VI SEMESTER

S. No.	Course code	Course Title	Credit load
1	AEC 302	Agricultural Finance and Co-Operation	2+1
2	PAT 302	Diseases of Field and Horticultural crops and their management -II	2+1
3	COM 311	Agro Informatics	1+1
4	ENS 301	Environmental Pollution and Management	1+1
5	AEN 301	Pests of Crops and Stored grain and their Management	2+1
6	AGR 303	Practical Crop Production - II *(Rabi* crops*)*	0+2
7	AGR 304	Principles of organic Farming	1+1
8	ABT 301	Plant Bio technology	2+1
9	PBG 302	Crop Improvement	2+1
10	OPT 301	Optional course	1+1
11	NCC 101	NCC* **Total**	**13+11=24**
		***Non-gradial courses compulsory courses**	

AEC 302 Agricultural Finance and Co - operation (2+1)

Theory

Unit 1: Agricultural Finance – Nature and Scope : Agricultural Finance- meaning, scope and significance, credit needs and its role in Indian agriculture. Agricultural credit: meaning, definition, need, classification. Sources of credit - advantages and disadvantages - Rural indebtedness- History and Development of rural credit in India.

Unit 2: Financial Institutions : Sources of agricultural finance: institutional and non-institutional sources and their roles, commercial banks - social control and nationalization of commercial banks. Micro financing including KCC, Micro finance – SHG Models, Lead Bank Scheme, RRBs, Scale of finance and unit cost. Cost of credit. An introduction to higher financing institutions – RBI, NABARD, ADB, IMF, world bank, Insurance and Credit Guarantee Corporation of India. Recent development in agricultural credit: Rural credit policies of Government – Subsidized farm credit - Differential Interest Rate (DIR) Scheme – Loan relief measures

Unit 3: Farm Financial Analysis: Credit analysis: 4 R's, 7 P's and 3C's of credit. Preparation of bankable projects / Farm credit proposals – Feasibility; Appraisal - Time value of money: Compounding and Discounting - Undiscounted and Discounted measures. Preparation and analysis of financial statements – Balance Sheet, Income Statement and Cash Flow Statement. Basic guidelines for preparation of project reports - Bank norms – SWOT analysis.

Unit 4: Co-operation: Agricultural Cooperation in India – Meaning, brief history of cooperative development in India - Pre and Post - Independence periods and Co-operation in different plan periods, objectives, principles of cooperation, significance of cooperatives in Indian agriculture. Co-operating credit structure: short term and long term. Agricultural Cooperation - credit, marketing, consumer and multi-purpose cooperatives, farmers' service cooperative societies, processing cooperatives, farming cooperatives, cooperative warehousing; role of ICA, NCUI, NCDC, NAFED. Strength and weakness of co-operative credit system, Policies for revitalizing co-operative credit.

Unit 5: Banking and Insurance: Negotiable Instruments: Meaning, Importance and Types - Central bank: RBI – functions - Credit control – Objectives and Methods: CRR, SLR and Repo rate - Credit rationing - Dear money and cheap money - Financial Inclusion and Exclusion: credit widening and credit deepening monetary policies. Credit gap: Factors influencing credit gap. Non - Banking Financial Institutions (NBFI). NPA – Causes, consequences and mitigation. Crop Insurance: Schemes, Coverage, Advantages and Limitations in Implementation - Estimation of Crop Yields - Assessment of crop losses, Determination of compensation - Weather based crop insurance, features, determinants of compensation. Livestock Insurance Schemes Agricultural Insurance Company of India Ltd (AIC): Objectives and functions.

Practical

Determination of most profitable level of capital use. Optimum allocation of limited amount of capital among different enterprise. Analysis of progress and performance of cooperatives using published data. Analysis of progress and performance of commercial banks and RRBs using published data. Visit to a commercial bank, cooperative bank / cooperative society to acquire first - hand knowledge of their management, schemes and procedures. Visit to District Central Co-operative Bank (DCCB) to study its role, functions and procedures for availing loan – Fixation of Scale of Finance. Estimation of credit requirement of farm business – A case study. Preparation and analysis of Balance Sheet, and Cash Flow Statement – A case study. Exercise on Financial Ratio Analysis. Appraisal of farm credit proposals – A case study. Preparation and analysis of income statement – A case study. Preparation of Bankable

projects / Farm Credit Proposals and appraisal - Undiscounted methods and Discounted methods. Techno-economic parameters for preparation of projects for various agricultural products and its value added products. Seminar on selected topics. Analysis of Different Crop Insurance Products / Visit to crop insurance implementing agency.

Theory Schedule

1. Agricultural Finance - meaning, scope and significance, credit needs and its role in Indian agriculture.
2. Agricultural credit: meaning, definition, need and classification.
3. Sources of credit - advantages and disadvantages.
4. Rural indebtedness - History and Development of rural credit in India.
5. Sources of agricultural finance: institutional and non-institutional sources - their roles.
6. Commercial banks - social control and nationalization of commercial banks.
7. Micro financing including KCC, Micro finance – SHG Models, Lead bank scheme.
8. RRBs, Scale of finance and unit cost. Cost of credit.
9. An introduction to higher financing institutions–RBI, NABARD, ADB, IMF and World Bank.
10. Role of Insurance and Credit Guarantee Corporation of India.
11. Recent developments in agricultural credit.
12. Rural credit policies of Government: Subsidized farm credit- Differential Interest Rate (DIR) Scheme – Loan relief measures
13. Credit analysis: 4 R's, 7 P's and 3C's of credit.
14. Preparation of bankable projects / Farm credit proposals – Feasibility.
15. Appraisal: Time value of money: Compounding and Discounting - Undiscounted and Discounted measures.
16. Preparation and analysis of financial statements – Balance Sheet, Income Statement and Cash Flow Statement.
17. **Mid Semester Examination**
18. Basic guidelines for preparation of project reports- Bank norms – SWOT analysis.
19. Agricultural Cooperation in India – Meaning, brief history of cooperative development in India.
20. Pre and Post - Independence periods and Co-operation in different plan periods, objectives, principles of cooperation, significance of cooperatives in Indian agriculture.
21. Co-operating credit structure: short term and long term. Agricultural Cooperation - credit, marketing, consumer and multi-purpose cooperatives, farmers' service cooperative societies, processing cooperatives, farming cooperatives, cooperative warehousing;
22. Role of ICA, NCUI, NCDC and NAFED.
23. Strength and weakness of co-operative credit system, Policies for revitalizing co-operative credit.
24. Negotiable Instruments: Meaning, Importance and Types.
25. Central bank: RBI – functions, Credit control – Objectives and Methods: CRR, SLR and Repo rate.
26. Credit rationing - Dear money and cheap money.
27. Financial Inclusion and Exclusion: credit widening and credit deepening monetary policies.
28. Credit gap: Factors influencing credit gap.
29. Non - Banking Financial Institutions (NBFI). NPA – Causes, consequences and mitigation.
30. Crop Insurance: Schemes, Coverage, Advantages and Limitations in Implementation.
31. Estimation of Crop Yields - Assessment of crop losses, Determination of compensation.
32. Weather based crop insurance, features, determinants of compensation.
33. Livestock Insurance Schemes
34. Agricultural Insurance Company of India Ltd (AIC): Objectives and functions.

Practical Schedule

1. Determination of most profitable level of capital use.
2. Optimum allocation of limited amount of capital among different enterprise.
3. Analysis of progress and performance of cooperatives using published data.
4. Analysis of progress and performance of commercial banks and RRBs using published data.
5. Visit to a commercial bank, cooperative bank / cooperative society to acquire first - hand knowledge of their management, schemes and procedures.
6. Visit to District Central Co-operative Bank (DCCB) to study its role, functions and procedures for availing loan – Fixation of Scale of Finance.
7. Guest lecture on Role and functions of Commercial Bank and Lead Bank / NABARD and its Role and Functions.
8. Estimation of credit requirement of farm business – A case study.
9. Preparation and analysis of Balance Sheet and Cash Flow Statement – A case study.
10. Exercise on Financial Ratio Analysis. Appraisal of farm credit proposals – A case study.
11. Preparation and analysis of income statement – A case study.
12. Preparation of Bankable projects / Farm Credit Proposals and appraisal.
13. Undiscounted methods and Discounted methods.
14. Techno-economic parameters for preparation of projects for various agricultural products and its value added products.
15. Analysis of Different Crop Insurance Products / Visit to crop insurance implementing agency.
16. Seminar on selected topics.
17. **Practical Examination.**

References

1. Muniraj, R. 1987. Farm Finance for Development. Oxford & IBH. New Delhi.
2. Subba Reddy, S and P. Raghu Ram. 2011. Agricultural Finance and Management. Oxford & IBH. New Delhi.
3. Lee, W.F., M.D. Boehlje, A.G. Nelson and W.G. Murray. 1998. Agricultural Finance. Kalyani Publishers. New Delhi.
4. Mammoria, C.B. and R.D. Saxena. 1973. Cooperation in India. Kitab Mahal. Allahabad. Patnaik, V.E. and A.K. Roy. 1988. Cooperation and Cooperative Management. Kalyani Publishers. Ludhiana.

1. PAT 302 Diseases of Field and Horticultural crops and their management-II (2+1)

Theory

Etiology, symptoms, mode of spread, survival, epidemiology and integrated management of important diseases

Unit-I Diseases of cereals: Wheat

Unit- II Diseases of Pulses, Oilseeds and Cash crops

Pulses: chick pea and lentil; **Oilseeds:** sunflower and mustard; **Cash crops:** sugarcane and cotton

Unit- III Diseases of Fruits and vegetables crops

Fruits: mango, citrus, grapevine, sapota, jackfruit, pineapple, ber, apple, peach plum and strawberry; **Vegetables:** cucurbits, peas, potato, beet root, radish, cassava, colacasia and yam

Unit- IV Diseases of Spices, Plantation and Flower crops

Spices: chillies, turmeric, ginger, onion, garlic, coriander, cardamom; **Plantation crops:** black pepper and vanilla; **Flower crops:** rose, Jasmine, marigold,crossandra, chrysanthemum, tube rose , carnation, lillium and orchids

Unit- V Diseases of medicinal crops and mushroom cultivation

Medicinal crops: gloriosa, coleus, stevia and aloe; **Mushroom cultivation:** Importance of mushroom and cultivation of button mushroom, oyster mushroom, milky mushroom and paddy straw mushroom- pest and diseases of mushroom

PRACTICAL

Study of symptoms and host parasite relationship of the important diseases of wheat, chick pea, lentil, sunflower , mustard , cotton, sugarcane, mango , citrus, grapevine, sapota , jackfruit , pineapple, ber, apple , peach, plum , strawberry, cucurbits , potato , peas , beet root , radish , cassava, colacasia, yam , chillies, turmeric, ginger, onion, garlic, coriander, cardamom, black pepper, vanilla, rose, Jasmine, marigold, crossandra, chrysanthemum, tube rose , carnation, lillium , orchids, gloriosa, coleus, stevia and aloe and cultivation of button mushroom, oyster mushroom, milky mushroom and paddy straw mushroom.

THEORY

Etiology, symptoms, mode of spread, survival, epidemiology and integrated management of

1. Diseases of wheat
2. Diseases of chickpea and lentil
3. Diseases of sunflower and mustard
4. Diseases of cotton
5. Diseases of sugarcane
6. Diseases of mango
7. Diseases of citrus
8. Diseases of grapevine
9. Diseases of sapota, jack fruit , pineapple and ber
10. Diseases of apple
11. Diseases of peach, plum and strawberry
12. Diseases of cucurbits
13. Diseases of Potato-I (Fungal diseases)
14. Diseases of Potato-II (bacterial and viral diseases)
15. Diseases of peas, beet root and radish

16. **Mid semester examination**
17. Diseases of cassava, colacasia and yam
18. Diseases of chillies
19. Diseases of turmeric and ginger
20. Diseases of onion and garlic
21. Diseases of cardamom and coriander
22. Diseases of black pepper, betel vine and vanilla
23. Diseases of rose and jasmine
24. Diseases of marigold, crossandra and chrysanthemum
25. Diseases of tube rose and carnation
26. Diseases of lillium and orchids
27. Diseases of gloriosa and coleus
28. Diseases of stevia and aloe
29. Diseases of stored grains and their management
30. Post harvest diseases of fruit and vegetables
31. Mushroom-edible and poisonous mushroom- importance of mushroom
32. Cultivation of button mushroom and oyster mushroom
33. Cultivation of milky mushroom and paddy straw mushroom
34. Pest and diseases of mushroom

PRACTICAL

Study of symptoms and host-parasite relationship of:

1. Diseases of wheat
2. Diseases of chick pea, lentil, sunflower and mustard
3. Diseases of cotton and sugarcane
4. Diseases of mango and sapota
5. Diseases of citrus and grapevine
6. Diseases of jackfruit , pineapple, ber, apple , peach, plum , strawberry
7. Diseases of cucurbits
8. Diseases of potato , peas , beet root and radish
9. Diseases of cassava, colacasia and yam
10. Field visit/ exposure visit to hilly fruits , vegetables and plantation crops / mushroom unit
11. Diseases of chillies, turmeric and ginger
12. Diseases of coriander, cardamom, black pepper and vanilla,
13. Diseases of rose, Jasmine, marigold and crossandra
14. Diseases of tube rose , carnation, lillium and orchids,
15. Diseases of gloriosa, coleus, stevia and aloe
16. Cultivation of oyster , milky and paddy straw mushroom cultivation
17. Final practical examination

Reference Books

1. Arjunan.G. Karthikeyan, G, Dinakaran ,D. Raguchander,T. 1999 Diseases of Horticultural Crops, AE Publications, Coimbatore.

2. Rangasawmi ,G and Mahadevan, A. 1998. Diseases of crop Plants in India, Prentice Hall of India Pvt. Ltd., New Delhi
3. Prakasam, V., Valluvaparidasan, V., Raguchander, T. and K.Prabakar. 1997. Field crop diseases, AE Publication, Coimbatore.

E- Books

1. Agrios, G.N. 2008. Plant Pathology, Academic Press, New York
2. Rangaswami, G. 2005. Diseases of Crop plants in India. Prentice Hall of India Pvt. Ltd., New Delhi
3. Thakur, B.R. 2006. Diseases of field crops and their management

COM 311 Agro- Informatics (1+1)

Theory

Unit I: Information and Communication Technology (ICT)

ICT and its importance – Computer Fundamentals - Basic anatomy of the computer system: Input devices, CPU, Output devices, Memory: Primary and secondary - Software – Types: System software, Application software and Utility software – Software terminologies: Firmware, Liveware, Freeware, Shareware, Commercial software, Proprietary software, Semi-free software - Internet - World Wide Web – URL – Domain names - Protocols: HTTP, HTTPS - Internet Applications: Email, File sharing web apps, Social Networks, Online shopping, Video Conferencing – HTML: Introduction, Editor, HTML Documents – Tags: <head>, <body>, <title>, <heading>, <paragraph>, </br>, <table>, <li>, <ul>, <href>, <img>, <hr> and <marquee>.

Unit II: Spreadsheet and Database

Electronic spreadsheet – Microsoft Excel - Worksheet manipulation: insert, delete, move, copy and hide worksheet – Cell manipulation: copy, edit and format cell data – Charts - Create Bar and Pie charts - PIVOT table - DBMS: Database terms: Data, Database, DBMS, RDBMS, Row, Column, Table – Database Architecture – Data types: char, varchar(), int, float() – Use of databases in agriculture.

Unit III: C Programming

Introduction to Computer Programming – Programming languages - Translators: Compilers and Interpreters - Algorithm – Flowchart - Introduction to C – Structure of C program - Data types, Variables, Constants, Operators: Arithmetic, Relational, Logical, Assignment - Input/Output: scanf(), printf() - Control statements: if, if else – Loop: while, do while, for.

Unit IV: Agroinformatics

Agroinformatics – Needs and objectives - e-Agriculture : Concept, Meaning, Terminologies and Importance - e-Agriculture – National and International scenario - ICT for Data collection, formation of development programmes, monitoring and evaluation of programmes - Decision support systems: Taxonomy, Components, Framework, Classification and applications in Agriculture -Expert systems - Concepts and Importance – Components – User Interface – Knowledge Base – Inference Mechanism – Inference Rule - Designing an Expert Systems - Advantages and disadvantages of Expert Systems - Information systems for supporting farm decisions.

Unit V: Models and Computer Controlled Devices

Introduction to computer based agricultural models: Model, Simulation, Systems analysis models, Subsystems, Types: Mechanistic process models, Operational models, Statistical models and dynamic simulation models - List of agricultural models - Computer controlled devices – Sensor – Drones – Robots – Internet of Things (IoT) and Cloud Computing for Agriculture.

Practical

Innards of computer – Booting and shutdown – Practice of DOS commands: dir, cd, mkdir, rmdir, del, cls, attrib, ren, copy, move, ipconfig, ping - Software practices – Installation / Uninstallation – Windows apps: Sticky Notes, Steps Recorder, Snipping Tool – Pin and unpin the programs – System tray customization – Shortcut keys - Microsoft Excel - Entering a formula in a cell, Built-in functions: SUM, AVERAGE, MIN, MAX, COUNT, COUNTIF, IF – Import and export data - Charts - Create Bar and Pie charts – PIVOT table - MS-ACCESS: Creating agriculture database – Entering, editing, deleting data – Creating Forms – Query wizard: select, update, delete – Reports - Internet Applications: Email, File sharing web apps: Dropbox, Google drive - Social Networks, Online shopping, Video Conferencing – Creating a web page: HTML editor – Tags: <head>, <body>, <title>, <heading>, <paragraph>, </br>, <table>, <li>, <ul>, <href>, <img>, <hr> and <marquee> - Develop algorithms and represent the same in the flowchart for

the following problems -To calculate Leaf Area Index (LAI) -To calculate the Crop Growth Rate (CGR) - To find the greatest average seed sales of two districts during samba season - Familiarizing with the Integrated Development Environment of C Editor for coding, saving, compiling, debugging and executing – C Programs: Display TNAU motto "Till, Toil, Triumph" – Calculate Leaf Area Index (LAI) – Calculate the Crop Growth Rate (CGR) - Find the greatest average seed sales of two districts during samba season - e-Agriculture – Leveraging social media in agriculture (Social networks) - ICT in agriculture – Paperless data collection using google survey tools - Online photo and video editing tools - Simulating crop yield: InfoCrop - Base file creation for rice and maize (Weather, Varietal characters, Agronomy practices, Soil data) – Interpretation - InfoCrop – Climate change impact studies on rice and maize - Smartphone mobile apps in Agriculture for farm advices, crop protection, market price, postharvest management - Decision support systems - Expert systems - Information systems for supporting farm decisions - Crop calendar – Crop planning tool for farmers.

Lecture Schedule

1. Introduction to Computers - Basic anatomy of the computer system: Input devices, CPU, Output devices, Memory: Primary and secondary.
2. Software – Types: System software, Application software and Utility software – Software terminologies: Firmware, Liveware, Freeware, Shareware, Commercial software, Proprietary software, Semi-free software.
3. Internet - World Wide Web – URL – Domain names - Protocols: HTTP, HTTPS - Internet Applications: Email, File sharing web apps, Social Networks, Online shopping, Video Conferencing – HTML: Introduction, Editor, HTML Documents – Tags: <head>, <body>, <title>, <heading>, <paragraph>, </br>, <table>, <li>, <ul>, <href>, <img>, <hr> and <marquee>.
4. Electronic spreadsheet – Microsoft Excel - Worksheet manipulation: insert, delete, move, copy and hide worksheet – Cell manipulation: copy, edit and format cell data – Charts - Create Bar and Pie charts - PIVOT table.
5. DBMS: Database terms: Data, Database, DBMS, RDBMS, Row, Column, Table – Database Architecture – Data types: char, varchar(), int, float() – Use of databases in agriculture.
6. Introduction to Computer Programming – Programming languages - Translators: Compilers and Interpreters - Algorithm – Flowchart.
7. Introduction to C – Structure of C program - Data types, Variables, Constants, Operators: Arithmetic, Relational, Logical, Assignment - Input/Output: scanf(), printf().
8. Control statements: if, if else – Loop: while, do while, for.
9. **Mid-Semester Examination**
10. Agroinformatics – Needs and objectives - e-Agriculture : Concept, Meaning, Terminologies and Importance
11. e-Agriculture – National and International scenario
12. ICT for Data collection, formation of development programmes, monitoring and evaluation of programmes.
13. Decision support systems: Taxonomy, Components, Framework, Classification and applications in Agriculture.
14. Expert systems - Concepts and Importance – Components – User Interface – Knowledge Base – Inference Mechanism – Inference Rule - Designing an Expert Systems - Advantages and disadvantages of Expert Systems - Information systems for supporting farm decisions.
15. Introduction to computer based agricultural models: Model, Simulation, Systems analysis models, Subsystems, Types: Mechanistic process models, Operational models, Statistical models and dynamic simulation models - List of agricultural models.
16. Computer controlled devices – Sensor – Drones – Robots.
17. Internet of Things (IoT) and Cloud Computing for Agriculture.

Practical Schedule

1. Innards of computer – Boot and shutdown – Windows apps: Sticky Notes, Steps Recorder, Snipping Tool – Pin and unpin the programs – System tray customization – Shortcut keys.
2. Software practices – Installation / Uninstallation – Practice of DOS commands: dir, cd, mkdir, rmdir, del, cls, attrib, ren, copy, move, ipconfig, ping.
3. Microsoft Excel - Entering a formula in a cell, Built-in functions: SUM, AVERAGE, MIN, MAX, COUNT, COUNTIF, IF – Import and export data - Charts - Create Bar and Pie charts – PIVOT table.
4. MS-ACCESS: Creating agriculture database – Entering, editing, deleting data – Creating Forms – Query wizard: select, update, delete – Reports.
5. Internet Applications: Email, File sharing web apps: Dropbox, Google drive - Social Networks, Online shopping, Video Conferencing – Creating a web page: HTML editor – Tags: <head>, <body>, <title>, <heading>, <paragraph>, </br>, <table>, <li>, <ul>, <href>, <img>, <hr> and <marquee>.
6. Develop algorithms and represent the same in the flowchart for the following problems -To calculate Leaf Area Index (LAI) -To calculate the Crop Growth Rate (CGR) - To find the greatest average seed sales of two districts during samba season.
7. Familiarizing with the Integrated Development Environment of C Editor for coding, saving, compiling, debugging and executing – C Programs: Display TNAU motto "Till, Toil, Triumph" – Calculate Leaf Area Index (LAI) – Calculate the Crop Growth Rate (CGR) - Find the greatest average seed sales of two districts during samba season.
8. Looping statements: Calculate the average yield of last 10 years Rice yield of our District - Write a C program to find total, maximum, minimum and average rain fall of last five years in our District.
9. e-Agriculture – Leveraging social media in agriculture (Social networks).
10. ICT in agriculture – Paperless data collection using google survey tools - Online photo and video editing tools.
11. Simulating crop yield: InfoCrop - Base file creation for rice and maize (Weather, Varietal characters, Agronomy practices, Soil data) – Interpretation.
12. InfoCrop – Climate change impact studies on rice and maize.
13. Smartphone mobile apps in Agriculture for farm advices, crop protection, market price, postharvest management.
14. Decision support systems
15. Expert systems - Information systems for supporting farm decisions.
16. Crop calendar – Crop planning tool for farmers.
17. **Final Practical Examination**

Reference:

1. Introduction to Information Technology, 2012, Second Edition, ITL Education Solutions Limited, PEARSON Education.
2. Firuza Aibara, HTML 5 for Beginners, 2012, Shroff Publications.
3. John Walkenbach, Excel 2010 Bible, Wiley publishing, Inc
4. Balagurusamy, E., Programming in ANSI C, 2017, Seventh Edition, McGraw Hill Education.
5. Saravanan, R., Kathiresan, C and Indra Devi, T., 2011. Information & communication technology for agriculture and rural development. New India Publ. Agency.
6. Aggarwal, P.K., Naveen Kalra and Subhash Chander, Infocrop: A generic simulation model for annual crops in tropical environments, Indian Agricultural Research Institute, New Delhi.
7. Malcolm J. Blackie, Information Systems for Agriculture, 2012, Springer Netherlands.
8. Smart Sensing Technology for Agriculture and Environmental Monitoring, 2012, Editors: Mukhopadhyay and Subhas Chandra (Ed.), Springer
9. John Billingsley, Arto Visala and Mark Dunn, 2008, Robotics in Agriculture and Forestry – 46th Chapter from book Springer Handbook of Robotics.

1. Introduction to Expert Systems, 3rd Edition by Peter Jackson
2. Introduction to Artificial Intelligence and Expert Systems, 2007 by Dan W. Patterson.
3. Balagurusamy, E., Computing Fundamentals & C Programming, Second Edition, 2017, McGraw Hill Education.
4. A.S. Sandhu, 2004. Text book on Agricultural Communication Process and Methods. Oxford & TBH.
5. C.J. Date: Data Base Design, Addison Wesley.

E-Reference

1. https://www.scribd.com/document/249057939/InfoCrop-Help
2. InfoCrop: A dynamic simulation model for the assessment of crop yields, losses due to pests, and environmental impact of agro-ecosystems in tropical environments. P.K. Aggarwal et al., Agricultural Systems 89 (2006) 47–67.
3. http://www.sciencedirect.com/science/article/pii/S0168169916303623
4. Web-based crop model: Web InfoCrop – Wheat to simulate the growth and yield of wheat
5. http://excelpro.ir/wp-content/uploads/2015/10/Excel-2010-Bible.pdf
6. https://www.researchgate.net/publication/226105300_Decision_Support_Systems_Concepts_Progress_and_Issues_-_A_Review
7. *https://www.hindawi.com/journals/js/2015/195308/ Applications of Smartphone-Based Sensors in Agriculture: A Systematic Review of Research*
8. http://ncert.nic.in/ncerts/l/kect214.pdf
9. http://teacherlink.ed.usu.edu/tlresources/training2/Google/GoogleForms.pdf
10. http://www.fao.org/publications/card/en/c/24f624ea-7891-45e8-9b24-66cbf13f004d/
11. http://indiagovernance.gov.in/files/ict_in_agriculture.pdf
12. www.manage.gov.in/studymaterial/AKM-E.pdf
13. https://www.researchgate.net/publication/233910963_Application_of_Cloud_Computing_in_Agricultural_Sectors_for_Economic_Development

ENS 301 – Environmental Pollution and Management (1+1)

Theory

Unit-I-Pollution in Environment-Introduction-Pollution- Pollutants – Contaminants – Source and types of pollution in Soil-Water-Air-Impact on environment-Pollution Status in India

Unit– II Waste water Management: Waste water – Different types of waste water-pollutants and contaminants-Impact of waste water on ecosystem –Eutrophication – Biomagnification – Water borne diseases –Wastewater treatment methods – Physical, chemical and Biological – General water treatments-Wastewater recycling – Constructed wetlands-Reed bed system -Legislation and standards

Unit-III-Management of polluted soils: Soil pollutants – Sources – Urban and Industrial – Heavy metal – Pesticides – PAH's and PCB's-E-Waste-Fate of pollutants in Soil - Management of soil pollution – Bio and phyto remediation of polluted soil

Unit-IV - Air Pollution and its Management: Air pollutants from industrial and domestic sources **–** Fate of air pollutants-Air pollution indicators - Monitoring and Control measures – Role of plants in controlling air pollutants-Legislation and Air quality standards - – Noise Pollution – Sources, Effect and Control Measures-Indoor air pollution and control measures

Unit-V- Solid waste management: Solid waste –Sources – Sludge from Industry and farm waste-Characteristics – Environmental problems – Management of sludge and farm wastes – Disposal methods

– Sanitary land fills – Incineration – Pyrolysis - Recycling –Energy recovery –Composting – Vermicomposting – Maturity indices assessment-Standards and Legislation

Unit-VI-Environmental standards, Regulation and EIA - Environmental standards-CPCB Norms for discharging industrial effluents to public sewers- CDM and Carbon foot print-Environmental Impact Assessment: Stages of EIA -Monitoring and Auditing – Environmental clearance procedure in India

Lecture Schedule:

1. Introduction-Pollution- Pollutants – Contaminants – Source and types of pollution in Soil-Water-Air-Impact on environment-Pollution Status in India
2. Waste water – Different types of waste water-pollutants and contaminants-Impact of waste water on ecosystem –Eutrophication – Biomagnification – Water borne diseases –
3. Wastewater treatment methods – Physical, chemical and Biological – General water treatments-
4. Wastewater recycling – Constructed wetlands-Reed bed system -Legislation and standards
5. Soil pollutants – Sources – Urban and Industrial – Heavy metal – Pesticides – PAH's and PCB's-E-Waste
6. Fate of pollutants in Soil - Management of soil pollution – Bio and phyto remediation of polluted soil
7. Air pollutants from industrial and domestic sources **–** Fate of air pollutants-Air pollution indicators – Air pollution episodes-Monitoring and Control measures–
8. Role of plants in controlling air pollutants- Legislation and Air quality standards,
9. **Mid Semester Examination**
10. Noise Pollution, Sources, Effect and Control Measures, Indoor air pollutants and control mesures
11. **S**olid waste –Sources – Sludge from Industry and farm waste-Characteristics – Environmental problems
12. Management of solid waste, Disposal methods, Sanitary land fills, Incineration, Pyrolysis
13. Recycling –Energy recovery –Composting – Vermicomposting – Maturity indices assessment-Standards and Legislation
14. Environmental standards-CPCB Norms for discharging industrial effluents to public sewers

15. Environment Impact Assessment,Introduction, Stages of EIA, -Monitoring and Auditing
16. CDM and Carbon foot print
17. Environmental clearance procedure in India

Practical Schedule

1. Sample collection and preservation from contaminated sistes
2. Waste water treatment by physical (column study with vermiculite and activated charcoal) and chemical (Alum treatment)
3. Waste water treatment through constructed wetland system and charecterisation
4. Estimation of Chlorides, Phosphates in waste water
5. Analysis of Nitrogen in industrial effluent and sludge
6. Collection of PAH's contaminated soils and analysis by GC-MS
7. Biosorption of heavymetal (Cr) by using Water hyacinth and analysis through AAS
8. Pesticide Residue analysis in contaminated water
9. Analysis of SPM in air, Methane and CO_2 in Municipal dumping site
10. Assessing the efficiency of plants to control Indoor air pollutants
11. Analysis of Organic carbon in Sludge and Organic manure
12. Composting and Vermicomposting of farm wastes
13. Energy recovery from wastes
14. Maturity indices of compost- C:N ratio and Phytotoxicity test
15. Maturity indices of compost: starch iodine test and sulphide test
16. Visit to water treatment plant
17. **Final practical examination**

Reference:

1. Tyler Miller and Scot Spoolman. 2009. Living in the Environment (*Concepts, Connections, and Solutions).* Brooks/cole, Cengage learning publication, Belmont, USA
2. P.D. Sharma, 2009, Ecology and Environment, Rastogi Publications, Meerat, India **E-Books:** Chiras D.D., 2016. Environmental Science, Tenth Edition. Jones & Bartlett Learning, Burlington, MA. ISBN: 978-1-284-05705-8, 708 Pages

AEN 301 Pests of Crops and Stored Produces and their Management (2+1)

Theory

Unit I: Distribution, bionomics, symptoms of damage and management strategies for insects and non-insect pests of rice, wheat, maize, sorghum, cumbu, ragi, tenai,redgram, green gram, black gram, bengal gram, cowpea, groundnut, castor, gingelly, sunflower, safflower, jatropa, soybean and mustard.

Unit II. Distribution, bionomics, symptoms of damage and management strategies of insects and non-insect pests of cotton and sugarcane, green manures (Sunnhemp, Sesbania, Daicha. Glyricidia), forage crops (Lucere and Subabul)

Unit III: Distribution, bionomics, symptoms of damage and management strategies of insect and non insect pests of Brinjal, Bhendi, Tomato, Chillies, Onion, Garlic, Moringa, Amaranthus, Crucifers, Cucurbits, Mango, Citrus, Banana, Guava, Grapevine and Sapota

Unit IV: Distribution, bionomics, symptoms of damage and management strategies of insect and non insect pests of Pomegranate, Papaya, Aonla, Apple, Pine apple, Custard apple and Jack, Potato, Sweet potato, Tapioca, Yam, Colocasia, Coconut, Arecanut, Tea, Coffee, Cashew, Cocoa, Betelvine, Ginger, Turmeric, Coriander, Cardamom, Pepper, Curry leaf and Tamarind

Unit V: Distribution, bionomics, symptoms of damage and management strategies of insect and non insect pests of Rose, Jasmine, Crossandra, Chrysanthemum, Tuberose, Cut flowers, Glory lily, Coleus, Stonebreaker, Aswagantha, Senna, Periwinkle and Lawn. Distribution, bionomics, symptoms of damage and management strategies of pests of and stored products. Rodents and birds of agricultural importance and their management. Locusts and their management.

Practical

Identification of symptoms of damage and life stages of important pests of different field crops *vi.,* cereals, millets, pulses, oilseeds, cotton, sugarcane and green manure crops and horticultural crops *viz.,* vegetables, fruits, spices, tubers, plantation crops, flower crops, medicinal plants, lawn and stored products.

Lecture schedule:

Distribution, bionomics, symptoms of damage and management strategies for insects and non-insect pests of

1. Rice – Sucking pests
2. Rice – Borers and defoliators
3. Maize, sorghum and cumbu
4. Wheat, ragi and tenai
5. Redgram, bengalgram, blackgram, greengram and cowpea
6. Groundnut, gingelly and sunflower
7. Castor, soybean, safflower, jatropha and mustard
8. Cotton – Sucking pests
9. Cotton – Bollworms, borers and defoliators
10. Sugarcane
11. Green manures and forage crops - sunnhemp, sesbania, daincha, lucerne, subabul and gliricidia
12. Brinjal, bhendi and tomato
13. Chillies, onion, garlic, moringa and amaranthus
14. Crucifers
15. Cucurbits

16. Mango
17. **Mid semester examination**

Citrus and banana

Guava, grapevine and sapota
Pomegranate, papaya and aonla Apple,
pine apple, custard apple and jack

Potato, sweet potato, tapioca, yam and
colocasia Coconut and arecanut
Tea and coffee

Cashew, cocoa and betelvine Ginger,
turmeric and coriander, Cardamom,
pepper, curry leaf and tamarind

Rose, jasmine, crossandra, chrysanthemum, tuberose and cut flowers Gloriy
lily, coleus, stone breaker, aswagantha, senna, periwinkle and lawn

Role of physical, biological, mechanical and chemcial factors in deterioration of
grain Stored product pests

Methods of grain storage and various methods of stored product pest management
Mites, slugs and snails, rodents and bird pests
Locusts and their management

Practical schedule: Identification of symptoms of damage and life stages of pests of

1. Pests of rice
2. Pests of maize, sorghum , cumbu, ragi and tenai
3. Pests of pulses
4. Pests of groundnut, gingelly sunflower and castor
5. Pests of cotton
6. Pests of sugarcane
7. Pests of green manures and forage crops -sunnhemp, sesbania, daincha, lucerne, subabul and gliricidia
8. Pests of brinjal, bhendi and tomato
9. Pests of chillies,onion, garlic, moringa and amaranthus
10. Pests of crucifers and cucurbits
11. Pests of mango, citrus, sapota, banana, grapevine and guava
12. Pests of pomegranate, aonla, papaya, jack, pine apple, custard apple, ber and apple
13. Pests of potato, sweet potato and tapioca
14. Pests of coconut , cashew, cocoa , betelvine , coffee and tea
15. Pests of turmeric, ginger, coriander, cardamom, pepper and curry leaf
16. Pests of rose, jasmine, crossandra, chrysanthemum and tuberose
17. Pests of stored products

References:

1. Manisegaran, S. and R.P.Soundararajan. 2010. *Pest Management in Field Crops- Principles and Practices.* Agrobios, Jodhpur, India. 316p. {ISBN (10): 81-7754-321-0}
2. David, B.V. and V.V. Ramamurthy. 2011. *Elements of Economic Entomology*, Namrutha Publications, Chennai. 386 p. {ISBN: 978-81-921477-0-3}
3. Muthukrishnan,N., N.Ganapathy, R.Nalini and R.Rajendran.2005. *Pest Management in Horticultural Crops.* New Madura Publishers, Madurai. 325p. {ISBN: 81-902832-0-0}
4. Awasthi, V.B. 2007. *Agricultural Insect Pests and their Control,* Scientific publishers (India), Jodhpur, 267p. {ISBN 81-7233-491-5}

5. Dhaliwal, G.S. and Ramesh Arora. 2004. *Integrated pest management Concepts and Approaches,* Kalyani Publishers, Ludhiana, 427p. {ISBN: 81-7663-904-4}
6. Regupathy, A. and R.Ayyasamy. 2013. *A Guide on Crop Pests*. Namrutha Publications, Chennai, 368 p. {ISBN: 978-81-921477-1-0}
7. Srivastava, K.P. and G.S. Dhaliwal. 2011. *A text book of Applied Entomology*. Vol. II, Kalyani Publishers, Ludhiana. 368p. {ISBN: 978-81-272-6752-0}
8. Nair,M.R.G.K.1986. *Insects and mites of crops in India.* Publications and Information Division, ICAR, NewDelhi. 408p.
9. ParvathaReddy.2010*. Insect, Mite and Vertebrate Pests and their Management in Horticultural Crops.* Scientific Publishers, Jodhpur. 384p. {ISBN: 978-81-7233-628-8}
10. Butani, D.K. and M.G.Jotwani.2013. *Insects in Vegetables.* Daya Publishing House, NewDelhi. 356p.
11. Regupathy,A. and R.Ayyasamy.2013. *A Guide on Crop Pests.* Namrutha Publications, Chennai.368p. {ISBN: 978-81-921477-1-0}
12. Nair, M.R.G.K. 1995. *Insects and Mites of Crops in India.* Indian council of Agricultural Research, New Delhi, 408p.
13. Ayyar, T.V.R. 1963*. Hand Book of Economics Entomology for South India.* Govt. Press Madras.
1. Sivasubramanian, P., K.Samiayyan, N.Ganapathy, K. Bhuvaneswari and S.Jayaprabhavathi.2012. *A treatise on Integrated Pest Management.* Associated Publishing Company, New Delhi. 287 p.
14. Srivastava, K.P. and D.K.Butani. 2009. *Pest Management in Vegetables* (Vol. I & II). Studium Press (India) Pvt. Ltd., New Delhi . 777p. {ISBN: 978-81-907577-3-7}
15. Sathe,T.V. 2012. *Pests of Ornamental Plants.* Daya Publishing House, New Delhi.199p. {ISBN: 978-81-7035-757-5}

E- References:

1. http://www.ncipm.org.in
2. http://agritech.tnau.ac.in/
3. http://www.nbaii.res.in/
4. http://www.nrcg.res.in/
5. ipm.illinois.edu

AGR 303 Practical crop Production – II (Rabi crop) (0+2)

- Each student will be allotted a minimum land area of 100/200 m^2 and he / she will do all field operations in the allotted land from field preparation to harvest and processing.
- Field preparation, seed, treatment, nursery raising, sowing, nutrient, water and weed management and management of insect-pests diseases of crops, harvesting, threshing, drying winnowing, storage and marketing of produce.
- Any irrigated dry crop (maize / sorghum / pearl millet / finger millet / cotton / groundnut / sunflower / sesame)

Practical Schedule for Irrigated dry crop (Eg. Maize):

- Ecosystem - Climate and weather - Seasons and varieties of Tamil Nadu
- Selection of field - Main field preparation - seed treatment - Application of manures and fertilizers - Sowing - Weed management and practicing pre- emergence application of herbicides - Thinning and gap filling - Estimation of plant population - Top dressing - Weed management - Water management - Pest management - Observation on nutrient and weeds - Recording growth, yield attributes and yield
- Harvesting, threshing and cleaning the produce - Cost of cultivation and economics

1 & 2 .Study of ecosystems, climate, weather, seasons and varieties of Tamil Nadu
3 & 4. Selection of field for maize cultivation
5 & 6. Acquiring skill in seed treatment practices
7 & 8. Study and Practice of main field preparation for maize
9 & 10. Practicing of application of manures and fertilizers for maize
11 & 12. Practicing sowing of maize
13 &14. Acquiring skill in pre-emergence application of herbicides
15 &16. Estimation of plant population and acquiring skill in gap filling and thinning
17 & 18. Observation on nutritional deficiency symptoms and corrective measures
19 & 20. Study of weeds and weed management in maize
20 & 21. Recording growth parameters and assessing dry matter production
22 & 23 Study of water management practices for maize
24 & 25. Observation of insect pests and diseases and their management
26 & 27. Estimation of yield and yield parameters in maize
28 & 29. Harvesting, threshing and cleaning of the produce
30 & 31. Harvesting, threshing and cleaning of the produce
32 & 33. Working out cost of cultivation and economics
34. **Practical**

References:

Ahlawat, I.P.S., Om Prakash and G.S.Saini.2010. Scientific Crop Production in India. Rama Publishing House, Meerut.

Crop Production Guide. 2012. Directorate of Agriculture, Chennai and Tamil Nadu Agricultural University, Coimbatore.

Rajendra Prasad. 2012. Text Book on Field Crop Production, Indian Council of Agrl. Research, New Delhi. Reddy,S.R. 2012. Agronomy of field crops. Kalyani publishers, New Delhi.

Chidda Singh.1997. Modern techniques of raising field crops. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. Crop Production Guide. 2012. Directorate of Agriculture, Chennai and Tamil Nadu Agricultural University, Coimbatore.

E-References:

www.cimmyt.org

AGR 304 Principles of Organic Farming (1+1)

Theory:

Unit - I: Components and Principles of Organic Cotton

Organic farming: Definition - Scope - principles and concepts - history of organic farming - global scenario - biodiversity: importance and measure to preserve biodiversity - pre requisites for Organic farming:- Soil organic carbon: status and improvement strategies.

Unit - II: Organic sources of Nutrients

Organic sources of nutrients - manures and other inputs - on farm and off farm sources - organic waste recycling - methods - Soil and crop management - inter cropping, crop rotation, green manures, cover crops, mulching - bio fertilizers.

Unit - III: Non - Chemical weed and Pest disease management

Non-chemical weed management methods: preventive, physical, cultural, mechanical and biological measures - Bio-intensive pest and disease management.

Unit - IV: Indigenous Technical Knowledge (ITK)

Indigenous Technical Knowledge (ITK) in organic agriculture - scientific rationale - soil, nutrient, weed, water, management - prospects and problems in organic farming.

Unit - V: Certification of label

Organic certification - NPOP guidelines - Certification agencies in India - crop production standards - Quality considerations - labeling and accreditation process - marketing and export opportunities.

Lecture Schedule:

1. Organic farming; definition - prospects - principles and concepts - History and genesis of organic farming in World and India: Present status in World, India and Tamil Nadu.
2. Introduction to bio - diversity; importance and measures to preserve bio - diversity.
3. Pre-requisites and basic steps for organic farming; conversation to organic farming - planning and processes in practices - IFS approach - Integration of animal components.
4. Organic carbon; status and improvement strategies - conservative tillage systems.
5. Sources of organic manures - plant, animal and microbial origin - on - farm resources; FYM, green manures, crop residues, poultry manure, sheep and goat manures, biogas slurry and vermicompost.
6. Off-farm resources; coir pith, press mud, oilcakes, flyash, bio compost, minerals, bone meal, bio fertilizers, traditional preparations.
7. Organic waste recycling methods and techniques - composting, vermicomposting, *in situ* composting - system approach.
8. Soil and crop management in organic farming; Inter cropping and companion planting, crop rotation green manures and cover crops, mulching.
9. **Mid semester examination**
10. Weeds - Ecology - habitat management of weeds - Non - chemical weed management methods; preventive, physical, cultural, use of tools and implements and biological measures - good crop husbandry practices.
11. Integrated pest and diseases management - bio control agents, bio rational pesticides; minerals, botanicals, soaps, trap crops, bird perches, and traditional preparations - sanitation.
12. Indigenous technical knowledge (ITK) in organic agriculture - rationale and principles - general, indigenous practices for soil, nutrient, weed, water pest and disease management in farming - ITK's in farmers practice.
13. Benefits and problems in organic farming.

14. Organic farming; Promotional activities; role of government and NGO's - action plan - policy considerations.
15. Economic evaluation of organic production systems - cost - benefit analysis and comparison with conventional systems.
16. Organic certification - procedures - certification agencies in India - labeling, marketing and export opportunities.
17. Crop production standards - NPOP guidelines - principles, recommendations and standards - Quality considerations - assessment methods - premium and export opportunities.

Practical Schedule:

1. Resource inventory of organic farm- Soil sampling and analysis for organic carbon and pesticide residues / contaminants.
2. Raising of green manures (Sunnhemp / Daincha / Fodder cowpea).
3. Incorporation of green manure - seed treatment and raising of field crop (Rice / Maize / Cowpea / Cotton / Gingelly).
4. Hands on practice on preparatory cultivation; soil and water conservation methods.
5. Hands on experience on recycling techniques; bio-composting and vermicomposting.
6. Quantification of nutrients from organic sources and application of manures and bio- fertilizers.
7. Exposure visit to an organic farm to learn ITK based preparations.
8. Organic crop production and weed management.
9. Skill development in composting farm residues.
10. Organic crop production and pest management.
11. Exposure visit to bio-control agent (*Pseudomonas, Trichoderma* etc.,) production units.
12. Organic crop production and diseases management.
13. Skill development in vermicompost preparation.
14. Hands on training on grading, packaging and post-harvest management.
15. Exposure visit to organic market out lets.
16. Exposure visit to organic certification agencies / Directorate of Organic Certification, Tamil Nadu.
17. **Practical Examination**

References:

Dahama, A.K.2009. Organic farming for sustainable agriculture, Agrobros publishers.

SP. Palaniappan and K Annadurai. 2008. Organic Farming: Theory and Practice. 2008. Scientific Publishers.

Panda, S.C. 2012. Principles and Practices of Organic Farming. Agribios (India), Jodhpur.

Gehlot, D. 2010. Organic Farming- Components and Management. Agribios (India), Jodhpur.

Dushyant Gehlot . 2010. Organic farming: Components and management.Agrobios (India), Jodhpur.

Ranjan Kumar Biswas.2014. Organic farming in India. N.D.Publishers.New Delhi.

E:References:

1. www.ifoam.org
2. www.apeda.org
3. www.cowindia.org
4. www.ncof.org
5. www.earthfooda.co.uk,
6. www.newfarm.org/training

ABT 301 Plant Biotechnology (2+1)

Theory

Unit I Basics of Plant Tissue Culture

Plant tissue culture: Concepts, history and scope - Media and Culture Conditions - Sterilization techniques- Regeneration methods - morphogenesis, organogenesis and embryogenesis - culture types - callus culture and cell suspension culture; shoot tip and meristem tip culture; anther and pollen culture; ovule and embryo culture

Unit II Applied Plant Tissue Culture

Micropropagation - banana and ornamental plants; National certification and Quality management of TC plants- Applications of organ culture - Meristem tip culture (virus free plants) and anther culture (doubled haploids)- Protoplast isolation and fusion- somaclonal variation- synthetic seeds - secondary metabolite production- invitro germplasm conservation

Unit III Basic Molecular Biology

Genome organization- prokaryotes vs eukaryotes- Central dogma of life - Structure of nucleic acids - DNA replication, aminoacids and their classification- genetic codes- transcription, translation and protein synthesis- Structure of a gene, regulation of gene expression, Operon concept- basic techniques in molecular biology-Blotting techniques- Polymerase chain reaction- DNA sequencing methods.

Unit IV Recombinant DNA Technology and Genetic Transformation

DNA manipulation enzymes: Polymerases, restriction endonucleases and ligases - Different types of vectors: plasmids, phagemids, cosmids, BAC - Construction of recombinant DNA molecules- Bacterial transformation **-** Direct and indirect gene transfer methods in plants: microinjection, electroporation, particle bombardment, *Agrobacterium* mediated method - Tissue specific promoters, selectable and scorable markers, reporter genes- Molecular analysis of transgenic plants – Transgenic plants: herbicide, pest and disease resistant, abiotic stress resistant, nutritional enhancement and traits for improved quality- Detection of GMOs **–** regulations and biosafety.

Unit V Molecular Marker Technology and Molecular Breeding

DNA markers - hybridization based markers (RFLP) - PCR based markers: RAPD, SSR, AFLP, and SNPs - DNA fingerprinting of crop varieties – Development of mapping populations- linkage and QTL analysis- principles, methods and applications of Marker Assisted Selection in crop improvement- Applications of Plant Genomics and genome databases

Practicals

Biotech Laboratory organization, safety regulations – basics of reagents and solution preparation- Plant tissue culture media preparation- shoot tip culture (rose) - Meristem culture (tapioca)- Micro propagation of banana - Callus culture – Culturing of E. coli and determination of growth curve-Isolation of bacterial plasmid DNA- Restriction Digestion and Ligation- Competent cell preparation and Bacterial transformation – confirmation of transformation through colony screening - DNA extraction from plants- Quantification of DNA and quality check through Agarose gel electrophoresis - Molecular marker analysis- DNA fingerprinting using RAPD/SSR markers - NTSys- analysis of diversity in crop plants-Visit to tissue culture units /biotech labs in seed industry/Bt cotton field/tissue culture banana fields

Lecture Schedule

1. Plant tissue culture: Concepts, history and scope
2. Media and Culture Conditions and Sterilization techniques
3. Regeneration methods - morphogenesis, organogenesis and embryogenesis
4. Culture types - callus culture and cell suspension culture; shoot tip and meristem tip culture
5. Anther and pollen culture; ovule and embryo culture
6. Micropropagation - banana and ornamental plants
7. National certification and Quality management of TC plants
8. Meristem tip culture (virus free plants) and anther culture (doubled haploids)
9. Protoplast isolation and fusion- somaclonal variation-synthetic seeds
10. Secondary metabolite production, *invitro* germplasm conservation
11. Genome organization- prokaryotes vs eukaryotes
12. Central dogma of life - Structure of nucleic acids
13. DNA replication- Mechanism
14. Transcription and Post transcriptional processing - RNA splicing
15. Translation - Amino acids and their classification, genetic codes and protein synthesis
16. Concept and structure of a gene- classical and modern concept
17. **Mid semester Examination**
18. Regulation of gene expression, Operon concept
19. Blotting techniques and Polymerase chain reaction
20. DNA sequencing methods
21. DNA manipulation enzymes: Polymerases, restriction endonucleases and ligases
22. Different types of vectors: plasmids, phagemids, cosmids, BAC
23. Construction of recombinant DNA molecules- Bacterial transformation
24. Direct and indirect gene transfer methods in plants: microinjection, electroporation, particle bombardment, *Agrobacterium* mediated method
25. Tissue specific promoters, selectable and scorable markers, reporter genes,Molecular analysis of transgenic plants
26. Transgenic plants: herbicide, pest and disease resistant, abiotic stress resistant,
27. Transgenic plants: nutritional enhancement and traits for improved quality
28. Detection of GMOs **–** regulations and biosafety.
29. DNA markers - hybridization based markers (RFLP) - PCR based markers: RAPD, SSR, AFLP, and SNPs
30. DNA fingerprinting of crop varieties
31. Development of mapping populations
32. Linkage and QTL analysis
33. Principles, methods and applications of Marker Assisted Selection in crop improvement
34. Applications of Plant Genomics and genome databases

Practical schedule

1. Biotech Laboratory: Organization and Safety Regulations
2. Basics of Reagents and Solution Preparation
3. Plant Tissue Culture Media Preparation
4. Shoot Tip Culture of Rose
5. Meristem Tip Culture of Tapioca
6. Micropropagation of Banana
4. Callus Culture
5. Isolation of Bacterial Plasmid DNA
6. Restriction Digestion and Ligation
7. Competent Cell Preparation and Bacterial Transformation
8. Confirmation of Transformation through Colony Screening

9. Genomic DNA Extraction from Plants
10. Quantification of DNA and Quality Check through Agarose Gel Electrophoresis
11. DNA Fingerprinting using PCR
12. NTSys- Analysis of Diversity in Crop Plants
13. Visit to Tissue Culture Units /Biotech Lab in Seed Industry/Bt Cotton Field – Lateral Flow Strip Assay
14. **Final Practical Examination**

Reference

Chawla. H S. 2009. **Introduction to Plant Biotechnology (3/e).** CRC Press , London. 730 P ISBN 9781578086368

Boopathi, N. M. 2013. Genetic Mapping and Marker Assisted Selection - Basics, Practice and Benefits. Springer Publications

Brown, T. A. 2010. **Gene Cloning and DNA Analysis: An Introduction,** 6th Edition, Wiley-Blackwell- Companion site (Chapters 1 to 12 and 15)

Chahal, G. S. and Gosal, S. S. 2003. *Principles and Procedures of Plant Approaches Breeding Biotechnological and Conventional*. Narosa Publishing House, New Delhi

Dubey, R. C. 2014. A textbook of Biotechnology. 5th revised Edn. S. Chand Publications. New Delhi

George, E. F, Hall M. A. and Geert-Jan De Klerk. 2009. **Plant Propagation by Tissue Culture,**

3rd Edition, Springer, The Netherlands. 501p.

Gupta, P. K. , 2015. *Elements of Biotechnology* 2nd Edn. Rastogi and Co. , Meerut.

Neal Stewart, Jr. C. 2008. Plant Biotechnology and Genetics: Principles, Techniques and

Applications John Wiley & Sons, Inc ISBN: 978-0-470-04381-3

Nelson, D. S. and M. M. Cox. 2012. **Lehninger's Principles of Biochemistry. Sixth edition. Chapters- 1,3,8,9,25,26,28** (weblinks, tutorials and lecture companion art) W. H. Freeman and

Razdan M K, 2014. *Introduction to plant Tissue Culture* 2nd Edn. Science Publishers, inc. USA.

Singh, B. D. 2012. *Plant Biotechnology*. Kalyani publishers, Ludhiana

Tomar, R. S. , Parakhia, M. V. , Patel, S. V. and Golakia, B. A. , 2010. *Molecular markers and Plant Biotechnology*, New Publishers, New Delhi.

Xu**,** Y 2010. **Molecular Plant Breeding.** International Maize and Wheat Improvement Centre (CIMMYT). 752 Pages

E- Reference

1. http://www. isaaa. org/india/- Briefs
2. http://www. nal. usda. gov.
3. http://www. agbiotechnet. com.
4. http://www. agbioworld. org
5. http://www. cropgen. org.
6. http://www. agbiosafety. unl. edu/.

PBG 302 Crop Improvement (2+1)

THEORY

Unit I: Cereals

Place of origin – putative parents – related wild species – breeding objectives–breeding methods– conventional and innovative methods-heterosis breeding and important varieties in following cereals: Rice, Wheat,Maize,Sorghum, Pearl millet,Finger millet

Unit II: Pulses and Oilseeds

Place of origin – putative parents – related wild species – breeding objectives–breeding methods– conventional and innovative methods-heterosis breeding and important varieties in following crops Pulses: Redgram , Bengal gram, Greengram, Blackgram, Cowpea, Soybean. Oilseeds: Groundnut, Sunflower,Gingelly, Castor, Rape and Mustard.

Unit III:Cash crops, FodderandHorticultural crops

Place of origin – putative parents – related wild species – breeding objectives–breeding methods– conventional and innovative methods-heterosis breeding and important varieties in following crops

Fibres: Cotton; Sugars: Sugarcane; Starch: Potato; Fumitories: Tobacco, Fodder: Guinea grass, Napier, Cumbu – Napier, Lucerne,*Stylosanthes*; Horticultural crops: Bhendi, Tomato, Brinjal, Papaya, Banana

Unit IV: Breeding for Biotic and Abiotic stresses and Quality

Breeding for insect resistance – mechanisms, basis, genetics of insect resistance - suitable breeding methods- merits and demerits of resistance breeding; Breeding for disease resistance – horizontal and vertical resistance- Gene for gene hypothesis – mechanisms, genetics of disease resistance; Suitable breeding methods for disease resistance- exploitation of vertical resistance in plant breeding- multilines, gene pyramiding, gene deployment.

Breeding for Abiotic stress – drought – mechanisms, basis, genetics of drought resistance - suitable breeding methods -limitations of drought resistance breeding; Breeding for Abiotic stress – salinity and alkalinity;

Breeding for quality traits- Important quality traits in different crops- nutritional quality of cereals and pulses-Genetics of nutritional traits-breeding methods- Breeding for low toxic substances- limitations of breeding for enhanced nutritional quality

Unit V: Hybrid seed production techniques and ideotype breeding

Hybrid seed production techniques in rice, maize and redgram

Ideotype breeding- main features-difference between traditional and ideotype breeding- - crop ideotypes in rice, wheat, cotton- steps in ideotype breeding- merits and demerits of ideotype breeding

PRACTICAL

Observation on floral biology – anthesis and pollination – selfing – crossing techniques – observation on cultivated germplasm, wild species – Experimental design – handling segregating generations- Yield trials in following crops- Rice, Maize and Sorghum,Pearl milletand Finger millet, Redgram, Bengal gram, Green gram, Black gram, Cowpea and Soybean, Groundnut and Sunflower, Sesame and Castor, Cotton, Sugarcane, Guinea grass, Cumbu – Napier hybrids, Lucerneand*Stylosanthes*,Bhendi, Brinjal, Tomato, Papaya and Banana, Study of quality characters in rice, Study of donor parents for different characters,

General seed production techniques in field crops, Visit to AICRP and seed production plots of different field crops

Lecture schedule

Place of origin – putative parents – related wild species – breeding objectives–breeding methods– conventional and innovative methods-heterosis breeding and important varieties in following crops:

1. Cereals: Rice.
2. Cereals: Rice.
3. Cereals: Rice.
4. Cereals: Wheat
5. Cereals : Maize
6. Cereals: Sorghum
7. Cereals: Pearl millet, Finger millet,
8. Pulses: Redgram
9. Pulses: Greengram, Blackgram,
10. Pulses: Soybean, Bengal gram
11. Pulses: Cowpea
12. Oilseeds: Groundnut
13. Oilseeds: Gingelly, Rapeseed and Mustard
14. Oilseeds: Castor and Sunflower
15. Fibres: Cotton
16. Sugars: Sugarcane
17. **Mid Semester Examination.**
18. Starch: Potato
19. Fumitories: Tobacco
20. Forage grassesand legumes: Guinea grass, Napier, Cumbunapierhybrid,Lucerne,*Stylosanthes*
21. Breeding for sexually propagated horticultural crops-Bhendi, Tomato
22. Breeding for sexually propagated horticultural crops- Brinjal, Papaya
23. Breeding for clonally propagated horticultural crops- Banana
24. Breeding for insect resistance – mechanisms, basis, genetics of insect resistance- suitable breeding methods- merits and demerits of resistance breeding
25. Breeding for disease resistance –horizontal and vertical resistance- Gene for gene hypothesis – mechanisms, genetics of disease resistance
26. Suitable breeding methods for disease resistance- exploitation of vertical resistance in plant breeding- multilines, gene pyramiding, gene deployment.
27. Breeding for Abiotic stress – drought – mechanisms, basis, genetics of drought resistance - suitable breeding methods-limitations of drought resistance breeding
28. Breeding for Abiotic stress – salinity and alkalinity
29. Breeding for quality traits- Important quality traits in different crops- nutritional quality of cereals and pulses-
30. Genetics of nutritional traits-breeding methods- Breeding for low toxic substances-limitations of breeding for enhanced nutritional quality
31. Hybrid seed production techniques in rice
32. Hybrid seed production techniques in maize
33. Hybrid seed production techniques in redgram

34. Ideotype breeding- main features-difference between traditional and ideotype breeding- - crop ideotypes in rice, wheat, cotton- steps in ideotype breeding- merits and demerits of ideotype breeding

Practical schedule

Observation on floral biology – anthesis and pollination – selfing – crossing techniques – observation on cultivated germplasm, wild species – Experimental design – handling segregating generations- Yield trials in following crops.

1. Rice
2. Maizeand Sorghum
3. Pearl milletandFinger millet
4. Redgram, Bengal gramand Soybean
5. Green gram,Black gram and Cowpea
6. Groundnut and Sunflower.
7. Sesame and Castor
8. Cotton
9. Sugarcane
10. Guinea grass, Cumbu – Napier hybridsLucerne and *Stylosanthes*
11. Bhendi, Brinjal, Tomato
12. Papayaand Banana
13. Study of quality characters in rice
14. Study of donor parents for different characters
15. General seed production techniques in field crops
16. Visit to AICRP and seed production plots of different field crops
17. **Final Practical Examination**

References

- Singh, B.D. 2007. Plant breeding - Principles and methods.
- Phundan Singh. 2015. Essentials of Plant Breeding. Kalyani Publishers, New Delhi
- Harihar Ram and HariGovind Singh, 1994. Crop breeding and Genetics. Kalyani Publishers, New Delhi.
- D.N.Bharadwaj.2012. Breeding Field Crops. Agrobios (India),Jodhpur - 342002
- HariHar Ram,2011. Vegetable Breeding– Principles and Practice, Kalyani Publishers, New Delhi.
- N.Kumar.2006. Breeding of horticultural crops- Principles and Practices. New India Publishing Agency. New Delhi
- D.A.Sleper and J.M.Poehlman. 2007. Breeding Field Crops. Blackwell Publishing Professional (USA)
- H.H.Ram. 2011. Crop Breeding and Biotechnology. Kalyani Publishers (India)
- Chopra, V.L. 1990. Plant Breeding. Theory and Practice. Oxford and IBH Publishing Co., New Delhi.
- Daniel Sundararaj, D., G.Thulasidas, and M. Stephan Dorairaj. 1997. Introduction to Cytogenetics and Crop improvement. Popular Book Depot, Chennai - 15.
- Sharma, J.R. 1994. Principles and practice of Plant Breeding. Tata McGraw - Hill Publishing Co. Ltd., New Delhi.

❖ Singh, R.B., R.M. Singh and B.D. Singh, 1984. Advances in Cytogenetics and crop improvement. Kalyani Publishers, New Delhi.

E- References

1. www.cimmyt.org
2. www.nbpgr.nic.in
3. www.irri.org
4. www.icrisat.org

	Optional courses for 2 credits		
S. N.	**Code No.**	**Courses**	**Credit Hours**
1.	CRP 351	Physiological Techniques in crop production	2 (1+1)
2.	SAC351	Designer fertilizer Production	2 (1+1)
3.	SAC352	Rejuvenation of Deteriorated lands	2 (1+1)
4.	SAC353	Soilless crop production	2 (1+1)
5.	SAC354	Instrumental methods of analysis	2 (1+1)
6.	SST 351	Seed entrepreneurship skill development and management	2 (1+1)
7.	AGR 351	Weed and water management	2 (1+1)
8.	PGP 351	Plant Genetic Resources Collection, Conservation and Utilization	2 (1+1)
9.	NEM 351	Commercial Production of Nematode Antagonistic bio-agents	2 (1+1)
10.	AGM351	Downstream Processing for Industrially Important Microbial Products	2 (1+1)
11.	AGM 352	Microbial Enzymes	2 (1+1)
12.	AGM 353	Microbial Quality and Safety of Foods	2 (1+1)
13.	AGM 354	Plant –Microbe Interaction	2 (1+1)
14.	AGM 355	Quality Control of Bio-inoculants	2 (1+1)
15.	SAC 355	Crop and Pesticide Chemistry	2 (1+1)

CRP 351 Physiological Techniques in crop production (1+1)

Unit I Stress physiology: Abiotic Stress: Water deficit – impact of drought on crop productivity - characteristic features of drought tolerant plants, Drought resistance and tolerance mechanisms, Osmotic adjustment and osmoregulation, stress proteins, Water use efficiency – carbon isotope discrimination-Physiological traits associated with drought and Mitigation techniques. Flooding: Physiological mechanism of adaptation, Mitigation techniques, Temperature stress: High and Low Temperature, Tolerance mechanisms - Functions of HSPs and CSPs, Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems – Enzymatic and Non-Enzymatic, Physiological traits associated with high and low temperature, Mitigation techniques. Salt stress: Physiological basis of tolerance mechanisms, Physiological traits associated with salt stress, Mitigation techniques. UV stress and climate change: Physiological adaptation of crops to UV radiation and tolerance mechanisms.

Unit II Nutriophysiology: Diagnosis and correction measures for nutritional disorders including Macro, Micro and secondary nutrients in Cereals, Pulses, Oilseeds, Fibre and Sugar crops; Fruits, Vegetables, Flowers, Spices, Plantation and Aromatic crops. Impact of heavy metals on physiology and productivity of crops, Phytoremediation, Importance of beneficial elements – Na, Si, Se, Co.

Unit III Hormonal physiology: Role of hormones in plant growth and yield enhancement, stress management and quality improvement - Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene and Brassinosteroids. Role of other phytohormones in crop production-triacontanol, polyamines, jasmonates and salicylic acid, New generation PGRs - 1- MCP, Triazoles, strigalactone, pro-hexadione Ca.

Unit IV Production Physiology: Physiological limitations of crop productivity, Physiological and genetic basis of crop environment interaction, Plant architecture – Ideotype concept, Crop photosynthetic efficiency – C_3 , C_4 and CAM Strategies to improve the crop photosynthesis, Source- sink balance and Harvest Index.

Unit V Postharvest physiology: Environmental factors influencing senescence, ripening and postharvest life of fruits, flowers, vegetables and seeds. Physiological and biochemical aspects of senescence and fruit ripening. Regulatory role of ethylene in senescence and ripening, Pre and post harvest measures to influence shelf life.

Theory Lecture schedule

7. Classification of abiotic stresses - Drought – types-Drought resistance and tolerance mechanisms-adaptations-Physiological traits associated with drought -osmotic adjustment.
8. Reactive Oxygen Species- scavenging enzymes- stress proteins-water use efficiency – carbon isotope discrimination- concept -mitigation techniques.
9. Flooding - Physiological mechanism of adaptation- physiological traits associated with flooding- Role of ethylene.

15. Temperature stress-High and Low Temperature -Tolerance mechanisms-Functions of HSPs and CSPs - Physiological traits associated with high and low temperature.
16. Salt stress - Physiological basis of tolerance mechanisms –adaptations- Physiological traits associated with salt stress.
17. Physiological adaptation of crops to high and low light and UV radiation.
18. Impact of heavy metals on physiology and productivity of crops –Phytoremediation.
19. **Mid Semester examination**
20. Diagnosis and correction measures for nutritional disorders in Cereals, Millets, Pulses, Oilseeds.

21. Diagnosis and correction measures for nutritional disorders in Fibre, Sugar crops, Fruits and Vegetable, Flowers, Spices, Plantation, Medicinal and Aromatic crops.
22. Importance of beneficial elements – Na, Si, Se, Co- Effect of crop specific application of beneficial elements.
23. Role of hormones in plant growth and yield enhancement, stress management and quality improvement – Auxins, Gibberellins and Cytokinins.
24. Role of hormones in plant growth and yield enhancement, stress management and quality improvement –Abscisic acid, Ethylene and Brassinosteroids.
25. Role of other phytohormones -triacontanol, polyamines, jasmonates and salicylic acid. New generation PGRs - 1- MCP, Triazoles, strigalactone, pro-hexadione Ca.
26. Physiological limitations of crop productivity, Physiological and genetic basis of crop environment interaction, Plant architecture – Ideotype concept.
27. Crop photosynthetic efficiency – C_3, C_4 and CAM Strategies to improve the crop photosynthesis, Source- sink balance and harvest index.
28. Environmental factors influencing senescence and ripening-Physiological and biochemical aspects of senescence and fruit ripening-Factors affecting post harvest life of fruits- measures for enhancing the shelf life of fruits, vegetables and flowers.

Practical schedule

1. Determination of osmotic potential
2. Gas Exchange measurements using Infra Red Gas Analyzer
3. Stress induction response techniques
4. Water Use Efficiency or Transpiration Efficiency of crops
5. Estimation of anti oxidant enzymes activity – Catalase and peroxidase
6. Estimation of Membrane thermal stability
7. Bioassay for Cytokinins
8. Effect of PGRs on flowering
9. Effect of PGRs on fruit ripening
10. Influence of ABA on stomatal regulation
11. Diagnosis of nutritional disorders and their amelioration measures
12. Nutrient application techniques
13. Estimation of Macro nutrients in plant samples
14. Estimation of micro and secondary nutrients using AAS
15. Field Visit I- Diagnosis of nutrient disorders
16. Field Visit II-Postharvest storage facilities
17. **Final practical Examination**

References

1. Barker AB &Pilbeam DJ. 2007. Handbook of Plant Nutrition. 2nd Edition, CRC Press, Taylor & Francis Group. Pp 1-773.
2. Bewley, J. D. and Black, M. 1985. Seed Physiology of Development and Germination. Plenum Publishing Corp. New York, NY. pp 70-73.
3. Bleasdale, J. K. A. 1984. Plant Physiology in Relation to Horticulture. 2nd Ed. MacMillan & Avi Publishing Company, USA.
4. Leopold, A. C. and Kriedemann, P. E. 1985. Plant Growth and Development. 3rd Ed. McGraw-Hill, New York, pp 545.
5. Madhava Rao KV, Raghavendra, AS and Janardhan Reddy K. 2006. Physiology and Molecular Biology of Stress Tolerance in Plants. Springer publishers, Netherland.
6. Taiz. L. and Zeiger. E. , 2015 (Sixth edition). Plant Physiology and Development. Publishers: Sinauer Associates, Inc. , Massachusetts, USA.

7. Wilkins MB. 1969. Physiology of Plant Growth and Development. Tata McGraw-Hill, New York, pp 127-162.

E-REFERENCES

1. http://www. plantphys. net
2. http://www. plantstress. com
3. http://www. ipni. net
4. http://www. edis. ifas. ufl. edu
5. http://www. greenair. com/plantlnk. htm
6. http://www. tvdsb. on. ca

AGR 351 WEED AND WATER MANAGEMENT (1+1)

Unit - I : Weeds: Introduction, Definitions; harmful and beneficial effects, classification,; crop weed competition and allelopathy. Methods of weed control: physical, cultural, chemical and biological methods. Integrated weed management.

Unit – II: Herbicides - Classification, characteristics, formulations, methods of application; advantages- Weed management in major field crops - aquatic and problematic weeds and their control.

Unit – III: Role of water in plant growth - Importance of irrigation- Soil - water - plant relationship - Soil Plant Atmospheric Continuum (SPAC) - Hydrological cycle - Soil water movement - soil moisture constants - Moisture extraction pattern - Absorption of water.

Unit IV: Crop water requirement- Factors affecting water requirement- Factors affecting water requirement. Scheduling of irrigation – Water use efficiency

Unit V: Methods of irrigation: surface, sub-surface sprinkler and drip irrigation – Micro irrigation: layout, suitability, merits and scope.

Practical

Identification of weeds in wetlands, gardenland and drylands – Practicing different methods of weed control -Calculations on weed control efficiency and weed index; Classification and characteristics of herbicides - Computation of herbicide doses- Study of herbicide application equipment and calibration; Demonstration of methods of herbicide application;

Estimation of soil moisture - Measurement of irrigation water through water measuring devices (flumes, weirs and water meter) - Calculation of irrigation water requirement (problems)- Acquiring skill in land shaping for different surface irrigation methods - Operation and economics of drip and sprinkler irrigation systems - Estimation of crop water requirement - Irrigation efficiency (problems) –

Lecture Schedule :

1. Weeds - Definition, classification
2. Characteristics of weeds, harmful and beneficial effect of weeds.
3. Crop weed interactions - Critical crop weed competition, competitive and allelopathic effects of weeds and crops.
4. Methods of weed control: physical, cultural
5. Methods of weed control: chemical and biological methods. Integrated weed management.
6. Herbicides - Classification, characteristics, formulations,
7. Methods of herbicide application
8. Weed management in major field crops - aquatic and problematic weeds and their control.
9. **Mid semester examination**
10. Role of water in plants - Importance of irrigation
11. Soil - Plant -water relationship - Soil-plant-atmospheric continuum - Hydrologic cycle - absorption of water and evapotranspiration.
12. Soil water movement - saturated and unsaturated flow and vapour movement - soil moisture constants and their importance in irrigation.
13. Available soil moisture - definition and importance - moisture extraction pattern
14. Crop water requirement - factors affecting crop water requirement -Critical stages for irrigation - water requirement for different field crops.
15. Scheduling of irrigation - Different approaches- Water use efficiency
16. Methods of irrigation - surface (flooding, beds and channels, border strip, ridges and furrows, broad bed and furrows, surge irrigation) and sub-surface methods.

17. Micro irrigation system (drip and sprinkler irrigation) - suitability, components, layout, operation, advantage and disadvantage.

Practical schedule:

1. Identification, classification and characterization of wetland weeds.
2. Identification, classification and characterization of gardenland and dryland weeds.
3. Practicing skill development on cultural and non chemical weed management.
4. Identification, classification and characterization of herbicides.
5. Practicing skill development on herbicide application techniques.
6. Practicing Skill development on spray equipment's and spray fluid calibration.
7. Calculation of herbicide quantity and recommendation for different eco systems
8. Working out weed index, weed control efficiency and economics in weed management studies.
9. Estimation of soil moisture by gravimetric method and tensiometer.
10. Estimation of soil moisture by resistance blocks and neutron probe and other improved devices.
11. Measurement of irrigation water with flumes and weirs.
12. Calculation of irrigation water based on source, water flow, soil moisture status and depth of irrigation.
13. Land leveling and land shaping - Beds and channels - ridges and furrows.
14. Layout, operation and maintenance of drip and sprinkler irrigation systems.
15. Estimation of crop water requirement by direct and indirect methods.
16. Calculations on irrigation efficiency parameters.
17. **Practical examination**

References:

Gupta, O. P. 1998. Modern Weed Management. Agro Botanica Bikaner, India.

Subramanian, S. A. Mohammed Ali and R. Jayakumar. 1991. All about Weed Control. Kalyani Publishers, New Delhi.

Jaganathan R. , and R. Jayakumar. 2003. Weed Science Principles, Kalyani Publishers, New Delhi.

Das, P. C. 2015. Weed Science. New India Publishing Agency, Jaipur Michael, A. M. 1997. Irrigation: Theory and Practice Vikas Publishers.

Sankara Reddy, G. H. and T. Yellamanda Reddy. 1997. Efficient use of irrigation water. Kalyani Publishers

Reddy, S. R. 2012. Irrigation Agronomy. Kalyani publishers, NewDelhi

Nirmal Tripathy. 2014. Irrigation,Watershed and Drainage. Agrotech Press, Jaipur

Gupta,A. K. 2014. Irrigation and Drainage. Oxford Book Company, Jaipur

Israelsen, O. W. 2012. Irrigatiom Principles and Practices. Axis Books (India), Jodhpur.

Michael, A. M. 2009. Irrigation- Theory and Practice, Vikas Publishing House, Noida

E-References:

1. www.tnau. ac. in
2. www. fao. org
3. www. tnau. ac. in/agriportal www. irri. org
4. www. wcc. nrcs. usda. gov/nrcsirrig www. wcc. nrcs. sda. gov/irrig. info. html www. croinfo. net/irrigschedule. html

AGM 351 Downstream Processing for Industrially Important Microbial Products (1+1)

Unit I - Introduction to Bio separation Processes

Role and importance of bioseparations in biotechnological processes. Problems and requirements of bioproduct purification. Cost- cutting strategies. Characteristics of biological mixtures. Classification of bioproducts - Biological activity, Analysis of purity-Process economics- Capital and operating cost analysis

Unit II - Physical Methods of Separation

Centrifugation and filtration. Cell disruption methods; enrichment operations: precipitation methods- with salts, organic solvents, and polymers; extractive separations - aqueous two-phase extraction, supercritical extraction; adsorption methods; membrane based separation theory - types of membranes, types of membrane processes - dialysis; ultrafiltration; microfiltration and reverse osmosis.

Unit III Physical and chemical methods - Isolation of products

Physico-chemical basis of bio-separation processes. Removal of particulate matter, biomass and insolubles: flocculation; sedimentation; adsorption: isotherm, batch, continuous and scale-up of adsorption; extraction: solvent separation, equipment and modes of extraction. Aqueous-two-phase extraction process, supercritical fluid extraction. Precipitation of proteins-methods and scale-up.

Unit IV Isolation of Products - Chromatographic methods of purification

Chromatography - principles, instruments and performance parameters. Paper, TLC, adsorption, gel filtration, reversephase, ion-exchange, hydrophobic interaction, bioaffinity, pseudo affinity chromatographic techniques; GC, HPLC, HPTLC, FPLC, parafusion chromatography and membrane based chromatographic techniques and sample preparation. Electrophoretic separations.

Unit – V Finishing Operations

Products polishing: Crystallization and drying; Purification of antibiotics, amino acids, enzymes and organic acids, proteins, pigments, plant growth hormones, monoclonal antibodies, human growth hormones – Insulin etc.

Practical

Kinetics of a bacterium / yeast in batch culture- doubling time, specific growth rate and growth curve. Batch cultivation of microbes for product formulation; calibration of pH probe, medium preparation, sterilization, and calibration of dO_2 probe. Inoculation of a bacterial / yeast strain in fermentor for batch production of an enzyme / biomass/ ; estimation of kinetic parameters of product formation, biomass production and substrate utilization. Laboratory centrifugation for separation of biomass from fermentation broth. Filtration and microfiltration for solid-liquid separation. Extraction of crude enzyme from microbial biomass and enzyme assay. Production of microbial secondary metabolites and product recovery. Mechanical cell disruption by homogenization: determination of product release kinetics. Sonication of microbial cell suspensions and determination of product release kinetics. Salting out of proteins by precipitation with ammonium sulphate. Precipitation of proteins with acids or bases: determination of isoelectric point. Batch adsorption of an acid on activated charcoal. Solvent extraction and aqueous two-phase extraction of proteins. Gel-filtration chromatography of a protein - salt mixture. Ion-exchange chromatography of a positively charged protein. Gas chromatography for quantitative estimation of volatiles- ethanol. SDS-PAGE of proteins and determination of molecular weight.

Lecture Schedule

1. Role and importance of bio separations in biotechnological processes. Problems and requirements of bioproduct purification
2. Cost- cutting strategies. Characteristics of biological mixtures. Classification of bio products
3. Biological activity, Analysis of purity. Process economics. Capital and operating cost analysis
4. Centrifugation and filtration-Cell disruption methods
5. Enrichment Operations: precipitation methods(with salts; organic solvents and polymers)
6. Extractive separations; aqueous two-phase extraction; supercritical extraction and adsorption methods
7. Membrane based separation theory - types of membranes; types of membrane processes – dialysis, ultrafiltration, microfiltration and reverse osmosis
8. Physico-chemical basis of bio-separation processes. Removal of particulate matter, biomass and insolubles: flocculation; sedimentation
9. **Mid semester evaluation**
10. Adsorption – Isotherm,batch, continuous and scale-up of adsorption
11. Extraction: solvent separation, equipment and modes of extraction. Aqueous two-phase extraction process, supercritical fluid extraction.
12. Precipitation of proteins: methods and scale-up. Chromatography - principles, instruments and practice
13. Paper; TLC, adsorption, gel filtration; reverse phase, ion-exchange, hydrophobic interaction, bioaffinity ; pseudo affinity chromatographic techniques
14. GC, HPLC, FPLC HPTLC, parafusion chromatography and membrane based chromatographic techniques and sample preparation. and electrophoretic separation
15. Products polishing. Crystallization and drying. Purification of antibiotics
16. Purification of amino acids,organic acids, enzymes and proteins
17. Monoclonal antibodies; human growth hormones – Insulin etc

Practical Schedule

1. Kinetics of a bacterium / yeast in batch culture: calculation of doubling time, specific growth rate, and plotting of growth curve.
2. Preparation of fermentor and accessories for batch cultivation of microbes: calibration of pH probe, medium preparation, sterilization, and calibration of dO_2 probe.
3. Inoculation of a bacterial / yeast strain in fermentor for batch production of an enzyme / biomass: estimation of kinetic parameters of product formation, biomass production and substrate utilization.
4. Laboratory centrifugation for separation of biomass from fermentation broths. Filtration and microfiltration for solid-liquid separation.
5. Extraction of crude enzyme and assay of enzyme
6. Production of secondary metabolites from microbes and recovery
7. Mechanical cell disruption by homogenization: determination of product release kinetics.
8. Sonication of microbial cell suspensions and determination of product release kinetics.
9. Salting out of proteins by precipitation with ammonium sulphate.
10. Precipitation of proteins with acids or bases: determination of isoelectric point.
11. Batch adsorption of an acid on activated charcoal.
12. Solvent extraction and aqueous two-phase extraction of proteins.
13. Gel-filtration chromatography of a protein-salt mixture.
14. Ion-exchange chromatography of a positively charged protein.
15. Gas chromatography for quantitative estimation of volatiles: ethanol.
16. SDS-PAGE of proteins and determination of molecular weight
17. **Final Practical Examination**

Reference

1. Sivasankar B. , 2010. Bioseparations: Principles and Techniques, PHI, New Delhi .
2. Stanbury, P. F. , Whitaker, A. and Hall, S. J. 2016. Principles of Fermentation Technology, BH Elsevier Publications, Third Edition.
3. Harrison, R. G. Todd, P. , Rudge, S. R. andPetrides, D. P. , 2003. Bioseparation Science and Engineering, Oxford University Press.
4. Costa,C. A. and CabralJ. S. 1991. Chromatographic and Membrane Processes in Biotechnology, Publisher: Kluwer Academic Publishers, The Nether lands.
5. Harrison et al. 2006. Bioseparation Science and Engineering. Oxford Univ. Press.
6. Nooralabettu Krishna Prasad, 2010. Downstream Process Technology: A New Horizon in Biotechnology, PHI, New Delhi.
7. Jenkins, R. O. 1992. Product Recovery in Bioprocess Technology, Biotechnology by Open Learning Series, Butterworth- Heinemann, London, Second Edition.

AGM 352 MICROBIAL ENZYMES (1+1)

Unit I: Introduction: Introduction and Scope, General distinctive features and industrial applications. Enzymes: Historical perspectives, Nomenclature and classification of enzymes. Isozymes, biological roles, activation energy, chemical nature of enzymes, characteristics of enzymes, 3'D' structure of enzymes, active site, factors affecting enzyme activity, modifiers of enzyme activity, enzyme activators, enzyme inhibitors and allosteric enzymes.

Unit II: Enzyme kinetics: Kinetics of single substrate reactions, Estimation of *Michaelis - Menten* parameters, multi substrate reactions, mechanisms and kinetics, turnover number, types of inhibition, kinetic models: substrate and product inhibition, allosteric regulation of enzymes, *Monod ChangeuxWyman* model, pH and temperature effect on enzymes and deactivation kinetics. Vitamins and their co-enzymes: structure and functions with suitable examples. Metallo enzymes and metal ions as co-factors and enzyme activators.

Unit III: Extraction and purification of microbial enzymes: Importance of enzyme purification, different sources of enzymes. Extracellular and intracellular enzymes. Physical and chemical methods used for cell disintegration. Enzyme fractionation by precipitation - using temperature, salt, solvent, pH, *etc*. , Liquid-liquid extraction -ultra filtration, ionic exchange, gel chromatography, affinity chromatography and other special purification methods. Enzyme crystallization techniques. Criteria of purity of enzymes.

Unit IV: Industrial applications of enzyme and enzyme engineering: Industrial applications: Microbial enzymes in textile, leather, wood industries and detergents. Enzymes in clinical diagnostics. Enzyme sensors for clinical processes and environmental analyses. Enzymes as therapeutic agents. Enzyme engineering: Chemical modification and site-directed mutagenesis to study the structure-function relationship of industrially important enzymes. Cloning- strain improvement.

Unit V: Enzyme formulation: Physical and Chemical techniques for enzyme immobilization – adsorption - matrix entrapment encapsulation - cross-linking - covalent binding - examples; advantages and disadvantages of different immobilization techniques. Freeze drying and spray drying of immobilized enzymes.

Practical

Amylase production using *Bacillus amyloliquefaciens*and its assay. Protease production by using *Bacillus* isolate and its quantification. Production of cellulase by solid state fermentation (SSF) of rice straw through lignocellulolytic fungi: (a) Estimation of filter paper lyase activity (b) Estimation of carboxy methyl cellulase activity. Production and estimation of xylanase from rice straw through submerged fermentation. Immobilization of microbial cells for enzyme production. Protease production from *Bacillus subtilis* using soybean meal. Purification of fungal α - amylase or bacterial protease by fractionation, chromatographic techniques and electrophoretic separation. Studies on enzyme kinetics of alpha amylase / protease- optimization of parameters *viz*. , substrate, enzyme concentration, reaction temperature, reaction pH, K_m, V_{max} and metal ions as activators and inhibitors. Enzyme extraction-concentration- ultrafiltration- chromatography- microencapsulation.

Lecture schedule

1. Introduction and scope, general distinctive features and industrial applications.
2. Enzymes: historical perspectives, nomenclature and classification .
3. Isozymes, biological roles, activation energy, chemical nature of enzymes.
4. Characteristics of enzymes, 3'D' structure of enzymes, active site, factors affecting enzyme activity.
5. Modifiers of enzyme activity, enzyme activators, enzyme inhibitors; allosteric enzymes.

6. Kinetics of single substrate reactions, estimation of *Michaelis - Menten* parameters, multi substrate reactions, mechanisms and kinetics; turnover number.
7. Types of inhibition; Kinetic models: substrate and product inhibition; Allosteric regulation of enzymes.
8. *Monod Changeux Wyman* model, pH and temperature effect on enzymes and deactivation kinetics.
9. **Mid Semester Examination**
10. Vitamins and their co-enzymes: structure and functions with suitable examples. Metallo enzymes and metal ions as co-factors and enzyme activators.
11. Importance of enzyme purification, different sources of enzymes. Extracellular and intracellular enzymes.
12. Physical and chemical methods used for cell disintegration. Enzyme fractionation by precipitation - using temperature, salt, solvent, pH, *etc*. , liquid-liquid extraction.
13. Ionic exchange, gel chromatography, affinity chromatography and other special purification methods. Enzyme crystallization techniques. Criteria of purity of enzymes.
14. Industrial applications: Microbial enzymes in textile, leather, wood industries and detergents. Enzymes in clinical diagnostics. Enzyme sensors for clinical processes and environmental analyses. Enzymes as therapeutic agents.
15. Enzyme engineering: Chemical modification and site-directed mutagenesis to study the structure-function relationship of industrially important enzymes. Cloning- strain improvement.
16. Physical and Chemical techniques for enzyme immobilization – adsorption - matrix entrapment encapsulation - cross-linking - covalent binding - examples;
17. Advantages and disadvantages of different Immobilization techniques - overview of applications of immobilized enzyme systems

1. &2. Amylase production using*Bacillus amyloliquefaciens*in submerged and solid state fermentationand its assay.
3. & 4. Protease production using*Bacillus* isolate and its quantification.
5. Production of cellulase by solid state fermentation (SSF) of rice straw through lignocellulolytic fungi - Estimation of filter paper lyase activity.
6. Production of cellulase by SSF of rice straw through lignocellulolytic fungi- Estimation of carboxy methyl cellulase activity.
7. Production and estimation of xylanase from rice straw through submerged fermentation.
8. Immobilization of microbial cells for enzyme production.
9. Protease production from *Bacillus subtilis*using soybean meal.
10. -12. Purification of fungal alpha-amylase or bacterial protease by fractionation, chromatographic techniques and electrophoretic separation.

13-14. Studies on enzyme kinetics of alpha amylase / protease - optimization of parameters *viz*. , substrate, enzyme concentration, reaction temperature, reaction pH, K_m, V_{max} and metal ions as activators and inhibitors.

15-16. Enzyme extraction- concentration-ultrafiltration-chromatography- microencapsulation

17. **Final Practical**

Reference

1. Alexander N. Glazer, Hiroshi Nikaido. 2007. Microbial Biotechnology, Second Edition, ISBN 9780521842105, Cambridge University Press.
2. Trevor Palmer and Philip L. Bonner, 2004. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, East- West Press.

1. Shuler, M. L. and F. Kargi, 2002. Bioprocess Engineering : Basic Concepts, Second Edition, Pearson.
2. Blanch, H. W and D. S. Clark, 1997. Biochemical Engineering, Marcel & Dekker, Inc. ,.
3. Bailey, J. E and D. F. Ollis, 1986. Biochemical Engineering Fundamentals, Second Edition, McGraw-Hill.
4. Nicholas C. Price and Lewis Stevens, 1982. Fundamentals of Enzymology, Oxford University Press.
5. Alan Wiseman, 1999. Handbook of Enzyme Biotechnology, Third Edition, Ellis Harwood Publications.

E-Reference: James Lee, M. , Biochemical Engineering, PHI, USA, e-Book Version 2. 1, 2002.

AGM 353 MICROBIAL QUALITY AND SAFETY OF FOODS (1+1)

Unit I Introduction: Food safety risks and assessment– characteristic features of spoilage - significance of spoilage of different groups of foods - cereal and cereal products, vegetables and fruits, meat, poultry, sea foods, milk and milk products, packed and canned foods.

Unit II Food borne infections and intoxications: Food borne pathogens- food infections and intoxications of food borne diseases – bacteria, fungal, protozoa and viral. Investigation and management of food borne diseases.

Unit III Techniques for detection of pathogens and toxins : Advanced laboratory techniques for food-borne pathogens: principle, working and application of GC-MS, HPLC, LC/MS, inductively coupled Plasma Mass Spectroscopy, TOF and PCR-real time PCR. DGGE. Metagenomics, proteomics and immunological methods

Unit IV Food standards: Food standards – HACCP concepts, principles – EU, FDA and WHO standards - CODEX – Food Law & regulations - HACCP principles & applications – GM foods – SSOP – GMP & GAP – Food traceability- Food Audit - functions, duties and responsibilities of food safety regulators.

Practical

Food sampling procedures – Preparation & plan - Examination of microorganisms of by aerobic plate count -Assessing *Bacillus cereus,* coliforms*, Campylobacter, Salmonella* and *Staphylococcus* in various food samples. Microbiological examination of canned foods. Rapid detection of pathogens and toxins in foods– HACCP of fruits and vegetables - visit to food processing industry.

Lecture Schedule

1. Food Safety Risks - biological, chemical, physical risks; risk assessment.
2. Physical and chemical changes during food spoilage.
3. Significance of microbial spoilage of different groups of foods - cereals, vegetables and fruits, packed and canned foods.
4. Significance of microbial spoilage of different groups of foods-meat, poultry, sea foods, milk and milk products.
5. Food borne pathogens – food infection – intoxication - bacterial food borne diseases – viral and protozoa.
6. Mycotoxicoses in foods – occurrence and economic significance and food control measures.
7. Analytical techniques and their working principles for the detection of toxin in foods – GC-MS, HPLC and HPTLC.
8. Analytical techniques and their working principles for the detection of toxin in foods -LC/MS, ICP – MS and TOF.
9. **Mid Semester Examination**
10. Molecular Detection of Food borne Pathogens - PCR, real time PCR, DGGE, metagenomics, proteomics and immunological methods
11. Food standards – India, EU, FDA and WHO Standards of Food Safety
12. Food laws & Regulations - CODEX
13. HACCP concepts, principles and applications
14. GM foods and current guidelines for production and labeling
15. Food Safety – Standard Sanitation Operating Procedures; GMP, GAP for food safety
16. Food traceability– significance - Food safety Audit
17. Functions, duties and responsibilities of food safety regulators

Practical schedule

1. Different sampling plan in food and preparation for various foods
2. Determination of aerobic plate counts in food
3. Enumeration of yeasts and molds in food
4. Detection and confirmation of *Bacillus cereus* in food
5. Microbiological hazard analysis in processed fruit product
6. Microbiological hazard analysis in water - water quality control
7. Microbiological hazard analysis in fresh vegetables – *Campylobacter* and *Salmonella*
8. Microbiological hazard analysis in beverages - Detection of coliforms
9. Microbiological techniques for cereal based food analysis
10. Microbiological hazard analysis in meat products - *Staphylococcus aureus*
11. Rapid detection of toxin producing *Escherichia coli* (STEC) in food products –PCR method
12. Detection of aflatoxin in groundnut and maize kernels
13. Hazard Analysis and Critical Control Point (HACCP) of Fruits / vegetables
14. Hazard Analysis and Critical Control Point (HACCP) of processed foods
15. Visit to Food Processing industry
16. Microbiological examination of canned foods
17. **Final Practical Examination**

Reference Books

1. Adams, M. R. and Moss, M. O. 1995. Food Microbiology. The Royal Society of Chemistry, Cambridge.
2. Frazier, W. C. and Westhoff, D. C. 1988. Food Microbiology. TATA McGraw Hill Publishing Company Ltd. , New Delhi.
3. Jay, J. M. 1987. Modern Food Microbiology. CBS Publishers and distributors, New Delhi.
4. Banwart, G. J. 1989. Basic Food Microbiology. Chapman & Hall New York.
5. Board, R. C. 1983. A Modern Introduction to Food Microbiology. Blackwell Scientific Publications, Oxford.
6. Robinson, R. K. 1990. Dairy Microbiology Elsevier Applied Science, London.
7. Hobbs, B. C. and Roberts, D. 1993. Food Poisoning and Food Hygiene. Edward Arnold.
8. Lund B. M. , Baird Parker A. C. , and Gould G. W. 2000. The Microbiological Safety and Quality of Foods. Vol. 1-2, ASPEN Publication, Gaithersberg, MD.
9. Gould G. W. 1995. New Methods of Food Preservation. Blackie Academic and Professional, London.

AGM 354 PLANT-MICROBE INTERACTIONS (1+1)

Unit I Introduction: Introduction to plant - microbe interactions; types of interaction -positive and negative. Plants as microbial habitat. Spermosphere, phyllosphere and endophyticmicroorganisms. Bacterial secretion systems, gene regulation and quorum sensing in bacterial - plant interactions. Role of plant- microbial interactions in soil health and plant growth promotion. Signalling - effect of microbial signalling on plant productivity and plant signalling on microbial diversity and activity in the soil.

Unit II Plant- microbe interaction –I : Beneficial bacteria – *Arthrobacter*, *Azospirillum, Azoarcus Bacillus*, *Burkholderia*, *Frankia, ,Gluconacetobacter, Herbaspirillum,Paenibacillus*, *Pseudomonas*, *Rhizobium, Streptomyces* and*Xanthomonas* - host interactions and plant growth promotion. *Agrobacterium* induced tumorigenesis and rhizogenesis. Azolla - *Anabaena* symbiosis.

Unit III Plant– microbe interaction –II: Mutualistic fungal symbionts. Ectomycorrhizal and endomycorrhizal fungi. Infection processes. Interactions with host plants and other soil microbes. Infection processes- fungi and toxins. Induced resistance. Secondary product responses and fungal virulence. Lichens, algal and bacterial interaction.

Unit IV Applications – Agriculture and industries: Plant growth promoting bacteria-types and mechanism of plant growth promotion. Biocontrol agents- types and mechanism of action. Induced resistance: Protein defenseresponses and systemic responses. Phytoremediation**.** Industrial application and medicinal applications – antiviral, anti-cancerous, immunosuppressive and antioxidants.

Unit V Techniques to study plant–microbe interactions: Techniques to study plant- microbe interactions - Phytortron, Rhizotron and Confocal Laser Scanning Microscope.

Practical

Collection and assay of root exudates. Characterization of root exudates. Studying the effect of root exudates on selected bacterial population. Isolation of ecto and endorhizosphere microorganisms. Isolation ofspermospheremicorganisms from germinating seeds. Isolation and purification of endophytic and phyllosphere microorganisms from rice. Visit to plantations and collection of ectomycorrhizal fruiting bodies, orchidaceous and ericoid mycorrhizal root samples and lichens. Examination of endomycorrhizal infection in orchids and ericaceous plants. Examination of lichens associated with trees. Collection and examination of *Anabaena azollae* associated with Azolla*.* Testing rhizogenesis by *A. rhizogenes*in laboratory conditions.

Lecture Schedule

1. Introduction to plant - microbe interactions; types of interaction - positive and negative. Plants as microbial habitat.
2. Role of microbial diversity in soil health and plant growth promotion.
3. Signalling – effect of microbial signalling on plant productivity.
4. Effect of plant signalling on microbial diversity and activity in the soil.
5. Spermosphere andphyllospheremicroroganisms; endophytic microorganisms.
6. Bacterial secretion systems, gene regulation and quorum sensing in bacterial - plant interaction
7. &8. Beneficial bacteria – *Arthrobacter*, *Azospirillum, Azoarcus, Bacillus*, *Burkholderia*, *Frankia, Gluconacetobacter, Herbaspirillum,Paenibacillus*, *Pseudomonas*, *Rhizobium, Streptomyces* and*Xanthomonas* - host interactions and plant growth promotion
9. **Mid Semester Examination**
10. *Agrobacterium* induced tumour formation and root proliferation*;* exploitation of tumorigenesis and rhizogenesis. Mutualistic fungal symbionts

11. Ectomycorrhizal and endomycorrhizal fungi. Infection processes. Interactions with host plants and other soil microbes
12. Infection processes - fungi and toxins. Secondary product and fungal virulence
13. Azolla - *Anabaena* symbiosis. Association of lichens with trees
14. Plant growth promoting bacteria- types and mechanism of plant growth promotion
15. Biocontrol agents- types and mechanism of action
16. Induce Resistance-Induced Systemic Resistance (ISR) and Systemic Acquired Resistance (SAR)
17. Protein defense responses and systemic responses

1. Collection of root exudates
2. Assay of root exudates – growth regulator/sugars
3. Studying the effect of root exudates on selected bacterial population – well diffusion assay
4. Isolation and purification of ectorhizophere – rhizosphere and rhizoplane microorganisms
5. Isolation and purification of endophytic microorganisms from rice
6. Isolation and purification of phyllosphere microorganisms from rice
7. Isolation and purification of *Rhizobium*
8. Isolation and purification of *Frankia*from*Casuarinaequisetifolia*
9. Visit to plantations and collection of ectomycorrhizal fruiting bodies, lichens, orchid and ericaceous mycorrhizae infected root samples
10. Examination of ectomycorrhizal fruiting bodies and isolation of ectomycorrhizal fungi
11. Examination of lichens associated with trees; orchidaceous and ericoid mycorrhizae fungal infection in plants
12. Examination of AM fungal infection in plants
13. Collection and examination of AM spores from soil
14. Testing *Agrobacterium tumefaciens* induced tumour formation in dicotyledonous plants in laboratory conditions
15. Testing *A. rhizogenes* induced root proliferation in laboratory conditions
16. Collection and examination of endosymbiont associated with Azolla
17. **Final Practical Examination**

Reference Books

1. Kamal B. , Normand B. and Fouad D. 2009. Plant-microbe interactions.
2. Chrispeels M. J. and D. E. Sadava. 2003. Plants, Genes, and Crop Biotechnology. Jones & Bartlett Publishers, Boston.
3. Susan I. 1992. Fungal-Plant Interactions, Chapman Hall,
4. George A. 2005. Plant Pathology, Academic Press, Fifth Edition.

E - Reference

1. Nautiyal C. S. and Patrice, D. 2008. Molecular mechanism of Plant and Microbe Coexistence, Springer-Verlag Berlin Heidelberg
2. Lugtenberg, B. 2015. Principles of Plant-Microbe Interactions. Microbes for Sustainable Agriculture, Springer International Publishing Switzerland

AGM 355 QUALITY CONTROL OF BIOINOCULANTS (1+1)

UNIT I: Overview of bioinoculant production and quality control. Nitrogen fixers-types. P solubilizers and mobilizers. Potassium releasing bacteria. Microbial transformation of micronutrients zinc, sulphur, iron *etc*. PPFM – PGPR. Mass production methods. Introduction to quality control standards. FCO standards.

UNIT II: Quality control of *Rhizobium* inoculants-Purity checking of mother culture-morphological, biochemical and cultural characteristics of *Rhizobium*-Cross inoculation groups-recent classification-methods for testing nodulation-Estimation of nitrogen fixation – direct & indirect methods - Carrier based and liquid inoculants - FCO standards-scope for new formulations-quality control at different stages of production.

UNIT III: Quality control of *Azospirillum* and *Azotobacter* inoculants-purity checking of mother culture-morphological,biochemical and cultural characteristics-different species-Nitrogen fixation-ARA and microkjeldhal method-Quality control at different stages of production-Quality control of PSB- Purity checking of mother culture-Morphological,biochemical and cultural characteristics-Quantitative and qualitative assay for P solubilization-FCO standards.

UNIT IV: Endophytic nitrogen fixation in sugarcane-*Gluconacetobacterdiazotrophicus*- Potash releasing bacteria-Characteristics-Mechanism of K release – PPFM - PGPR and bioinculants for micronutrients-Quality control of Mycorrhizae-Ecto and Endo mycorrhiza-AMF-Morphological and cultural characteristics-root infection test and spore count-IP by MPN technique-mechanism of P mobilization-Hairy root organ culture.

UNIT V: Cyanobacterialbiofertilizers-types-nitrogen fixing cyanobacteria-Heterocysts-role of akinetes in survival-soil based composite culture-new formulations-quality testing-population by MPN technique-*Azolla-Anabaena* symbiosis-spore inoculum production-rapid methods for quality control of biofertilizers-molecular and immunological methods. Quality of biocontrol agents-*Pseudomonas* and *Trichoderma*.

Practical

Quality control of *Rhizobium*- *Azospirillum*- *Azotobacter*- morphological and biochemical characterization-Nodulation by Roll paper towel technique-N_2 fixation by ARA- sampling methods-population estimation in broth and inoculants by SPC/MPN methods- P solubilzing bacteria- Available P estimation in Pikosviskya's broth - Organic acid production by titrable acidity-Acid and alkaline phosphatase activity - Quantitative estimation- enumeration of population in hydroxy appetite medium-AM fungi- spore count by wet sieving method- root infection studies by staining with tryphan blue-IP estimation by MPN- hairy root culture Potassium releasing bacteria-quantification of K release-population estimation- PPFM, PGPR, SOB, Zn solubilizing bacteria-qualitative and quantitative assays-

Cyanobacteria- Composite culture-enumeration of population by haemocytometer count and MPN technique-*Azolla*- determination ofheterocyst frequency-sporocarps-spore inoculum production- rapid methods for quality control- Molecular methods –immunological methods.

Lecture schedule

1. Overview of bioinoculant production and quality control
2. Nitrogen fixing microbes-symbiotic , associative symbiotic, nonsymbiotic and endophytic nitrogen fixation-Mechanism of nitrogen fixation
3. Phosphate solubilizing and mobilizing microbes-Mechanism of action
4. Potash releasing bacteria -PPFM-PGPR- Zinc solubilizers- Sulphur oxidizers-mechanism

5. Mass production methods of bacterial, fungal and algal biofertilizers
6. Introduction to quality control standards-BIS-FCO standards - Sampling methods
7. Purity checking of *Rhizobium* mother culture-Morphological, biochemical and cultural characteristics-cross inoculation groups-recent classification
8. *In vitro* methods for testing nodulation- Roll paper towel technique-MPN counts, growth pouches/tubular pots -N_2 fixation-direct & indirect methods –N estimation by Microkjeldahl method,^{15}N technique & ARA-principles & methods-enumeration of population at different stages of production
9. **Mid Semester Examination**
10. Criteria for selection of carrier material-FCO standards (2011) for carrier based and liquid
11. Purity checking of *Azospirillum* and *Azotobacter* mother culture- morphological, biochemical and cultural characteristics-different species
12. Phosphobacteria-organisms involved-purity checking of mother culture- morphological, biochemical and cultural characteristics-quantification-available P estimation in broth-organic acid production-acid and alkaline phosphatase
13. FCO standards for *Azospirillum*, *Azotobacter* and phosphobacteria-quality control of inoculants at different stagesof production- Rapid methods for quality control-molecular and immunological methods. Quality of biocontrol agents-*Pseudomonas* and *Trichoderma*.
14. Potassium releasing bacteria- organisms involved-morphological, biochemical and cultural Characteristics-mechanism and quantification of K release
15. Endophytic nitrogen fixation-*Glucanoacetobacterdiazotrophicus*-PPFM, PGPR-bioinoculants for micronutrients *viz*. , sulphur, zinc and iron
16. Ecto and Endo mycorrhizae-AM fungi-morphological and cultural characteristics-mechanism of P mobilization-quality control-root infection-spore count and IP by MPN
17. Nitrogen fixing cyanobacteria-heterocysts-role of akinetes in survival-soil based composite culture-quality checking by MPN technique-*Azolla*-Anabaena symbiosis- heterocyst frequency-sporocarps-spore inoculum production-storage and shelf life

Practical schedule

1. Sampling methods and study of different inoculants-carrier based and liquid inoculants
2. Morphological, cultural and biochemical characterization of *Rhizobium*
3. Purity checking of *Rhizobium* strains-Leonard Jar, germination paper roll and tubular pot methods-MPN counts
4. Morphological, cultural and biochemical characterization of *Azotobacter*
5. Estimation of N_2 fixation- Acetylene Reduction Assay of nodules/cultures
6. Estimation of N_2 fixation in broth under *in vitro* conditions-Microkjeldahl method
7. Quantitative and qualitative assay for phosphobacteria-Available P estimation in Pikosviskya's broth by Olsen's method and organic acid production by titrable acidity
8. Assay of acid and alkaline phosphatase activity of phosphobacterial cultures
9. Enumeration of population of *Rhizobium* at different stages of production with Congo red YEMA by SPC method
10. Enumeration of population of *Azospirillum* different stages of production with N free bromothymol blue (Nfb) semi solid medium by MPN method
11. Enumeration of population of *Azotobacter* at different stages of production with Waksman No. 77 medium by SPC method
12. Enumeration of population of phosphobacteria at different stages of production with Sperber' shydroxy appetite medium by SPC method
13. Quality control of AM fungi-Spore count by wet sieving, root infection by Tryphan blue staining and Infective propagules by MPN

14. Potassium releasing bacteria- quantification of K release
15. Cyanobacterial inoculants-microscopic examination, determination of heterocyst frequency& population estimation by haemocytometer count and MPN method
16. **Final Practical Examination**

Reference Books

1. Maheshwari, D. K. and R. C. Dubey, 2008. Potential Microorganisms for Sustainable Agriculture - A techno-Commercial Perspective. I. K. International Publishing House Pvt. Ltd. , New Delhi and Bangalore
2. Rai, M. K. 2006. Hand book of microbial biofertilizers. CRC press.
3. Bagyaraj, D. J. and A. Manjunath. 1990. Mycorrhizal symbiosis and plant growth, Univ. of Agricultural Sciences, Bangalore, India.
4. Kannaiyan S. 2002. Biotechnology of Biofertilisers. Kluwer Academic publishers &Narosa Publishing House.
5. Motsara M. R. , Bhattacharya P. , and Srivastava B. 1995. In: Biofertilizer Technology, Marketing and Uses -A Source Book cum Glossary. Fertilizer Development and Consultancy Organization, New Delhi.
6. Somasegaran, P. and H. J. hoben. 1985. Methods in Legume-*Rhizobium* Technology, NifTAL Project and MIRCEN, University of Hawaii, Paia, USA
7. SubbaRao, N. S. 1993. Biofertilizers in Agriculture and Forestry. Oxford and IBH Publishing Co. Ltd. , New Delhi.

E- Reference

1. Biofertilizers and Organic Fertilizers in Fertilizer (Control) Order, 1985
2. FNCA biofertilizer project group, 2006. Biofertilizer Manual, Japan Atomic Industrial Forum, MEXT, Tokyo, Japan.

SAC 351DESIGNER FERTILIZER PRODUCTION (1+1)

Theory- Syllabus

UNIT I

Designer Fertilizers - Definitions - Concepts - Historical development - Scope and Need - Scenario of Multi nutrient deficiencies in soils and plants.

UNIT II

Designer Fertilizers – Classification- Production and Characterisation - Speciality / Customized fertilizer mixtures - Fortified fertilizers - Pelleted fertilizers - Multi nutrient liquid formulations.

UNIT III

Foliar Formulations - Leaf nutrient analysis -Value added fertilizers- enriched with organics/chelates- methods and guidelines for preparing designer Fertilizers- Filler materials- Industries and approved formulations.

UNIT IV

Quality of Designer fertilizers- Compatibility of fertilizer materials - issues in storability, hygroscopicity, clogging, etc. - Toxicity - Advantages and Disadvantages - Key Challenges - Crop response to designer fertilizers - Agricultural, Horticultural, high value crops- yield and quality - Soil health - Nutrient use efficiencies

UNIT V

Feasibility of using designer fertilizers for drip fertigation- Poly houses - roof gardening- Quality Standards- Specifications - Guidelines for Patenting, Licensing and Registration of newer products

Lecture Schedule

1. Designer Fertilizers - Definitions - Concepts -Historical development
2. Scope and need for Designer Fertilizes –Multi nutrient deficiencies in soils and plants - Critical limits - current scenario of multi nutrient disorders
3. Classification-Types- Speciality / Customised, Fortified and Pelleted fertilizers, Multi-nutrient liquid formulations
4. Speciality / Customised Fertilisers- Definitions- Production-characteristics- sources - suitability for crops -Merits and Demerits
5. Fortified fertilizers-Definitions- Production-characteristics-sources-suitability for crops-Merits and Demerits
6. Pelleted fertilizers - Definitions- Production- characteristics- sources- suitability for crops -Merits and Demerits
7. Multi nutrient liquid formulations - Definitions- Production- characteristics- sources - suitability for crops -Merits and Demerits
8. Foliar Formulations - Leaf nutrient analysis - organic and synthetic chelates
9. Mid semester examination
10. Value added fertilizers- enriched with organics/chelates
11. Methods and guidelines for preparing designer Fertilizers - Filler materials
12. Industries and Approved formulations and mixtures - Advantages and Disadvantages - Key Challenges
13. Quality of designer fertilizers - Compatibility of fertilizer materials - issues in storability, hygroscopicity, clogging, etc - Toxicity
14. Crop response to designer fertilizers - Agricultural and Horticultural crops- Yield and Quality- Soil health and Nutrient use efficiencies
15. Feasibility of using designer fertilsiers for drip fertigation - Poly houses - roof gardening
16. Quality Standards-Specifications for designer fertilisers
17. Guidelines for Patenting, Licensing and Registration of newer products

Practical Syllabus

Preparation of Designer Fertilizer Mixtures for major agricultural, Horticultural and High value crops- Preparation of multi nutrient liquid formulations for drip fertigation, poly houses, roof gardening - Preparation of pelletised fertilizer mixtures for high value crops and roof gardening- Preparation of fortified fertilizer mixtures for major agricultural and horticultural crops- Preparation of value added fertilsiers - Assessing the storability of the formulations and mixtures -Machineries in designer fertilizer production - Computation of cost effectiveness of the designer fertilizers - Visit to Designer Fertilizer manufacturing Unit- Protocols for establishing a Designer Fertilizer Production Unit - Procedures for Licensing, registration and Patenting.

Practical schedule

1. Preparation of Designer Fertilizer Mixtures for major agricultural crops: Rice/ Pulse
2. Preparation of Designer Fertilizer Mixtures for major horticultural crops : Banana/ Tapioca
3. Preparation of Designer Fertilizer Mixtures for high value crops : Turmeric/Cotton
4. Preparation of multi nutrient liquid formulations for drip fertigation : Sugarcane/Turmeric
5. Preparation of multi nutrient liquid formulations for poly houses: Tomato/ Cucumber/Capsicum
6. Preparation of pelletised fertilizer mixtures for high value crops : Maize/ Turmeric/Cotton
7. Preparation of pelletised fertilizer mixtures for roof gardening : Chillies/ Brinjal/ Greens
8. Preparation of fortified fertilizer mixtures for major agricultural crops: Maize, Groundnut
9. Preparation of fortified fertilizer mixtures for major horticultural crops: Onion, Bhendi
10. Preparation of value added fertilizers
11. Assessing the storability of the mixtures and formulations
12. Machineries in designer fertilizer production
13. Computation of cost effectiveness of the designer fertilizers
14. Visit to Designer Fertilizer manufacturing Unit
15. Protocols for establishing a Designer Fertilizer Production Unit - Guidelines and budget
16. Procedures for Licensing, registration and Patenting
17. **Final practical examination**

References

1. Hagin, J. and B. Tucker (2012). Fertilization of Dry land and Irrigated Soils, Springer Science & Business Media, 06-Dec-2012 - Technology & Engineering, 190 pages
2. John Havlin, Samuel L. Tisdale, James D. Beaton, Werner L. Nelson (2013) Soil Fertility and Fertilizers: An Introduction to Nutrient Management, Pearson, 2013 - Technology & Engineering - 516 pages
3. Hari Lal Singh Tandon (2012) Fertilizer Management: Balance-efficiency-profitability Fertilizer Development and Consultation Organization, Arid regions agriculture - 187 pages
4. Anac,D. and P. Martin Pravel (1999). Improved crop quality by nutrient management , Kluwer Academic Publications, London Springer Science & Business Media, 30-Sep,1999 - Science - 310 pages
5. Gustafson,A. F. (2013) Handbook of Fertilizers - Their Sources, Make-Up, Effects, And Use,Read Books Ltd, 16-Apr-2013 - Technology & Engineering - 170 pages
6. Kolay,A. K. (2007) Manures and Fertilizers Atlantic Publishers & Dist, Fertilizers - 173 pages
7. UN Industrial Development Organization(1998), Fertilizer Manual, Int'l Fertilizer Development Center, Springer Science & Business Media, 31-Mar-1998 - Nature - 616 pages
8. Casper, M. S. (1973). Liquid fertilizers, Noyes Data Corp. , 1973 - Technology & Engineering - 268 pages

SAC 353 Soilless Crop Production (1+1)

Unit I : Protected agriculture overview and scope - Introduction to soilless cultivation of plants - History of solution culture - Present status of hydroponics - Nutrient requirements - Absorption of nutrients by the roots and interaction between the roots and the soil solution - Nutrient ratios - Effects of pH, EC and nutrient ratios on plant growth, yield and quality

Unit II : Containers - Grow bag / container media – formulations - their properties - Systems with aggregates as substrate - bag culture, container culture, trough culture, thin layer systems, other alternative systems - effect of volume and shape of container. Hydroponic systems - Systems involving solely water as a substrate - deep water culture, floating hydroponics, Nutrient Film Technique, plant plane hydroponics, aeroponics.

Unit III : Container media - Description of substrates -sand, gravel, rockwool, expanded minerals, pumice, zeolite, pyroclastic materials, peat, coir, tree bark, sawdust, wood fibres, etc. - Physical properties – impact of physical properties on irrigation management. Chemical properties - Container media analyses - Total and available nutrients - Microbiology and phytosanitation in container media

Unit IV : Composition of nutrient solution: Calculation of nutrient solutions for open systems/ closed systems: concept of drainage solution plus fresh water - Management of nutrient solution - Nutrient solution recycling - Irrigation control - characteristics of irrigation systems : capacity, uniformity - Delivery Systems : overhead systems, drip irrigation, sub-irrigation. Irrigation scheduling : preset schedule, sensor-based schedule, transpiration-based schedule

Unit V : Equipments in Soilless culture - Automated delivery of nutrient solution - sensor based monitoring - moisture, nutrient, temperature and humidity sensors - Integrated system development for electronic control of equipments for irrigation and nutrient solution recycling. Nutrient solution disinfection - heating, UV-irradiation, chemical treatments by means of ozone, hydrogen peroxide, chlorine, iodine, etc. - membrane filtration - slow sand filtration

Lectures

1. Importance and scope of protected agriculture; Factors affecting crop growth under protected cultivation – temperature, light intensity, CO_2 and humidity
2. Introduction to soilless cultivation of plants; Various systems of soil-less crop production - bag culture, container culture, trough culture, thin layer systems, other alternative systems. .
3. History of solution culture and Present methods of hydroponics - deep water culture, floating hydroponics, Nutrient Film Technique, plant plane hydroponics, aeroponics. - Basic needs and suitable crops for hydroponics.
4. Calculation of nutrient solution – mixing of nutrients, concentration and method, dose and time of application; Management of nutrient solution.
5. Fertilization - Nutrient requirements by crops, absorption of nutrients, nutrient ratios and its effect on crop growth and yield; Sensor based nutrient management.
6. Containers – kinds of substrates - sand, gravel, rockwool, expanded minerals, pumice, zeolite, pyroclastic materials, peat, coir, tree bark, sawdust, wood fibres, etc. – resources and methods of preparation.
7. Physical properties of substrates - air to water ratios, bulk density, particle size distribution, porosity, water release curves, hydraulic conductivity
8. Chemical properties of substrates - pH, electrical conductivity, ion sorption, ion exchange, concentration and composition of ions, cation exchange capacity.

9. **Mid semester examination**
10. Standardization of soil-less media and solution culture
11. Irrigation systems – Drip irrigation, sub-irrigation, matric suction irrigation and irrigation management.
12. Automated irrigation system – sensor based, transpiration based schedule
13. Equipments used in soil-less cultivation – various sensors used
14. Sterilization of substrate in grow bag media and disinfection of nutrient solution in hydroponics.
15. Day to day maintenance of soil-less system of crop production.
16. Suitability of crops for growing under green house cultivation; specific technology for raising vegetable crops under protected cultivation.
17. Economics and Business opportunities in soil-less system of crop production.

Practical

Propagation of plants for culture by hydroponics - testing seeds or cutting using media for adaptation to soilless culture - Growing crops in solution culture observation on growth and maturity phases - Growing crops in water culture and identification of plant nutrient deficiencies / nutritional stresses - Control of acidity of solutions by regulation of pH of nutrient solutions or by control of the sources of N - Formulation of nutrient solutions - Factors governing stability of Nutrient solutions - solubility of salts, purity of constituents, buffering of acidity, quality of water - Regulation of salinity in nutrient solutions – record of change in concentration of soluble salts in nutrient solutions - Culture of plants by nutrient film technique – growing plants using thin layers of water which flow by roots in a designed chamber - Evaluation of solid media in solution culture – growth of plants in solid media - sand, gravel, sawdust, perlite, etc. - Visit to commercial hydroponics greenhouse

Lecture Schedule

1. Preparation of soilless media using different substrates for grow bag method and sowing crop.
2. Preparation of solution culture for hydroponics and sowing crop.
3. Estimation of physical characteristics of grow bag media (cocopeat, vermiculite)
4. Determination of chemical properties like pH, EC, CN ratio of grow bag media.
5. Determination of water soluble and exchangeable nutrients in grow bag media.
6. Evaluation of porosity of medium based on moisture characteristic/ water retention curve.
7. Computation of container capacity, air filled porosity of grow bag media
8. Estimation of moisture constants by pressure plate apparatus and computation of available water and water holding capacity.
9. Preparation of common nutrient solution for hydroponics and drip system.
10. Preparation of fertilizer pellet packs for crops under matric suction irrigation.
11. Nutrient monitoring study using sensors in grow bag media.
12. Nutrient monitoring study using sensors in continuous recycling solution culture.
13. Assembling water lines and measurement of water consumption under drip / matrix suction irrigation.
14. Recording of operations involved in devices – peristaltic pump, filter pump, injectors, solenoid valves
15. Study of circuitry for sensor based nutrient monitoring system with wireless controls.
16. Visit to successful greenhouse cultivation system
17. **Practical examination**

References

Burt, C. , K. O'Connor, and T. Ruehr. 1998. Fertigation. ITRC, California Polytechnic State University, San Luis Obispo, CA. FAO. 1990. Soilless Culture for Horticultural Crop Production.

Jones, J. Benton. 1983. A Guide for the Hydroponic and Soilless Culture Grower. Timber Press. Jones, J. Benton. 2005. Hydroponics: A Practical Guide for the Soilless Grower. 2nd ed. CRC Press. Boca Raton.

Kipp, J. A. , G. Wever and C. de Kreij. 2000. International Substrate Manual. Elsevier, the Netherlands.

Marschner, H. 1995. Mineral Nutrition of Higher Plants (2nd ed.). Academic Press, London. Mengel, K. and Kirkby, E. A. 2001. Principles of Plant Nutrition (5th ed). Kluwer Academic Publishers, Dordrecht.

Raviv, M and Lieth, J. H. (eds.) 2008. Soilless Culture, Theory and Practice. Elsevier, London. Schwartz, M. 1995. Soilless Culture Management. Springer-Verlag, Berlin. Proceedings of the World Congress on Soilless Culture: Agriculture in the coming millennium. Editors, A. Bar-Tal, Z. Plau. 2001.

SAC 354 Instrumental Methods of Analysis (1+1)

Unit I: Principles of instrumentation- classification of instrumental methods – selection of instruments - Principles involved in digestion methods – dry ashing and wet digestion – open vs closed digestion - Block digester , microwave digester and IR digestion systems - components -operation - special consideration

Unit II : Automated methods – Principle and applications - Total N analyser, CN analyser

Unit III: Optical methods – spectrophotometry – visible, ultraviolet and infrared spectrometry - Principle - Instrumentation – sample handling and measurement - method development and validation - accuracy

Unit IV : Emission and absorption Spectroscopy - principles and applications - flame photometry, atomic absorption spectrophotometry, inductively coupled plasma emission spectrometry - instrumentation - features and operation of components - sample handling - errors - fault finding - trouble shooting

Unit V : Chromatography techniques – classification - paper chromatography, TLC - Gas chromatography- HPLC , GC – MS - principles - Instrumentation - sample preparation and handling - errors – trouble shooting

Lecture schedule

1. Basic principles in instrumental method of analysis
2. Principle and practice of digestion methods
3. Principle and practice of N analyser and CN analyser
4. Spectrophotometry : Types, Principle and instrumentation
5. Spectrophotometry: Sample handling and measurement, method development and validation and checking for accuracy
6. Emission spectroscopy (Flame Photometer) : Instrumentation, interferences, trouble shooting and maintenance
7. Absorption spectroscopy (Atomic Absorption Spectrophotometer) : Principle, instrumentation, features and operation of components
8. Absorption spectroscopy (Atomic Absorption Spectrophotometer): Sample handling and measurement, errors due to molecular and ionic species, matrix effect and other interferences, trouble shooting and maintenance
9. Mid semester examination
10. Absorption spectroscopy (Inductively Coupled Plasma Emission Spectrometer) : Concepts and instrumentation
11. Absorption spectroscopy (Inductively Coupled Plasma Emission Spectrometer) : Preparation of samples and standards, interferences, trouble shooting and maintenance
12. Principle and practice of paper chromatography, Thin layer chromatography
13. Gas chromatography : Principle, Types and instrumentation
14. Gas chromatography : Operation ,sample handling, maintenance and trouble shooting and applications
15. High Performance Liquid Chromatography : Principle, Instrumentation and operation

16. High Performance Liquid Chromatography : Sample preparation , method development, maintenance and troubleshooting
17. GC – MS : Principle , instrumentation, Sample preparation , method development, maintenance and troubleshooting

PRACTICAL

Collection and processing of samples - Digestion of samples – block digester and microwave digester methods - N analyser – Specrophotometry - UV –Vis Spectrophotometer -- Emission spectroscopy - Flame photometer – Absorption spectroscopy – Atomic Absorption Spectrophotometer

(AAS) and Inductively Coupled Plasma Emission Spectrometer (ICP) – Chromatography - Gas Chromatography and High Performance Liquid Chromatography- Procedures for establishing a analytical laboratory

PRACTICAL SCHEDULE

1. Collection and processing of samples (Soil, plant, water, manure and fertilizer)
2. Digestion of samples by block digester/microwave digester and sample preparation for different analysis
3. N anlyser : Calibration , sample estimation and results interpretation
4. UV -Vis spectrophotometer : Getting acquainted with parts of UV -Vis spectrophotometer and preparation of standards
5. UV -Vis spectrophotometer : Calibration, sample estimation (P/S/B) and results interpretation
6. Flame photometer : Getting acquainted with components of flame photometer and preparation of standards, calibration, sample estimation (P/S/B) and results interpretation
7. Getting acquainted with components of AAS and standards (micronutrients and heavy metal) preparation
8. Calibration and sample estimation for micronutrients and heavy metals by AAS
9. Getting acquainted with components of ICP
10. Calibration , sample estimation for elements by ICP and results interpretation
11. Analyte extraction from sample and separation for GC
12. Calibration , sample introduction and interpretation of results in GC
13. Analyte extraction from sample and separation for HPLC
14. Calibration, sample introduction and interpretation of results in HPLC
15. Visit to a analytical laboratory (Government/Private)
16. Procedures for establishing a analytical laboratory – Guidelines and budget
17. **Practical examination**

References

Chatwal, G. and Anand. 2005. *Instrumental Methods of Chemical Analysis*. Academic Press. Muralidhar aRao, D. , A. V. N Swamy and D. Dharaneeswara Reddy. 2013. *Instrumental Methods of Analysis*. CBS Publishers & Distributors Pvt. Ltd. , New Delhi.

Skoog, A. , Holler, F and Nieman, A. 2007. *Principles of Instrumental Analysis* (6^{th} Ed.). Thomson Brooks/Cole publishing. ISBN: 9780030020780.

Willard M, Merritt LL & Dean JA. 1989. *Instrumental Methods of Analysis*. (7^{th} Ed). Wadsworth Publishing Compnay, Boston, USA. ISBN :9780534001423.

E-References

1. http://blogs. rediff. com/ticconcvibi1985/2013/05/12/download-ebook-modern-hplc-for-practicing-scientists-free/
2. http://cdn. intechopen. com/pdfs-wm/26275. pdf
3. http://faculty. ksu. edu. sa/Dr. almajed/Books/practical%20HPLC. pdf
4. http://web. uni-plovdiv. bg/plamenpenchev/mag/books/spectroscopy/PRIMER. PDF

SAC 352 Rejuvenation of Deteriorated Lands (1+1)

Theory syllabus

Unit I : Type, factors and processes of soil / land deterioration and its impact on soil productivity, including soil fauna, bio deterioration and environment. Land rejuvenization and conservation / management techniques; afforestation and sylviculture and soil carbon restoration.

Unit II: Causes, reclamation and management of soil physical deterioration - surface and sub surface hard pans, shallow, slowly permeable and highly permeable and fluffy paddy soils; soil erosion, ravine and sand dune, coastal and seasonally inundated soils and mined land.

Unit III : Causes, reclamation and management of salt-affected soils – saline, sodic and saline sodic soils; acid and acid sulphate soils; laterite soils.

Unit IV : Extent, diagnosis and mapping of land deterioration by conventional and modern RS-GIS tools. Monitoring land deterioration by fast assessment and modern tools.

Unit V : Land use policy, incentives and participatory approach for reversing land deterioration; global issues for twenty first century.

Practical

Determination of gypsum requirement in sodic soils, lime requirement in acid soils and soil erodibility indices – field reclamation of saline, saline-sodic, sodic and acid soils. . Characterization of soil physical constraints - surface and sub surface hard pans, shallow, slowly permeable soils, and fluffy paddy soils - characterization of mined out and ravine lands, laterite, sand dune, coastal and seasonally inundated soils.

Lecture schedule

1. Type, factors and processes of soil / land deterioration.
2. Soil / land deterioration impact on soil productivity, including soil fauna, bio deterioration and environment.
3. Land rejuvenization and conservation techniques; Land configuration techniques; Surface / vertical mulching.
4. Afforestation and sylviculture methods; Soil carbon restoration – use of industrial C- rich by products.
5. Causes, reclamation and management of soil physical deterioration - surface and sub surface hard pans, shallow, slowly permeable and highly permeable and fluffy paddy soils.
6. Causes, management of soil erosion.
7. Causes, reclamation and management of mined and ravine lands.
8. Causes, reclamation and management of sand dunes, coastal and seasonally inundated soils.
9. Mid semester examination
10. Causes, reclamation and management of saline and saline sodic soils
11. Causes, reclamation and management of sodic soils
12. Causes, reclamation and management of acid and acid sulphate soils.
13. Causes, reclamation and management of laterite soils.
14. Extent, diagnosis and mapping of land deterioration by conventional and modern RS-GIS tools.
15. Monitoring land deterioration by fast assessment and modern tools.
16. Land use policy, incentives and participatory approach for reversing land deterioration.
17. Global issues for twenty first century.

Practical schedule

1. Practicing field reclamation of saline soils and assessing its impact and cost benefit.
2. Practicing field reclamation of saline-sodic soils and assessing its impact and cost benefit.
3. Practicing field reclamation of sodic soils by gypsum application and assessing its impact and cost benefit.
4. Practicing field reclamation of sodic soils by press mud application and assessing its impact and cost benefit.
5. Practicing field reclamation of sodic soils by spent wash application and assessing its impact and cost benefit.
6. Practicing field reclamation of acid soils and assessing its impact and cost benefit.
7. Practicing management of surface and sub surface hard pans and assessing its impact and cost benefit.
8. Practicing management of slowly permeable and highly permeable and fluffy paddy soils and assessing its impact and cost benefit.

9 to 13. Field visit and characterization of eroded, ravine and mined out lands, sand dune, coastal, seasonally inundated and laterite soils and assessing its management impact and cost benefit.

14. Field visit to agro forestry and sylviculture farms and assessing its impact on soil conservation.
15. Assessing the suitability of industrial byproducts for eco friendly recycling through soil conservation and rejuvenization.
16. Diagnosis and mapping of land degradation using RS and GIS tools.
17. **Final Practical examination.**

References

Biswas TD and Narayanasamy G. (Eds.). 1996. Soil Management in Relation to Land Degradation and Environment. Bull. Indian Soc. Soil Sci. 17, New Delhi.

Doran JW and Jones AJ. 1996. Methods of Assessing Soil Quality. Soil Science Society of America, Madison.

Greenland DJ and Szabolcs I. 1994. Soil Resilience and Sustainable Land Use. CABI.

Lal R, Blum WEH, Vailentine C and Stewart BA. 1997. Methods for Assessment of Soil Degradation.

Sehgal J & Abrol IP. 1994. *Soil Degradation in India - Status and Impact*. Oxford & IBH.

SAC 355 Crop and Pesticide Chemistry (1+1)

Unit-I : Chemistry of Agricultural Crops: Chemical constituents of plants - Proximate and ultimate constituents - Chemical composition and nutritional quality of cereals, pulses and forage crops. Chemical composition and nutritional quality of oilseeds and sugarcane. Post harvest changes in Sugarcane.

Unit-II : Chemistry of Horticultural Crops, alkaloids and Essential oils: Chemical composition and nutritional quality of fruits, vegetables, spices, condiments, tuber crops and beverages. Post harvest changes in fruits. Chemistry of medicinal and aromatic plants.

Unit-III : Pesticides and its Formulations: Pesticides - Definition - Classification-Trends in pesticide use. Pesticide formulations -dusts, wettable powders, emulsifiable concentrate, granules. Insecticides - classification-. Characteristics, Mode of action and use of Organophosphates - Carbamates - Pyrethroids Botanicals, Insect Growth Regulators and Newer insecticides.

Unit-IV : Fungicides and Herbicides : Fungicides - classification of fungicides -properties, mode of action of inorganic, organic and systemic fungicides - Rhodenticides- Zinc phosphide - Aluminium phosphide - Bromodiolone Herbicides - classification - properties - mode of action of inorganic and organic herbicides like phenoxy compounds, substituted ureas, amides, thiocarbamates, triazines, pyridines, imidazolines and sulphonyl ureas.

Unit-V : Pesticides and Environment : Insecticide Act and Insecticide Rules - Fate of pesticides in soil- Impact of pesticides on environment

Practical

Estimation of moisture, ash, crude protein, P, K and crude fibre in plant samples - Determination of reducing and non-reducing sugars in jaggery — Oil content in Groundnut- Estimation of total solids, ascorbic acid, titratable acidity in fruits- Phenols/ Mucilages in Vegetables - HCN content in Tapioca/ Sorghum - Analysis of pesticides - Physical tests - Bulk density, wettability, suspensibility, Emulsion stability -. Estimation of pesticide residues in soil, water , vegetables, fruits and pesticidal calculations. Visit to Pesticide Testing Laboratory.

Lecture Schedule

1. Chemical composition and nutritional quality of cereals and pulses - Rice, wheat, maize, minor millets, Red gram, blackgram, and soybean. Starch synthesis and protein synthesis
2. Chemical composition and nutritional quality of oil seed crops - Groundnut, sesame, sunflower, castor, coconut and palm.
3. Chemical composition and nutritional quality of sugarcane -Sucrose synthesis - Post harvest changes in sugarcane. Nutritional quality of forage crops.
4. Chemical composition and nutritional quality of fruits - Mango, banana, papaya, grapes, guava, apple and pomegranate. Chemistry of post harvest changes in fruits.
5. Chemical composition and nutritional quality of vegetables- Tomato, bhendi, brinjal, moringa, greens, cauliflower, radish and peas.
6. Chemical composition of spices and condiments (Turmeric, chillies, pepper, ginger, onion, garlic and Beverages (tea and coffee). Tuber crops- Potato & Tapioca
7. Alkaloids in medicinal plants (Cinchona, Gloriosa, Coleus and Aloevera)

8. Pesticides - Definition - Classification-Trends in pesticide use
9. **Mid semester Examination**
10. Pesticide formulations - dusts - wettable powders, flowables, sprays –Emulsion concentrates – water soluble liquids - granules, fumigants and aerosols - characteristics and uses.
11. Insecticides classification -Characteristics, Mode of action and use of Organophosphates(Chlorpyriphos, Phorate, Dimethoate, Quinalphos and Profenophos)
12. Characteristics, Mode of action and use of Carbamates (Carbaryl, carbofuran, carbosulfan, aldicarb) and synthetic pyrethroids (Deltamethrin, Fenvalerate, Cypermethrin and Lambdacyclothrin)
13. Characteristics, Mode of action and use of Botanicals (nicotine and neem), Insect Growth Regulators (Novaluron, Buprobasin and GABA inhibitors) and *and newer insecticides (Neonicotinoids - Imidachloprid, Thiachloprid, Acetamiprid, Flupendiamide, Fipronil, Emamectin, Thiomethoxam, Indoxacarb, Chlorantraniliprole)*
14. Fungicides - Classification – Inorganics (sulfur) and Organic fungicides (Chlorobenzene and Chlorothalanil) - Characteristics, mode of action and use
15. Characteristics, mode of action and use of Systemic fungicides (Benomyl, Carbendazim, Metalaxyl, Quinones, Diclones, Dicarboximides –vincozolin).
16. Herbicides - Classification of herbicides - Characteristics, Mode of action and use of 2, 4-D, Sulfonyl ureas - Metsulfuron, Pyrosulfuron, Imidazoline, Alachlor, Butachlor, Oxyfluorfen, Fulchloralin, Pendimethalin, Atrazine, Paraquat and Glyphosate. Bisperipac sodium.
17. Fate of pesticides in soil-Impact of pesticides on the environment , Highlights of Insecticide Act - 1968 and Insecticide Rules -1971

Practical schedule

1. Sampling, processing and storage of plant materials for chemical analysis -Estimation of moisture and ash content
2. Preparation of tri acid extracts of plant samples -Estimation of P and K in triple acid extract
3. Estimation of crude protein
4. Estimation of crude fibre
5. Estimation of reducing and non-reducing sugars in jaggery
6. Estimation of oil content in groundnut
7. Estimation of total solids, ascorbic acid and titrable acidity in fruit samples
8. Estimation of phenols in vegetables / Mucilages in Bhendi
9. Determination of HCN content in Tapioca/ forage sorghum
10. Determination of bulk density in dust formulation, wettability and suspensibility test in wettable powder formulations
11. Estimation of emulsion stability in EC formulation
12. Estimation of pesticide residues in soil using GC/HPLC
13. Estimation of pesticide residues in Water / Soft drinks using GC/HPLC
14. Estimation of pesticide residues in Vegetables using GC/HPLC
15. Estimation of pesticide residues in Fruits using GC/HPLC & Pesticide requirement calculations
16. Visit to Pesticide Testing Laboratory
17. **Practical Examination**

References

1. Brijesh Tiwari and Narpinder Singh. 2012. Pulse Chemistry and Technology. Scientific Publishers, Jodhpur, India.
2. Hand book of Agriculture, 2009. Published by Indian Council of Agricultural Research, New Delhi 110 012. Pp. 1583
3. Paul H. Moore and Frederik C. Botha. 2014. Sugarcane : Physiology, Biochemistry and Functional Biology (World Agriculture Series). Amazon Publishers, India.
4. Petra Marschner. 2012. Marschner's mineral nutrition of higher plants. 3rd Edition. ISBN: 978-0-12-384905-2. Elsevier publications.
5. Yash P. Kalra, 1998, Handbook of Reference Methods for Plant Analysis, Taylor & Francis Group, LLC, New york, London
6. Dodia, D. A. , I. S. Patel and G. M. Patel. 2010. Botanical Pesticides for Pest Management. Amazon Publishers, India.
7. Gupta,A. 2006. Pesticide Residue in Food commodities. Agrobios Publishers, Jodhpur.
8. Hassall, K. A. 2013. The Chemistry of pesticides, their metabolism, mode of action and uses in crop production. Scientific Publishers, Jodhpur, India.
9. Koul, 0. , G. S. Dhaliwal, S. Khohar and R. Singh. 2014. Biopesticides in Sustainabie Agriculture. Progress and Potential. Amazon Publishers, India.
10. Mac Bean, C. 2013. The Pesticide Manual: A World Compendium. Amazon Publishers, India.
11. Sree Ramulu, U. S. 1979. Chemistry of Insecticides and Fungicides - Oxford and IBM Publishing Co, New Delhi.

e-references

1. www. apo-tokyo. org/OOe-books/AG-12_Leg
2. www. researchgate. net/. . . Chemical_composition. . . nutritional. . . /60b7d52b. . .
3. www. pulsecanada. com/food. . . nutrition/composition. . . /Canadian-Pea-Co. . .
4. www. wiley. com >. . . > Food Types > Functional Foods & Nutraceutical
5. www. iipr. res. in/csciences. html
6. www. aiou. edu. pk/FoodSite/Research%20Papers/48. pdf
7. www. plantphysiol. org/content/124/4/1532. full
8. www. amazon. in/Medicinal-Plants-Chemistry-Properties. . . /1578083958
9. www. tandfonline. com > List of Issues > Table of Contents
10. www. studiauniversitatis. ro/v15/pdf/20-2010/20. . . /SU20-2-10Caunii. pdf
11. www. fao. org/docrep/t0073e/t0073e01 . htm
12. www. pulseaus. com. au/. . . /Pulses%20Nutritional%20Value%20and%20Th. .
13. www. researchgate. net/. . . Nutritional. . . oilseeds/. . . /9fcfd50633dab9e5d7. pd.
14. www. uvm. edu/extension/cropsoil/wp-content/uploads/turner_refining. pdf
15. journals. cambridge. org/article_S0021859600040156
16. www. intechopen. com/. . . /pesticides-in-the-modern-world-trends-in-pestic. . .
17. cibrc. nic. in/insecticides_rules. htm
18. www. agcsa. com. au/static/atm_articles/html/3_3c. html
19. www. agf. gov. bc. ca > Agriculture > Pesticide Wise

PBG 351 Plant Genetic Resources : Collection, Conservation and Utilisation (1+1)

Theory

Unit I Concepts in agrobiodiversity : Origin and history of agriculture; conservation and agricultural development; the central role of agrobiodiversity: trends and challenges; centers of crop plant origin and diversity; Crop Wild Relatives and their role in crop domestication; dynamics of domestication; concept of gene pool; agrobiodiversity regions of India- geographical distribution of crops of Indian origin

Unit II: Planning and execution of collection missions : Importance and need for collection missions; planning and execution of collection missions ; Logistics for collection; GIS- Information on collection sites; Passport data and its importance in collection missions; use of flora and herbaria for planning collections; National and international policies and procedures to be adopted in collection missions

Unit III : Concepts in PGR conservation : *In situ* and *ex situ* conservation: concept of biosphere reserves, gene sanctuaries, on-farm conservation, seed genebanks, field genebanks, botanical gardens, herbal gardens, *in vitro* repositories and cryo-genebanks; short-, medium- and long-term conservation, concept of base, active and working collections

Unit IV: International and national policies : International framework and PGR networks; International treaties and policies in relation to agrobiodiversity conservation and sustainable use; CBD , UPOV ; National policies and legal frame work; Organisations; Biodiversity authority; PPV and FR authority; National Biodiversity Authority, IP issues with respect to ITKs and communities safe guarding biodiversity

Practical

Concepts and methods for computing biodiversity; Alpha and beta models; Calculation of species richness and endemism. Field visits to biosphere reserves – *in situ* methods of conservation. Visit to Field gene banks and understanding the modalities of conservation. Visit to Ramiah Gene Bank to understand the concepts of medium and long term storage in seed gene banks – Seed acquisition, processing, packing, barcoding, viability monitoring, registration and documentation. Visit to clonal gene banks. Biotechnology in conservation - *In vitro* methods of conservation. Exposure to cryoconservation methods. Concepts of PGR documentation and related web resources. Crop genetic diversity - Concepts of core and mini core collections. Molecular methods in PGR documentation and fingerprinting. Planning a Pre breeding programme with adapted and unadapted germplasm. Crop wild relatives - designing a Pre breeding programme with Crop Wild relatives. PGR- Global and National policies. Learning the institutional policies and modalities in exchange and utilization of PGR at TNAU

Lecture schedule:

1. Origin and history of agriculture; conservation and agricultural development-the central role of agrobiodiversity – Methods to estimate biodiversity- trends and challenges
2. Crop diversity - centers of crop plant origin and diversity , Concepts of gene pools
3. Biodiversity hotspots - Global – Indian- Regions of agobiodiversity
4. Crop wild relatives – domestication of crops
5. Dynamics of crop domestication with special reference to Rice, Wheat, Maize and Tomato
6. Germplasm exploration and collection – Eco-Geographical issues to be considered in planning explorations- – use of GIS and GPS principles during explorations
7. Planning the logistics and execution of collection missions- Global collection missions and achievements

8. Sampling strategies to be adopted in collections – Data recording and handling including passport data, collection of herbaria of samples etc during collection missions
9. **Mid semester examination**
10. Historical issues related to PGR conservation, scientific basis of PGR conservation – Types :*In situ* and *ex situ* conservation:
11. *In Situ* Conservation methods : concept of biosphere reserves, gene sanctuaries,and on-farm conservation
12. *Ex Situ* conservation methods : Field gene banks and seed gene banks
13. *Ex Situ* conservation methods : Cryo conservation, *in vitro* conservation, DNA banks, conservation of microspores and mega spores
14. Concept of base, active and working collections, core collections and reference sets
15. International framework and PGR networks; International treaties and policies in relation to agrobiodiversity conservation and sustainable use; CBD and UPOV convention
16. National polices: National Biodiversity Authority, PPV & FR authority, IP issues with respect to ITKs and communities safe guarding biodiversity
17. Utilization of Plant Genetic Resources – Pre-breeding concepts for use of adapted and un-adapted germplasm in crop improvement programmes

Practical schedule:

1. Concepts and methods for computing biodiversity; Alpha and beta models;
2. Calculation of species richness and endemism
3. Field visits to biosphere reserves – *in situ* methods of conservation
4. Visit to Field gene banks and understanding the modalities of conservation
5. Visit to Ramiah Gene Bank to understand the concepts of medium and long term storage in seed gene banks – Seed acquisition, processing, packing, barcoding
6. Visit to Ramiah Gene Bank to understand the concepts of medium and long term storage in seed gene banks – viability monitoring, registration and documentation
7. Visit to clonal gene banks
8. Biotechnology in conservation - *In vitro* methods of conservation
9. Exposure to cryoconservation methods
10. Concepts of PGR documentation and related web resources
11. Crop genetic diversity - Concepts of core and mini core collections
12. Molecular methods in PGR documentation and fingerprinting
13. Planning a Pre breeding programme with adapted and unadapted germplasm
14. Crop wild relatives - designing a Pre breeding programme with Crop Wild relatives
15. PGR- Global and National policies
16. Learning the institutional policies and modalities in exchange and utilization of PGR at TNAU
17. **Practical Examination**

Reference

Engels J. M. and Visser, L. **(**eds.). 2003. A guide to effective management of germplasm collections. IPGRI Handbook for Genebanks No. 6. IPGRI, Rome, Italy.

Guarino, L. , Rao, V. R. and Reid, R. **(**eds.). 1995. Collecting plant genetic diversity. CAB International, Wallingford, UK.

E references:

Food and Agriculture Organization **(**FAO) Commission on Biodiversity for Food and Agriculture; www. fao. org/biodiversity

http://www. bioversityinternational. org/uploads/tx_news/Molecular_markers_f or_ gene bank_management_1082. pdf

SST 351 Seed entrepreneurship skill development and management (1+1)

Unit I : Current status of National and Global Seed Industry and future perspectives Seed plan - Supply chain management - Significance of Seed Replacement Rate (SRR) Formal and informal seed sector - Seed trade - Role of International agencies in cross border trading (UPOV, OECD, ISTA, IPPC, AOSA, AOSCA) Varietal registration - Seed legislation and regulatory frame works (Seeds Act and Rules, Seed Control Order 1983 and amendments - PPV&FRA 2001).

Unit II : Seed promotional policies and programmes – NPSD 1988 - National seed policy 2002- Seeds Bill 2004 - EXIM policy - Domestic and International organizations involved in seed business - NSC, SSC,NSAI

- International Seed Federation (ISF) - Asia Pacific Seed Association (APSA) - National seed quality regulatory system - Seed Certification Agencies - Notification - Seed Testing Laboratories - Central and Referral laboratories - Uniformity in quality regulation - International Seed quality regulatory system - OECD varietal certification - International Seed analysis certificate - ISTA membership and accreditation system.

Unit III : Seed Export and Import - procedures and guidelines - Germplasm exchange rules and directions - Plant Quarantine system and Sanitary and Phyto Sanitary (SPS) issues and measures for export and import of seeds - NBPGR, FAO - Human resource skill development - Financial requirements and their significance in successful seed company management - Seed company - Corporate affairs – components - Registration and establishment - Grant and issue of license - Seed preference assessment

- Seed Rolling Plan - OPVs and hybrids - Role of Seed multiplication Ratio (SMR) - Varietal Replacement Rate (VRR).

Unit IV : Post harvest handling and machineries - Principles of seed drying, cleaning and upgradation - their significance in seed shelf life preservation - Risk coverage of carry over seeds - factors affecting seed storage - infrastructure facilities - ambient and advanced storage structures - Pre and post seed quality control - management checks and balances - their significance in seed trade - Linkages with various organizations for effective seed trade and business management - Farmers centric and market driven strategies for sustaining seed business and achieving seed security - Seed pricing - pricing policies of public and private agencies - strategies - methods and factors affecting prices.

Lecture schedule

1. Current status of National and Global Seed Industry and future perspectives
2. Seed plan - Supply chain management - Significance of Seed Replacement Rate (SRR) - Formal and informal seed sector
3. Seed trade - Role of International agencies in cross border trading (UPOV,OECD, ISTA IPPC, AOSA, AOSCA)
4. Varietal registration - Seed legislation and regulatory frame works (Seeds Act and Rules, Seed Control Order 1983 and amendments - PPV&FRA 2001)
5. Seed promotional policies and programmes – NPSD 1988 - National seed policy 2002- Seeds Bill 2004 - EXIM policy
6. Domestic and International organizations involved in seed business – NSC, SSC,NSAI- International Seed Federation (ISF) - Asia Pacific Seed Association(APSA)
7. National seed quality regulatory system- Seed Certification Agencies- Notification - Seed Testing Laboratories - Central and Referral laboratories - Uniformity in quality regulation.

8. **Mid semester examination**
9. International Seed quality regulatory system - OECD varietal certification - International Seed analysis certificate - ISTA membership and accreditation system
10. Seed Export and Import - procedures and guidelines - Germplasm exchange rules and directions - Plant Quarantine system and Sanitary and Phyto Sanitary (SPS) issues and measures for export and import of seeds - NBPGR, FAO etc
11. Human Resource skill development - Financial requirements and their significance in successful seed company management
12. Seed company - Corporate affairs - components- Registration and establishment - Grant and issue of license
13. Seed preference assessment - Seed Rolling Plan - OPVs and hybrids - Role of Seed multiplication Ratio (SMR) - Varietal Replacement Rate (VRR)
14. Post harvest handling and machineries - Principles of seed drying, cleaning and upgradation - their significance in seed shelf life preservation
15. Risk coverage of carry over seeds - factors affecting seed storage - infrastructure facilities - ambient and advanced storage structures
16. Pre and post seed quality control - management checks and balances - their significance in seed trade - Linkages with various organizations for effective seed trade and business management
17. Farmers centric and market driven strategies for sustaining seed business and achieving seed security - Seed pricing - pricing policies of public and private agencies - strategies - methods and factors affecting prices

Practical schedule

1. Basic components in establishment of seed company and organizational setup - staffing pattern - Registration procedures - Company - seed producer
2. Visit to public and private sector seed companies
3. Preparation of seed rolling plan
4. Visit to seed production plots - Study on field inspection procedures
5. Lay out and designing of seed processing unit and infrastructure
6. Lay out and designing of large and small scale seed storage facilities
7. Layout and establishment of seed quality control laboratory
8. Financial assistance for seed company establishment - Central Sector Seed Schemes - NABARD - Financing organizations
9. Preparation of projects for financial assistance for establishment of seed company - Micro, small and medium enterprises etc. ,
10. Project preparation on establishment of seed processing units and seed storage infrastructures for financial assistance
11. Visit to seed dealer and retail outlets
12. Value addition techniques for seed preservation, marketing and minimizing post harvest quality losses
13. Management of legal issues related to seeds - stop sale order, punitive action, punishment and appeal - appellate authority
14. Visit to Seed Testing laboratories - Notified and ISTA accredited
15. Preparation of company status report and analysis of critical issues on sustaining seed business
16. Downgrading of seeds - Upgradation and improvement of seed standards of “sales returned seeds” for placing in market
17. **Final practical examination**

References

1. Dadheech, P. K. 1996. Seed Programming. Management system and concepts. Lok Sahitna Kendra. Jodhpur.
2. Gurudev Gingh and Asokan, S. R. , 1997. Management of seed activity. Oxford and IBH Publishing Co. , New Delhi.
3. Ramalingam, C. K. Sivasubramaniam and A. Vijayakumar. 1997. A Guide to seed legislation. Rassi Computers, Madurai
4. Trivedi, R. K. and M. Gunasekaran. 2013. Indian Minimum Seed Certification Standards. Dept. of Agriculture & Cooperation, Ministry of Agriculture, Govt. of India, New Delhi.
5. Compendium of Seed Legislation. 2013. Dept. of Agriculture & Cooperation, Ministry of Agriculture, Govt. of India, New Delhi

Online references

1. www. fao. org
2. www. seednet. gov. in
3. www. agricoop. nic. in
4. www. agri. nic. in

NEM 351 Commercial Production of Nematode Antagonistic bio-agents (1+1)

THEORY

Unit 1 : Concepts and definition of biocontrol agents **–** Economic yield loss caused by plant parasitic nematodes in agricultural and horticultural crops – Ecofriendly management of plant parasitic nematodes - Types of bioagents – Fungal antagonistic organisms – Applications – Dosage - Commercial formulations available in India – Merits and demerits.

Unit 2: *Paecilomyces lilacinus* – *Pochonia chlamydosporia* - Morphological identification of colony – Conidiaspore and Chalmydospores identification –- Isolation from eggs - Mode of action – Host range - virulence – effect of biotic and abiotic factors on growth – compatibility with chemical inputs.

Unit 3: Sterilization – Types and Preparation of sterilizing agents – Equipments used – Principle of autoclave – Principle of Laminar Air Flow Chamber – Fermentor – Laboratory up-keep – Haemocytomenter – Assessment of spore load – colony forming unitis.

Unit 4: Preparation different culture media – Maintenance of pure culture - Mother culture – Subculturing – Mass culturing techniques – solid and liquid formulations - Commercial Formulations – Carrier materials – Packing – Quality control and shelf life.

Unit 5: Market demand analysis - Economics – Establishment of pilot plant – Infrastructure - Budget preparation – Marketing and cost-benefit analysis – risk analysis – Environmental impact test with vertebrate and invertebrate organisms.

Lecture Schedule

1. Introduction - Economic yield loss caused by plant parasitic nematodes in agricultural and horticultural crops. Concepts and definition of biocontrol agents.
2. Types of bioagents – Fungal antagonistic organisms – Applications – Dosage - Commercial formulations available in India – Merits and demerits
3. *Purpureocillium lilacinum (=Paecilomyces lilacinus)* – Morphological identification of colony, phialids and conidia spore
4. *Pochonia chlamydosporia* - Morphological identification of colony. Conidia spore and Chalmydospores identification
5. Isolation of *P. lilacinum* and *P. chlamydosporia* from nematode eggs and mode of action.
6. Host range of *P. lilacinum* and *P. chlamydosporia* - virulence and effect of biotic and abiotic factors on growth – compatibility with chemical inputs
7. Sterilization – Types and Preparation of sterilizing agents – Equipments used for production of bioagents.
8. Principle of Autoclave, Laminar Air Flow Chamber and Fermentor
9. Laboratory up-keep – Preparation of cleaning solutions – preparation of stock solutions
10. Haemocytomenter – Assessment of spore load – colony forming units.
11. Preparation of different culture media – Maintenance of pure culture - Mother culture – Subculturing
12. Mass culturing techniques – solid and liquid formulations – Shelf life
13. Commercial Formulations – Carrier materials – Packing – Quality control and shelf life.
14. Market demand analysis – Economics
15. Establishment of pilot plant – Infrastructure requirement – cost analysis
16. Budget preparation – Marketing and cost-benefit analysis – risk analysis
17. Environmental impact test with vertebrate and invertebrate organisms

PRACTICAL:

Plant parasitic nematodes eggs isolation – Eggs parasitization tests with *Paecilomyces lilacinus* and *Pochonia chlamydosporia* – Fungal specific media preparation – Pure culture - Preparation of common culture media – subculturing of *Paecilomyces lilacinus* - subculturing of *Pochonia chlamydosporia* – Preparation of broth – Inoculation – Incubation in mechanical shaker – *In vitro* bioefficacy test on root knot nematode - Fermentation process – Haemocytometer – Assessing spore load in broth – Preparation of commercial formulation – Quality control test - Packing – Analyzing market potential and demand – Conducting environmental impacts test with termites, saprophytes, honeybees, earthwarm etc. , - Visit to commercial production unit (HRS, Ooty).

1. Isolation of eggs of plant parasitic nematodes.
2. Eggs parasitization tests with *Purpureocillium lilacinum*
3. Eggs parasitization tests with *Pochonia chlamydosporia*
4. Fungal specific media preparation – Pure culture - Preparation of common culture media
5. Subculturing of *P. lilacinum* and *Pochonia chlamydosporia*
6. Preparation of broth – Inoculation – Incubation in mechanical shaker
7. *In vitro* bioefficacy test on root knot nematode with *Purpureocillium lilacinum*
8. *In vitro* bioefficacy test on root knot nematode with *Pochonia chlamydosporia*
9. Fermentation process
10. Haemocytometer – Assessing spore load in broth
11. Preparation of commercial formulation
12. Quality control test Packing
13. Analyzing market potential and demand
14. Conducting environmental impacts test with termites, saprophytes,
15. Conducting environmental impacts test with honeybees, earthworm
16. Visit to commercial production unit (HRS, Ooty).
17. **Practical Examination**