mutation Breeding | 3(2-1) |
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Theory

Mutation: importance and achievements in plant breeding. Classes of mutagens. Induction of mutation, detection, evaluation and utilization of induced mutants. Factors modifying the effectiveness of irradiation in seed treatment. Determination of LD50. Effectiveness and efficiency for inducing cytological changes. Gamma garden. Induced mutations through transposable elements. Molecular basis of Mutation: Targeting Induced Local Lesions in Genomes (TILLING); making Kill Curve, development and handling of TILLING populations, high throughput screening of point mutations. Observations in M1 and procedure for selection in later generations. Use of mutants in hybridization program. Improvement of specific characters through induced mutation. Mutation breeding research in some vegetatively propagated crops. Bio-safety concerns.

Practical

Radiation treatment techniques. Radio sensitivity of field crops. Cytological analysis of mutants. Field observations and selection procedure of mutagenic material. Visit to various mutation research facilities.

Recommended Books

1. Purohit, S.S. 2010. Mutation Breeding. Agrobios, India.
2. Datta, S.K. 2005. Role of Classical Mutation Breeding in Crop Improvement. Daya, New Delhi, India
3. Van Harten, A.M. 1998. Mutation breeding. Theory and Practical Applications. Cambridge University Press, Cambridge, U.K.
4. Amir, M. and R.C. Borstel. 1985. Basic and Applied Mutagens. Plenum Press, New York, USA.
5. Singh, B.D. 2004. Plant Breeding, Principles and Methods. Kalyani Publishers, New Delhi, India
6. Shu, Q.Y. (ed) 2009. Induced Plant Mutations in the Genomics Era. Joint FAO/IAEA Program for Nuclear Techniques in Food and Agriculture, Rome, Italy.

World Wide Web

http://tilling.fhcrc.org:9366/files/Welcome_to_ATP.html
http://www.licor.com/bio/applications/4300_applications/tilling.jsp

Theory

Definition and scope of population genetics; Allelic frequency and polymorphism. Organization of genetic diversity. Hardy-Weinberg law and factors affecting population structure. Mating systems: random, assortative and dis-assortative. Population models: consequences of genetic drift. Genetic differentiation of populations. Inbreeding in small populations, effective population size. Wahlund's Principle, patterns of migration; natural selection; over-dominance, heterozygote inferiority. Mutation, selection and shifting balance. Genetic erosion: consequences and gene conservation

Recommended Books

1. Hamilton, M. B. 2009. Population Genetics. Wiley and Blackwell. Sussex, UK.
2. Harri, D.L. 2007. Principles of Population Genetics. Sinauer Associates, Sunderland, Massachusetts, USA.
3. Neal, D. 2003. Introduction to Population Biology. Cambridge University Press, Cambridge, UK.
4. Falconer, D.S. and T.E.C. Mackay. 1996. Introduction to Quantitative Genetics. Longman, London.
5. Brown, A.G.D., M.T. Clegg, A.L. Kahler and B.S. Weir. 1990. Population Genetics, Breeding and Genetic Resources. Sinauer Associates, Sunderland, Massachusetts, USA.

Theory

Role of cereals in human food. Genomic relationship among various species of cereal crops: wheat, rice, maize, barley, oats and triticale. Genetics of morphological, physiological and grain quality characters in cereal crops. Genetics of disease and insect resistance. Genetic basis of resistance/tolerance against abiotic stresses. Strategies for improvement of cereal crops for specific traits.

Practical

Problems relating to genetic analysis in wheat, rice, maize and barley. Estimation of grain quality. Identification and scoring of cereal diseases, screening of cereal cultivars for drought resistance and salt tolerance in lab and field conditions. Visit to various cereal research institutes.

Recommended Books

1. Datta, S.K. 2008. Rice Improvement in the Genomics Era. CRC Press, New York, USA.
2. Sleper D.A. and J.M. Poehlman. 2006. Breeding Field Crops. Blackwell Publishers, Iowa State University Press, Ames, USA.
3. Nevo, E., A.B. Korol, A. Beiles and T. Fahima. 2002. Evolution of Wild Emmer and Wheat Improvement. Springer-Verlag, Germany.
4. Slafer, G.A., J.L. Molina-Cano, J.L. Araus and I. Romagosa (eds.). 2002. Barley Science: Recent Advances from Molecular Biology to Agronomy of Yield. Food Product Press, New York, USA.
5. Hallauer, A.R. (ed.). 2001. Specialty Crops. CRC Press, Florida, USA.

Theory

Importance of cotton in national and global economy. Description of various species of cotton. Evolutionary history and cultivated species of cotton. Cotton genomics, Transgenic Cotton, Contemporary issues in transgenic cotton production and CLCuD susceptibility. Breeding Cotton for Stress Environments. Organic and coloured cotton. Introduction to genome organization and sources of resistance/tolerance (gene families) against CLCuD and other stresses. Utilization of wild species of *Gossypium* in breeding programs. Components of genetic defense umbrella, R gene mediated resistance. Cotton fibre quality traits, cotton fibre developmental stages, control of fibre elongation and maturity. Strategies to improve cotton fiber quality.

Practical

Methods of measuring cotton fibre strength, fineness and maturity. Cladogram construction of various gene families involved in fiber development. Exploring cotton fibre EST databases. DNA markers for various traits. Data recording on plant and fibre characters and genetic analyses.

Recommended Books

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. (5th ed.) Iowa State University Press Ames, USA.
2. Rafiq, M. 2004. Cotton: An Introduction. ICAC Washington DC, USA.
3. Shiron, J. (Editor). 2004. Transgenic Cotton. Science press, 16 Donghuangchenggen North Street Beijing, China.
4. Singh, P. 2004. Cotton Breeding. Kalyani Publishers. New Delhi, India.
5. Johnie, N.J. and S. Saha. 2001. Genetic improvement of Cotton-emerging techniques. Oxford and IBH Publishing Co., New Delhi, India.

World Wide Web:

<http://www.cotton.org/journal/archive.cfm>

Theory

Significance of edible oil in the economy of Pakistan. Major issues of oilseed crops: conventional and non-conventional. Genetic relationship among different Brassica species. Genetic resources and their exploitation in oilseed crops. Genetic basis of qualitative, quantitative and oil quality traits. Genetics of double low traits and its utilization. Genetics of male sterility and its use in sunflower and canola hybrid seed production. Strategies for genetic improvement of oilseeds. Progress in oilseed crops genomics. Exploitation of innovative tools in oilseed crops breeding. New trends in long chain fatty acids.

Practical

Specification and characteristics of edible oil, oil content, fatty acid, iodine number, acid value, hydrogenation and sponification. Methods and equipment used for oil extraction and analysis. Fatty acid profile of various edible and industrial oils. Genetic evaluation of different fatty acids in oilseeds. Visit to various vegetable oil and ghee industries.

Recommended Books

1. Ramanath, T. 2004. Applied Genetics of Oilseed Crops. Daya, New Delhi, India
2. Nagata, T. and S. Tabata (ed).2003. Brassica and Legumes: From Genome Structure to Breeding. Springer Verlag, New York, USA.
3. Kimber, D. and D.I. McGregor. 1995. Brassica Oilseeds: Production and Utilization. Cambridge, UK.
4. Verma, D.P.S. 1996. Soybean: Genetics, Molecular Biology and Biotechnology. Biotechnology in Agriculture Series, No 14. CABI Publishing Co. USA.
5. Robbelen, G. and R.K. Downey. 1990. Oil Crops of the World: Their Breeding and Utilization, McGraw-Hill Publishing Company, New York, USA.

World Wide Web

1. <http://www.parc.gov.pk/1SubDivisions/NARCCSI/CSI/rapeseed.html>
2. http://archive.idrc.ca/library/document/091017/chap3_e.html
3. <http://www.soygenetics.org/>

Theory

Evolutionary history of sugarcane and sugar beet. Genetic barriers in sugarcane flowering and their possible solutions. Management of fuzz production and germination. Genetic determination of quality parameters and their utilization. Genetics of different parameters in sugarcane and sugar beet. Role of polyploidy in sugar crops. Genetic relationship between cane yield and sugar recovery. Strategies for genetic improvement in sugar crops. Role of biotechnology in sugar crops improvement.

Practical

Estimation of Brix value of sugarcane. Collection of data for various plant traits in sugar crops and their statistical analysis. Visit to research institutes and sugar industries.

Recommended Books

1. Henry, R.J. and C. Kole. 2010. Genetics, Genomics and Breeding of Sugarcane. Taylor and Francis, London, UK.
2. Malik, K.B. 2009. Cane and Sugar Production. Punjab Agriculture Research Board, Lahore, Pakistan.
3. Draycott, A.P. 2006. Sugar beet. Blackwell Publishing Ltd., Oxford, UK.
4. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops (5th ed.) Iowa State University Press, Ames, Iowa, USA.

Theory

Molecular approaches of gene manipulation in plants. Techniques for locating genes. Importance of gene cloning in industry. Restriction endonucleases and ligases. Cloning vehicles. DNA probing and blotting techniques. Types of PCR, cDNA synthesis and expression analysis. Genetic transformation and its types. Selection for recombinants: identification and selection of cloned gene. Development of transgenic plants. Benefits and problems related with transgenic plants. Bioinformatics.

Practical

Extraction and purification of plasmid, genomic DNA and RNA. Restriction mapping. PCR and electrophoresis. Genetic transformation of bacteria and plants. Visit to National Institutions working in Genetic Engineering and Biotechnology.

Recommended Books

1. Slater, A., N.W. Scott and M.R. Fowler. 2008. Plant Biotechnology: the Genetic Manipulation of Plants. Oxford University Press, Oxford, UK.
2. Liang, G.H. and D.Z. Skinner. 2005. Transgenic Crops. Haworth Press. Inc., NY, USA.
3. Chawla, H.S. 2004. Introduction to Plant Biotechnology. Science Publishers, New Hampshire, USA.
4. Watson, J.D., T.A. Baker, S.P. Bell, A. Gann, M. Levine and R. Losick. 2004. Molecular Biology of the Gene. Pearson Education, London, UK.
5. Jackson, J,F, and Linskens. 2002 (Ed) Testing for Genetics Manipulation in plants (Molcular Methods of Plant Analysis Vol 22) Springer-Verlag, Berlin, Germany.
6. Old, R.W. and S.B.P. Primose. 2000. Principles of Gene Manipulation: An Introduction to Genetic Engineering. Blackwell, London, UK.

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| PBG 714 | Evolution of Field Crops | 3(3-0) |
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Theory

Theories of evolution. Co-evolution, phylo-genetic history of evolution. Concept of species, isolating mechanisms, different types/modes of speciation. Various sources of variation, role of genetic polymorphism, migration, mutation, hybridization and polyploidy in evolution. Natural selection, patterns of selection. Wide crosses and species resynthesis in crops. Evolution and species relationship in important field crops. Evolutionary trends in crops, important plant adaptations in climatic vagaries. Evolution of genes and genomes of field crops. Introduction of various software for phylo-genetic relationships.

Recommended Books

1. Hancock, J. 2004. Plant Evolution and the Origin of Crop Species. (2nd ed) Oxford University Press, USA
2. Willis, K.J. and J.C. McElwain. 2002. Evolution of Plants. Oxford University Press, Oxford, UK.
3. Strickberger, M.W. 2000. Evolution. Jones and Bartlett, New York, USA.
4. Ladizinsky, G. 1998. Plant Evolution Under Domestication. Kluwer Academic Publishers New York, USA.
5. Smartt, J. and N.W. Simmonds (eds.) 1995. Evolution of Crop Plants. (2nd ed.). Longman Scientific and Technical, Essex, England.
6. Fehr, W.R. 1987. Principles of Cultivar Development, Vol. 2: Crop Species. Macmillan Pub Co., NY, USA

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| PBG 715 | Advanced Cytogenetics | 3(3-0) |
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Theory

Endosymbiotic theory of evolution of organelles. Heteroploidy. Autopolyploidy: occurrence and general characteristics. Haploids vs monoploids, artificial production of haploids and dihaploids. Theoretical genetic ratios for single gene locus, genetic data, linkages in autopolyploids. Allopolyploidy: origin, evidences of homology between chromosomes. Aneuploidy: trisomics, monosomics, nullisomics, their transmission and factors influencing transmission. Substitution lines and their use in crop improvement. Cytogenetics of apomixes. Introduction to florescent and genomic *in situ* hybridization techniques.

Recommended Books

1. Puertas, M.J. and T. Naranjo. 2005. Plant Cytogenetics: Cytogenetic and Genome Research. S. Karger Publishers.
2. Schulz-Schaeffer, J. 1981. Cytogenetics: Plants, Animal, Humans. Springer-Verlag, New York. USA.
3. Singh, R. J. 2005. Plant Cytogenetics. CRC Press, London, UK.
4. Swanson, C.P., T. Merz and W.J. Young. 1981. Cytogenetics. (2nd ed.) Prentice Hall international Inc., Englewood Cliff, New Jersey, USA.

Theory

Introduction to plant genomics. The structure of plant genomes. Origin and evolution of plant nuclear, mitochondrial and plastid genomes. Physical organization and gene contents of cytoplasmic genomes. Organization of DNA into chromosomes. Construction of genomic DNA libraries. Physical mapping of plant chromosomes. Molecular marker systems for gene mapping. DNA based markers. Genome sequencing strategies. Gene discovery from sequence data. ESTs and full length cDNA libraries. Transposable elements and transcription factors. Identification of genes by mutagenesis – forward and reverse genetic approaches. T-DNA mutagenesis, RNAi, TILLING, delete a gene and combinatorial gene silencing. Comparative genomics – case study of cereal genomes. Epigenomics and its applications in crop plants. Current prospectus and future scenario of plant genomics.

Practical

Taxonomic and molecular identification of various crop progenitors in the field. Analysis of gene family evolution. *In silico* expression profiling of genes. Analysis of *cis* and *trans* acting elements.

Recommended Books

1. Cullis C.A., and J. Wiley. 2004. Plant Genomics and Proteomics: Wiley Online Library.
2. Daniell, H, and C. Chase. 2004. Molecular Biology and Biotechnology of Plant Organelles: chloroplasts and Mitochondria: Kluwer Academic Pub.
3. Leister, D. 2005. Plant Functional Genomics: CRC.
4. Meksem, K, G. Kahl, and H. Shapiro. 2005. The Handbook of Plant Genome Mapping: Wiley Online Library.
5. Somers, D.J., Langridge, P and J.P. Gustafson. 2009. Plant Genomics Methods and Protocols; Series: Methods in Molecular Biology, Vol. 513. Humana Press.

Theory

Ideotype concept; its genetic basis, identification and development of an ideotype. Current scenario and future concerns. Participatory plant breeding. Components of variation, estimation of additive and non-additive variances. Heritability and its role in selection. Testing $G \times E$; Stability analysis; Enhancement of genetic gain in plant breeding. Mating designs: Diallel, North Carolina design I, II and III. Uses of mating design in plant breeding. Selection indices and their uses. Significance and utilization of wide crosses. Marker assisted selection and its application in plant breeding.

Practical

Expected mean squares and their use in plant breeding. Response to selection, Estimation of variance components and heritability from the mating designs. Application of various mating designs and selection indices. Use of computer software.

Recommended Books

1. Singh, R.K. and B.D. Chaudhary, 2004. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi, India.
2. Falconer, D.S. 2003. Introduction to Quantitative Genetics. Textbook Publisher, London, U.K.
3. Kang, M.S. (ed). 2003. Handbook of Formulas and Software for Plant Geneticists and Breeders. Harworth Press Inc, LA, USA.
4. Kang, M.S. (Ed) 2002. Quantitative Genetics, Genomics and Plant Breeding. CABI, Sussex, UK.
5. Kang, M.S. and H.G. Gauch. 1996. Genotype by Environment Interaction. CRC Press, New York, USA.
6. Kearsey, M.J. and H.S. Pooni. 1996. The Genetical Analysis of Quantitative Traits. Chapman and Hall, Ltd. London, U.K.

Theory

Nature of parasitism, pathogenicity and expression of disease resistance. Mendelian, quantitative and cytoplasmic resistance in host. Genetics of host-pathogen interaction and various models. Horizontal and vertical resistance. Identification of disease resistance sources. Host/non-host resistance. Nature and genetic mechanism of resistance. Transfer of genetic resistance. Pyramiding genes for resistance. Evaluation of plant resistance to insect and diseases. Molecular approaches to insect and disease resistance.

Practical

Inoculation techniques for various plant diseases. Study of differentiation among disease susceptibility, disease escape, tolerance, resistance and immunity. Measurement of resistance by using different scoring scales and their statistical analysis. Visit to specialized research institutes.

Recommended Books

1. Agrios, G.N. 2005. Plant Pathology. Elsevier Academic Press. Burlington, USA.
2. Singh, D.P. and A. Singh. 2005. Disease and Insect Resistance in Plants. Science Publishers, New Hampshire, USA.
3. Sadasivam, S., and B. Thayumanavan (ed). 2003. Molecular Host Plant Resistance to Pests. Marcel Dekker, New York, USA.
4. Kranz, J. (Ed) 2002. Comparative Epidemiology of Plant Diseases. Springer, NY, USA
5. Gunasekaran, M. and D.J. Weber (ed). 1995. Molecular Biology of the Biological Control of Pests and Diseases of Plants. Department of Botany and Range Science, Brigham Young University, Provo, Utah.
6. Johnson, R. 1992. Breeding for Disease Resistance. Kluwer Academic Publishers Group, Dordrecht. The Netherlands.
7. Vanderplank, J.E. 1984. Disease Resistance in Plants. (2nd ed.) Academic Press, Inc., Orlando, Florida, USA.

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| PBG 719 | Development and Seed Production of Hybrids in Crops | 3(2-1) |
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Theory

Principles for hybrid seed production. Heterosis, classification and its genetic basis. Hybrid types. Two and three-line systems of hybrid development. Development and maintenance of parental lines (A, B and R lines). Evaluation of inbred lines for general and specific combining ability. Production technology for hybrid seed in field crops and vegetables. Isolation (temporal and spatial), planting ratios and synchronization of male and female parents. Commercial use of hybrid vigor. Field standards, genetic purity, harvesting and handling of hybrid seed. Economic aspects of hybrid seed production.

Practical

Development of inbred lines. Estimation of GCA and SCA. Selection and maintenance of A, B and R lines under field conditions. Use of gametocytes, induction of male sterility and evaluation of hybrids. Visit to private and public research institutes engaged in commercial hybrid seed production.

Recommended Books

1. Sleper D.A. and J.M. Poehlman. 2006. Breeding Field Crops. Blackwell Publishers, Iowa State University Press, Ames, USA.
2. Singal, W.C. 2004. Hybrid Seed Production. Kalyani Publishers, New Delhi, India.
3. Basra, A.S. 2000. Hybrid Seed Production in Vegetables: Rationale and Methods in Selected Crops. Food Product Press. New York, USA.
4. Feistritzer, W.P. and A.F. Kelly (eds.) 1987. Hybrid Seed Production of Selected Cereal, Oil and Vegetable Crops. FAO Plant Production and Protection Paper 82, FAO, Rome, Italy.

Theory

Importance of biometry in plant improvement. Selection indices. Diallel cross system. Genetic analysis of additive-dominance model, adequacy tests, limitations and assumptions for additive-dominance model, combining ability analysis, line x tester analysis and generation mean analysis. Regression and correlation analysis. Genotypic and phenotypic correlation analysis. Path coefficient analysis. Heritability and its role in selection. Multivariate analysis. Principal Component and Bi-plot Analysis.

Practical

Numerical examples regarding genetic analysis. Assessment of genotypic and phenotypic correlations, and partitioning of genotypic correlation into direct and indirect path ways. Use of software for biometrical analysis.

Recommended Books

1. Singh, R.K. and B.D. Chaudhary. 2004. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi, India.
2. Mead, R., R.N. Curnow and A.M. Hasted. 2003. Statistical Methods in Agriculture and Experimental Biology. Chapman and Hall, London, UK.
3. Townend, J. 2002. Practical Statistics for Environmental and Biological Statistics. John Wiley, New York, USA.
4. Becker, W.L. 1993. Manual of Quantitative Genetics. Washington State University Press, Pullman, Washington, USA.

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| PBG 721 | Special Problem | 1(1-0) |
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Student will be assigned a special topic for searching literature relevant to a particular problem or conducting an experiment or any other appropriate activity. Student has to compile a comprehensive report on the title assigned.

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| PBG 722 | Seminar (MSc Hons) | 1(1-0) |
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Student will be given a topic on a particular problem in the field of plant breeding and genetics. Student has to deliver a presentation in an open house gathering on the title assigned.

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| PBG 723 | Thesis (MSc Hons) | 10(0-10) |
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| PBG 724 | Seminar-I (PhD) | 1(1-0) |
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Student will be given a topic on a particular problem in the field of plant breeding and genetics. Student has to deliver a presentation in an open house gathering on the title assigned.

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| PBG 725 | Seminar-II (PhD) | 1(1-0) |
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Student has to defend his/her Ph.D Synopsis in an open house gathering.

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| PBG 726 | PhD Dissertation | 20(0-20) |
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ANNEXURE - A

English I (Functional English)

Objectives: Enhance language skills and develop critical thinking.

Course Contents:

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

Comprehension

Answers to questions on a given text

Discussion

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

Listening

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

Translation skills

Urdu to English

Paragraph writing

Topics to be chosen at the discretion of the teacher

Presentation skills

Introduction

Note: Extensive reading is required for vocabulary building

Recommended Books:

1. **Functional English**
 - a) Grammar
 1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492

2. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506
- b) Writing
 1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.
 - c) Reading/Comprehension
 1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.
 - d) Speaking

English II (Communication Skills)

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

Course Contents:

Paragraph writing

Practice in writing a good, unified and coherent paragraph

Essay writing

Introduction

CV and job application

Translation skills

Urdu to English

Study skills

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

Academic skills

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

Presentation skills

Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended Books:

Communication Skills

- a) Grammar

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.
- b) Writing
1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
 2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
- c) Reading
1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
 2. Reading and Study Skills by John Langan
 3. Study Skills by Richard York.

English III (Technical Writing and Presentation Skills)

Objectives: Enhance language skills and develop critical thinking

Course Contents:

Presentation skills

Essay writing

Descriptive, narrative, discursive, argumentative

Academic writing

How to write a proposal for research paper/term paper

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

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

Recommended Books:

Technical Writing and Presentation Skills

- a) Essay Writing and Academic Writing
 1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
 2. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
 3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.
- b) Presentation Skills
- c) Reading

The Mercury Reader. A Custom Publication. Compiled by Northern Illinois University. General Editors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharon. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

ANNEXURE - B

Pakistan Studies (Compulsory)

Introduction/Objectives

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

Course Outline

1. Historical Perspective

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

2. Government and Politics in Pakistan

Political and constitutional phases:

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

3. Contemporary Pakistan

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

Recommended Books

1. Burki, Shahid Javed. *State & Society in Pakistan*, The MacMillan Press Ltd 1980.

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

ANNEXURE - C

ISLAMIC STUDIES (Compulsory)

Objectives:

This course is aimed at:

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

Detail of Courses

Introduction to Quranic Studies

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

Study of Selected Text of Holly Quran

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

Study of Selected Text of Holly Quran

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

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

1. Life of Muhammad Bin Abdullah (Before Prophet Hood)
2. Life of Holy Prophet (S.A.W) in Makkah
3. Important Lessons Derived from the life of Holy Prophet in Makkah

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

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

Introduction to Sunnah

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

Selected Study from Text of Hadith**Introduction to Islamic Law & Jurisprudence**

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

Islamic Culture & Civilization

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

Islam & Science

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

Islamic Economic System

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

Political System of Islam

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

Islamic History

1. Period of Khlaft-E-Rashida
2. Period of Umayyads
3. Period of Abbasids

Social System of Islam

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

Reference Books

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

ANNEXURE - D

Note: One course will be selected from the following six courses of Mathematics.

COMPULSORY MATHEMATICS COURSES FOR BS (4 YEAR)

**(FOR STUDENTS NOT MAJORING IN
MATHEMATICS)**

1. MATHEMATICS I (ALGEBRA)

Prerequisite(s): Mathematics at secondary level

Credit Hours: 3 + 0

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

Course Outline:

Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions. *Matrices:* Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule.

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

Sequences and Series: Arithmetic progression, geometric progression, harmonic progression. *Binomial Theorem:* Introduction to mathematical induction, binomial theorem with rational and irrational indices. *Trigonometry:* Fundamentals of trigonometry, trigonometric identities.

Recommended Books:

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

2. MATHEMATICS II (CALCULUS)

Prerequisite(s): Mathematics I (Algebra)

Credit Hours: 3 + 0

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

Course Outline:

Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities. *Limits and Continuity:* Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

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

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

Recommended Books:

1. Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8th edition), 2005, John Wiley, New York
2. Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text)
3. Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston
4. Thomas GB, Finney AR, *Calculus* (11th edition), 2005, Addison-Wesley, Reading, Ma, USA

3. MATHEMATICS III (GEOMETRY)

Prerequisite(s): Mathematics II (Calculus)

Credit Hours: 3 + 0

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

Course Outline:

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

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

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

Recommended Books

1. Abraham S, Analytic Geometry, Scott, Freshman and Company, 1969
2. Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
3. Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston

4. COURSE FOR NON-MATHEMATICS MAJORS IN SOCIAL SCIENCES

| | | |
|-------------------------------|---|--------------------------------|
| <i>Title of subject:</i> | : | MATHEMATICS |
| <i>Discipline</i> | : | BS (Social Sciences). |
| <i>Pre-requisites</i> | : | SSC (Metric) level Mathematics |
| <i>Credit Hours</i> | : | 03 + 00 |
| <i>Minimum Contact Hours:</i> | : | 40 |
| <i>Assessment</i> | : | written examination; |
| <i>Effective</i> | : | 2008 and onward |

Aims : To give the basic knowledge of Mathematics and prepare the students not majoring in mathematics.

Objectives : After completion of this course the student should be able to:

- Understand the use of the essential tools of basic mathematics;
- Apply the concepts and the techniques in their respective disciplines;
- Model the effects non-isothermal problems through different domains;

Contents :

1. Algebra

Preliminaries: Real and complex numbers, Introduction to sets, set operations, functions, types of functions. *Matrices*: Introduction to matrices, types of matrices, inverse of matrices, determinants, system of linear equations, Cramer's rule. *Quadratic equations*: Solution of quadratic equations, nature of roots of quadratic equations, equations reducible to quadratic equations. *Sequence and Series*: Arithmetic, geometric and harmonic progressions. *Permutation and combinations*: Introduction to permutation and combinations, *Binomial Theorem*: Introduction to binomial theorem. *Trigonometry*: Fundamentals of trigonometry, trigonometric identities. *Graphs*: Graph of straight line, circle and trigonometric functions.

2. **Statistics**

Introduction: Meaning and definition of statistics, relationship of statistics with social science, characteristics of statistics, limitations of statistics and main division of statistics. *Frequency distribution:* Organisation of data, array, ungrouped and grouped data, types of frequency series, individual, discrete and continuous series, tally sheet method, graphic presentation of the frequency distribution, bar frequency diagram histogram, frequency polygon, cumulative frequency curve. *Measures of central tendency:* Mean medium and modes, quartiles, deciles and percentiles. *Measures of dispersion:* Range, inter quartile deviation mean deviation, standard deviation, variance, moments, skewness and kurtosis.

Recommended Books:

1. Swokowski. E. W., '*Fundamentals of Algebra and Trigonometry*', Latest Edition.
2. Kaufmann. J. E., '*College Algebra and Trigonometry*', PWS-Kent Company, Boston, Latest Edition.
3. Walpole, R. E., '*Introduction of Statistics*', Prentice Hall, Latest Edition.
4. Wilcox, R. R., '*Statistics for The Social Sciences*',

5. **MATHEMATICS FOR CHEMISTRY**

Credit Hours: 3

Prerequisites: Mathematics at Secondary level

Specific Objectives of Course:

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

Course Outline:

Preliminaries: Real Numbers and the Real Line, *Functions and their graphs:* Polynomial Functions, Rational Functions, Trigonometric Functions, and Transcendental Functions. Slope of a Line, Equation of a Line, Solution of equations involving absolute values, Inequalities. *Limits and Continuity:* Limit of a Function, Left Hand and Right Hand Limits, Continuity, Continuous Functions. *Derivatives and its Applications:* Differentiation of Polynomial, Rational and Transcendental Functions, Extreme Values of Functions. *Integration and Indefinite Integrals:* Integration by Substitution, Integration by Parts, Change of Variables in Indefinite Integrals. Least-Squares Line.

Recommended Books

1. Thomas, Calculus, 11th Edition. Addison Wesley publishing company, 2005.
2. H. Anton, I. Bevens, S. Davis, Calculus, 8th edition, John Willey & Sons, Inc. 2005.
3. Hughes-Hallett, Gleason, McCallum, et al, Calculus Single and Multivariable, 3rd Edition. John Wiley & Sons, Inc. 2002.
4. Frank A. Jr, Elliott Mendelsohn, Calculus, Schaum's Outline Series, 4th edition, 1999.
5. E. W. Swokowski, Calculus and Analytic Geometry PWS Publishers, Boston, 1983.
6. John H. Mathews, Numerical Methods for Mathematics Science and Engineering, Prentice-Hall, Second Edition 1992.

6. MATHEMATICS FOR PHYSICS

Contents:

1. **Preliminary calculus.**
 - Differentiation
Differentiation from first principles; products; the chain rule; quotients; implicit differentiation; logarithmic differentiation; Leibnitz' theorem; special points of a function; theorems of differentiation.
 - Integration
Integration from first principles; the inverse of differentiation; integration by inspection; sinusoidal function; logarithmic integration; integration using partial fractions; substitution method; integration by parts; reduction formulae; infinite and improper integrals; plane polar coordinates; integral inequalities; applications of integration.
2. **Complex numbers and hyperbolic functions**
 - The need for complex numbers
 - Manipulation of complex numbers
Additions and subtraction; modulus and argument; multiplication; complex conjugate; division
 - Polar representation of complex numbers Multiplication and division in polar form
 - de Moivre's theorem
Trigonometrical identities; finding the nth roots of unity; solving polynomial equations
 - Complex logarithms and complex powers
 - Applications to differentiation and integration
 - Hyperbolic functions

Definitions; hyperbolic-trigonometric analogies; identities of hyperbolic functions; solving hyperbolic equations; inverses of hyperbolic functions; calculus of hyperbolic functions

3. Series and limits

- Series
- Summation of series
Arithmetic series; geometric series; arithmetico-geometric series; the difference method; series involving natural numbers; transformation of series
- Convergence of infinite series
Absolute and conditional convergence; convergence of a series containing only real positive terms; alternating series test
- Operations with series
- Power series
Convergence of power series; operations with power series
- Taylor series
Taylor's theorem; approximation errors in Taylor series; standard McLaurin series
- Evaluation of limits

4. Partial differentiation

- Definition of the partial derivative
- The total differential and total derivative
- Exact and inexact differentials
- Useful theorems of partial differentiation
- The chain rule
- Change of variables
- Taylor's theorem for many-variable functions
- Stationary values of many-variable functions
- Stationary values under constraints

5. Multiple integrals

- Double integrals
- Triple integrals
- Applications of multiple integrals
Areas and volumes; masses, centers of mass and centroids; Pappus' theorems; moments of inertia; mean values of functions
- Change of variables in multiple integrals
Change of variables in double integrals;

6. Vector algebra

- Scalars and vectors

- Addition and subtraction of vectors
- Multiplication by a scalar
- Basis vectors and components
- Magnitude of a vectors
- Multiplication of vectors
Scalar product; vector product; scalar triple product; vector triple product
- Equations of lines and planes
Equation of a line; equation of a plane
- Using vectors to find distances
Point to line; point to plane; line to line; line to plane
- Reciprocal vectors

7. **Matrices and vector spaces**

- Vectors spaces Basic vectors; the inner product; some useful inequalities
- Matrices
- The complex and Hermitian conjugates of a matrix
- The determinant of a matrix
Properties of determinants
- The inverse of a matrix
- The rank of a matrix
- Simultaneous linear equations
N simultaneous linear equations in N unknowns
- Special square matrices
Diagonal; symmetric and antisymmetric; orthogonal; Hermitian; unitary normal
- Eigen vectors and eigen values
Of a normal matrix; of Hermitian and anti-Hermitian matrices; of a unitary matrix; of a general square matrix
- Determination of eigen values and eigen vectors Degenerate eigen values

8. **Vector calculus**

- Differentiation of vectors Composite vector expressions; differential of a vector
- Integration of vectors
- Space curves
- Vector functions of several arguments
- Surfaces
- Scalar and vector fields
- Vector operators

- Gradient of a scalar field; divergence of a vector field; curl of a vector field
- Vector operator formulae
- Vector operators acting on sums and products; combinations of grad, div and curl
- Cylindrical and spherical polar coordinates
- Cylindrical polar coordinates; spherical polar coordinates.

ANNEXURE - E

Statistics-I

Credit 3 (2-1)

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

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

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

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

Practical:

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

Recommended Books:

1. Introduction to Statistical Theory Part- I by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)
2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. A. Concise Course in A. Level Statistic with world examples by J. Crashaw and J. Chambers (1994)
4. Basic Statistics an Inferential Approach 2nd Ed. (1986) Fran II. Dietrich-II and Thomas J. Keans

Statistics-II

Credit 3 (2-1)

Sampling Probability and non-Probability Sampling, Simple random sampling stratified random sampling Systematic sampling error, Sampling distribution of mean and difference between two means. Interference Theory: Estimation and testing of hypothesis, Type—I and type-II error,

Testing of hypothesis about mean and difference between two means using Z-test and t-test, Paired t-test, Test of association of attributes using χ^2 (chi-square) Testing hypothesis about variance.

Practical:

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

Recommended Books:

1. Introduction to Statistical Theory Part-II by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)
2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. Principles and Procedures of Statistics, A Bio-material approach, 2nd Edition, 1980 by R. G. D. Steel and James H. Torrie
4. Statistical Procedures for Agricultural Research 2nd Edition (1980) by K. A. Gomez and A. A. Gomez

ANNEXURE - F

Introduction to Information and Communication Technologies

Course Structure: Lectures: 2 Labs: 1 **Credit Hours: 3**
Pre-requisite: None **Semester: 1**

Course Description:

This is an introductory course on Information and Communication Technologies. Topics include ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications. After completing this course, a student will be able to:

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

Course Contents:

Basic Definitions & Concepts

Hardware: Computer Systems & Components

Storage Devices, Number Systems

Software: Operating Systems, Programming and Application Software

Introduction to Programming, Databases and Information Systems

Networks

Data Communication

The Internet, Browsers and Search Engines

The Internet: Email, Collaborative Computing and Social Networking

The Internet: E-Commerce

IT Security and other issues

Project Week

Review Week

Text Books/Reference Books:

1. Introduction to Computers by Peter Norton, 6th International Edition, McGraw-Hill

2. Using Information Technology: A Practical Introduction to Computer & Communications by Williams Sawyer, 6th Edition, McGraw-Hill
3. Computers, Communications & information: A user's introduction by Sarah E. Hutchinson, Stacey C. Swayer
4. Fundamentals of Information Technology by Alexis Leon, Mathews Leon, Leon Press.

ANNEXURE - G

Functional Biology-I

Credit Hours 3+0

Biological Methods

Principles of Cellular Life
Chemical Basis
Structure and Function
Principles of Metabolism
Energy Acquisition
Principles of Inheritance
Mitosis and Meiosis
Chromosomes
Observable Inheritance Patterns
DNA Structure and Function
RNA and Proteins
Genes
Genetic Engineering and Biotechnology

Biodiversity
Fundamental Concept of Biodiversity
One or two examples of each of the following from commonly found organism
Prions
Viruses
Bacteria
Protistans
Algae
Fungi
Plants
Crops
Animals
Invertebrates
Vertebrates

Reading

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

Functional Biology-II

Credit Hours 3+0

Myths and Realities of Evolution

Microevolution
Speciation
Macroevolution

Level of Organization
Plants
Tissues
Nutrition and Transport
Reproduction
Growth and Development

Animals
Tissue, Organ System and Homeostasis
Information Flow and Neuron
Nervous System
Circulation and Immunity
Nutrition and Respiration
Reproduction and Development

Ecology and Behavior
Ecosystems
Biosphere
Social Interactions
Community Interactions
Human Impact on Biosphere
Environment Conservation

Reading

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

Note:

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

Functional Biology-II

Credit Hours 3+0

Myths and Realities of Evolution

Microevolution
Speciation
Macroevolution

Level of Organization
Plants
Tissues
Nutrition and Transport
Reproduction
Growth and Development

Animals
Tissue, Organ System and Homeostasis
Information Flow and Neuron
Nervous System
Circulation and Immunity
Nutrition and Respiration
Reproduction and Development

Ecology and Behavior
Ecosystems
Biosphere
Social Interactions
Community Interactions
Human Impact on Biosphere
Environment Conservation

Reading

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

Note:

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

RECOMMENDATIONS

1. In under-graduate scheme of studies, PBG-501, PBG-503, PBG-505, PBG-507, PBG 508 and PBG-509 were declared as core courses for students majoring in Plant Breeding and Genetics which will be taught at all agricultural universities and colleges. However, other courses on different crops may be changed according to regional specific agricultural requirements.
2. All agricultural universities and colleges should adopt semester system and NCRC (HEC) approved curricula of PBG.
3. The courses PBG-701, PBG-702, PBG-703 and PBG-704 were decided as core courses in the scheme of studies of Plant Breeding and Genetics at post-graduate level and these courses will be taught in every agricultural university/college of the country.
4. Members of the committee showed concern about the change in the nomenclature of the PBG degree being offered in few universities of the country. The members after thorough discussion recommended that uniformity in nomenclature of the degree must be ensured and maintained.
5. PBG faculty should avail the HEC facility in procurement of softwares relevant to PBG and Learning Management System for strengthening research and academics.
6. Workshops/trainings sponsored by HEC were strongly recommended to ensure regular updating of teaching faculty about new developments in their area of expertise.
7. Visits to National/International Research Institutes were emphasized to abreast students and faculty members of newly emerging techniques in Plant Breeding and Genetics.