Course title: Molecular Markers and Breeding				
Course code: BBP 150	No. of credits: 4		L-T-P: 54-2-0	Learning hours: 56
Pre-requisite course code and title (if any): None				
Department: Department of Biotechnology				
Course coordinator(s): Anandita Singh		Course instructor(s): Anandita Singh		
Contact details: asingh@teri.res.in				
Course type: Advanced		Course offered in: Semester 2		

Course description: This advanced course has been designed to provide perspectives on experimental methods for analysis of natural genetic variation applied in molecular breeding and crop improvement. The course integrates phenotype-centric principles of genetics with molecular phenomenon and explanations permitting navigation from gene to function. The first module describes characteristic features and organization of plant genome, promotes an understanding on dynamic nature of plant genomes in context to evolutionary forces causing gene and genome variation. Molecular basis of traditional and contemporary DNA marker technologies is presented as a critical appraisal of relative efficiencies of marker techniques in polymorphism detection, throughput (low/ medium/ high) and genome coverage. Second module discusses applicability of markers for assessment of genetic diversity, forward mapping, gene discovery, plant variety protection, DNA bar-coding and hybrid purity tests amongst others. Details on strategies for generation of mapping populations, trait mapping, marker-assisted breeding and selection are presented to inculcate an appreciation on the concepts of breeding by design. Allied approaches for genome mapping used primarily in animal systems are covered for providing exposure. Deployment of current molecular tools to complement conventional breeding methodologies for precise and efficient tracking, screening and selection of desirable genetic backgrounds are presented. Finally, a brief introduction on integration of next generation genomics platforms for genome-wide analysis is provided to illustrate frontier areas of research in genetic improvement of plant species.

Course objectives:
1. To introduce current status of research underpinning plant genome analysis .
2. To provide a comparative account on diverse genotyping tools applied in molecular breeding, taxonomy, conservation genetics, gene flow and quantitative genetics.
3. To integrate the principles of genetics with molecular biology.

Course contents				
S.No	Topic	L	T	P
Module1	**DNA marker technologies for genome analysis**			
1.	**The dynamic plant genomes:** Natural genetic Variation; mechanisms and causes of DNA polymorphisms: Recombination and DNA rearrangements, Point mutations-to-polyploidy; SNP as a concept.	2	0	0
2.	**Genome Organization:** Nuclear and organellar genomes; C-Value paradox, Unique and repeat DNA sequences; Classification of Repeat elements: Tandem, Interspersed (Impact of transposable elements in modelling genomes), Micro-satellites, Mini-satellites, hyper-variability of VNTRs,	3	0	0

3.	**DNA fingerprinting and profiling techniques:** Distinguishing phenotypic, biochemical markers and DNA based markers; Methodological repertoire of DNA fingerprinting techniques: Molecular basis of dominant and co-dominant markers, Restriction Fragment Length Polymorphism, MAAP (Multiple Arbitrary Amplicon Profiling) and other PCR based markers (DNA Amplification Fingerprinting, Arbitrarily Primed PCR, Randomly Amplified Polymorphic DNA, SSRs, STMS, SCARs, Inter-SSRs, Amplified Fragment Length Polymorphism, Selectively Amplified Microsatellite Polymorphic Loci, Inter retrotransposon amplified polymorphism, retrotransposon-microsatellite amplified polymorphism, Intron spanning markers, SNP based marker assays (CAPs, dCAPs, dHPLC, molecular beacons, 5'nuclease assay/Taqman assays, FEN based Invader reactions), Eco-TILLING (Targeting induced local lesions in the genome), high-throughput genotyping techniques: Diversity Array Technology (DArTs), SNP and tiling arrays.	24	0	0
Module2	**Applications of marker technology**			
4.	**Assessment of genetic diversity:** Introduction to geographical diversity, center of origin and diversity of plant species, gene pools (primary, secondary and tertiary), Principles of numerical taxonomy, Case studies, binary matrix to phenetic dendograms, structure analysis and other software tools for phenetics,	1	2	0
5.	**Forward mapping for gene discovery and functional genomics:** Traits (simple and complex; continuous and dis-continuous variation), Construction of genetic linkage maps; Linkage mapping software packages and interfaces; **Trait Mapping;** Map based cloning/ positional cloning for gene discovery, Navigating from genetic to physical map (methodologies and challenges).	5	0	0
6.	**Mapping populations in plants:** F2 populations**,** RILs (recombinant inbred lines), Backcross lines, NILS (Near Isogenic Lines), HIF (Heterogeneous Inbred Families), AILs (Advanced Intercross Lines), Pseudo-test-cross mapping, NAM (Nested Association mapping), MAGIC (Multi-parent advanced generation inter-cross), Bi-parental mapping vs Multi-parent mapping.	6	0	0
7.	**Breeding by design:** Marker Assisted Selection (MAS), gene/QTL introgression and pyramiding, Foreground and back ground selection for introgression of QTL by SSR markers, BSA (Bulked Segregant Analysis), Leveraging genetic resources from wild (Exotic genetic libraries and introgression lines).	6	0	0
8.	**Other application of molecular markers:** Genotyping tools as plant variety protection, DNA bar-coding technology, hybrid purity tests, diagnostics (transgenics, forensics), establishing clonal fidelity, Fingerprinting for BAC assembly for physical maps.	1	0	0
9.	**Supplementary mapping tools and methodologies:** Radiation Hybrid Maps, HAPPY mapping, Comparative/Synteny mapping.	3	0	0
10.	**Genomics platforms for genome-wide analysis:** DARTseq, GBS (genotyping by sequencing) and other third generation sequencing platforms, GEBVs (Genomics estimated breeding values), GWAS (Genome-wide association studies).	3	0	0
	Total	**54**	**2**	**0**

Evaluation criteria:
1. 2 minor tests   30% (each)
2. 1 major test (end semester)   40%

Learning outcomes:
1. An understanding on versatile research approaches employed for genome elucidation.
2. Ability to provide a molecular explanation for phenotype oriented breeding practices and strategies.
3. Ability to rationalize the selection of a suitable genotyping tool for applications including assessment of molecular. breeding, taxonomy, conservation genetics, gene flow and quantitative genetics.

Pedagogical Approach:
Lectures and tutorials, discussions, interactions, case studies and examples drawn from original research articles.

Skill Set:
1. Generating DNA fingerprints and profiles for forensics.
2. Testing Hybrid purity.
3. Diagnosing varieties, cultivars, accessions and land races.
4. Ascertaining clonal fidelity for tissue culture raised regenerants.
5. Applying MAS (Marker Assisted Selection) strategies in breeding programmes.
6. Introgressing transgenes for development of new plant varieties.
7. DNA bar-coding technology.
8. Evaluating gene-flow in transgenic field trials.
9. Formulating appropriate conservation strategies.

Employability:
1. Forensic Science laboratories.
2. Genotyping and sequencing companies.
3. Agri-biotechnology and seed companies.
4. Tissue culture and horticulture companies.
5. Law firms and knowledge processing organizations (IP management consultancy).
6. Regulatory bodies and funding agencies.

Materials:
Required text
Suggested readings

1. J. He., *et al. Plant Sci 5:484-488* (2014).
2. R.K. Varshney., *et. al. PLOS Biology 12: e1001883* (2014).
3. W. Tobias *et al. BMC Genetics 14:85-89* (2013).
4. D.J. Somers. (Humana Press, Business Media, 2009).
5. C. Kole, A.G. Abott. (Science Publishers, 2008).
6. R.K. Varshney, R. Tuberosa. (Springer, 2008).
7. C. Kole (Springer Verlag, Berlin, 2007).
8. B.C.Y. Collard., *et al. Euphytica 142: 169-196* (2005).
9. K. Meksem, G Kahl. The Handbook of Plant Genome Mapping: Genetic and Physical Mapping (Wiley-Blackwell, 2005).
10. J.D. Peleman, J.R. van der Voort. *Trends in Plant Science. 8: 330-339* (2003).
11. H.J. Newbury. Plant Molecular Breeding (CRC Press, 2003).
12. A. Rafalski. *Curr. Opinion in Plant Biol. 5: 94–100* (2002).
13. D.B. Goldstein, M.E. Weale. *Current Biology 11:576 -581* (2001).
14. A.F. Griffiths., *et al.* (WH Freeman & Co, 2000).
15. P. Vos, *et al. Nucl Acids Res 23: 4407-4414* (1995)
16. K. Weising., *et al.* DNA fingerprinting in fungi and plants. (CRC Press, Boca Raton, 1995).
17. A. Konieczny, F.M. Ausubel. *The Plant J. 4: 403–410* (1993).
18. E.S. Lander., *et al. Genomics, 1:174–181* (1987).
19. D. Botstein, *et al. Am. J. Hum. Genet. 32:314–331* (1980).

Additional information (if any):
Student responsibilities: 1. Class attendance. 2. Study of course materials as specified by the instructor.

Reviewers:
This course, in its present revised form, has been reviewed by:
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