

FACULTY OF AGRICULTURE
DEPARTMENT OF MICROBIOLOGY
M.Sc.(Ag) Microbiology
(Full Time) (2012 – 2013)
SCHEME OF EXAMINATIONS

SEMESTER WISE – First Semester
Semester - I

S.No	Code No.	Title	Credit
1	AGM 611	Principles of Microbiology	2+1 = 3
2	AGM 612	Microbial Genetics	2+1= 3
3	STA 613	Statistical methods and Design of Experiments	2+1= 3
4	COM 614	Computer Programming and its Applications	1+1 =2
5	AGM 011	Research	0+2 = 2
5	PGS 611	Research Methodology (0+1)	**
6	PGS 612	Basic concepts and Laboratory Techniques (0+1)	**
Total			7+6=13

Semester - II

S.No	Code No.	Title	Credit
1	AGM 621	Microbial Physiology and Metabolism	2+1 = 3
2	AGM 622	Soil Microbiology	2+1 = 3
3	AGM 022	Research	0+4 = 4
4		Minor outside the Department	2+1 = 3
5	PGS 622	Technical writing and Communication skills (0+1)	**
6	PGS 623 (e- course)	Intellectual property and its management in Agriculture (1+0)	**

Total 6+7 = 13

Semester - III

S.No	Code No.	Title	Credit
1	AGM 711	Food and Dairy Microbiology	2+1 = 3
2	AGM 712	Biofertilizer Technology	1+1 = 2
3		Minor outside the Department	2+1 = 3
4		Minor outside the Department	2+1 = 3
5	AGM 033	Research	0+6 = 6
6	AGM 031	Seminar	0+1 = 1
7	PGS 714	Library and Information services (0+1)	**

Total 7+11 = 18

Semester - IV

S.No	Code No.	Title	Credit
1	AGM 721	Microbial Biotechnology	2+1 = 3
2	AGM 044	Research	0+6 = 6
3	AGM 045	Viva – Voce	0+2 = 2
4	PGS 725 e- course	Disaster Management (1+0)	**

Total 2+9 = 11

Total Credits 22+33= 55

M.Sc. (Ag) MICROBIOLOGY (Part – Time)
SEMESTER – WISE DISTRIBUTION

Semester - I

S.No	Code No.	Title	Credit
1	AGM 611	Principles of Microbiology	2+1 = 3
2	AGM 612	Microbial Genetics	2+1 = 3
3	STA 613	Statistical methods and Design of Experiments	2+1 = 3
4	COM 614	Computer Programming and its Applications	1+1 = 2
6	PGS 611	Basic concepts and Lab Techniques (0+1)	**

Total 7+4= 11

Semester - II

S.No	Code No.	Title	Credit
1	AGM 621	Microbial Physiology and Metabolism	2+1 = 3
2	AGM 622	Soil Microbiology	2+1 = 3
3		Minor outside the Department	2+1 = 3
4	PGS 622	Technical writing and Communication skills (0+1)	**
5	PGS 623 E – course	Intellectual property and its management in Agriculture (1+0)	**

Total 6+ 3 = 9

Semester - III

S.No	Code No.	Title	Credit
1	AGM 711	Food and Dairy Microbiology	2+1 = 3
2		Minor outside the Department	2+1 = 3
3		Minor outside the Department	2+1 = 3
4	AGM 011	Research	0+2 = 2
5	PGS 714	Library and Information services (Non credit) (0+1)	**

Total 6 + 5 = 11

Semester - IV

S.No	Code No.	Title	Credit
1	AGM 721	Microbial Biotechnology	2+1 = 3
2	AGM 022	Research	0+4 = 4
3	PGS 725 e- course	Disaster Management (0+1)	**

Total 2 + 5 = 7

Semester - V

S.No	Code No.	Title	Credit
1	AGM 712	Biofertilizer Technology	1+1 = 2
2	AGM 033	Research	0+6 = 6
3	AGM 713	Seminar	0+1 = 1

Total 1 + 8 = 9

Semester - VI

S.No	Code No.	Title	Credit
1	AGM 044	Research	0+6 = 6
2	AGM 045	Viva – Voce	0+2 = 2

Total 0 + 8 = 8

Total Credits 22 + 33 = 55

DEPARTMENT OF AGRICULTURAL MICROBIOLOGY
M.SC.,(Ag.) AGRICULTURAL MICROBIOLOGY
DISTRIBUTION OF SUBJECTS (2012 – 2013)

CORE SUBJECTS (20 CREDITS)

AGM 611	Principles of Microbiology	2+1 = 3
AGM 612	Microbial Genetics	2+1 = 3
AGM 621	Microbial Physiology and Metabolism	2+1 = 3
AGM 622	Soil Microbiology	2+1 = 3
AGM 711	Food and Dairy Microbiology	2+1 = 3
AGM 712	Biofertilizer Technology	1+1 = 2
AGM 721	Microbial Biotechnology	2+1 = 3

Total = 13+7 = 20

MINOR SUBJECTS (9 CREDITS)

	I st Semester	2+1 = 3
	II nd Semester	2+1 = 3
	III rd Semester	2+1 = 3

Total = 6+3 = 9

SUPPORTING SUBJECTS (5 CREDITS)

STA 613	Statistical methods and Design of Experiments	2+1 = 3
COM 614	Computer Programming and its Applications	1+1 = 2

Total = 3+2 = 5

Research		0+20 = 20
Seminar		0+1 = 1

Total = 0+21 = 21

Total Credits = 22+33=55

NON – CREDIT COMPULSORY COURSES : SIX COURSES ARE OF
GENERAL NATURE AND ARE COMPULSORY FOR MASSTER'S
PROGRAMME

CODE COURSE TITLE CREDITS

PGS 611 Research Methodology (0+1)

PGS 612 Basic concepts and Laboratory Techniques (0+1)

PGS 622 Technical writing and Communication skills (0+1)

PGS 623 (e- course) Intellectual property and its management in
Agriculture (1+0)

PGS 714 Library and Information services (0+1)

PGS 725 e- Course Disaster Management (1+0)

SEMESTER - I

AGM 611 : PRINCIPLES OF MICROBIOLOGY (2+1)

Objectives

To study the fundamentals and principles of microbiology in which historical development, identification, isolation of different types of microorganisms, growth and nutritional requirements of microorganisms has been included

Theory

Unit-I : History and Basic Techniques of Microbiology

Historical developments contributions of Antony van Leeuwenhoek, Louis Pasteur, Robert Koch, Alexander Fleming, S. A . Waksman, Edward Jenner and other recent innovations in the field of microbiology. Microscope – Types of Microscope – Micrometry. Sterilization – Principles and methods of sterilization.

Unit-II: Culture Techniques

Prokaryotic and Eukaryotic microorganism, Different types of microorganisms in nature – Bacteria, Fungi, Actinomycetes, Algae, Virus, Protozoa - importance in natural processes – Culture techniques – Types of media – Maintenances of cultures.

Unit-III: Identification & Nutrition requirements of microorganisms

Study of microorganisms – Methods of isolation and identification – Nutrient requirements of microorganism – carbon, nitrogen and mineral metabolism- Autotrophic, heterotrophic and chemolithotrophic microorganisms

Unit – IV: Growth of Microorganisms

Growth of microorganisms, Generation time, Different phases of growth curve – Microbes in extreme environments – principles of staining, types of staining – importance of microorganisms in the industrial processes and agriculture.

Unit- V: Serology and immunology Techniques.

Principles of Immunology – Serology, Serological techniques, Antigen - antibody reactions – Agglutination and precipitation reactions – Applications of serology – principles of microbial genetics.

Practical

Staining techniques – Simple and Differential straining – Preparation of growth media – Liquid, solid and semi solid media – Selective enrichment and common media for the growth, Determination of carbon nitrogen and mineral requirements for microbial growth- Determination antibody reactions – Agglutination test.

Lecture Schedule

Theory

- 1) Introduction – Microbiology - Historical developments - Pioneers in Microbiology.
- 2) Contributions of Louis Pasteur and Robert Koch,
- 3) Contributions of Alexander Fleming, S.A.Waksman and others contributions.
- 4) Microscopy – Principles and Optics.
- 5) Simple and Compound Microscopes.
- 6) Bright Field and Dark Field Microscope.
- 7) Phase contrast Microscope and Fluorescent Microscope.
- 8) Electron Microscopes – Transmission electron microscopes and Scanning electron microscopes.
- 9) Sterilization principles and methods.
- 10) Importance of Microorganisms - their role in nature - Prokaryotic and Eukaryotic Microbes – their differentiation.
- 11) Microbial world - Systematic position of microorganisms -Types of microorganisms- Bacteria and Fungi
- 12) Types of microorganism – Actinomycetes, Algae, Protozoa and Viruses.
- 13) Study of Microorganisms - Techniques for isolation.

- 14) Identifications of microorganisms.
- 15) Serial dilution, Selective and enrichment culture techniques for isolation of microorganisms.
- 16) Purification of microorganisms by various methods.
- 17) Nutrition of Microorganisms - Nutritional grouping of microorganisms.
- 18) Mid semester Examination
- 19) Autotrophs and Hetrotrophs.
- 20) Phototrophs and Chemotrophs.
- 21) Staining, Principles of Staining and Nature of dyes.
- 22) Types of staining – Simple, Differential staining.
- 23) Negative and Spore staining.
- 24) Types of media – Simple, defined and enriched media with examples.
- 25) Aerobic and anaerobic cultures
- 26) Methods of maintenance of cultures.
- 27) Preservation of microbial cultures – Fresh media – Mineral oil – Lyophilization – Storage at low temperatures.
- 28) Growth of Microorganism – Growth pattern and growth curve - generation time - Chemostat, diauxenic and monoauxenic growth curve - growth yield.
- 29) Importance of Microorganisms in Industry.
- 30) Microorganisms in Agriculture
- 31) Principles of Immunology – Serological techniques
- 32) Antigen and antibody – agglutination and precipitations reactions
- 33) Principles of microbial genetics
- 34) Review of lectures.

Practical

- 1) Preparation of different growth media for culturing microorganisms.
- 2) Enrichment, Selective and Differential media.

- 3) Examination of microorganisms.
- 4) Staining techniques - Simple staining.
- 5) Differential staining.
- 6) Structural staining flagella staining
- 7) Physical characters of bacteria
- 8) Biochemical characters of bacteria.
- 9) Biochemical characters of bacteria.
- 10) Determination of microbial metabolites.
- 11) Growth curve of bacteria and yeast.
- 12) Testing different carbon requirements.
- 13) Testing of nitrogen requirements
- 14) Chemical mutagenesis
- 15) Antigen antibody reaction.
- 16) Agglutination reactions
- 17) Practical examination.

References:

- 1) Atlas, R.M. 2000. Microorganisms in our world, Mosby Year Book Inc. Wm. C. Brown Pub., Oxford
- 2) Brock, T.D. and M. T. Madigan, 1991. Biology of Microorganisms. 6th Ed. Prentice Hall, New Jersey John I. Ingraham and C.A.Ingraham 2000. Introduction to Microbiology. Second Edition. Thomson Books, USA.
- 3) Pelczar M.J., E.C.S. Chan and N.L.Krieg. 1996. Microbiology. Mc Graw- Hill International Edition, NY.
- 4) Prescott, L.M., P.Harley and A. Klein. 2003. Microbiology. 5th Edition. Mc Grew Hill, USA.
- 5) Schlegel, H.G. 2004. General Microbiology, 7th Edition, Cambridge University Press, NY.

Semester – I

AGM 612 : MICROBIAL GENETICS (2+1)

Objective

To educate the students to understand the fundamental aspects of microbial genetics, Nucleic acid structure and function mutation and genetic recombination in Prokaryotes and Eukaryotes and Fungal genetics

Theory

Unit-I: Nucleic acids, Genomic organization

Evolution of microbial genetics - Nucleic acids - DNA and RNA- arrangement of nucleotides in DNA- general concepts of DNA replication- salvage and *de novo* pathways of nucleotide synthesis - replicon model and replication operations- DNA synthesis *in vitro* – denaturation and renaturation of nucleic acids – gene and genome – Nucleotide sequencing - gene expression and its regulation – process of transcription, translation and transcriptional regulation – prokaryotic and eukaryotic genome – functional genome and proteome – Molecular basis for genome evolution and concepts of Phylogenetics.

Unit –II : Genetic variability – Mutation

Genetic variability in microorganisms – Mutation and Genetic recombination- Mutation in bacteria - spontaneous and induced mutations - Natural selection of mutants – Induction of mutation in microorganisms – Physical and chemical mutagenic agents - DNA damages and modifications in nucleotide sequences – Photo reactivation – nucleotide excision and repair - Different types of mutants and their scoring.

Unit – III: Genetic Engineering

Cloning and transformations - restriction endo nucleases – vectors – plasmids and cosmids – isolation of gene, cloning and transformation in prokaryotes and eukaryotes – *Ti* and *Ri* plasmids and their role in transgenics.

Unit –IV: Genetic recombination

Transformation – cellular competence and environmental conditions required for transformation. Genetic recombination in prokaryotic microorganisms - *in vivo* and *in vitro* recombination – mechanism of recombination - Conjugation in bacteria - intergeneric and intrageneric conjugation – chromosome mapping - transduction - general , restricted transductions and abortive transductions – Transposons and mechanism of transposition – site specific recombination.

Unit-V: Genetic variability and Bacteriophages

Reproduction in bacteria and fungi and segregation of genetic characters, Genetics of fungi – genetic variability through sexuality and Para sexuality in fungi - mutation in fungi –classical genetics of *Neurospora crassa* and yeast fungi. Bacteriophage genetics – structure of the phage particle – Mutant phages – process of infection -

Practical

DNA isolation from bacteria and study of the plasmid profile – DNA sequencing - Mutation studies in bacteria – Spontaneous mutation and induction of mutation by physical and chemical mutagenesis – Replica plating technique and isolation of auxotrophic and drug resistant mutants Biological mutagenesis by transposons –Studying the frequency of mutation – Conjugation experiments in bacteria – Conjugative plasmids – intergeneric and intrageneric plasmid transfer – interrupted mating experiments and chromosome mapping in *E.coli*. Isolation of bacteriophages titer value – Induction of mutation in *Neurospora crassa* with chemical mutagens and assessing the frequency of mutation – yeast genetics and recombination.

Lecture Schedule:

Theory

- 1) Microbial genetics – definition – evolution – Historical development.

- 2) Advantageous in microbial genetics - basic genetic material - gene, genome, genotype and phenotype.
- 3) Studying the nucleic acid – biochemical structure – nucleotides arrangements in nucleic acids - general concepts of DNA replication.
- 4) Salvage and *de novo* pathways of nucleotide synthesis - replicon model and replication operations-
- 5) DNA synthesis *in vitro* –denaturation and renaturation of nucleic acids – gene and genome.
- 6) Genetic differences of prokaryotic and eukaryotic microorganisms.
- 7) Prokaryotic and eukaryotic gene expression and regulation.
- 8) Nucleotide sequencing in bacterial DNA - Chemical method and other rapid methods.
- 9) Studying *E.coli* and yeast genome
- 10) Applications of genomic studies - functional genome and proteome –
- 11) Molecular basis for genome evolution and concepts of Phylogenetic grouping of microorganisms.
- 12) Genetic variability in microorganisms – Mutation and Genetic recombination- Mutation in bacteria- spontaneous and induced mutations.
- 13) Induction of mutation in microorganisms – Chemical and physical mutagens and mutagenesis.
- 14) Different types of mutations and mutants and their characters.
- 15) DNA damages and modifications in nucleotide sequences – Photo reactivation – nucleotide excision and repair .
- 16) Scoring the mutants and studying the rate of mutation.
- 17) Genetic recombination in prokaryotic microorganisms- *in vivo* and *in vitro* recombinations – mechanism of recombination.
- 18) Mid semester.

- 19) Conjugation in bacteria- fertility factor – F⁺ , F⁻ F' and Hfr cells and their mating processes.
- 20) Intergeneric and intrageneric recombination through conjugation – chromosome mapping by interrupted mapping.
- 21) Bacteriophage genetics – structure of the phage particle – lytic and lysogenic cycles – transducing phages - process of infection.
- 22) Transduction - general , restricted transductions and abortive transductions.
- 23) Transposons and mechanism of transposition – site specific recombination.
- 24) Transformation – cellular competence and environmental conditions required for transformation – enhancing the competence of bacterial cell for the uptake of DNA.
- 25) *In vitro* recombination – principles of cloning and transformations to create genetic variability.
- 26) Importance of restriction endo nucleases and vectors in cloning – plasmids and Cosmids as useful vectors.
- 27) Isolation of gene from prokaryotic and eukaryotic microorganisms, Cloning and transformation in prokaryotes and eukaryotes - *Ti* and *Ri* plasmids and their role in transgenic transformation.
- 28) Genetics of fungi – basis for genetic variability in fungi – sexual reproduction in lower and higher fungi.
- 29) Para sexuality in fungi – their importance in creation of genetic variability.
- 30) Extra nuclear DNA in fungi - 2 μ m circles – mitochondrial and chloroplast DNA.
- 31) Induction of mutation in fungi and their importance.
- 32) Genetics of *Neurospora crassa* - plasmids and plasmid like DNAs in *Neurospora* and their characters.
- 33) Genetics of yeast – mutation in yeast.
- 34) Review of lectures.

Practical schedule

- 1) Genetic purity in bacterial strains – single colony isolation.
- 2) Genetic purity of *Neurospora crassa* – single hyphal tip isolation.
- 3) Evaluation of Intrinsic antibiotic resistance characters in bacteria.
- 4) Studying the maximum allowable concentration level in bacterial strains.
- 5) Spontaneous mutagenesis for antibiotic resistance in *E.coli*.
- 6) Chemical mutagenesis in bacteria for heavy metal tolerance.
- 7) Induction of mutation in bacteria by UV light.
- 8) Induction of mutation in fungi for hyper pigmentation.
- 9) Conjugation in bacteria.
- 10) Isolation of bacteriophages and Phage titration.
- 11) Genomic DNA isolation in bacteria.
- 12) Isolation of plasmid DNA in *E.coli*.
- 13) Plasmid curing in *E.coli* by Acridine orange.
- 14) Agarose gel electrophoresis of DNA from *E.coli*.
- 15) Restriction digestion and size determination of plasmid DNA.
- 16) Preparation of competent cell in *E.coli* and transformation studies.
- 17) Practical examination

References

- 1) Brown, T.A. 1999. Genomes. John Wiley & sons (Asia) Pvt. Ltd. Singapore.
- 2) Freifelder, P. 1987. Microbial Genetics. Jones and Bartlett Publ. Boston, USA.
- 3) Idis N. Streips and Ronald E. Yazsbin. 2002. Modern Microbial Genetics. Wiley – Liss. John Wiley & sons, Inc., Publication
- 4) Maloy, S.R., J.E. Cronan and D.Friefelder. 1994. Microbial Genetics. Second Edition. Jones and Bartlett Publ. Boston, USA.

STA 613 – STATISTICAL METHODS AND DESIGN OF
EXPERIMENTS (2+1)

Unit I: Concepts in Statistics

Population and sample, parameter and statistic. Concept of Sampling – Simple random Sampling – Concept of Probability distribution – Binominal, Poisson and Normal distributions. F and Chi square distribution. Estimation: Point estimation, interval estimation, Degrees of freedom. Concept of Sampling distribution – Standard Error. Tests of Significance based on t, z, (Mean and equality of Means only). χ^2 test for goodness of fit.

Unit II: Correlation and Regression

Definition, types and methods of studying correlation – Properties of correlation coefficient. Regression – Measuring and uses of Regression analysis – Properties. Differences between correlation and regression. Regression co-efficient - simple, linear – multiple linear regression co-efficient – standard error of estimate – test of significance of observed regression co-efficient and co-efficient of determination – Non linear regression. Misuses of correlation and regression in agricultural research.

Unit III: Basic Designs

Agricultural experiments: Concepts – field studies – pot-culture – quantitative and qualitative variables. Errors: Sources of errors and estimate of errors. Basic principles of Design of Experiments – CRD – RBD – LSD layout and their analysis – efficiency.

Unit IV: Mean comparison and Missing data

Comparison of treatments – Least significant Difference method – Duncan's Multiple Range Test (DMRT). Missing plot technique in RBD and LSD (one and two missing). Concept of analysis of Covariance. Data transformation: Logarithmic square root and arc sine.

Unit V: Factorial Experiments

Concept of factorial experiments – 2^n , 3^2 Factorial experiments, Principle of confounding in factorial experiments – confounding in 2^3 Factorial experiments. Split-plot design and strip – plot design.

Practical

Estimation of samples statistic *viz.*, means, SD, SE and CV. Z-test, t-test and paired t-test. Comparison of two variances using F-test. Bartlett's test for homogeneity of variances. Chi-square test for test of goodness of fit and homogeneity of ratio test for independence of attributes. Computation of correlation co-efficient and its significance. Fitting of simple linear regression and testing the significance of regression co-efficient. Multiple linear regressions fitting and testing Determination of optimum plot size using uniformity trial. Analysis of CRD, RBD, LSD and DMRT. Analysis of multi-observation data (sampling in RBD) Missing plot technique in RBD with one or two missing values. Analysis of Factorial experiments conducted in RBD Analysis of Split-plot and Split-plot design. Analysis of data with transformations.

Theory schedule:

- 1) Definition of Population and sample
- 2) Difference between parameter and statistic
- 3) Concept of Sampling – Simple random Sampling
- 4) Concept of Probability distribution – Binominal, Poisson and Normal distributions.
- 5) F and Chi square distribution
- 6) Estimation - Point estimation, interval estimation, Degrees of freedom.
- 7) Concept of Sampling distribution – Standard Error.
- 8) Tests of Significance based on t, z, (Mean and equality of Means only). χ^2 test for goodness of fit.
- 9) Definition of correlation, significance & types
- 10) Properties of correlation coefficient

- 11) Definition of regression – Measuring and uses of Regression analysis – Properties.
- 12) Differences between correlation and regression.
- 13) Regression co – efficient - simple, linear –
- 14) Multiple linear regression co - efficient – standard error of estimate
- 15) Test of significance of observed regression co -efficient and co - efficient of determination –
- 16) Non linear regression. Misuses of correlation and regression in agricultural research.
- 17) Mid semester examinations
- 18) Characteristics of Agricultural experiments: Concepts – field studies –
- 19) Characteristics of Agricultural experiments -pot-culture – quantitative and qualitative variables.
- 20) Sources of errors and estimate of errors
- 21) Design of Experiments– Basic principles of CRD
- 22) Design of Experiments– Basic principles of RBD
- 23) Design of Experiments– Basic principles of LSD
- 24) Efficiency of designs -layout and their analysis
- 25) Comparison of treatments – Least significant Difference method
- 26) Duncan’s Multiple Range Test (DMRT).
- 27) Missing plot technique in RBD and LSD (one and two missing).
- 28) Concept of analysis of Covariance
- 29) Data transformation: Logarithmic square root and arc sine.
- 30) Concept of factorial experiments
- 31) 2^n , 3^2 Factorial experiments,
- 32) Principle of confounding in factorial experiments
- 33) Confounding in 2^3 Factorial experiments.
- 34) Split-pot design and strip – plot design.

Practical schedule:

- 1) Estimation of samples statistic *viz.*, means, SD, SE and CV.
- 2) Z-test, t-test and paired t-test.
- 3) Comparison of two variances using F-test
- 4) Bartlett's test for homogeneity of variances.
- 5) Chi-square test for test of goodness of fit and homogeneity of ratio test for independence of attributes.
- 6) Computation of correlation co-efficient and it's significance.
- 7) Fitting of simple linear regression and testing the significance of regression co-efficient.
- 8) Multiple linear regressions fitting and testing
- 9) Determination of optimum plot size using uniformity trial.
- 10) Analysis of CRD.
- 11) Analysis of RBD
- 12) Computation of LSD and DMRT
- 13) Analysis of multi-observation data (sampling in RBD)
- 14) Missing plot technique in RBD with one or two missing values.
- 15) Analysis of Factorial experiments conducted in RBD
- 16) Analysis of Split-plot and Split-plot design.
- 17) Analysis of data with transformations.

Reference Books

- 1) Bhattacharyya, G.K. and Johnson, R.A. 1997. Statistical concepts and methods, John Wiley and Sons, New York.
- 2) Crozon, F.E. and Cowden, D.J. 1986. Applied General Statistics, Prentice Hall of India, New Delhi.
- 3) Gomez, K.A. and Gomez, A.A. 1984. Statistical procedure for Agricultural Research, John Wiley and Sons, New York.
- 4) Panse, V.G. and Sukhatme, P.V. 1961. Statistical methods for Agricultural Workers, ICAR, New Delhi.
- 5) Ramaswamy, R, 1995. A text book of Agricultural Statistics, Wiley Limited, New Delhi.

COM 614 COMPUTER PROGRAMMING AND ITS APPLICATIONS (1+1)

Objectives

To understand the basic concepts of computer and their peripherals, to get the knowledge in office automation tools like MS Word, MS Excel, and MS Access. And to get exposed to the current trends in the internet and their usages. And also to make them acquire sound knowledge in various Agricultural statistical software and their analysis.

Theory

Unit – I: Introduction to Computer

Overview of computers - basic principle of operation - devices of a computer and their functions - current trends in hardware and software.

Computer applications - Operating systems - DOS - Windows - feature of windows - version of windows.

Unit – II: Word Processor

MS Word - Creation, Editing and Printing of a document - using the features of word like page setting, underlining, bold, italics, spell check, grammar check etc.-creation of tables in word, inserting graphics.

Unit-III: Data Processing & Database

MS Excel - creation of excel sheet - statistical analysis using the features in excel. MS Access - creation of database and retrieval - Query - Applications to Agricultures.

Unit-IV: Agricultural Statistical Software

SAS, MSTAT, IRRISTAT, AGRES, AGRISTAT, STATISTICA-MANOVA AND MANCOVA.

Unit-V: Internet

Internet Definition - getting the connectivity - service providers - web – sites – home page – email – retrieval of information from internet.

Theory Schedule

- 1) Introduction to computers, input, output devices and their operation.
- 2) Components of computers (hardware and software) and their applications.
- 3) Booting sequences of operating system (DOS, WINDOWS) and their features.
- 4) Introduction to word processor and their special features.
- 5) Creating, editing printing of a document, Formatting features (underline, bold, italic etc) and operation of table.
- 6) Introduction to data processing and creation of excel sheets, Working with different built-in-function.
- 7) Creating different types of graphs and working procedures of various statistical functions.
- 8) Importing and exporting objects among different application (MS-word, MS-excel, MS-access).
- 9) Mid semester Examination.
- 10) Database and MS- access- Creation, storing and retrieval of data from database.
- 11) Working of various statistical function (mean, variance, sd, T test etc).
- 12) SAS, MSTAT, IRRISTAT.
- 13) AGRES, AGRISTAT.
- 14) STATISTICA-MANOVA AND MANCOVA.
- 15) Introduction to internet, Features of internet.
- 16) Need for Internet service provider, creation and working principle of E-mail.
- 17) Information retrieval from various web pages of internet.

Practical Schedule

- 1) Introduction to hardware, software and operating systems.
- 2) Study of various DOS commands.
- 3) Creating and Editing of a word Document.
- 4) Study of various features in MS-WORD (spelling and grammar check, protection of a document).
- 5) Operation of tables and Mail-merge.
- 6) Working with different statistical packages in MS-EXCEL.
- 7) Drawing of different graphs for the given data.
- 8) Various string operations (Concatenation, count, left string, right string, type conversion etc.).
- 9) Table creation using wizards.
- 10)Forms and reports.
- 11)Retrieval of data from the database using queries.
- 12)Correlation and multiple regression analysis.
- 13)T test and Chi-square test, Creation of data file systat and importing a data file from other packages.
- 14)SAS, MSTAT, IRRISTAT.
- 15)AGRES, AGRISTAT, STATISTICA.
- 16)Creating E-Mail account (sending and receiving mails), Information retrieval from Internet.
- 17) Model Practical Examinations

REFERENCES

1. Kapoor V.K. 2004. Introduction to computers and Information systems.
New Delhi: Sultan Chand and sons.
2. Karthy Jacobs. 2007 “Microsoft office Excel”, The Express Line to Learning, Willey Chand & Sons, New Delhi.
3. Peter Norton’s 2001, “Introduction to Computer (4th edition)”, Tata McGraw-Hill Publishing Company Limited, New Delhi.

4. TNAU 2004, “Advanced Quantitative Techniques and Data Analysis” Training Manual-Argl. Engineering College and Research Institute, Coimbatore.
5. [Http: //en.wikipedia.org/wiki/Internet](http://en.wikipedia.org/wiki/Internet).

PGS 611 - RESEARCH METHODOLOGY (0+1)

(Non credit)

Research Ethics

Global agricultural research system - need, scope, opportunities, role in food security, poverty reduction and environmental protection; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC)-International fellowships for scientific mobility. Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics-Good Laboratory Practices – Plagiarism and Copy right rules.

Research Methodology

Selection of research topic - Literature collection - indexing the information - Preparation of index cards - Delineation of research objectives - Planning and designing experiments: Treatment details - statistical requirements in experimental design – Experimental lay out - conduct of field experiments - recording observations - types of observations - field, pot-culture, laboratory etc.- Processing of results - tabulation, statistical analysis etc. - Deriving conclusions - Documentation of results - photographing, preparation of charts, graphs etc. - Thesis writing - arrangement of different chapters - method of presentation - Interpretation of results and discussion - presentation of summary and conclusion - Research paper writing formats - presentations - critical evaluation of some research papers.

Lecture Schedule

Practical

- 1) Global agricultural research system: need, scope, opportunities, role in food security, poverty reduction and environmental protection
- 2) National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR)
- 3) International Agricultural Research Centres (IARC)-International fellowships for scientific mobility.
- 4) Research ethics: research integrity, research safety in laboratories and Welfare of animals used in research
- 5) Computer ethics, Standards and problems in research ethics
- 6) Good Laboratory Practices – Plagiarism and Copy right rules
- 7) Research topic selection – objective, Literature collection - source material - Index card preparation.
- 8) Review of literature - use of ARIS for retrieval of background information
- 9) Mid Semester
- 10) Setting hypothesis and Planning of the experiment, Experimental design - treatment formulation.
- 11) Statistical requirement in the experimental design, Layout for laboratory condition and pot experiment.
- 12) Field trial layout - plot size - labeling - management. Observation - time of observation - photographic preparation.
- 13) Results - tabulation of the results and statistical analysis. Preparation of graphs and charts.
- 14) Interpretation of the results and discussion, Thesis writing - Different chapters – arrangements.

- 15) Format of presentation - Introduction - review - material and methods –authenticated method - methods modified - Results - Discussion.
- 16) Preparation of research papers - writing material suitable to journal.
- 17) Summary, conclusion and Bibliography writing

References:

- 1) Anderson, J.B.H Durston and M.Pook 1977. Thesis and assignment writing wiley – Eastern Ltd, New Delhi.
- 2) Best J.W and J.V Kahn 1996. Research in Education. Prentice – Hall of India Ltd New Delhi.
- 3) Bhalla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publication.
- 4) Day R.A 1996. How to write and publish a Scientific paper, 4th Edition. Cambridge University Press.
- 5) Day. R.A 2000. Scientific English – A guide for Scientific and other Professionals. Second Edition, University Press.
- 6) Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.

PGS 612 - BASIC CONCEPTS AND LABORATORY TECHNIQUES
(Non credit)

Objectives

To acquaint the students about the basics of commonly used techniques in laboratory.

Practicals

Unit-I: Safety measures and common laboratory equipments

Safety measures while in labs; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers and micropipettes. Washing, drying and sterilization of glassware; Drying of solvents /chemicals

Unit-II: Preparation of standard solutions

Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparations of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values

Unit-III: Use and handling of laboratory equipments

Use and handling of vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath and water bath.

Unit-IV: Microscopy and media preparation

Use and handling of microscope and laminar flow - Preparation of media - differential, selective and enriched media. Methods of sterilization - physical methods- dry and moist heat, cold, filtration and radiation, chemical methods and disinfectants.

Unit-V: *In vitro* culture Techniques

Description of flowering plants in botanical terms in relation to taxonomy - seed viability test - pollen fertility test - tissue culture media - composition of media - media preparation - instant media - Aseptic manipulations - Autoclaving, flame sterilization - filter sterilization - Hot

water sterilization – procedure for *in vitro* culture of explants – leaf bit – stem bit – anthers – pollen – microspores – ovule and embryo.

Practical schedule

- 1) Safety measures in labs and handling of chemical substances
- 2) Common Laboratory equipments
- 3) Calibration and cleanliness of volumetric glass wares
- 4) Methods of expressing strength of solutions
- 5) Preparation of primary standard solutions and buffer solutions
- 6) Preparation of standard solutions for nutrient analysis of soil, plant and water.
- 7) Preparation of different agro-chemical doses for field experiments
- 8) Preparation of buffer solutions
- 9) Mid- Semester
- 10) Handling of Instruments- Vacuum pumps, thermometers, magnetic stirrer
- 11) Handling of instruments - Ovens, sand bath and water bath.
- 12) Handling and uses of microscopes and laminar flow
- 13) Sterilization by physical methods
- 14) Sterilization by chemical methods
- 15) Preparation of different media for culturing the micro organisms.
- 16) Description of flowering plants – seed viability test and pollen fertility test
- 17) Aseptic manipulations and media
- 18) *In vitro* culture of different explants

References

- 1) Furr, A.K. 2000. CRC Handbook of Laboratory safety. CRC press.
- 2) Jackson, M.L. 1997. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.
- 3) Prescott, L.M., P. Harley and A. Klein. 2003. Microbiology, 5th Edition, Mc.Graw Hill, USA.

- 4) Gupta, P.K. 1997. Elements of Bio technology, Rastogi Publications. Meerut.
- 5) Singh, B.D. 2005. Bio technology, Expanding Horizons , Kalyani Publications, New Delhi.

Semester - II

AGM 621 : MICROBIAL PHYSIOLOGY AND METABOLISM (2+1)

Objectives

The emphasis of the course will be enzymes, inter conversion of energy pathways glycolysis, oxygenic and photosynthesis and protein synthesis.

Theory

Unit-I: Microbial Nutrition and transport mechanisms

Microbial nutrition - Chemical composition of microbial cell - Macro and Micro-nutrients and their physiological functions - Nutritional diversity among prokaryotes. Mechanisms of nutrient transport in bacteria - passive diffusion - facilitated diffusion - primary active uptake - secondary active uptake - group translocation

Unit-II: Enzyme kinetics

Michaelis Menton kinetics - mechanisms of inhibition of enzyme activity - Co-enzymes and prosthetic groups. Principles of bio-energetics:- Laws of thermodynamics - Methods to determine free energy of biochemical reactions - High energy compounds.

Unit-III: Energy Generation

Generation of ATP, reducing power, development of proton gradient and biosynthesis of ATP by ATP synthase. Precursor metabolites by various metabolic pathways in aerobic heterotrophic, anaerobic heterotrophic, chemoautotrophic and photoautotrophic prokaryotes.

Unit-IV: Catabolic metabolism

Glycolysis - Pentose phosphate pathway - Entner Doudroff pathway - Oxidation of pyruvate -TCA cycle - Utilization of fatty acids, aliphatic hydrocarbons and aromatic compounds. Assimilation of nitrogen and sulphur - Oxygenic and anoxygenic photosynthesis - Mechanisms of Carbon - dioxide fixation in prokaryotes. Biosynthesis of macromolecules-Synthesis and assembly of cell wall components - Methods of studying biosynthesis- Biosynthesis of storage compounds

and energy reserves in bacteria- Biosynthesis of amino acids, nucleotides phospholipids, and isoprenoid compounds.

Unit-V: Microbial growth and protein synthesis

Regulation of metabolism control mechanisms operating at DNA level, transcription level, translation level post-translation level and regulation of protein activity – feed back control mechanisms. Microbial growth-Nature and expression of growth – Measurement of growth. Effect of environmental factors on microbial growth – Response of microorganism to stress. Sporulation in bacteria.

Practical

Growth of microorganisms on various carbon and nitrogen sources. Determination of molar growth YG and YATP. Development of growth curves based on colony forming units, temperature, pesticides antibiotics and nutrient concentration on growth and development of bacteria. The phenomenon of catabolic repression in bacteria. Use of radioactive isotopes in studying microbial metabolism photosynthetic pigments in bacteria.

Lecture schedule

- 1) Introduction and scope of Microbial physiology
- 2) Microbial nutrition – Chemical composition of Microbial cell.
- 3) Major and micronutrients and their physiological functions.
- 4) Nutritional diversity among prokaryotes.
- 5) Mechanism of nutrient transport in bacteria – Passive diffusion and Facilitated diffusion.
- 6) Primary active uptake – Secondary active uptake.
- 7) Group Translocation; Iron uptake and siderophores.
- 8) Enzyme kinetics: Michaelis Menton constant – CO-enzymes and Prosthetic group.
- 9) Mechanism of inhibition of enzyme activity.
- 10) Principles of Bioenergetics – Laws of Thermodynamics.

- 11) Methods to determine free energy of biochemical reactions – High energy compounds.
- 12) Microbial metabolism – Generation of ATP, Reducing power.
- 13) Development of proton gradient and biosynthesis of ATP by ATP phosphorylation.
- 14) Precursor metabolites by various metabolic pathways.
- 15) Glycolysis – Oxidation of pyruvate – TCA cycle – Glyoxylate cycle.
- 16) Oxygenic and anoxygenic photosynthesis.
- 17) Alternate pathway of glucose metabolism – HMP – Pentose phosphate pathway - Entner Duderoff Pathway.
- 18) Mid semester examination.
- 19) Precursor metabolites by various metabolic pathways in chemoautotrophic prokaryotes.
- 20) Assimilation of nitrogen and sulphur.
- 21) Precursor metabolites by various metabolic pathway in photoautotrophic prokaryotes.
- 22) Utilization of fatty acids, aliphatic hydrocarbons and aromatic compounds.
- 23) Mechanism of carbon di oxide fixation in prokaryotes.
- 24) Gluconogenesis – Biosynthesis of storage compounds and energy reserves in bacteria.
- 25) Synthesis and assembly of cell wall components.
- 26) Biosynthesis of macromolecules – Methods of studying biosynthesis.
- 27) Biosynthesis of Amino acids
- 28) Biosynthesis of Nucleotides.
- 29) Biosynthesis of phospholipids and isoprenoid compounds.
- 30) Regulation of metabolism – control mechanisms operating at DNA level, transcription level, translation level, post – translational level.
- 31) Regulation of protein activity – Feedback control mechanism.

- 32) Microbial growth – Nature and expression of growth – Measurement of growth.
- 33) Effect of environmental factors on microbial growth – Response of microorganisms.
- 34) Sporulation in bacteria.

Practical Schedule

1. Determination of molar growth yield – YG and YATP.
2. Growth of selected species of bacteria on various carbon sources.
3. Growth of selected species of bacteria on various nitrogen sources.
- 4&5. Development of growth curve of bacteria based on colony forming unit.
- 6&7. Development of growth curve of bacteria based on Turbidity measurement.
- 8&9. Development of growth curve of bacteria based on Protein content.
- 10-13. Effect of environmental factors such as pH, temperature, pesticides, antibiotics. Nutrition concentration on growth and development of bacteria.
14. The phenomenon of catabolic repression in bacteria.
15. Use of radioactive isotopes in studying microbial metabolism.
16. Photosynthetic pigment in bacteria.
17. Practical examination

References

- 1) Caldwell, D. R. 1995. Microbial Physiology and Metabolism. Wm. C. Brown, Publishers, Iowa, USA.
- 2) Karp, G. 2002. Cell and Molecular Biology. John Wiley & Sons, New York.
- 3) Medigan, M. T., Martinko, J. M. and Parker, J. 2000. Brock Biology of Microorganisms Prentice – hall International (UK) Limited,

London.

- 4) Moat, A. G. and J. W. Foster. 1995. Microbial Physiology. Wiley – LISS Inc. New York, USA.
- 5) Sundara Rajan, S. 2003. Introduction to Bioenergetics. Ammol Publishers, New Delhi.
- 6) Whitmore, G. 2002. Metabolism, Biosynthesis and Biochemical Emergencies. Swarup & sons, New Delhi.

Semester II

AGM 622 : SOIL MICROBIOLOGY (2+1)

Objectives

To educate the students on different soil biological processes and its significance in the biodissolution of various plant nutrients.

Theory

Unit – I: Importance of microorganisms in soil

Development of Soil Microbiology - Distribution of microorganisms in soil - quantitative and qualitative microflora of different soils - Role of microorganisms in soil fertility - Influence of soil and environmental factors on microflora - moisture, pH, temperature, organic matter, agronomic practices etc. - Distribution of microorganisms in manure and composts- Influence of soil amendments on soil microflora.

Unit – II: Microorganisms in soil processes

Microorganisms in soil processes - carbon cycle - organic matter decomposition - Humus formation - Nitrogen cycle – Mineralization - Ammonification - Nitrification, Denitrification - reactions - organisms involved - factors affecting nitrogen transformation. Nitrogen fixation - symbiotic, non symbiotic, associative symbiotic and endophytic organisms- process of nitrogen fixation.

Unit – III: Microbial Transformation of nutrients

Microbial transformation of phosphorus, iron, sulphur and micronutrients in soil - phosphorus solubilization by phosphobacteria - sulphur cycle and sulphur bacteria - iron bacteria and their importance. Interrelationships between plants and microorganisms - Rhizosphere concept - quantitative and qualitative studies – R : S ratio - Rhizoplane - Spermosphere - Phyllosphere microorganisms and their importance in plant growth.

Unit – IV: Role of AM fungi and PGPR in soil

Mycorrhiza - ectomycorrhiza and endomycorrhiza – AM fungi - distribution and importance – PGPR organisms - Plant growth regulators

and phytotoxin production by microorganisms - use of soil microorganisms for pest and disease control.

Unit-V: Pesticides and Soil microflora

Pesticide and soil microflora - interactions - Microbial decomposition of chemicals applied to soil. Effect of pesticides on soil microorganisms – Xenobiotics in soil.

Practical

Enumeration of microbial population in soil - qualitative and quantitative distribution. Isolation of symbiotic nitrogen fixing bacteria - Non symbiotic and associative symbiotic bacteria - Nitrification - denitrification. Organic matter decomposition - CO₂ evolution. Isolation of phosphobacteria - Isolation of sulphur and iron bacteria. Rhizosphere - Spherosphere - Phyllosphere microorganisms. AM fungi - root infection – ectomycorrhizae - Associative and antagonistic relationships among soil microorganisms - Microbial degradation of pesticides and herbicides.

Lecture Schedule

Theory

- 1) Introduction to Soil Microbiology.
- 2) Distribution of microorganism in surface and subsurface Native flora - Introduced organism.
- 3) Qualitative and quantitative microflora of different soils.
- 4) Role of microbes in Soil fertility.
- 5) Nitrogen, phosphorus and other micro nutrients
- 6) Factors affecting the survival - Bacterial growth curve effect of pH, temperature, organic matter - cultivation practices.
- 7) Distribution of microorganisms in manures and compost.
- 8) Influence of soil amendments soil microflora.
- 9) Carbon cycle - Humus formation.
- 10) Organic matter decomposition - Aerobic - and anaerobic flora.
- 11) Nitrogen cycle - Nitrogen fixing organisms.

- 12) Aerobic and anaerobic - Symbiotic nitrogen fixation.
- 13) Non symbiotic nitrogen fixation.
- 14) Associative symbiotic 'N' fixers.
- 15) Endosymbiotic nitrogen fixation.
- 16) Ammonification in the soil and the factor affecting nitrification and denitrification.
- 17) Denitrification in the soil and the factor affecting nitrification and denitrification.
- 18) Mid semester examination.
- 19) Microbial transformation of Phosphorus.
- 20) Microbial transformation iron – Iron bacteria and iron toxicity.
- 21) Microbial transformation of sulfur - Sulfur bacteria and sulfur toxicity.
- 22) Inter relationship between plant and Microorganisms.
- 23) Inter relationship between microbes and microbes – Beneficial and Harmful.
- 24) Rhizosphere concept - Qualitative and quantitative changes around rhizosphere region.
- 25) Rhizosphere effect – R/S Ratio -Rhizoplane.
- 26) Phyllosphere and Spherosphere microorganisms and their importance in plant growth.

- 27) Mycorrhiza - ectomycorrhiza and endomycorrhiza.
- 28) *Frankia* and its importance.
- 29) Plant growth promoting substance - important organism producing PGPR activity.
- 30) Use of soil microorganism for pest and disease control.
- 31) Pesticide and soil microflora - interaction – amendments.
- 32) Microbial decomposition of chemicals and pesticide.
- 33) Microbial decomposition of xenobiotic compounds.
- 34) Review of Lectures.

Practical

- 1) Enumeration of Microbial population in different soil - qualitative and quantitative distribution.
- 2) Isolation of symbiotic nitrogen fixing organism - *Rhizobium*
- 3) Characterization of the symbiotic nitrogen fixer - *Rhizobium*
- 4) Isolation of non symbiotic Nitrogen fixing organism *Azotobacter*
- 5) Isolation of *Beijerinckia*
- 6) Associative symbiotic Nitrogen fixers
- 7) Isolation and identification of soil algae
- 8) Nitrification - denitrification
- 9) Organic matter decomposition - CO₂ evolution
- 10) Rhizosphere - Spherosphere - Phyllosphere
- 11) *Frankia* isolation
- 12) Mycorrhizae isolation - and plant infection
- 13) Associative and antagonistic micro organism
- 14) Isolation of PGPR
- 15) Isolation of Fe bacteria
- 16) Isolation of sulfur bacteria & phosphobacteria
- 17) Practical examination.

INOR COURSE 2+1 (To be enclosed)

References

- 1) Coyne, M.S. 2000. Soil Microbiology, CBS Publications, New Delhi.
- 2) Paul E.A and F.E. Clark 1996. Soil Microbiology and Biochemistry, Academic Press. California.
- 3) Subba Rao, N.S. 1977 . Soil microorganisms and plant growth Oxford & IBH Publishing Co., New Delhi.
- 4) Subba Rao, N.S 2001. Soil Microbiology, Oxford and IBH publishing House. India.

PGS 622 **TECHNICAL WRITING AND COMMUNICATION
SKILLS (0+1)

Objective

To equip the students with skills *Viz.*, writing of dissertations, research papers, etc. and to communicate and articulate in English

Practical

Grammar - Tenses, parts of speech, clauses, punctuation marks;
Error analysis - Common errors; Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers. Proof reading. Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Structure of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

Practical schedule

- 1) Grammar (Tenses, parts of speech)
- 2) Grammar (clauses, punctuation marks)
- 3) Error analysis (Common errors); Concord; Collocation;
- 4) Phonetic symbols and transcription;
- 5) Accentual pattern: Weak forms in connected speech
- 6) Participation in group discussion
- 7) Facing an interview; presentation of scientific papers.
- 8) Technical Writing- Various forms of scientific writings- theses, technical papers
- 9) Mid -semester

- 10) Technical Writing- reviews, manuals
- 11) Structure of thesis and research communications
- 12) Writing of abstracts, summaries, précis, citations etc
- 13) Commonly used abbreviations in the theses and research communications
- 14) Illustrations, photographs and drawings with suitable captions
- 15) Pagination, numbering of tables and illustration, numbers and dates in scientific write-ups
- 16) Editing and proof-reading
- 17) Writing of a review article.

Suggested Readings

1. Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.
2. Mohan K. 2005. *Speaking English Effectively*. MacMillan India.
3. Richard WS. 1969. *Technical Writing*. Barnes & Noble.
4. Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*. Abhishek.
5. Wren PC & Martin H. 2006. *High School English Grammar and Composition*. S.Chand & Co.

PGS 623: INTELLECTUAL PROPERTY AND ITS
MANAGEMENT IN AGRICULTURE (1+0)
(E-course)

Objective

The Course Objective of the course is to create awareness about intellectual property rights in agriculture. The course deals with management of patents, trademark, geographical indications, copy rights, designs, plant variety protection and biodiversity protection. The students will be taught on the Marketing and Commercialization of Intellectual Properties.

Theory

Unit - I:

World Trade Organization- Agreement on Agriculture (AoA) and Intellectual Property Rights (IPR) - Importance of Intellectual Property Management - IPR and Economic growth- IPR and Bio diversity -Major areas of concern in Intellectual Property Management -Technology Transfer and Commercialization-Forms of different Intellectual Properties generated by agricultural research.

Unit - II:

Discovery *versus* Invention - Patentability of Biological Inventions - Method of Agriculture and Horticulture- procedure for patent protection: Preparatory work. Record keeping, writing a patent document, filing the patent document -Types of patent application-patent application under the Patent cooperation treaty (PCT).

Unit - III:

Plant genetic resources -Importance and conservation - Sui Generic System -Plant Varieties Protection and Farmers Rights Act-Registration of Extant varieties -Registration and protection of New Varieties / Hybrids / Essentially Derived Varieties - Dispute prevention and settlement -Farmers' Rights.

Unit - IV:

Trademark- Geographical Indications of Goods and Commodities – Copy rights- Designs – Biodiversity Protection.

Unit - V

Procedures for commercialization of technology - Valuation, Costs and Pricing of Technology- Licensing and implementation of Intellectual Properties- Procedures for commercialization – Exclusive and non exclusive marketing rights-Research Exemption and benefit sharing .

Theory Schedule

- 1) World Trade Organization - Agreement on Agriculture (AoA) and Intellectual Property Rights (IPR)
- 2) Importance of Intellectual Property Management - IPR and Economic growth- IPR and Bio diversity
- 3) Major areas of concern in Intellectual Property Management - Technology Transfer and Commercialization
- 4) Forms of different Intellectual Properties generated by agricultural research.
- 5) Discovery *versus* Invention Patentability of Biological Inventions –
- 6) Method of Agriculture and Horticulture- procedure for patent protection:
- 7) Preparatory work. Record keeping, writing a patent document, filing the patent document
- 8) Types of patent application-patent application under the Patent cooperation treaty (PCT). Plant genetic resources
- 9) Mid Semester Examination
- 10) Importance and conservation
- 11) Sui Generic System –Plant Varieties Protection and Farmers Rights Act- Registration of Extant varieties
- 12) Registration and protection of New Varieties / Hybrids / Essentially Derived Varieties - Dispute prevention and settlement

- 13) Farmers' Rights. Trade mark-Geographical Indications of Goods and Commodities – Copy rights- Designs
- 14) Biodiversity Protection.
- 15) Procedures for commercialization of technology - Valuation, Costs and Pricing of Technology
- 16) Licensing and implementation of Intellectual Properties- Procedures for commercialization
- 17) Exclusive and non exclusive marketing rights-Research Exemption and benefit sharing.

Suggested Readings

- 1) Ganguli, P. 2001. *Intellectual Property Rights –Unleashing the Knowledge Economy*. Tata McGraw Hill, New Delhi.
- 2) Gupta, A.K., 2003. *Rewarding Conservation of Biological and Genetic Resources and Associated Traditional Knowledge and Contemporary Grass Roots Creativity*, Indian Institute of Management, Ahmedabad.
- 3) Khan S.A., and Mashelkar R. 2004. *Intellectual Property and Competitive Strategies in the 21st Century*. Kluwer Law International, The Hague.

Semester - III

AGM 711: FOOD AND DAIRY MICROBIOLOGY (2+1)

Objectives:

The emphasis of the course will be on the basic principles and applied aspects of food microbiology such as characteristics of food microflora, food preparation, food spoilage, fermented foods and dairy microbiology.

Theory

Unit – I: Food Microflora

Introduction and importance of food microbiology – Incidence and behavior of microorganisms in food – Primary sources of contamination in food – Intrinsic and extrinsic parameters of food affecting microbial growth – Assessing microbial load in foods.

Unit – II: Food Preservation

Principles of food preservation – Methods of preservation Physical methods – High temperature, Low temperature, drying, osmotic pressure, irradiation, chemical methods – Class I and II chemicals. Food manufacturing practices – HACCP – Quality control in food processing industries. Food quality control and standards.

Unit - III: Food Spoilage

Microbial spoilage of different types of food – spoilage of cereals and cereal products, fruits and vegetables, meat, egg and poultry, sea foods, canned foods. Food poisoning - Botulism – Food borne infections – Food pathogens – Mycotoxins.

Unit IV: Fermented Foods.

Fermentation of pickles, sauerkraut, bread, vinegar, idli, microorganisms as food – single cell proteins – application of microbial enzymes in food industries.

Unit V: Dairy Microbiology

Microorganisms of milk and milk products – preservation of dairy products – pasteurization – Microbial spoilage of dairy products – Fermented dairy products – Diseases spread by microbes through milk.

Practicals

Microbiological examination of normal fruits, spoiled fruits, vegetables, normal cereal, spoiled cereal and sugar products. Microbiological examination of water samples, Microbiological examination of cereals and sugar products, Food preservation with chemicals, Food preservation with low temperature, Food preservation with high temperature - 'D' value calculations - determination of Thermal death point, Microbiological examination of spoiled canned foods, Microbiological examination of spoiled meat and fish, Microbiological survey of utensils and processing plants, Assessing the load of coliform bacteria as indicator organisms, Methylene blue reduction test, Microbiological examination of milk and Visit to dairy units.

Lecture Schedule

- 1) Introduction and importance of food microbiology.
- 2) Incidence and behavior of microorganisms in food.
- 3) Sources of microorganisms found in food.
- 4) Intrinsic and extrinsic parameters of food affecting microbial growth.
- 5) Assessing microbial load in food.
- 6) Principles of food preservation.
- 7) Physical methods of preservation – heat processing
- 8) Chilling and freezing drying.
- 9) Osmotic pressure irradiation.
- 10) Chemicals used as preservatives in food
- 11) Food manufacturing practices
- 12) HACCP
- 13) Quality control in food processing industries

- 14) Food quality control and food standards
- 15) Microbial spoilage of cereal and cereal products
- 16) Spoilage of fruits and vegetables
- 17) Spoilage of Meat
- 18) Mid Semester
- 19) Spoilage of egg and poultry
- 20) Spoilage of sea foods
- 21) Spoilage of canned foods
- 22) Food poisoning – Botulism
- 23) Food borne infection – food pathogens
- 24) Mycotoxins
- 25) Fermented foods pickles sauerkraut
- 26) Bread Vinegar and Idli fermentations
- 27) Single cell proteins
- 28) Application of microbial enzymes in food industries.
- 29) Microbial spoilage of dairy products.
- 30) Preservation of dairy products
- 31) Pasteurization methods.
- 32) Fermented dairy products.
- 33) Diseases spread by microorganism through milk.
- 34) Review of lectures.

Practical

- 1) Microbiological examination of normal fruits and vegetables.
- 2) Microbiological examination of spoiled fruits and vegetables
- 3) Microbiological examination of normal cereal and sugar products.
- 4) Microbiological examination of spoiled cereal and sugar products
- 5) Microbiological examination of water samples
- 6) Microbiological examination of cereals and sugar products
- 7) Food preservation with chemicals
- 8) Food preservation with low temperature
- 9) Food preservation with high temperature - 'D' value calculations -

determination of Thermal death point.

- 10) Microbiological examination of spoiled canned foods
- 11) Microbiological examination of spoiled meat and fish
- 12) Microbiological survey of utensils and processing plants.
- 13) Assessing the load of coliform bacteria as indicator organisms.
- 14) Methylene blue reduction test.
- 15) Microbiological examination of milk.
- 16) Visit to dairy units.
- 17) Practical examination.

Reference

- 1) Banwari, G.J. 1998. Basic Food Microbiology. CBS Publishers and Distributors, New Delhi. India
- 2) Jay, J.M. 1987. Modern Food Microbiology CBS publishers and Distributors. New York.
- 3) King, R.D and P.S.J. Cheetam, 1986 Food Biotechnology, Elsevier Applied Science, New York
- 4) Maz, 2000. Enzymes and Food ,IBH Publish. Delhi
- 5) Srivasta, M.L. 2002 Handbook of Milk Microbiology, Daya Publ. Delhi
- 6) Steinkraus, K.H. 1983. Hand Book of Indigenous fermented food. Marcel Dekker Inc. New York, USA.

AGM 712 : BIOFERTILIZER TECHNOLOGY (1+1)

Theory

Objectives:

To study the basic principles and application methodologies of different microbial inoculants in order to improve the ecological competence and stability of bioinoculum.

Unit – I: Concepts of microbial inoculants

Types of inoculants - Bacteria, Fungi and Algal inoculants - Importance of microbial inoculants - Nutrient mobilization - Organic matter decomposition - Metal recovery - Pest and disease control.

Unit-II: Group of Biofertilizers

Rhizobium, *Azospirillum*, *Azotobacter*, *Gluconacetobacter*, *Frankia* and Algal fertilizer - Blue green algae – *Azolla*. Phosphobacteria, AM fungi. K mobilizing bacteria, Minerals mobilizing bacteria.

Unit –III: Microbial inoculants other than biofertilizers

Metal recovery - *Thiobacillus*, Pest and disease control - *Bacillus thuringiensis*, *Trichoderma* etc - Organic matter decomposition- Cellulolytic and lignolytic fungi -*Trichoderma*, *Beauveria*, *Entomophthora*, *Metarhizium*, etc.

Unit –IV: Biochemistry of nitrogen fixation

Biochemistry of nitrogen fixation – nitrogenase - hydrogenase - Assay of nitrogen fixation. Biochemistry and physiology of actinorhizal nodules - Nitrogen assimilation - Transfer of fixed nitrogen in symbiotic system.

Unit – V: Principles of mass production of bioinoculants

Fermentation techniques - Raw materials - Fermentation media - Inoculum preparation – curing - carrier materials. Quality control- Regulation and standards - quality control organizations. Marketing and monitoring field performance - Economics of microbial inoculants production – Problems and constraints in Biofertilizer production.

Practical

Isolation, screening for efficiency and strain improvement of different types of inoculants - *Rhizobium*, *Azospirillum*, Phosphobacteria, *Trichoderma*, *Metarhizium*, *Bacillus thuringensis*, *Bacillus sphaericus*, etc. Mass multiplication techniques of *Rhizobium*, *Azotobacter*, *Gluconacetobacter*, *Azospirillum*, BGA, Phosphobacteria and K mobilizing bacteria - AM fungi - Spore count and infection percentage - Fermentor - fermentation requirements - Types of carriers-preparation of carrier based inoculants -shelf life - methods of applications - Quality control of inoculants.

Lecture schedule

- 1) Biofertilizers - definition - Development of the concept - Contribution of microorganisms to soil fertility.
- 2) Different groups of biofertilizers - bacterial, algal, fungal biofertilizers, etc.
- 3) Nitrogen fixing microorganisms - Phosphate solubilizing microorganisms, Symbiotic nitrogen fixing bacteria - *Rhizobium* classification - Cross inoculation groups - Characteristics Infection - root nodule formation - leghaemoglobin - nitrogen fixation.
- 4) Associative symbiosis - *Azospirillum* - species distribution - Characterization- Importance of *Gluconacetobacter* and its distribution. Non-symbiotic nitrogen fixation - *Azotobacter* - Characterization.
- 5) Actinorhizal association - *Frankia* - Importance - location, biochemistry and physiology of actinorhizal nodules. Phosphate solubilization by microorganisms-bacteria and fungi involved general characters and importance.
- 6) Algal biofertilizers - Blue green algae - distribution - occurrence - Morphological variation - Characteristics.
- 7) Azolla - Anabaena symbiosis - Importance - Azolla growth behavior - multiplication - Sporulation, etc.

- 8) Mycorrhiza - Ectomycorrhiza – Endomycorrhiza.
- 9) Mid semester examination.
- 10) Role of mycorrhiza in crop production. Microbial inoculants in nutrient- mobilization, K mobilizing bacteria and minerals mobilizing bacteria - Organic matter decomposition.
- 11) Role of microorganisms in bioleaching, metal recovery, pest and disease control.
- 12) Biochemistry of nitrogen fixation - Nitrogenase and hydrogenase enzyme.
- 13) Principles of mass production-Large scale production of bacterial biofertilizers - growth characteristics, Fermentation - Principles and techniques - inoculum preparation. Carrier materials - Types and quality characteristics of an ideal carrier, preparation of inoculant packets, Shelf life-quality control of biofertilizers - BIS specifications.
- 14) Field performance of biofertilizers, Methods of application.
- 15) Algal multiplication - large scale production - application methods
- 16) Azolla - Mass multiplication and method of application etc.
- 17) Mycorrhizae – VAM - Mass scale production - field performance - problems and prospects of a biofertilizers.

Practical

- 1) Isolation of *Rhizobium* from legume root nodules; purification and characterization of a *Rhizobium*.
- 2) Testing the efficiency - Leonard jar technique and plant infection test.
- 3) *Rhizobium* strain identification by immunological methods.
- 4) Isolation of *Azospirillum* from roots Rhizosphere.
- 5) Identification and characterization of *Azospirillum*.
- 6) Isolation and identification of *Azotobacter* and *Gluconacetobacter*.
- 7) Isolation of Phosphobacteria and K mobilizing bacteria from soil.
- 8) Quantitative determination of P-solubilization by Phosphobacteria.

- 9) Mass multiplication of bacterial biofertilizers in Fermentor.
- 10) Carrier material - preparation of inoculant packets.
- 11) Quality control - assessment of shelf life and storage methods.
- 12) Methods of application of bacterial biofertilizers – seed and soil.
- 13) Isolation, enumeration and identification of Blue green algae.
- 14) Blue green algae and Azolla - large scale production and method of application.
- 15) Mass production of *Trichoderma*, *Bacillus thuringiensis* and other insect pathogens.
- 16) Different genera of VA mycorrhizae and Mass multiplication of VAM-application methods.
- 17) Practical Examination

References

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- 2) Bhattacharyya., P and Tandon HLS. 2002. Dictionary of Biofertilizers and Organic Fertilizers. Fertilizer Development and Consultation Organization, New Delhi.,1-165.
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- 4) Ken. E. Giller 2001. Nitrogen fixation in tropical cropping systems. CABI Publishing, New York. 1- 409.
- 5) Motsora, M.R., P. Bhattacharaya and Beena Srivastava, 2001. Biofertilizer Technology, Marketing and usage - A source Book - cum – glossary - FDCO, New Delhi, P. 584.
- 6) Somasegaran, P and H.J. Hoben, 1994. Hand book for Rhizobia - Methods in legume, *Rhizobium* Technology Springer-Verlag, New York, P. 450.
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PGS 714 ** LIBRARY AND INFORMATION SERVICES (0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary -Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services - (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing - information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized - library services; Use of Internet including search engines and its resources; e-resources access methods.

Practical Schedule

- 1) Introduction to library and its services
- 2) Role of libraries in education, research and technology transfer;
- 3) Classification systems and organization of library
- 4) Sources of information- Primary –Sources
- 5) Sources of information -Secondary Sources and Tertiary Sources
- 6) Intricacies of abstracting and indexing services
- 7) Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.);
- 8) Tracing - information from reference sources; Literature survey
- 9) Mid- Semester
- 10) Citation techniques/Preparation of bibliography;
- 11) Use of CD-ROM Databases,

- 12) Online Public Access Catalogue and other computerized - library services
- 13) Online Public Access Catalogue and other computerized - library services
- 14) Use of Internet including search engines and its resources
- 15) Use of Internet including search engines and its resources
- 16) e-resources access methods.
- 17) e-resources access methods.

Semester - IV

AGM 721: MICROBIAL BIOTECHNOLOGY (2+1)

Objectives

To teach students about industrially useful microorganisms and use of fermentor for the production of various primary and secondary metabolites.

Theory

Unit-I: Microbial Fermentations

Concepts and scope of microbial fermentations - Inoculum - screening and selection - strain improvement - fermentation medium - Fermentation processes - Dual and multiple fermentation - continuous fermentation, batch fermentation.

Unit - II: Bioreactors

Bioreactors - types, designs and functional characteristics - scale up of fermentation- Upstream processing -Downstream processing - Fermentation economics

Unit -III: Production of organic solvents organic acids and amino acids

Fermentation processes and products - production of organic solvents: ethyl alcohol, glycerol, Acetone, butanol; Beverages; beer, wine etc., organic acids - butyric acid and propionic acid; Citric acid Lactic acid, acetic acids Gluconic Acid, Amino acids Lysine and glutamic acid

Unit-IV: Production of vitamins hormones and enzymes

Vitamins and growth factors -vitamin B2, Vitamin B12 and Vitamin C. Gibberelins - IAA, Enzymes - amylase, cellulase, gluco isomerase, pectinases, invertase, protease and lipase.

Unit -V: Immobilization and strain improvement of microorganisms

Principles of immobilization - Different kinds of immobilization techniques and their importance - Sources of industrially important microorganism in India and abroad. Biotransformation - steroid transformation. Use of genetically engineered microorganisms in

Biotechnology, Bioinsecticides, Biofertilizers, etc. Microbiologically produced food colours and food flavours.

Practical

Screening industrially useful microorganisms and their growth characteristics - Preparation of inoculum and fermentation media - Fermentation of alcohol, organic, acids, amino acids, enzymes and antibiotics - Immobilization techniques for increasing the fermentation efficiency- Bioassay techniques for antibiotics and vitamins - visit to alcohol production, and pharmacological industries - visit to Pasteur institute, Coonoor.

Lecture Schedule

Theory

- 1) Concepts and scope of fermentation technology.
- 2) Screening, selection and strain improvement of microorganisms
- 3) Strain improvement of microorganisms
- 4) Inoculum - fermentation medium
- 5) Dual and multiple fermentation.
- 6) Bioreactors - types, designs and functional characteristics
- 7) Scale up of fermentation - fermentation economics.
- 8) Dual and mixed inoculations - continuous and batch fermentations
- 9) Fermentation processes & products: Organic solvents- Production of ethyl and butyl alcohol, acetone etc.
- 10) Production of ethyl alcohol
- 11) Production of Acetone and butanol.
- 12) Production of Beer
- 13) Production of Wine
- 14) Production of Amino acid - Lysine,
- 15) Production of Glutamic acid.
- 16) Production of vitamins B₁₂ .
- 17) Production of Vitamins B₁₂ and Vitamin C

- 18) Mid semester examination
- 19) Production of Gibberellins.
- 20) Enzyme production - amylase
- 21) Enzyme production cellulase etc.
- 22) Enzyme production glucoisomerase
- 23) Production of organic acids
- 24) Production of citric acid,
- 25) Production of butyric
- 26) Production of propionic acid.
- 27) Antibiotic production: Penicillin,
- 28) Production of tetracycline and streptomycin.
- 29) Production of microbial polysaccharides.
- 30) Production of microbial insecticides, microbial nematicides
- 31) Principles of immobilization- techniques and importance;
- 32) Downstream processing
- 33) Use of genetically engineered microorganisms in Biotechnology, Bioinsecticides, Biofertilizers, etc.
- 34) Microbiologically produced food colours and food flavours.

Practical

- 1) Isolation of industrially important microorganisms
- 2) Selective isolation of actinomycetes - studying their growth characteristics.
- 3) Isolation and enumeration of Lactic acid bacteria.
- 4) Ethanol production by Yeast
- 5) Estimation of alcohol content by colorimetric and GLC.
- 6) Wine production by yeast - setting up a lab experiment estimation of alcohol content.
- 7) Enzyme production - amylase production.
- 8) Production of organic acids - citric acid production by solid state fermentation
- 9) Antibiotic production by different strains

- 10) Test of sensitivity against microorganisms.
- 11) Downstream processes of enzymes – dialysis.
- 12) Ion exchange chromatography - drying - cellulose column chromatography.
- 13) Ethanol production by immobilized yeast cells.
- 14) Bioassay techniques for antibiotics.
- 15) Large scale production of organic acids, large scale production of solvents using fermentor.
- 16) Visit to Distillery unit / visit to alcohol production, and pharmacological industries/visit to Pasteur institute
- 17) Final Practical examination

Reference

- 1) El-Mans, E.M.T and C.F.A Bryce 2002. Fermentation Technology and Biotechnology. Taylor and Francis, UK
- 2) Ghose, T.K and P.Ghose. 2003. Biotechnology in India, Springer Publishers, India
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- 4) Mukerji, K.G., V.P. Singh and K.L. Garg, 1987. Frontiers in Applied Microbiology Print House (India)
- 5) Prescott and Dunn. 1982. Industrial Microbiology. AVI Publishing Co., west port, Connecticut, U.S.A.
- 6) Stanbury, P.F., A. Whitaker and S.J. Hall 1995. Principles of fermentation Technology, Pergamon, UK.

PGS 725 ** DISASTER MANAGEMENT (1+0)
(e-Course)

Objectives

To introduce learners to the key concepts and practices of mitigation for natural disasters and calamities and to equip them to conduct thorough assessment of hazards, risks vulnerability and capacity building strategies.

Theory

Unit I

Natural Disasters - Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves.

Unit II

Climatic change: Global warming, Sea level rise, Ozone depletion, Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters.

Unit III

Building fire, coal fire, forest fire. oil fire, air pollution, water pollution, deforestation, Industrial waste water pollution, Disaster Management- Efforts to mitigate natural disasters at national and global levels.- India's Key Hazards, Vulnerabilities and Disaster Response Mechanisms in India-

Unit IV

Concept of disaster management, national disaster management framework; financial arrangements, role of NGOs, Community-based organizations, and media-Central, state, district and local administration. Dissemination of Disaster Warning, Response to natural disasters, national, state, district level, relief – food & nutrition – water – health – mental health services.

Unit V

Rehabilitation – tolerant and resistant crops- Resilient farming concepts – Bioshields Livelihood options – insurance and compensation- Clothing & utensils & fuel – shelter – relief camp – Sanitation and Hygiene. Preparedness – Emergency Operations Centres (EOCS).

Lessons

- 1) Natural Disasters Meaning and nature of natural disasters, their types and effects –
- 2) Floods, drought, cyclone, earthquakes Landslides, avalanches, volcanic eruptions, Heat and cold waves.
- 3) Climatic change- Global warming, Sea level rise, Ozone depletion
- 4) Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters
- 5) Building fire, coal fire, forest fire. oil fire,
- 6) Air pollution, water pollution, deforestation, Industrial wastewater pollution
- 7) Disaster Management- Efforts to mitigate natural disasters at national and global levels.
- 8) Mid-Semester
- 9) India's Key Hazards, Vulnerabilities and Disaster Response Mechanism in India
- 10) Concept of disaster management, national disaster management framework
- 11) Financial arrangements, role of NGOs, Community-based organizations, and media-
- 12) Central, state, district and local administration
- 13) Dissemination of Disaster Warning - Response to natural disasters, national, state, district level
- 14) Relief – food & nutrition – water – health – mental health services

- 15) Rehabilitation – tolerant and resistant crops- Resilient farming concepts – Bioshields Livelihood options – insurance and compensation-
- 16) Clothing & utensils & fuel – shelter – relief camp – Sanitation and Hygiene.
- 17) Preparedness – Emergency Operations Centres (EOCS).

References

1. Gautam D R 2009. Community Based Disaster Risk Reduction –, Mercy Corps, Lalitpur, Nepal.
2. Gupta HK. 2003. Disaster Management. Indian National Science Academy. Orient Blackswan.
3. Hodgkinson PE & Stewart M. 1991. Coping with Catastrophe: A Handbook of Disaster Management. Routledge.
4. Ministry of Home Affairs. 2010. Standard Operating Procedure for responding to natural disasters, Ministry of Home Affairs – Disaster management Division, New Delhi.
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